EPL297 Monitoring Report
Darwin Crocodile Farm

Reporting Period: 1 June 2022 – 31 May 2023

Porosus Pty Ltd

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RELIANCE, USES and LIMITATIONS

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ACRONYMS

ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
DCF	Darwin Crocodile Farm
DEPWS	Department of Environment, Parks and Water Security (Northern Territory)
DO	**d**issolved oxygen
EC	electrical conductivity
EPL	Environmental Protection Licence
FRP	filterable reactive phosphorous
LOR	limit of reporting
NATA	National Association of Testing Authorities
NOx	nitrate NO_3 + nitrite NO_2
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Agency
ORP	oxygen reduction potential
QA/QC	quality assurance, quality control
TN	total nitrogen
TP	total phosphorous
TSS	total suspended solids
WMPC Act	*Waste Management and Pollution control Act (*Northern Territory)

1 INTRODUCTION

Porosus Pty Ltd (Porosus) operate Darwin Crocodile Farm (DCF), located at Noonamah in the Northern Territory (NT); location shown in Figure 1-1. Water quality and soil monitoring is undertaken at DCF to ensure that operations do not impact waterways downstream i.e. Bees Creek, Elizabeth River and Darwin Harbour or groundwater beneath the stie. This monitoring is also a requirement of Environment Protection Licence 297 (EPL297), issued to Porosus by the Northern Territory Environment Protection Authority (NT EPA) under the *Waste Management and Pollution Control Act.*

Monitoring Reports are required annually, as per Condition 57 of EPL297. These must be prepared in accordance with the NT EPA 'Guideline for Reporting on Environmental Monitoring'. Each report must include all requirements as set out in EPL297 Condition 58.

This particular Monitoring Report covers all water quality and soil monitoring undertaken for the reporting period starting 1 June 2022 and ending 31 May 2023 (herein referred to as the 'reporting period'). This is the third Monitoring Report since commencement of EPL297 on 29 May 2020.

1.1 Purpose and scope

This monitoring report is prepared in accordance with the following EPL297 conditions:

Condition 57

The licensee must complete and provide to the NT EPA a Monitoring Report, as prescribed by this licence, by 31 May each year.

Condition 58

The licensee must ensure that each Monitoring Report:

58.1 is prepared in accordance with the requirements of the NT EPA 'Guideline for Reporting on Environmental Monitoring';

58.2 includes a tabulation of all monitoring data required as a condition of this licence;

58.3 calculations of maximum total annual loads of Nitrogen and Phosphorous required as a condition of this licence;

58.4 reports on trigger value exceedances and investigations required as a condition of this licence;

58.5 includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available); and

58.6 includes an assessment of environmental impact from the activity

1.2 EPL297 compliance monitoring and reporting

EPL297 authorises discharge to land using wastewater from the authorised discharge point, see Figure 1-2. The authorised discharge point is located at the southern end of the farm, where all wastewater from farm operations is directed. From here, the water is pumped to the irrigation area that encompasses the northern portion of the farm property, where it is irrigated onto fodder crops.

In order to monitor for potential environmental impacts from this activity, surface water, groundwater and soil monitoring at DCF is undertaken in accordance with Attachment A of EPL297 and all monitoring related conditions of the licence; i.e. Conditions 41 to 46. The DCF *Irrigation Management Plan* (EcOz 2020) details the monitoring sites, physical (field) and laboratory parameters measured, sampling methods and procedures. Monitoring site locations are shown below in Figure 1-3 and detailed in Table 4-1. Parameters to be measured, monitoring frequency and trigger values, taken from Attachment A of EPL297, are also outlined below in Table 4-2, Table 4-3, Table 4-4 and Table 4-5. In addition to the above, the volumes and timing of irrigated water application must be recorded; as per EPL297 Condition 37.

1.2.1 Unauthorised discharges

Any off-site discharge of wastewater from DCF is a non-compliance against Conditions 27 and 35 of EPL297. The situation currently is that during the wet season, the volumes of water flowing to the DCF southern boundary are in excess of what can be irrigated, and for extended periods, depending on rainfall, water in the ponds along the southern boundary flow over a spillway into the neighbouring property to the south. From here, the water then flows into the Elizabeth River. This passive discharge contains a component of farm wastewater, along with stormwater from across the DCF site, as well as a significant proportion of stormwater from offsite areas east of the Stuart Highway. Incidences of this off-site discharge must be recorded as a noncompliance as per Condition 49, and reported to the NT EPA, as per Condition 50.

Given the frequency and duration of these unauthorised discharges during the wet season, inquiry was made to the NT EPA as to how to approach non-compliance reporting. The following clarification was provided in a letter from the NT EPA on 15 October 2020:

- *Each unauthorised discharge would be considered a separate event and the non-compliance conditions would apply each time.*
- *The duration of each unauthorised discharge is from the time the discharge starts to the time it ceases. If the discharge is occurring during the notification then condition 51.2 would require it to be stated when the non-compliance began and that it is ongoing. Conditions 51.3, 51.6 and 51.7 will be key pieces on information if the discharge is ongoing.*
- *Condition 51.8 requires the Licensee to nominate a date for when an incident investigation report will be submitted to the NT EPA. It is suggested that if the discharge is ongoing then the nominated date is set for a period of time after discharge ceases or is expected to cease.*
- *Combining multiple discharge events in a single investigation report is acceptable provided that there is not considerable lag following the first event and that each discharge event is investigated adequately*

During the reporting period, off-site discharge over the southern DCF boundary commenced on 14 December 2022, following heavy early wet season rainfall and runoff during the preceding two months. The NT EPA was notified of this discharge in an email to waste.ntepa@nt.gov.au on 14 December 2022. Information addressing the Condition 51 requirements were provided, which concluded that an investigation report on the non-compliance would be provided upon completion of the discharge. This discharge continued throughout the wet season ending on the 30 May 2023. An incident investigation report is provided for this noncompliance in Section 7 below.

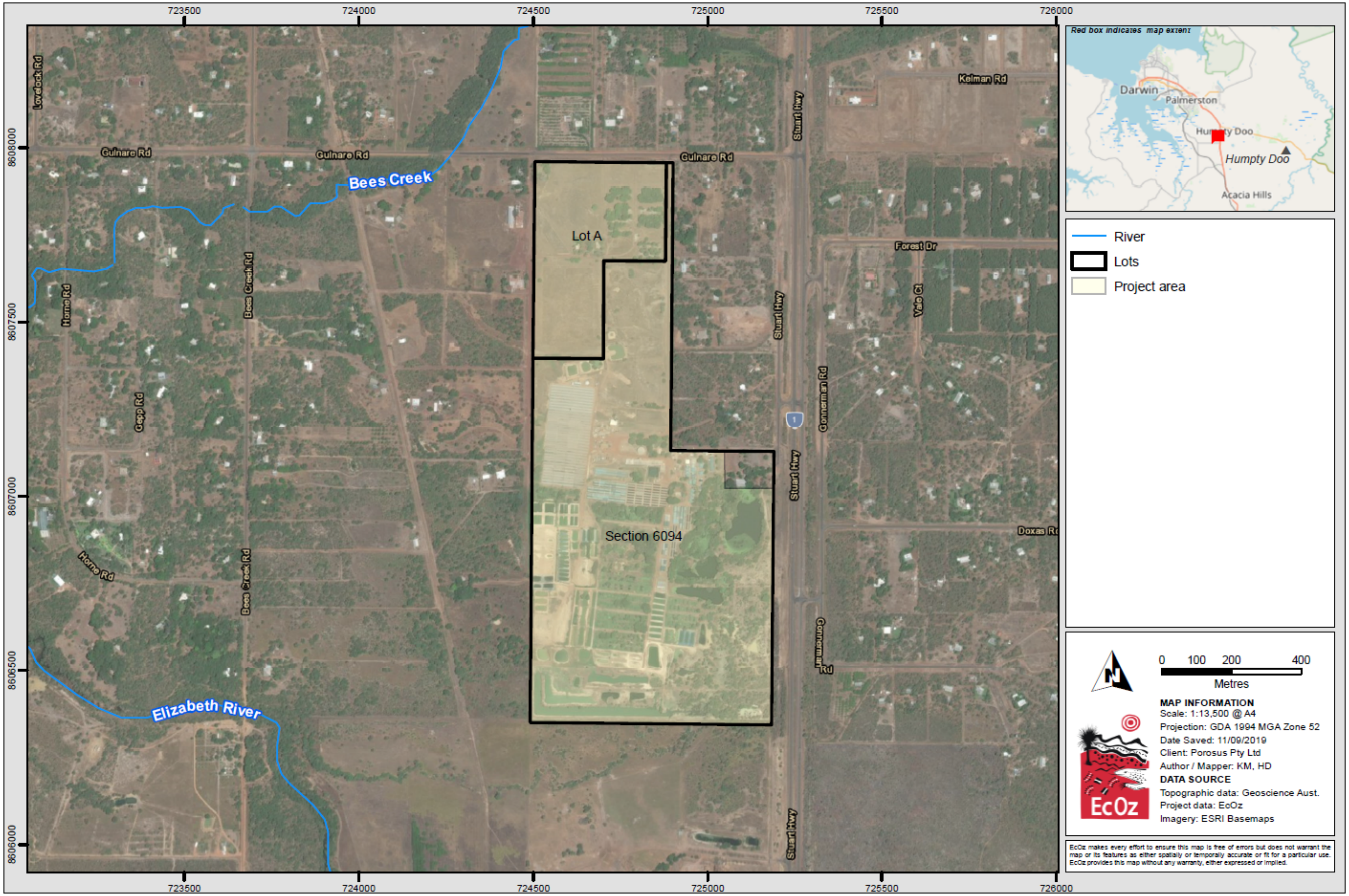

Figure 1-1. Map of DCF location

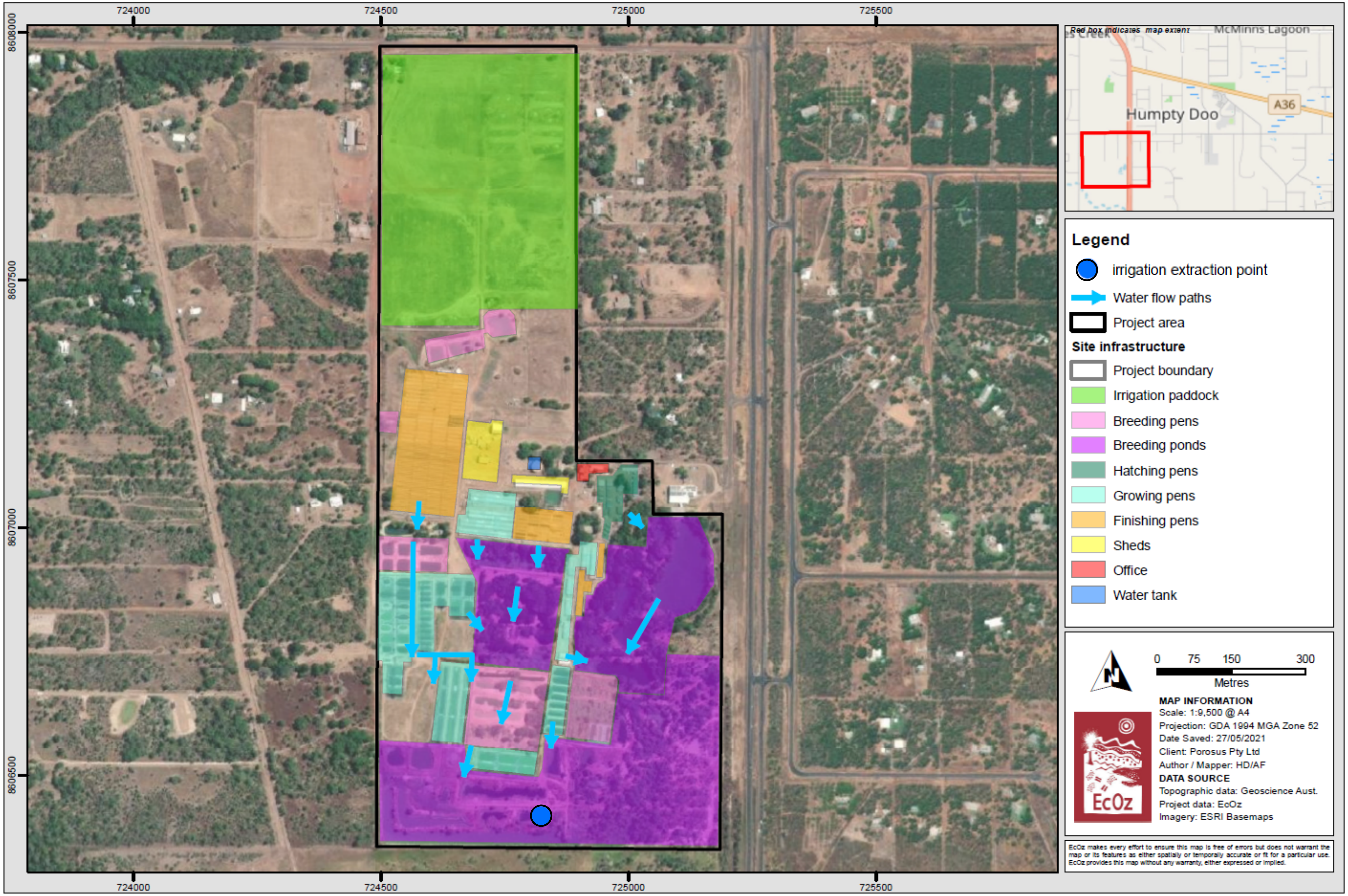

Figure 1-2. Map of DCF layout, flow paths, authorised discharge point and irrigation area

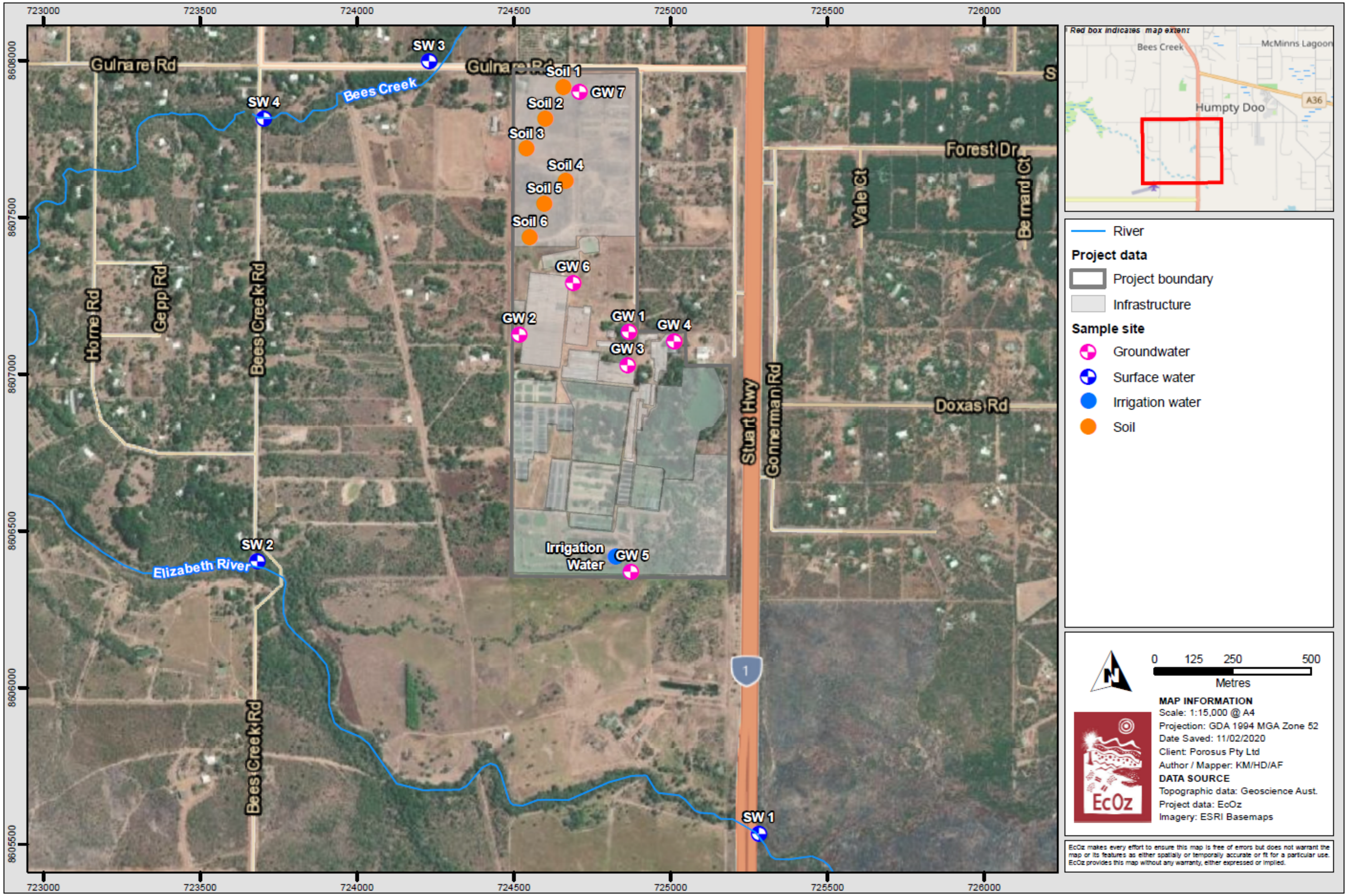

Figure 1-3. Map of DCF surface water, groundwater, and soil monitoring sites

2 DCF OPERATIONS OVERVIEW

The information provided below is a brief overview of DCF operations and environmental setting. For more detail, please refer to the following documents:

EcOz 2019, *Supporting information for the Darwin Crocodile Farm EPL application*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, October 2019

EcOz 2020, *Irrigation Management Plan, Darwin Crocodile Farm*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, February 2020

EcOz 2021, *Conceptual Site Model, Darwin Crocodile Farm*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, June 2021

In particular, for a review and assessment of the potential contaminants at DCF, their potential migration pathways and receptors, see the EcOz (2021) conceptual site model report.

2.1 Farm operations

The crocodile production process at DCF is summarised as follows:

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

Currently DCF harvests 200 - 300 animals per week for processing to produce raw crocodile skins, meat products and other saleable by-products. The processing is undertaken at a neighbouring processing facility (within the same lot). It operates as a separate business and manages its own wastewater through a septic system.

2.2 Water supply

DCF currently holds a groundwater extraction licence (Licence no. WSF01), which allows a maximum extraction entitlement of 700 ML/year combined from the six water supply bores at the site (i.e. GW1 to GW6 in Figure 1-3 and Table 3-2). Each bore has an automated flow meter to record the volumes of water extracted. Volumes must be reported to NT Water Resources Division as per the WSF01 licence conditions.

The aquifer utilised is in the Wildman Siltstone Formation. Each bore either specifically supplies a particular section(s) of the farm or supplies water directly to water storage facilities, which it then distributes as required to different farm areas for general crocodile husbandry.

The primary use of water is for regular flushing of the different pens for maintenance of hygiene and health of individuals. Due to the high quantities of water required during the cleaning of the pens, there are two water storage facilities: a 2.5 ML water tank and a 1.5 ML storage dam. These storage facilities allow for the pens to be cleaned and refilled experientially as crocodiles require access to clean water. On average, the water usage at DCF is estimated at 1,600 KL/day.

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

2.3 Wastewater flows

Water obtained from the bores is pumped through the hatchery, grower and finishing pens. The effluent from each stage discharges into numerous breeding lagoons and constructed earthen ponds on the property (Figure 1-2). The water flows through the breeding areas in a southerly direction before being detained in a series of large storage ponds on the southern boundary. This flow of wastewater through the lagoons facilitates a bioremediation process reducing the nutrient and microbial levels in the wastewater.

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

Water retained in the storage ponds on the southern boundary of the site is pumped to the irrigation area occupying the northern portion of site, where it is used to irrigate pasture grasses.

During the wet season, water at times flows over a spillway located along the southern boundary of the DCF into the neighbouring property to the south, from where it then flows into the Elizabeth River. This passive discharge contains a component of farm wastewater, along with stormwater from across the DCF site, as well as a significant proportion of stormwater from offsite areas east of the Stuart Highway.

A new wastewater storage facility was completed in November 2022 which aims to increase farm storage capacity of waste waters and reduce unauthorised discharges. Currently these ponds collect wastewater from pens prior to being discharged though the facilities drainage system to the southern boundary. It is the future intention that these new ponds will serve as the irrigation source with all site run off/ drainage and water from the existing irrigation source pond being pumped to these ponds prior to irrigation. This will allow irrigation to occur throughout the dry season when historically this has not been possible due to the irrigation source pond containing breeding crocodiles.

2.4 Environmental setting

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

Climate observations are made by the Bureau of Meteorology (BoM). The closest BoM weather monitoring station to the site with long-term data is McMinns Lagoon (station number No. 14219). Average annual rainfall recorded at this station is 1,894 mm, with the highest rainfall occurring in January and the lowest in June and July (Table 2-1). Almost 90% of the average annual rainfall typically falls between November and March. The average annual regional evaporation is 2,000 mm and exceeds the average annual rainfall. Evaporation is highest in October and lowest in January to March.

Table 2-1. Average rainfall and evaporation (taken from BoM Station No. 14219)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	459.6	382.0	321.9	106.2	17.6	1.2	0.8	3.5	15.9	81.0	183.7	312.4
Evaporation (mm)	146	126	146	156	161	156	171	189	204	220	189	161
Temperature (°C)	33.4	33.5	33.8	34.2	33.4	32.3	32.8	34.2	36.5	37.4	36.4	35.0

Surface water flows from the DCF operational areas to the southern boundary of the site. As mentioned above, during the wet season, water at times flows over a spillway located along this boundary into the neighbouring property, from where it then flows into the Elizabeth River. This passive discharge contains a component of farm wastewater, along with stormwater from across the DCF site, as well as a significant proportion of stormwater from offsite areas east of the Stuart Highway.

The irrigation area sheet flows to the north-western boundary of the site towards the drainage lines on Gulnare Road (approximately 170 m from site), which feeds into a separate arm of the Elizabeth River (Bees Creek). The Elizabeth River then flows into Darwin Harbour.

Darwin Harbour is a Site of Conservation Significance (see NT Government factsheet *Sites of Conservation Significance, Darwin Harbour*) and is highly valued by the community for its environmental, recreational, and cultural features; see the *Darwin Harbour Water Quality Protection Plan* (DLRM 2014).

Land use surrounding DCF includes mainly privately owned lots zoned as 'rural living' to the north, south and west, with the Stuart Highway bordering the site to the east. Many of these lots are rural subdivision that are used for private rural living, while some lots north and south of DCF are used for horticultural and agricultural purposes.

Soils on the property are predominately hydrosols and rudosols according to the Greater Darwin Region Land units (mapped at 1:25000 scale). Hydrosols are seasonally inundated and generally occur on coastal floodplains, swamps and drainage lines. Rudosols are very shallow soils with minimal pedological development.

3 RAINFALL, DISCHARGES AND WATER USAGE

3.1 Rainfall

Figure 3-1 shows monthly rainfall totals taken from the McMinns Lagoon BoM station 14219 for the reporting period. Average monthly rainfall totals are also shown for comparison. Rainfall was well above average for six out of eight of the wet months during the reporting period with January and March being below average. The total rainfall for the 12-month reporting period, 2,220mm, was well above the annual average of 1,894 mm.

The total rainfall for the same period last year (i.e. June 2021 to May 2022) was 1,806 mm, just below the annual average. This is particularly relevant when reviewing the groundwater bore standing water levels (SWLs) in Section 5.3 below.

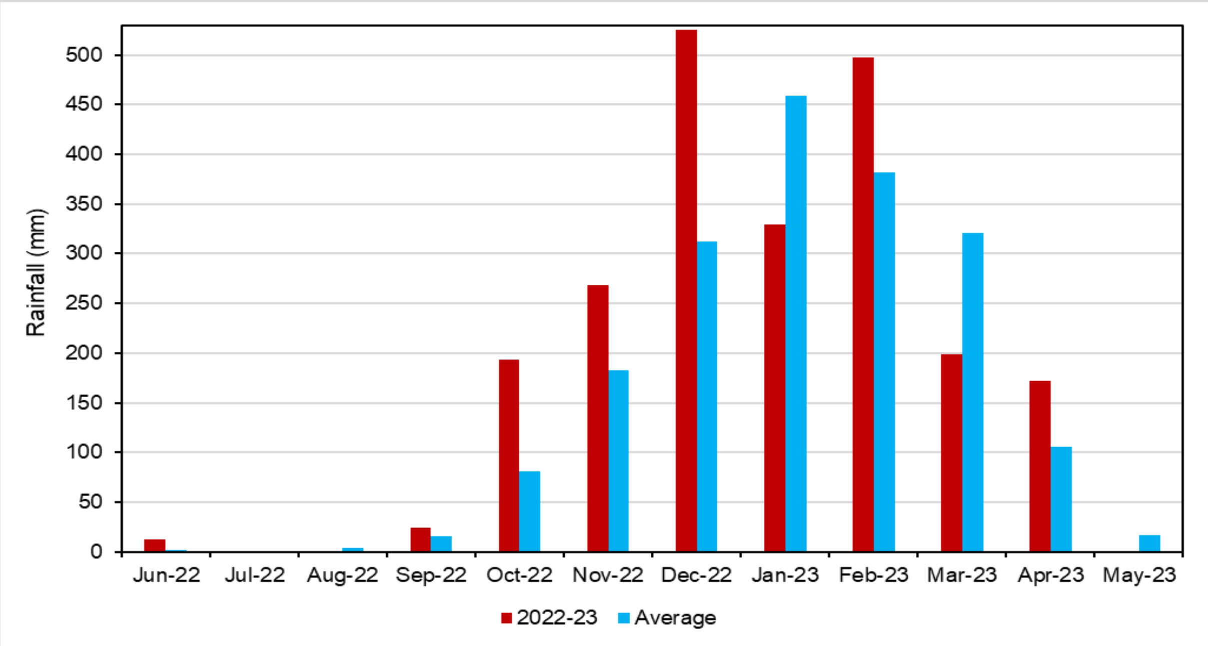

Figure 3-1. Monthly rainfall totals June 2022 to May 2023 (BoM station 14219)

3.2 Reporting period discharge details

Table 3-1 outlines the discharges that occurred to land i.e. irrigation applied to the irrigation area using water pumped from the authorised discharge point. Irrigation was mainly undertaken during the late dry season / early wet season period. Irrigation was timed to occur when soils in the irrigation area were not saturated to avoid runoff.

The total irrigation volume for this reporting period (6.78 ML) was a lot less than the previous reporting period (2020/21), where it was 13.11 ML. This is due to the above average wet season that limited the capacity of the irrigation area to handle additional water.

Table 3-1. Irrigation discharges during reporting period 1 June 2022 – 31 May 2023 Month Irrigated

Month	Irrigated (ML)
Jun 22	0
Jul 22	0
Aug 22	0
Sept 22	0
Oct 22	0
Nov 22	2.59
Dec 22	4.19
Jan 23	0
Feb 23	0
Mar 23	0
Apr 23	0
May 23	0
Total	**6.78**

3.3 Groundwater usage

As explained in Section 2.2 above, DCF currently holds a groundwater extraction licence (Licence no. WSF01), which allows a maximum extraction entitlement of 700 ML/year combined from the six water supply bores at the site. Table 3-2 below provides the monthly and yearly groundwater extraction volumes combined from all six bores for the current and previous reporting periods. Annual extraction volumes have remained below 700 ML since the licence was issued in 2015.

Table 3-3 provides the volumes extracted from each of the six bores for the previous and current reporting periods. Most water (around 71%) is extracted from GW3 (Main Bore), followed by GW6 and GW5 (14% and 12% respectively). The remaining 3% comes from the combined total extracted from GW1, GW2 and GW4.

Table 3-2. Monthly totals of groundwater extracted from the six bores combined for the current and previous reporting periods

Month	Volume extracted (kL) 2020/21	Volume extracted (kL) 2021/22	Volume extracted (kL) 2022/23
May	56,744	70,459	55,015
June	50,520	61,841	59,574
July	69,251	67,554	68,443
August	63,077	54,507	62,375
September	48,509	53,641	58,375
October	44,292	44,495	49,722
November	49,079	39,481	60,994
December	33,072	37,279	61,161
January	41,817	40,655	57,482
February	40,446	41,203	51,109
March	57,598	55,702	58,311
April	53,544	62,954	50,352
Total	**607,950**	**629,772**	**692,913**

Table 3-3. Groundwater bore details and volumes of water extracted for current (2022/23) and previous (2021/22) reporting periods

Registered Bore Number	EPL297 Monitoring Bore ID	DCF Bore Name	Latitude	Longitude	Total water extracted (kL) 2021/22	% of total	Total water extracted (kL) 2022/23	% of total
RN008775	GW1	Lindsay's Bore	-12.591672	131.069881	18,841	3%	18,016	3%
RN030548	GW2	West Wing Bore	-12.591763	131.066668	1,014	0.2%	1	0%
RN026341	GW3	Main Bore	-12.592629	131.069854	420,735	67%	492,832	71%
RN033646	GW4	Hatchery Bore	-12.591921	131.071218	2,954	0.5%	0	0%
RN034341	GW5	Murwangi Bore	-12.598577	131.070002	82,631	13%	86,106	12%
RN038879	GW6	Recirculation Bore	-12.590256	131.068242	103,597	16%	95,958	14%
RN025932	GW7	Monitoring Bore	-12.584753	131.068383	Not used for water supply	0%	0	0%

4 MONITORING UNDERTAKEN

During the reporting period, monitoring was undertaken as per EPL297 requirements using the methods outlined in the DCF *Irrigation Management Plan* (EcOz 2020). Below is an outline of the monitoring undertaken during the reporting period.

4.1 Monitoring sites

Surface water, ground water and soil monitoring sites are shown in Figure 1-3 and detailed in Table 4-1.

Table 4-1. Surface water, groundwater and soil monitoring details

Site ID	Context and Purpose	GPS Coordinates	
		Latitude	Longitude
Surface Water Sites			
Irrigation Source	"Authorised discharge point" listed in EPL297. Located at southern end of DCF property. All wastewater form farm operations flow to this point. Represents water applied to the irrigation area occupying the northern portion of DCF. Also represents passive discharge water quality flowing across the DCF southern boundary during the wet season.	-12.598208	131.069494
SW1	Elizabeth River upstream monitoring site – located upstream of DCF passive discharge from southern boundary.	-12.606080	131.073815
SW2	Elizabeth River downstream monitoring site – located downstream of DCF passive discharge from southern boundary.	-12.598357	131.059043
SW3	Bees Creek upstream monitoring site – located upstream of runoff from DCF irrigation area.	-12.583912	131.063956
SW4	Bees Creek downstream monitoring site – located downstream of runoff from DCF irrigation area.	-12.585606	131.059124
Groundwater Bores			
GW1	RN008775, Lindsay's bore used to supply water to farm operations.	-12.591672	131.069881
GW2	RN030548, West Wing Bore used to supply water to farm operations.	-12.591763	131.066668
GW3	RN026341, Main bore used to supply farm operations.	-12.592629	131.069854
GW4	RN033646, Hatchery bore used to supply water to farm operations.	-12.591921	131.071218
GW5	RN034341, Murwangi bore used to supply water to farm operations.	-12.598577	131.070002
GW6	RN038879, Recirculation bore used to supply water to farm operations.	-12.590256	131.068242
GW7	RN025932, Monitoring bore – used for groundwater quality monitoring beneath irrigation area. Bore is not equipped and not used for water supply.	-12.584753	131.068383
Soil Sites			
Soil 1 Soil 2 Soil 3 Soil 4	Soil sites are spread across the irrigation area	-12.584615 -12.585550 -12.586416 -12.587329	131.067910 131.067385 131.066839 131.067996

Soil 5		-12.587991	131.067379
Soil 6		-12.588947	131.066995

4.2 Monitoring frequency, parameters, and trigger values

Table 4-2. Monitoring program and trigger values for irrigation water

Monitoring sites	Parameter	Sampling frequency	Triger values
Authorised discharge point Latitude -12.598208° Longitude 131.069494°	pH	Monthly when discharging and quarterly when not discharging	6 – 9 [1]
	EC		1,300 µS/cm [1]
	Total N		125 mg/L [1]
	Total P		12 mg/L [1]
	E.coli, Enterococci, Total Coliforms		1,000 CFU/mL (fodder) [1]
	Cations and Anions (Ca, Mg, Na, K, SO4, Cl, CO_3 + HCO_3)		N/A

[1] Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 – Chapter 9 – Primary Industries (ANZECC, 2000)

Table 4-3. Monitoring program and trigger values for groundwater sites

Monitoring Sites	Parameter	Sampling frequency	Trigger values
GW1, GW2, GW3, GW4, GW5, GW6 and GW7	Standing Water Level (SWL)	Monthly	N/A
	pH	Quarterly	7 - 8.5 [1]
	EC		400 µS/cm [1]
	Total N		Any increase from the previous monitoring round
	Total P		
	E.coli, Enterococci, total coliforms		
	Cations and Anions (Ca, Mg, Na, K, SO4, Cl, CO3 + HCO3)		N/A

[1] Darwin Harbour Water quality Objectives for groundwater

Table 4-4. Monitoring program and trigger values for surface water sites

Monitoring sites	Parameter	Sampling frequency	Trigger values
SW1*, SW2, SW3* and SW4	pH	3 times during the Wet season (start; during; end)	6.0 – 7.5 * [1]
	EC		200 µS/cm * [1 2]
	Total N		0.23 mg/L * [1 2]
	Total P		0.01 mg/L * [1 2]
	E.coli, Enterococci, Total coliforms		Any increase from the previous monitoring round

* Trigger values not applicable

[1] Darwin Harbour Water Quality Objectives for freshwater rivers and streams

[2] If the concentration at SW1 is greater than the trigger value then the concentration at SW1 becomes the trigger value for that monitoring round.

Table 4-5. Monitoring program and trigger values for soil sites

Monitoring sites	Parameter	Sampling frequency	Trigger values *
Soil 1, Soil 2, Soil 3, Soil 4, Soil 5 and Soil 6	pH	Annually	6 - 8
	EC		Any increase from the previous monitoring round
	Total N		
	Notal P		
	E.coli, Enterococci and Total coliforms		

* B horizon results

4.3 Sampling procedures

All sampling is undertaken in accordance with the DCF Irrigation Management Plan (EcOz 2020) and the following standards and guidelines:

Australian/New Zealand 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), Standards Australia, New South Wales.

Australian Standard/New Zealand Standard on Water Quality Sampling - *Part 4: Guidance on sampling from lakes, natural and manmade* (AS/NZS 5667.4:1998), Standards Australia, New South Wales.

Australian/New Zealand Standard on Water Quality Sampling - *Part 6: Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998), Standards Australia, New South Wales.

Australian Standard/New Zealand Standard on Water Quality Sampling – *Part 10: Guidance on sampling of waste waters* (AN/NZS 5667.10:1998), Standards Australia, New South Wales.

Australian/New Zealand Standard on Water Quality Sampling – *Part 11: Guidance on sampling of groundwater* (AN/NZS 5667.11:1998), Standards Australia, New South Wales.

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

All sampling was carried out by either EcOz Environmental Consultants, or Maurita Fleming from Porosus, who has received on-site training in sampling methods from EcOz Senior Environmental Consultant Bill Dwyer, as well as on-going guidance from EcOz.

All laboratory samples are collected into ALS Laboratory-supplied sample bottles/jars; some of which contain preservative where required. Once collected, these samples are kept cold in an esky with ice bricks until dispatched to the ALS shopfront on the same day as sampling in order to meet holding times.

All surface water monitoring sites are sampled from the land using a long pole, with a lab-supplied sample bottle on the end, in order to gain a sample a few metres from the bank. Sample is decanted from this bottle into the ALS-supplied bottles. Field parameters (i.e. pH, temperature, dissolved oxygen, oxidation reduction potential, turbidity and electrical conductivity) are measured directly in the water body using a water quality meter.

All groundwater bores are equipped with a pump, except for GW7. The equipped bores are turned on and the water run for at least 10 min and until field parameters stabilise. Once this occurs the field parameters are recorded and lab samples collected directly into the lab-supplied bottles. GW7 is sampled using a low flow pump, and the bore is purged until stable field readings are achieved prior to recording the field parameters and collecting samples for laboratory analysis.

Soil samples are collected from the B horizon (around 0.4 to 0.5 m below ground surface) using a mechanical augur which is decontaminated between each sample site.

All surface water, groundwater and soil field parameters and observations are recorded on a dedicated Field Data Sheet, developed to ensure all EPL297 information requirements as per Condition 46 are collected. The field parameter meter is calibrated immediately prior to each sampling round.

All field and laboratory results are stored in an Excel database maintained by EcOz.

All field data sheets (scanned copies) and laboratory documentation are stored in an online filing system maintained by EcOz (M-Files). Porosus also maintain copies of all laboratory documentation.

4.4 Monitoring undertaken during reporting period

Table 4-6 lists the monitoring that was undertaken during the reporting period. Compliance against EPL297 monitoring requirements is outlined.

Table 4-6. Monitoring undertaken during the reporting period

Site ID	Frequency required	Dates sampled	Compliance with sampling frequency	Compliance with parameters measured
Irrigation Source	Monthly during discharge, quarterly when not discharging	09/11/2022 12/12/2022 04/01/2023	Compliant for three monitoring events. Samples were not collected during August, February, March and April monitoring events.	Compliant except physical parameters not collected during December and January samples.
SW1 SW2 SW3 SW4	Three times during wet season, start, mid ,end	11/09/2022	Non- Compliant – no sampling undertaken	
GW1 GW2 GW3 GW4 (decommissioned) GW5 GW6 GW7	Quarterly water quality	04/08/2022 09/11/2022 06/02/2023 11/05/2023	GW4 bore has been decommissioned. GW2 not operational/sampled during November, February or May sampling event. GW1 not operational/sampled during February sampling event.	Non-compliance for GW3, GW5 and GW6 (total coliforms). GW7 compliant. All other analytes complaint.
	Monthly SWLs	10/06/2022 10/07/2022 10/08/2022 07/09/2022 26/10/2022 17/11/2022 07/12/2022 03/01/2023 08/02/2023	Compliant. No readings from GW4 as it has been decommissioned. No readings available at bore 3 during august round.	

Site ID	Frequency required	Dates sampled	Compliance with sampling frequency	Compliance with parameters measured
		13/03/2023 10/04/2023 15/05/2023		
Soil 1 Soil 2 Soil 3 Soil 4 Soil 5 Soil 6	Annually	27/03/2023	Compliant	Non-compliant in pH, EC, TP (SS2 and SS6), Enterococci (all except SS6), Total coliforms (all except SS2). Compliant for Total N and E.coli

5 RESULTS AND DISCUSSION

5.1 Authorised discharge point water quality

Table 5-1 provides the water quality results for all sampling undertaken during the reporting period of the authorised discharge point (irrigation source). To allow for long-term trend analysis, this table also includes all results for the irrigation source since monitoring began in 2020, when EPL297 was issued.

During the reporting period, all parameter concentrations complied with the trigger values listed in EPL297 Appendix A, Table 1, except for total coliforms for all monitoring rounds. Total coliforms have always been above the trigger value of 1,000 CFU/100 mL since monitoring began. Concentrations however remain stable and are not increasing over time. The bacteria present are also low risk, given the faecal contamination indicators E. coli and enterococci have remained below the trigger value.

EC concentrations during the reporting period ranged between 233 µS/cm in February 2022 and 418 µS/cm during October 2021, which is consistent with the predominant GW3 groundwater water supply source (see Section 5.2 below) mixed with rainwater during the wet season. No long-term increasing trend is evident in the data going back to 2020.

Total nitrogen (TN) and total phosphorus (TP) concentrations were very low in comparison to the trigger values and no long-term increasing trend is evident. The median TN and TP concentrations calculated for the reporting period are 0.8 and 0.05 mg/L respectively. These concentrations are used in Section 6 below in calculating the total N and P loads applied to the irrigation.

5.2 Groundwater quality

Table 5-2 provides the groundwater quality results for all sampling undertaken during the reporting period. Key parameters are graphed in Figure 5-1 to Figure 5-5. To allow for long-term trend analysis, these graphs include all monitoring data collected since regular groundwater monitoring started at DCF in 2019.

pH predominantly remains within the trigger value range of 7.0 to 8.5 in bores GW2, GW3, GW5 and GW6, and no long-term increasing or decreasing trends are evident (see Figure 5-1). During the reporting period, GW4 and GW5 recorded slightly acidic pH values between 6.11 and 6.70, however these are not of concern unless values continue to decrease. GW7 appears to have a decreasing trend in pH values. The cause of this is not known and will be investigated if pH continues to decrease during the next monitoring round. Of note is that this bore recorded a field pH of 4.85 when it was tested in 1993 (see bore records available in NR Maps). Therefore, it is possible the groundwater in this area is naturally acidic.

EC concentrations during the reporting period were below the trigger value in GW1, GW4 and GW7, and above the trigger value in GW2, GW3, GW5, and GW6. Long-term EC concentrations remain stable and likely reflect the aquifer properties at each bore location (Figure 5-2). Of note is that the highest EC values are not associated with bore with the highest rates of water extraction. Around 64% of water is extracted from GW3 and less than 3% from GW2, yet the EC in GW2 is higher than in GW3.

Long-term TN concentrations (see Figure 5-3) show GW1 and GW7 mostly record concentrations above 3 mg/L), whereas all other bores consistently record concentrations below 3 mg/L (except for one isolated occasion for GW4). Long-term TN concentrations do not show any increasing trends in any of the bores.

Long-term TP concentrations (see Figure 5-4) do not show any consistently increasing trends in any of the bores. The reason for the spike in TP concentration in GW2 during the May 2022 monitoring round is not known and will be investigated if this continues during the next monitoring round. The long-term median concentration for all bores combined is 0.02 mg/L. This is the same as the median surface water TP concentration for the two upstream sites SW1 and SW3 (see Section 5.4 below).

Figure 5-5 shows total coliform concentrations since regular groundwater monitoring of this parameter started in 2020. More than 80% of the concentrations measured are less than 500 CFU/100 mL. On the occasions where concentrations have been above this, they have returned to low levels in subsequent monitoring rounds. The results from GW7 did show a significant increase in total coliforms in the last round of monitoring, however E. coli and enterococci was low. It is possible that there was cross-contamination of the sample that led to this result, and results of the next monitoring round should be analysed to compare.

E. coli and enterococci concentrations are always relatively low, with 80% of all E. coli concentrations measured since 2020 below 8 CFU/100 mL, and 80% of all enterococci concentrations below 10 CFU/100 mL. As such, most of the bacteria included in the total coliform concentrations do not appear related to faecal contamination.

5.3 Groundwater bore standing water levels

Standing water levels (SWLs) measured in all bores since monitoring commenced in 2020 are graphed in Figure 5-6. SWL's in all bores followed a similar trend to previous years with levels peaking towards the end of the wet season, however this year the peak was later (between March and April) compared with previous years (between February and March) which is reflective of the rainfall this season. In general, SWL's did not drop as low as the levels recorded in the previous monitoring year.

GW7 is not used for water supply, and GW2 has negligible extraction; both are located at least 400 m away from the highest usage bore GW3. As such, GW7 and GW2 are indicative of background SWL's in the absence of pumping. SWLs in these two bores do not reduce as much as the other bores during the dry season and during the wet season water levels increase significantly in these bores. GW1, GW4 and GW6 have low usage compared to GW3, however the reduction in SWLs in these bores, and their proximity to GW3, is indicating they are subject to drawdown effects from GW3 pumping. Monitoring of these bores over another wet season will provide an improved understanding of the seasonal variation in response to pumping.

5.4 Surface water quality

There were no surface water samples collected during this monitoring period therefore there is no analysis of surface water quality. Monitoring conducted over previous years has not identified any significant difference in concentration of water quality parameters between the upstream and downstream sites. Data analysis undertaken in previous years has also not shown any evidence of increasing trends of potential pollutants. There were no recorded incidents (other than standard site discharges) or unusual activities on-site that may have caused contamination issues downstream and no visual indicators of contamination in the creek. In consideration of historical trends, contamination risk in the surface water during this period is considered low.

Site management will ensure that surface water samples are collected during the next monitoring period in order to continue tracking any trends.

5.5 Soils

Table 5-3 provides the soil monitoring results for the reporting period i.e. the annual sampling round undertaken in March 2023. To allow for long-term trend analysis, this table also includes all results for soil sampling since the baseline (pre-irrigation) monitoring round was undertaken in 2019.

All sites recorded their lowest pH levels since monitoring began is 2019. Levels ranged from 4.8 (SS4) to 5.8 (SS5), meaning that none were within the target pH range of 6-8. This is a notable change in soil pH across the site which will be investigated going forward.

EC showed an increase at all sites from the previous monitoring round. SS5 and SS6 both recorded the highest EC to date of 71 and 221 respectively. SS5 is the only site that has displayed an increasing trend and will be investigated going forward.

All TN concentrations were lower compared to previous monitoring results at all sites. TP showed increased levels at SS2, SS4, and SS6 where other sites showed lowered levels.

All sites showed increased Enterococci concentrations from previous monitoring rounds. SS1, SS4, SS5, and SS6 all displayed increases in Total Coliforms with significant increases observed at SS5 and SS6, from 49 to >27000 and 47 to >28000 MPN/g respectively.

Table 5-1. Authorised discharge point (irrigation source) water quality monitoring results since monitoring began in 2020

Concentrations in breach of EPL297 trigger values for irrigation water highlighted in red

Site ID	Date	pH	EC	NOx as N	TKN as N	TN	TP	Ca	Mg	Na	K	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity	SO4	Chloride	Total Coliforms	*E.coli*	*Enterococci*
	Units	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	CFU/100mL
	LOR	-	-	0.01	0.1	0.1	0.01	1	1	1	1	1	1	1	1	1	1	1	1	1
EPL297 Appendix A, Table 1		**6.0-9.0**	**1300**	-	-	**125**	**12**	-	-	-	-	-	-	-	-	-	-	**1000**	**1000**	**1000**
Irrigation Source	24/02/2020	7.62	299	0.02	4.8	4.8	0.63											42000	2700	1400
Irrigation Source	10/03/2020	7.52	206	0.28	1.4	1.7	0.31											50000	3500	~300
Irrigation Source	2/09/2020	9.31	385	0.03	0.8	0.8	0.02	13	26	18	7	<1	17	140	158	4	29	5800	19	~5
Irrigation Source	10/12/2020	8.22	512	0.04	1.3	1.3	0.12	23	26	16	8	<1	<1	179	179	5	28	14000	36	32
Irrigation Source	14/01/2021	-	-	<0.01	0.5	0.5	0.02	19	11	5	3	<1	<1	103	103	2	8	1500	24	25
Irrigation Source	2/03/2021	-	-	<0.01	0.2	0.2	0.01	17	10	3	2	<1	<1	90	90	1	5	4400	8	<1
Irrigation Source	17/05/2021	8.82	663	<0.01	0.4	0.4	0.01	20	17	9	3	<1	<1	127	127	<1	11	12000	5	49
Irrigation Source	26/10/2021	-	418	<0.01	0.7	0.7	0.04	16	28	17	7	<1	<1	185	185	3	35	5800	93	~6
Irrigation Source	8/12/2021	-	374	<0.01	0.9	0.9	0.02	14	28	18	7	<1	7	149	156	3	33	4100	29	25
Irrigation Source	11/01/2022	-	284	0.03	1.3	1.3	0.27	21	20	11	6	<1	<1	153	153	4	19	7100	280	25
Irrigation Source	16/02/2022	7.41	233	<0.01	0.7	0.7	0.05	-	-	-	-	-	-	-	-	-	-	3100	~310	220
Irrigation Source	13/04/2022	-	238	<0.01	0.8	0.8	0.04	19	14	7	3	<1	<1	112	112	<1	10	2400	920	37
Irrigation Source	18/05/2022	7.78	297	<0.01	0.7	0.7	0.05	21	16	10	3	<1	<1	132	132	<1	13	~1500	130	~900
Irrigation Source	9/11/2022	7.26	399	<0.01	1.1	1.1	0.09	22	26	17	7	<1	<1	178	178	3	28	~2200	~16	15
Irrigation Source	12/12/2022			<0.01	1.4	1.4	0.13	21	21	13	6	<1	<1	153	153	3	22	>2400	66	57
Irrigation Source	4/01/2023		226	0.03	0.7	0.7	0.08	17	12	8	2	<1	<1	113	113	<1	10	14000	310	170

Table 5-2. Groundwater quality monitoring results since monitoring began in 2019

Concentrations in breach of EPL297 trigger values for groundwater highlighted in red

Site ID	Date	pH	EC	NOx as N	TKN as N	TN	TP	Ca	Mg	Na	K	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity	SO4	Chloride	Total Coliforms	*E.coli*	*Enterococci*
	Units	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	CFU/100mL
	LOR	-	-	0.01	0.1	0.1	0.01	1	1	1	1	1	1	1	1	1	1	1	1	1
EPL297 Appendix A, Table 2		7.0-8.5	400	-	-	any increase from previous	any increase from previous	-	-	-	-	-	-	-	-	-	-	any increase from previous	any increase from previous	any increase from previous
GW1	12/06/2019	5.63	308	6.68		7.8	<0.01	27	10	14	<1				114	3	25		12	12
GW1	25/02/2020	5.81	274	5.22		5.8	<0.01	18	7	19	<1				56	3	27			
GW1	2/09/2020	5.75	330	5.89	0.6	6.5	0.01	10	4	37	<1	<1	<1	31.0	31	1	55	2	<1	<1
GW1	10/12/2020	5.42	369	5.86	0.6	6.5	<0.01	8	4	35	<1	<1	<1	27	27	14	56	<1	<1	<1
GW1	2/03/2021	-	-	3.78	0.6	4.4	0.01	6	3	27	<1	<1	<1	15	15	<1	41	1	<1	<1
GW1	17/05/2021	6.10	315	6.06	0.7	6.8	<0.01	25	9	25	1	<1	<1	76	76	2	34	1700	130	10
GW1	12/08/2021	6.30	351	6.70	0.5	7.2	<0.01	36	13	17	<1	<1	<1	116	116	2	25	~34	~3	<1
GW1	11/11/2021	6.55	332	4.92	0.6	5.5	<0.01	31	13	12	<1	<1	<1	121	121	4	24	17000	1800	1400
GW1	16/02/2022	6.64	325	4.00	0.7	4.7	0.01	26	11	16	<1	<1	<1	92	92	3	25	~2600	530	~45
GW1	18/05/2022	6.11	347	5.98	0.7	6.7	<0.01	24	10	24	1	<1	<1	77	77	3	37	140	41	~4
GW1	4/08/2022	6.15	363	6.67	0.6	7.3	0.02	28	11	18	<1	<1	<1	95	95	3	33	<1	~4	<1
GW1	9/11/2023	6.34	250	5.08	0.7	5.8	0.02	7	3	35	<1	<1	<1	16	16	<1	48	~130	10	~7
GW1	11/05/2023	6.39	614	6.28	1.5	7.8	0.04	24	8	24	<1	<1	<1	84	84	3	42	22	~1	~1
GW2	25/02/2020	7.18	719	1.79		2.2	0.03	74	28	33	<1				278	7	41			
GW2	2/09/2020	6.99	615	1.47	0.2	1.7	<0.01	73.0	27.0	6.0	<1	<1	<1	318	318	3	6	2	<1	<1
GW2	2/09/2020	6.99	615	1.47	0.2	1.7	<0.01	73	27	6	<1	<1	<1	318	318	3	6	2	<1	<1
GW2	10/12/2020	7.09	801	1.93	0.2	2.1	0.02	82	27	16	<1	<1	<1	304	304	3	32	1800	59	95
GW2	2/03/2021	-	-	0.49	<0.1	0.5	0.04	68	28	45	8	<1	<1	322	322	9	57	730	5	720
GW2	17/05/2021	7.13	804	0.50	0.3	0.8	0.06	80	31	37	<1	<1	<1	345	345	9	39	410	<1	~60
GW2	12/08/2021	6.93	745	1.45	0.2	1.6	0.02	104	31	19	<1	<1	<1	344	344	5	30	~30	<1	95
GW2	11/11/2021	7.43	690	1.86	0.3	2.2	0.02	86	29	16	<1	<1	<1	324	324	5	31	~160	~30	100
GW2	18/05/2022	7.18	758	0.21	0.2	0.4	0.16	74	28	39	1	<1	<1	294	294	9	54	~200	~60	260
GW2	4/08/2022	7.01	730	1.47	0.3	1.8	0.03	83	28	17	<1	<1	<1	308	308	6	35	28	~290	26
GW3	16/07/2019	7.47	399	0.07		0.3	0.03	54	22	2	1				210	3	4		~<1	<1
GW3	25/02/2020	7.97	433	0.08		<0.1	0.02	54	22	2	1				101	2	4			
GW3	2/09/2020	7.34	468	0.08	<0.1	<0.1	0.07	57	23	2	1	<1	<1	243	243	3	4	<1	<1	<1
GW3	10/12/2020	7.61	496	0.08	<0.1	<0.1	0.02	53	20	3	1	<1	<1	234	234	3	4	<1	<1	<1
GW3	2/03/2021	-	-	0.21	<0.1	0.2	0.03	56	21	3	1	<1	<1	239	239	3	6	23	<1	<1
GW3	17/05/2021	7.68	480	0.27	0.1	0.4	0.07	58	21	3	1	<1	<1	237	237	2	4	28	<1	<1
GW3	4/08/2022	7.41	448	0.11	0.1	0.2	0.03	52	20	3	1	<1	<1	193	193	4	5	<1	~<1	<1
GW3	9/11/2023	6.94	412	0.10	0.1	0.2	0.05	55	22	2	1	<1	<1	243	243	3	4	~37	~3	<1
GW3	6/02/2023	7.59	399	0.29	0.1	0.4	0.03	55	20	2	1	<1	<1	214	214	3	4	960	<1	<1
GW3	11/05/2023	7.43	423	0.10	0.2	0.3	0.06	41	16	2	<1	<1	<1	226	226	3	4	97	<1	<1

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Site ID	Date	pH	EC	NOx as N	TKN as N	TN	TP	Ca	Mg	Na	K	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity	SO4	Chloride	Total Coliforms	*E.coli*	*Enterococci*
	Units	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	CFU/100mL
	LOR	-	-	0.01	0.1	0.1	0.01	1	1	1	1	1	1	1	1	1	1	1	1	1
EPL297 Appendix A, Table 2		7.0-8.5	400	-	-	any increase from previous	any increase from previous	-	-	-	-	-	-	-	-	-	-	any increase from previous	any increase from previous	any increase from previous
GW4	16/07/2019	7.07	325	0.33		0.4	0.02	41	17	3	<1				152	3	5		<1	<1
GW4	25/02/2020	6.88	336	0.36		0.4	<0.01	39	15	3	<1				115	2	6			
GW4	2/09/2020	6.78	381	0.40	<0.1	0.4	0.05	44	17	3	<1	<1	<1	188	188	3	6	<1	<1	<1
GW4	10/12/2020	6.73	459	0.39	<0.1	0.4	<0.01	40	15	4	<1	<1	<1	165	165	3	6	<1	<1	<1
GW4	2/03/2021	-	-	3.42	0.7	4.1	0.37	10	5	32	<1	<1	<1	43	43	5	41	130	2	<2
GW4	17/05/2021	6.45	386	1.43	0.3	1.7	0.05	26	10	19	<1	<1	<1	104	104	3	23	1	<1	<1
GW4	12/08/2021	6.59	297	0.37	<0.1	0.4	<0.01	34	14	8	<1	<1	<1	132	132	2	10	~3	<1	<1
GW4	11/11/2021	6.70	253	0.18	<0.1	0.2	0.02	25	12	7	<1	<1	<1	123	123	2	11	~8	~7	~6
GW5	16/07/2019	7.46	490	0.02		<0.1	<0.01	53	31	9	<1				225	2	19		~<1	<1
GW5	25/02/2020	6.93	542	0.03		<0.1	0.03	48	30	11	<1					2	20			
GW5	2/09/2020	7.46	580	0.03	0.1	0.1	0.02	59	35	12	<1	<1	<1	278	278	2	21	<1	<1	~1
GW5	10/12/2020	7.54	665	0.04	<0.1	<0.1	<0.01	54	30	10	<1	<1	<1	269	269	2	22	3	<1	<1
GW5	2/03/2021	-	-	<0.01	<0.1	<0.1	0.03	57	32	10	<1	<1	<1	282	282	2	23	2	<1	<1
GW5	17/05/2021	7.40	579	<0.01	<0.1	<0.1	0.03	58	31	12	<1	<1	<1	272	272	1	20	<1	<1	<1
GW5	12/08/2021	7.38	577	<0.01	1.9	1.9	0.07	64	32	11	<1	<1	<1	280	280	2	20	~1100	320	~6
GW5	11/11/2021	7.19	546	<0.01	<0.1	<0.1	0.03	57	33	10	<1	<1	<1	280	280	2	24	~1100	~200	31
GW5	16/02/2022	6.85	593	<0.01	<0.1	<0.1	0.02	54	32	12	<1	<1	<1	268	268	2	23	~<1	<1	<1
GW5	18/05/2022	7.05	554	<0.01	<0.1	<0.1	0.02	54	29	12	1	<1	<1	256	256	2	23	~230	~<1	10
GW5	4/08/2022	6.86	573	<0.01	<0.1	<0.1	0.01	53	29	12	<1	<1	<1	236	236	2	25	11	~17	~1
GW5	9/11/2023	6.62	563	<0.01	0.1	0.1	0.04	60	34	11	1	<1	<1	280	280	4	25	~9	<1	~6
GW5	6/02/2023	7.26	539	0.13	<0.1	0.1	0.05	50	30	10	<1	<1	<1	246	246	3	26	~2600	<1	<1
GW5	11/05/2023	6.73	540	0.02	<0.1	<0.1	0.04	43	31	9	<1	<1	<1	269	269	2	25	700	~1	<1

Site ID	Date	pH	EC	NOx as N	TKN as N	TN	TP	Ca	Mg	Na	K	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity	SO4	Chloride	Total Coliforms	*E.coli*	*Enterococci*
	Units	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	CFU/100mL
	LOR	-	-	0.01	0.1	0.1	0.01	1	1	1	1	1	1	1	1	1	1	1	1	1
EPL297 Appendix A, Table 2		7.0-8.5	400	-	-	any increase from previous	any increase from previous	-	-	-	-	-	-	-	-	-	-	any increase from previous	any increase from previous	any increase from previous
GW6	16/07/2019	7.14	587	1.65		1.6	0.01	74	27	6	<1				263	2	6		~<1	<1
GW6	25/02/2020	6.96	622	0.24		0.4	0.01	62	29	10	1					4	13			
GW6	2/09/2020	7.04	656	0.18	<0.1	0.2	<0.01	77	31	12	2	<1	<1	360	360	4	13	<1	<1	<1
GW6	10/12/2020	7.02	800	0.19	<0.1	0.2	<0.01	74	29	10	2	<1	<1	296	296	5	14	1	<1	<1
GW6	2/03/2021	-	-	0.30	<0.1	0.3	<0.01	77	30	10	1	<1	<1	320	320	5	19	10	1	<1
GW6	17/05/2021	7.11	663	0.22	<0.1	0.2	0.03	75	29	12	2	<1	<1	328	328	4	18	460	170	~1
GW6	12/08/2021	7.08	660	0.23	<0.1	0.2	<0.01	92	32	11	1	<1	<1	324	324	4	16	<1	<1	<1
GW6	11/11/2021	7.50	621	0.19	<0.1	0.2	0.01	76	31	10	2	<1	<1	334	334	4	17	~<1	~<1	<1
GW6	16/02/2022	6.90	661	0.26	<0.1	0.3	<0.01	74	31	11	1	<1	<1	310	310	5	18	~1	<1	~1
GW6	18/05/2022	7.19	636	0.27	<0.1	0.3	<0.01	72	28	12	2	<1	<1	288	288	5	21	~2	~<1	<1
GW6	4/08/2022	6.97	653	0.22	<0.1	0.2	0.02	73	28	12	1	<1	<1	313	313	5	22	<1	~600	<1
GW6	9/11/2023	6.62	620	0.24	0.1	0.3	0.03	77	31	12	2	<1	<1	330	330	5	20	~<1	<1	<1
GW6	6/02/2023	7.52	555	0.40	0.2	0.6	0.01	66	28	9	1	<1	<1	284	284	5	22	~39	~1	<1
GW6	11/05/2023	6.94	738	1.42	0.2	1.6	0.05	60	33	20	<1	<1	<1	294	294	6	64	85	18	~1
GW7	10/09/2019	6.97	66	3.56		4.1	<0.01	4.0	2.0	1.0	<1				7	<1	6.0		~<1	<1
GW7	25/02/2020	7.50	437	3.34		3.7	<0.01	40	28	6	<1					3	8			
GW7	10/12/2020	5.69	100	3.25	0.5	3.8	<0.01	5	5	2	<1	<1	<1	34	34	<1	4	270	<1	<1
GW7	18/05/2021	6.67	167	0.23	1.2	1.4	0.04	2	2	2	<1	<1	<1	25	25	1	4	4884	<10	243
GW7	12/08/2021	5.25	72.1	4.3	0.7	5	0.03	4	3	2	<1	<1	<1	5	5	<1	5	<1	<1	<1
GW7	11/11/2021	5.59	71.7	4.0	0.6	4.6	<0.01	4	3	1	<1	<1	<1	15	15	<1	6	~30	~<1	<1
GW7	16/02/2022	5.45	107.0	2.2	0.5	2.7	0.01	3	7	3	<1	<1	<1	10	10	20	4	~170	~<1	<1
GW7	18/05/2022	3.79	72.7	0.7	2.1	2.8	0.06	2	2	4	<1	<1	<1	26	26	<1	5	11000	400	~12
GW7	4/08/2022	5.49	69.3	3.6	0.4	4	<0.01	4	3	2	<1	<1	<1	5	5	<1	6	<1	~74	<1
GW7	9/11/2023	6.14	65.1	2.9	0.8	3.7	0.02	4	3	2	<1	<1	<1	9	9	<1	5	1400	~1	<1
GW7	6/02/2023	7.4	70.0	2.5	1.2	3.7	0.02	2	2	2	<1	<1	<1	18	18	<1	4	1500	~1	<1
GW7	11/05/2023	6.19	52.0	2.4	0.5	2.9	0.04	2	2	2	<1	<1	<1	13	13	<1	4	65000	~85	~120

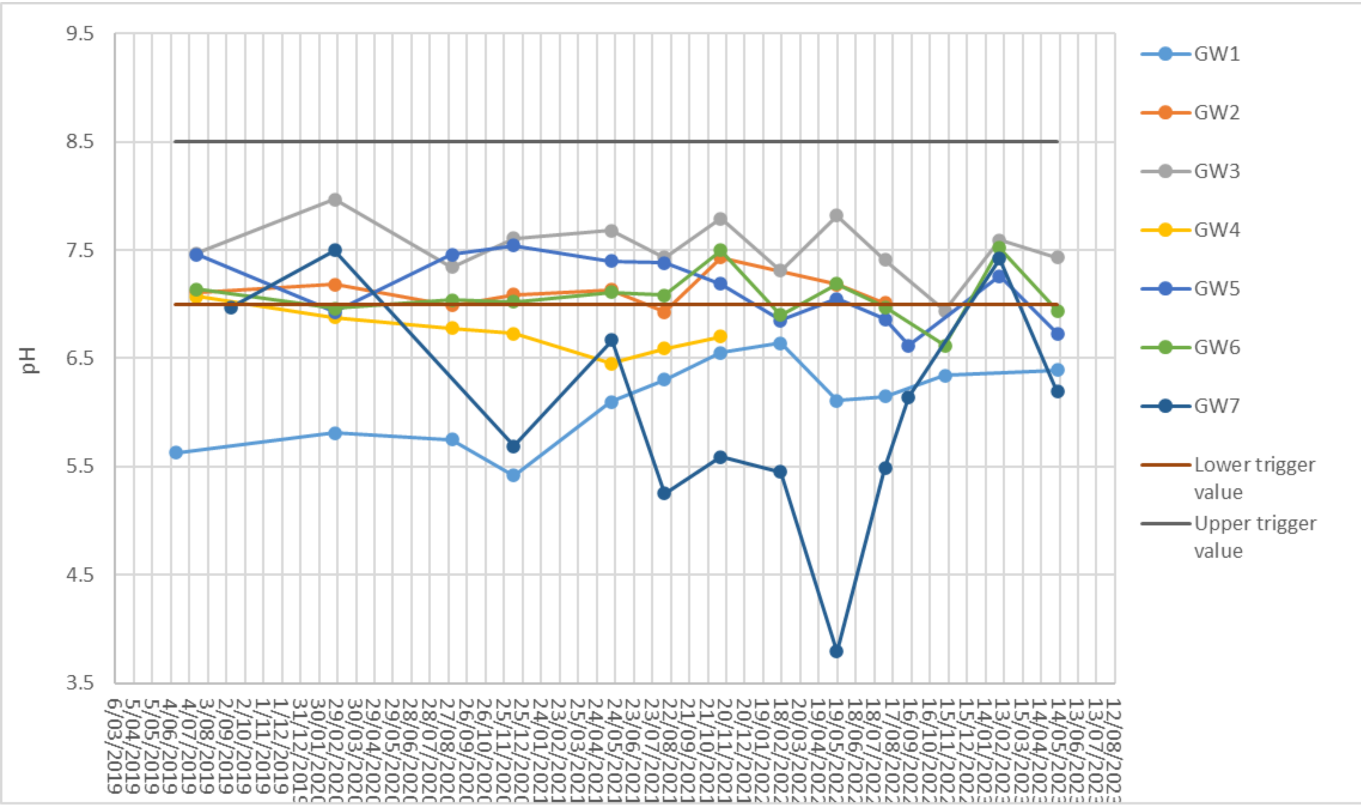


Figure 5-1. Graph of pH values measured in the groundwater bores since monitoring began in 2019

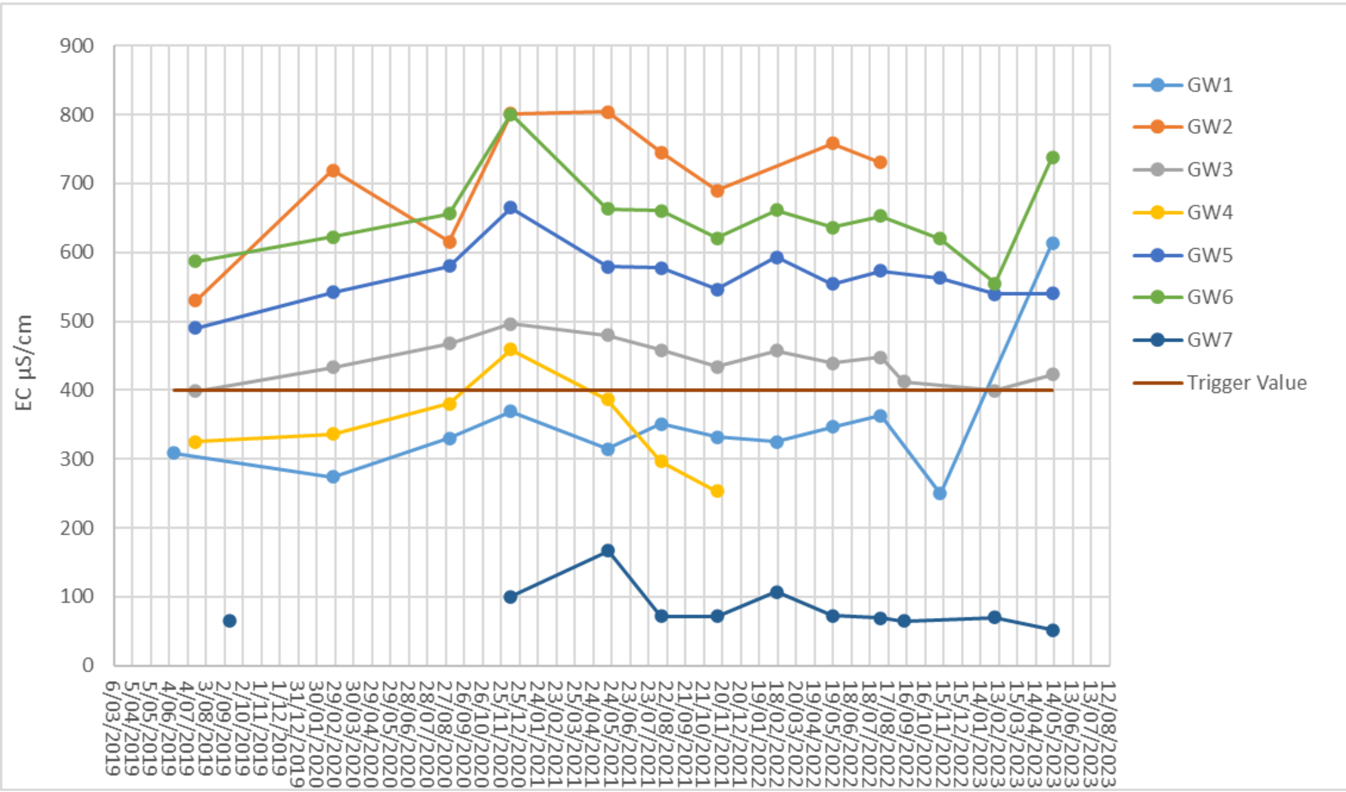


Figure 5-2. Graph of EC concentrations measured in the groundwater bores since monitoring began in 2019

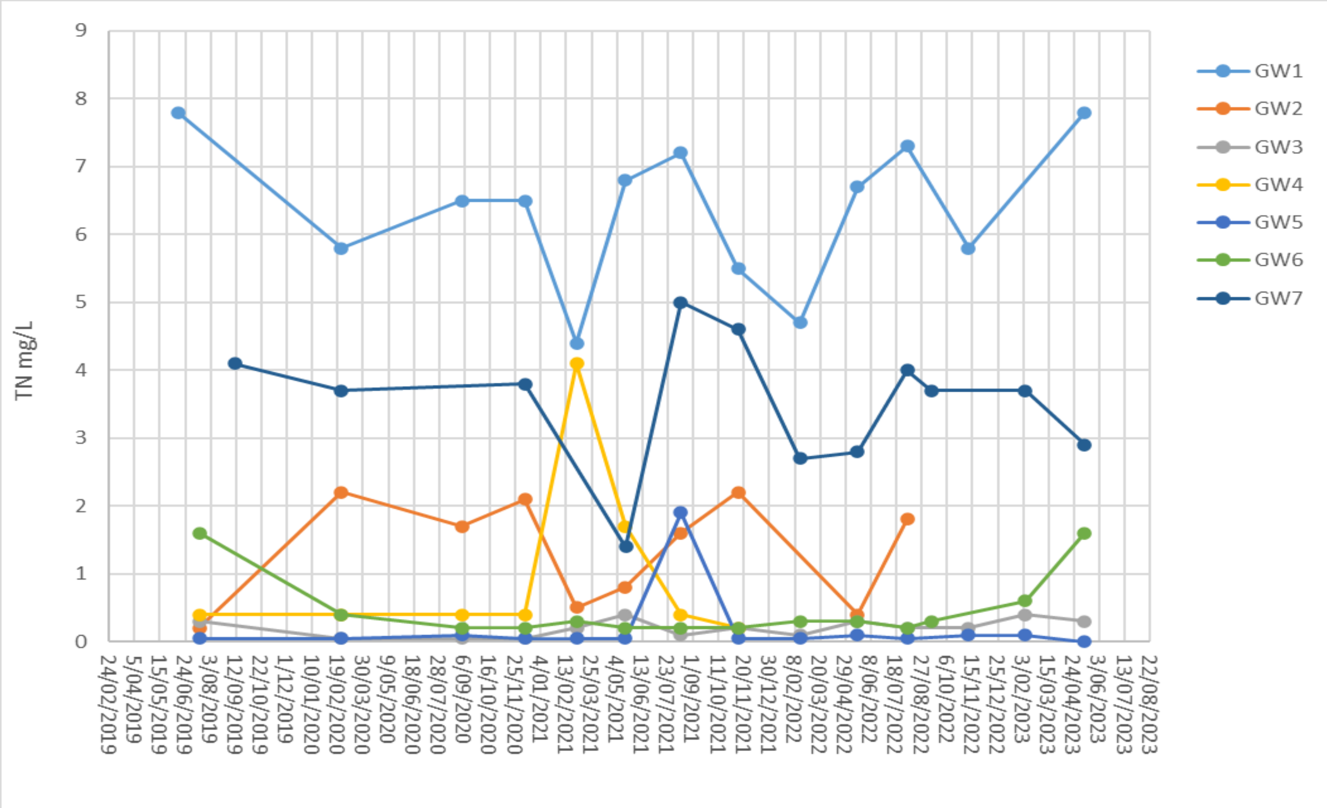


Figure 5-3. Graph of TN concentrations measured in the groundwater bores since monitoring began in 2019

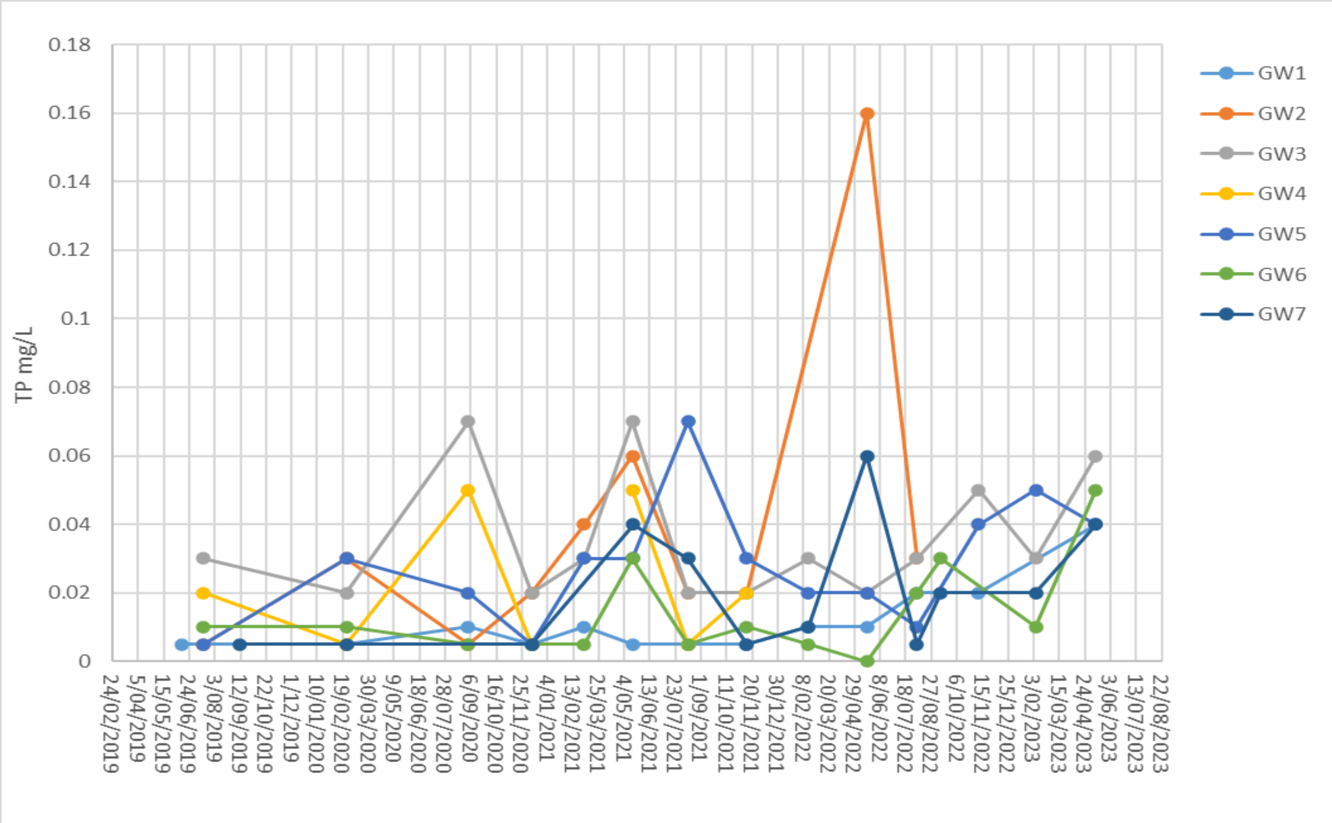


Figure 5-4. Graph of TP concentrations measured in the groundwater bores since monitoring began in 2019

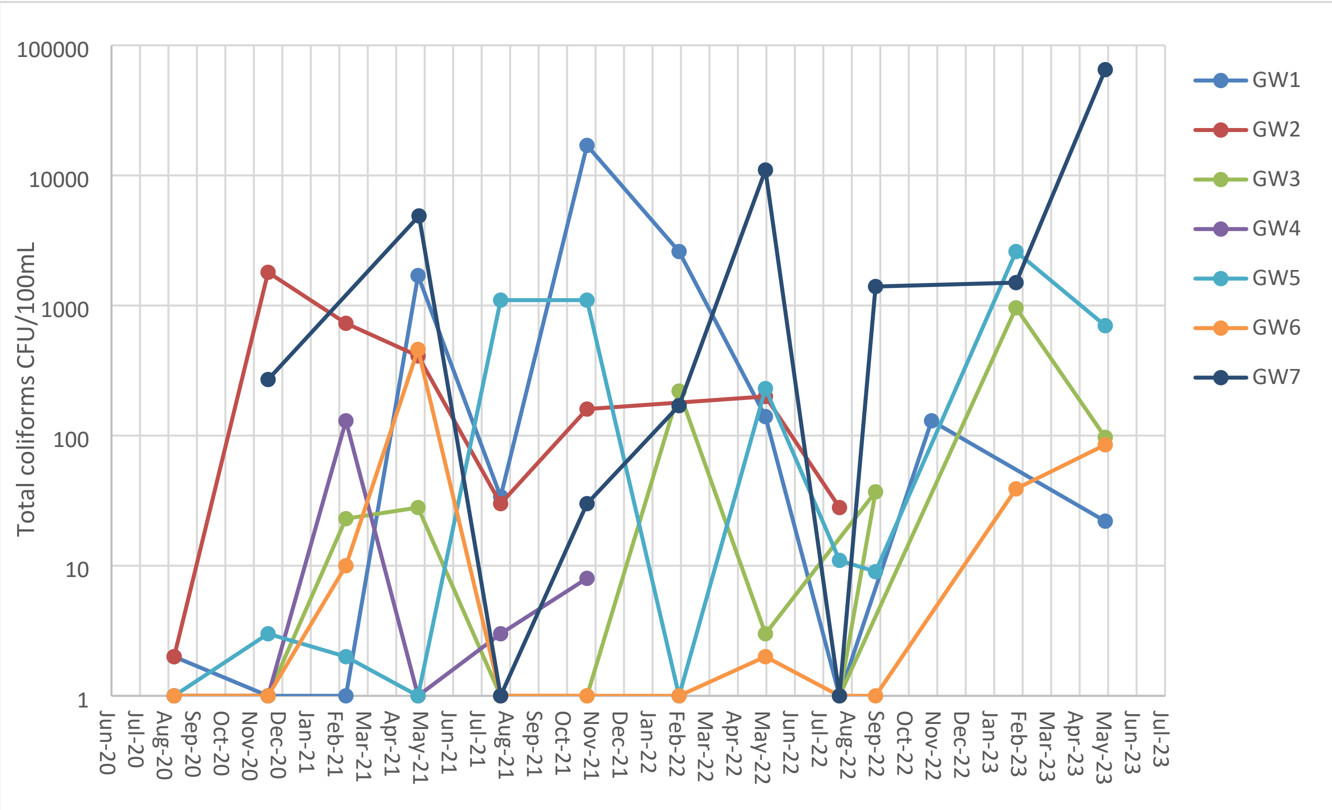


Figure 5-5. Graph of Total coliform concentrations measured in the groundwater bores since monitoring of this parameter began in 2020 (note logarithmic scale)

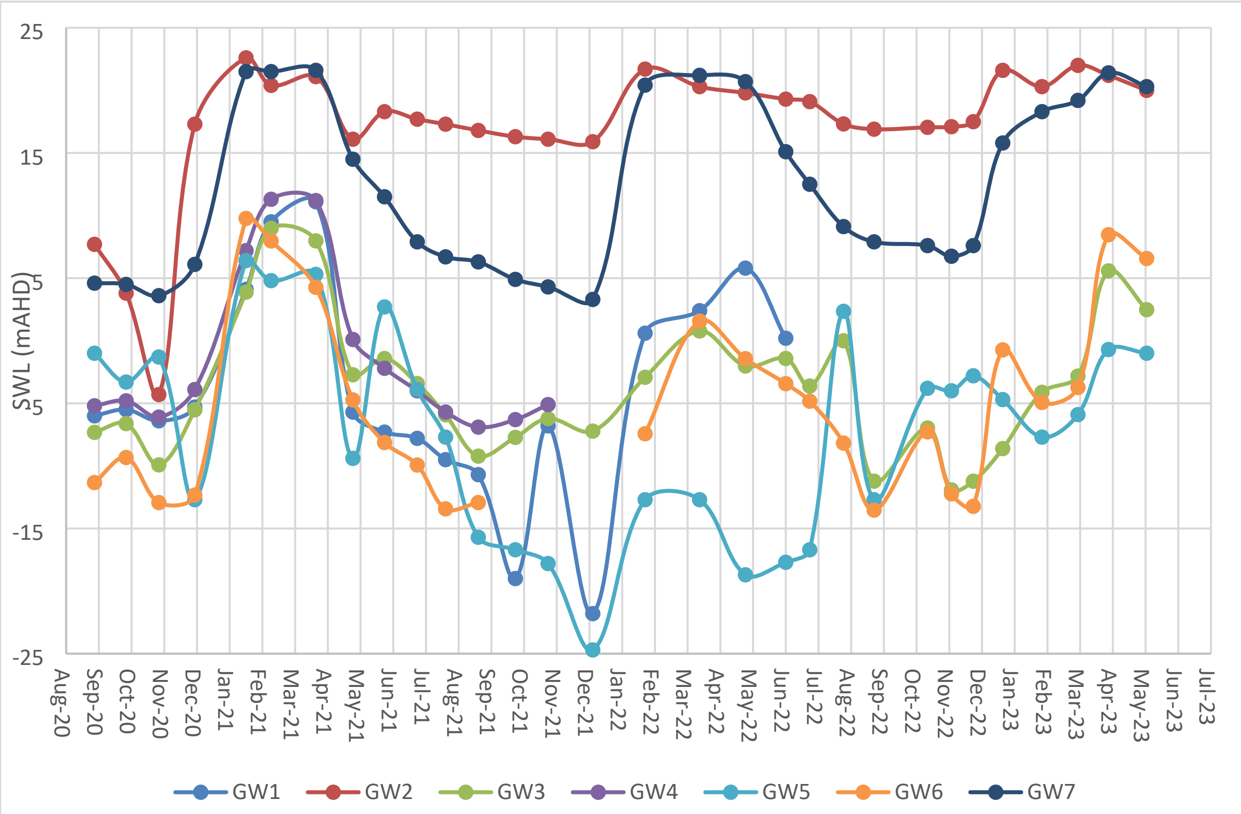


Figure 5-6. Graph of SWLs measured in the groundwater bores since monitoring began in 2020.

Table 5-3. Soil monitoring results since baseline sampling was undertaken in 2019

Concentrations in breach of EPL297 trigger values for groundwater highlighted in red.

Site ID	Date	pH	EC	NOx	TKN	TN	TP	Enterococci	Total Coliforms	*E.coli*
	Units:	pH units	µS/cm	mg/kg	mg/kg	mg/g	mg/kg	MPN/g	MPN/g	MPN/g
	LOR:	0.1	1	0.1	20	20	2	10	10	10
EPL297 Appendix A, Table		6-8	Any increase from previous			Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous
SS1	12/06/2019	6.0	11	0.5	340	340	86			
SS1	18/05/2021	5.5	30	1.1	310	310	95	2100	<11	<11
SS1	12/04/2022	6	8	0.5	340	340	91	21	49	<10
SS1	27/03/2023	5.1	14	0.4	300	300	58	990	370	<11
SS2	13/06/2019	7.4	6	1.5	250	250	46			
SS2	18/05/2021	5.7	32	0.9	560	560	137	520	78	<11
SS2	12/04/2022	6	6	0.4	260	260	56	16	49	<10
SS2	27/03/2023	5.5	29	0.4	230	230	67	150	<11	<11
SS3	13/06/2019	7.3	8	2.3	280	280	79			
SS3	18/05/2021	6.0	50	0.6	180	180	90	1100	120	<11
SS3	12/04/2022	6.2	7	1.2	220	220	81	28	49	<10
SS3	27/03/2023	5.2	36	0.6	190	190	62	350	22	<11
SS4	13/06/2019	7.8	9	2.1	400	400	78			
SS4	18/05/2021	5.1	25	0.6	360	360	99	2300	<11	<11
SS4	12/04/2022	5.4	8	1.0	210	210	49	<10	29	<10
SS4	27/03/2023	4.8	19	0.4	180	180	70	81	6700	<11
SS5	13/06/2019	8.0	6	6.2	1210	1220	794			
SS5	18/05/2021	6.1	48	0.4	300	300	319	79	22	<11
SS5	12/04/2022	7.6	63	1.2	1580	1580	2210	38	49	<10
SS5	27/03/2023	5.8	71	0.3	260	260	235	47	>27000	<11
SS6	13/06/2019	7.7	7	8.9	470	480	96			
SS6	18/05/2021	6.8	65	1.1	210	210	350	93	1200	<11
SS6	12/04/2022	6.9	9	1.4	270	270	178	<10	47	<10
SS6	27/03/2023	5.3	211	0.8	260	260	410	<12	>28000	<12

6 TOTAL N AND TOTAL P LOADS

Condition 37 of EPL297 states that:

The licensee must ensure that the total annual loads of Total Nitrogen and Total Phosphorus applied to land from the authorised discharge point do not exceed the calculated maximum total annual loads:

37.1 The total annual load for total nitrogen must be calculated using the equations detailed in the NSW environmental guideline Use of Effluent by Irrigation and be based on the specific soil type and crop present in the irrigation area receiving wastewater from the authorised discharge point.

37.2 The total annual load of total phosphorus must be based on the annual maximum uptake of phosphorus for the specific crop type present as listed in Table 4.2 of the NSW environmental guideline Use of Effluent by Irrigation

Total annual loads of TN and TP applied to the irrigation area using water from the authorised discharge point (irrigation source) are calculated below.

In regards to the total TN and TP load applied to the irrigation area during the reporting period, the total volume of irrigated water was 6.78 ML, and the median TN and TP concentrations of the irrigation water were 1.1 mg/L and 0.09 mg/L respectively. This equates to a total load of 7.45 kg of TN and 0.610 kg of TP applied to the irrigation area over the reporting period.

7 UNAUTHORISED DISCHARGE REPORT

This section provides an investigation report covering the unauthorised discharge of wastewater from DCF over the southern boundary of the site into the neighbouring property to the south. From here, water flows down a drainage line into the Elizabeth River, which then flows into Darwin Harbour.

The discharge started on 14 December 2022 and continued until 30 May 2023, caused by the accumulation of wet season rainfall and runoff into the ponds at the southern boundary of the site. Rainfall during the 2022-23 wet season was above the average (see Section 3.1 above). Discharge continued throughout, with a very small trickle continuing to flow over the spillway.

7.1 Non-compliance notification

The NT EPA was notified of the commencement of discharge on 14 December 2022 in an email to waste.ntepa@nt.gov.au. The following information addressing the Condition 51 requirements was provided in the email:

When the non-compliance was detected and by whom

14 December 2022 by Damien Brabrook

The date and time of the non-compliance

From 14 December 2022 at 15:00.

While the discharge has now stopped we expect any future rain to cause intermittent and then continual discharge until the end of the wet season.

As agreed this is notification of the beginning of our discharge, we will notify once the rains are over and there will be no further discharge.

<u>The actual and potential causes and contributing factors to the non-compliance</u>

There was a large build-up of foliage along our causeway which had been holding water from previous rains in the property. As we were expecting large amounts of rain last night we cleared the foliage from the causeway with an excavator, so that the foliage did not push our fence over. This caused an overflow.

<u>The risk of environmental harm arising from the non-compliance</u>

Minor. Discharges occur from this location every wet season, wastewater is heavily diluted by rainwater and flows towards a catchment that is subject to runoff from similar surrounding land uses (agricultural/horticultural). Surface water monitoring upstream and downstream will continue as per the EPL conditions.

<u>The action(s) that have or will be undertaken to ensure the non-compliance does not reoccur</u>

Continue to irrigate when we can, ensuring compliance with IMP.

<u>If no action was taken, why no action was taken</u>

NA

<u>A date when an incident investigation report will be submitted to the NT EPA</u>

On completion of the non-compliance, which is weather dependant.

7.2 Discharge volume

Discharge volumes over the spillway are calculated using the established relationship between water levels in the main pond and discharge flow rates, as derived by EnviroTech (2021) – see Main Pond Discharge Rating Derivation Report in Appendix A. Water levels in the main pond are continuously measured (every 10 minutes) using a logger and converted to a flow rate using the rating table in EnviroTech (2021).

The total volume of water over the spillway for the discharge starting on 14 December 2022 has been calculated as 4,884 ML. There were technical issues with the logger over this period so it is likely that the actual volume is higher than this.

As detailed in the report in Appendix A, the vegetation growth and debris build-up along the southern fence link and spillway, significantly impacts on the pond water level and the resulting volume calculations. Whilst debris has been cleared this season, each rain event results in more debris building up along the fence line. A significant proportion of the above calculated volume can be attributed to the eastern freshwater runoff which breaches the constructed diversion channel. Wastewater from DCF is expected to comprise a small proportion of the overall discharge volume.

7.3 Discharge water quality and environmental impacts

As discussed in Section 5.4, no surface water monitoring was undertaken during the monitoring period.

Monitoring conducted over previous years has not identified any significant difference in concentration of water quality parameters between the upstream and downstream sites. Data analysis undertaken in previous years has also not shown any evidence of increasing trends of potential pollutants. There were no recorded incidents (other than standard site discharges) or unusual activities on-site that may have caused contamination issues downstream and no visual indicators of contamination in the creek. In consideration of historical trends, contamination risk in the surface water during this period is considered low. Site management will ensure that surface water samples are collected during the next monitoring period in order to continue tracking any trends.

7.4 Corrective actions

A new wastewater storage facility was completed in November 2022 which aims to increase farm storage capacity of waste waters and reduce unauthorised discharges. Currently these ponds collect wastewater from pens prior to being discharged though the facilities drainage system to the southern boundary. It is the future intention that these new ponds will serve as the irrigation source with all site run off/ drainage and water from the existing irrigation source pond being pumped to these ponds prior to irrigation. This will allow irrigation to occur throughout the dry season when historically this has not been possible due to the irrigation source pond containing breeding crocodiles. The ponds have been sized based on historical rainfall data and wastewater generation volumes in order to minimise the risk of overflow.

Porosus also continue to improve the stormwater management from the Stuart Highway by creating diversions to minimise stormwater runoff entering the wastewater ponds.

8 CONCLUSIONS

All groundwater and soil monitoring was undertaken as per EPL297 Attachment A requirements, except for some minor non-compliances as listed in Table 4-6. Monitoring undertaken during the reporting period above. No sampling of surface water was undertaken in this period resulting in a non-compliance.

Groundwater results largely complied with the trigger values and no consistent increasing trends are indicated.

Loads of TN and TP currently applied to the irrigation area are sustainable.

Unauthorised discharge occurred during the 2022-23 wet season over the spillway along the southern DCF boundary. A non-compliance investigation report for this discharge in provided in Section 7 above and improvements to reduce the volume of discharge in future wet seasons are currently being formulated.

Soil quality in the irrigation area is potentially decreasing. It is recommended that sampling increase to biannually in order to determine any seasonal influence and better identify any trends in parameters measured.

9 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy*, ANZECC, Canberra, ACT.

ANZG 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian State and Territory Governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Bureau of Meteorology 2023, *Climate Data Online*. [online] Available at: http://www.bom.gov.au/climate/data/ [Accessed 16 May 2023]

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

DLRM 2014, *Darwin Harbour Water Quality Protection Plan*, Department of Land Resource Management, NT Government, Palmerston.

EcOz 2019, *Supporting information for the Darwin Crocodile Farm EPL application*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, October 2019

EcOz 2020, *Irrigation Management Plan, Darwin Crocodile Farm*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, February 2020

EcOz 2021, *Conceptual Site Model, Darwin Crocodile Farm*, report prepared for Porosus Pty Ltd by EcOz Pty Ltd, June 2021

APPENDIX A MAIN POND DISCHARGE RATING DERIVATION

Porosus Pty Ltd

Main Pond Discharge

Rating Derivation

Envirotech Monitoring Pty Ltd

4/5/21

Background

Envirotech Monitoring was commissioned by Porosus Pty Ltd in October 2020 to derive a discharge rating for the Main Pond spillway.

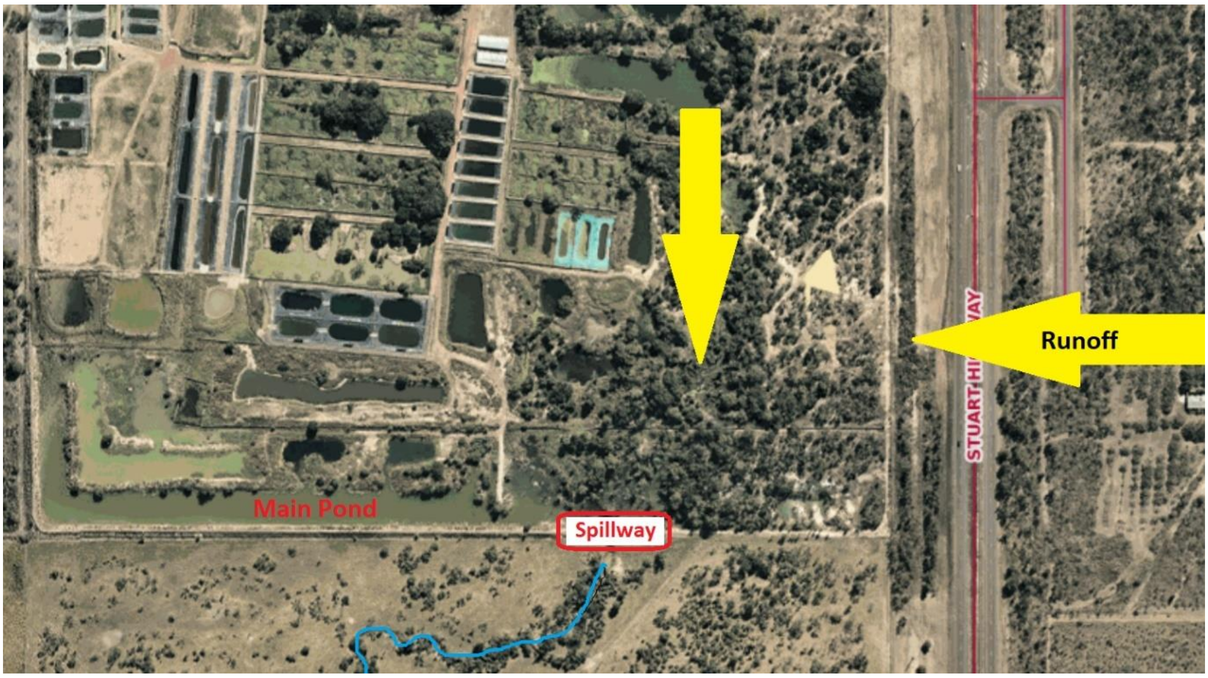
The purpose of the rating table was to enable the quantification of water flow over the spillway during wet season rainfall, and to assist with farm planning and reporting requirements.

This report presents the empirically derived rating, a quantification of the spillway discharges for 2020-21 and a discussion on issues and recommendations.

Site Layout

The pond named “main pond” is located on the southern side of the property and is home to several hundred crocodile.

It receives water from other ponds higher in the catchment to the north, as well as natural runoff from and east of the Stuart Highway. The spillway of the pond is located on the southern boundary of the property. Discharges over the spillway report to a small gully in the neighbouring property which carries the water to Bees creek and then onto the Elizabeth River.



The spillway design is a 60m low cut section of the southern earthen embankment wall which has been covered in rough concrete to prevent scouring. The boundary chainmesh fence and steel gates (to facilitate water flow through the fence) transect the spillway surface.

Figure 1 - Spillway and boundary fence

A diversion channel has been constructed on the property to capture catchment runoff from the east to minimise the volume of freshwater runoff entering the pond. Captured water is separated from the main pond by an earthen wall and is directed to the eastern side of the spillway where it mixes with any discharge from the main pond in the downstream gully.

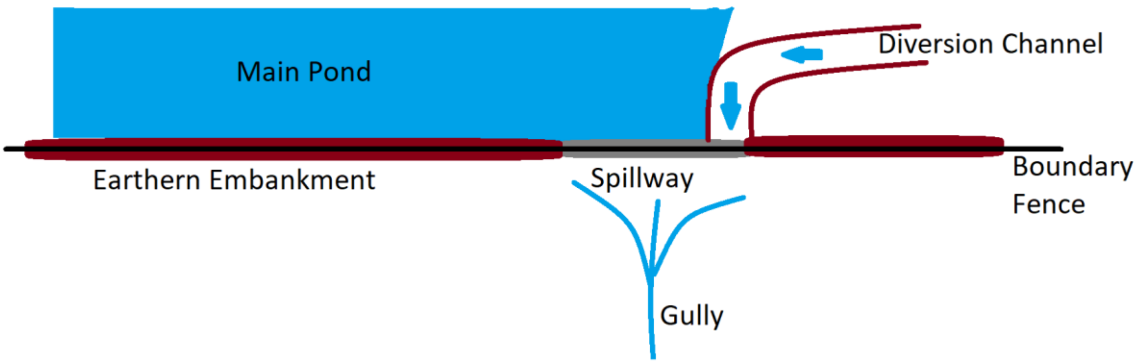


Figure 2 – Location of diversion drain relative to spillway and main pond

Flow quantification approach

Prior to the 2020/21 wet season, the site was assessed to identify a suitable method enabling quantification of main pond discharge over the spillway in coming and future wet seasons.

Measurement of flow in open channels is typically done either by permanent acoustic in situ instruments, or by empirically deriving a stage to flow relationship, and then deriving the flow from surrogate water level measurement.

Direct measurement of the flow at the spillway was deemed impossible due to its width and likely insufficient depth of water for measurement. Measurement of flows in the downstream gully would be required, however any flow from the diversion channel would have to be separately accounted for and deducted.

As the spillway is concrete it presents a stable section where changes to the hydraulic relationship are unlikely to change from erosion and deposition as is often the case in natural channels. Deriving a rating for the spillway based on the pond level was determined to be the best approach.

Installation of permanent in situ ultrasonic sensors was not considered, in order to keep complexity and costs down.

A staff gauge was installed to the main pond in October 2020 when water levels were low. The gauge was installed on the northern side of the pond along the access road to the water supply bore located in the main pond. This location was chosen to permit ease of access for reading during the wet season by Porosus staff.

Figure 3 – Main pond staff gauge

The nearby bore was utilised as a benchmark. Its local datum value at the time of installation was 1.542m. A water level logger was later installed on 30/12/2020 next to the staff gauge to collect continuous measurements of pond water level. After derivation of the rating, such logged data could then be used to calculate the annual volume of pond water discharging over the spillway.

Rating derivation

Early in the 2020/21 wet season, the diversion channel failed and all runoff water from the east catchment reported directly into the pond. As a result, all flow over the spillway only came from the pond and no separate measurements of diversion channel flow were necessary.

Flows were measured in the downstream gully at various times over the wet season and related back to water levels in the main pond. However, whilst onsite it was discovered that pond water levels were being influenced by both aquatic vegetation growing on and fouling up against the fence. To identify the true pond water levels for a given flow such vegetation debris had to be cleared each visit. Not all vegetation was able to be successfully cleared which resulted in greater than expected variance in the data collected.

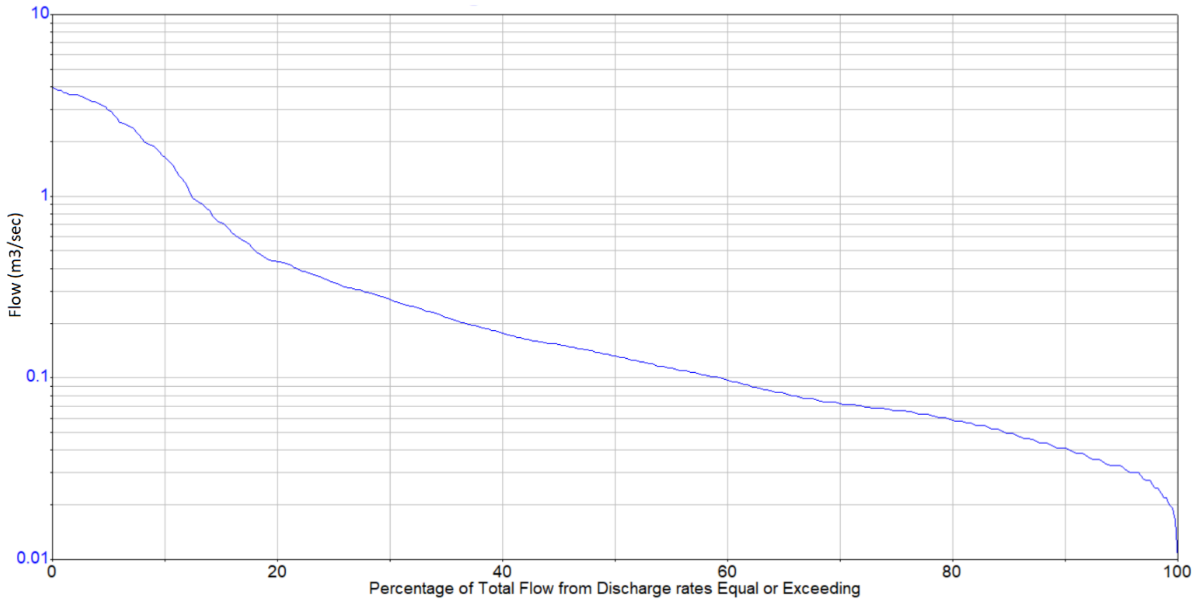
Table 1 presents the derived rating table. The stage range for the table is very short which is expected given the width of the spillway. Flow values below 0.34m are considered to be within a 5% error. Reported flow values above 0.34m are potentially up to 50% above in error (probability correlating with extent over 0.34m) due to the lack of data obtained at those flows.

Table 1 – Derived rating table for main pond spillway.

Gauge Height (m)	Flow (m^3/sec)
0.18	0
0.19	0.0274
0.2	0.0548
0.21	0.0829
0.22	0.113
0.23	0.144
0.24	0.176
0.25	0.208
0.26	0.243
0.27	0.282
0.28	0.321
0.29	0.367
0.3	0.427
0.31	0.497
0.32	0.621
0.33	0.881
0.34	1.19
0.35	1.59
0.36	2.16
0.37	2.94
0.38	3.94

According to the flow duration curve presented in Figure 4, flows in excess of 0.34m contribute approximately 10% to the total annual discharge (based on 2020-21 data). Despite the higher error, the net contribution to an annual total calculation is low and considered low concern for current needs. Given the above average high intensity storm activity during 2020-21 future frequency and duration of flows above 0.34m are likely to be lower and of even less impact to annual total calculations.

Figure 4 - Flow duration curve for 2020-21 data



Whilst errors of only 5% have been specified for pond levels below 0.34m, this only holds true if the pond water level is unaffected by vegetation growth or debris. During site visits throughout the 2020-21 wet season it was regularly noted that the pond level was consistently higher than its true level by the damming effect of plant growth on the spillway.

Due to the large width of the spillway, a small increase in water level in the pond will result in a comparatively large increase in flow volume. It only takes a small amount of build-up on the fence line to inflate the pond water level. If such values are used directly against the rating table then the referenced flows have the potential to be over 100% in error of the true flow in the downstream gully.

Figure 5 is a photograph of the vegetation growth on the spillway as of 29/4/21. The recorded pond level on the gauge was 0.296m corresponding to a flow of approximately 0.420m^3/sec from the rating table yet flow in the downstream gully was approximately 0.030m^3/sec or a gauge height of 0.195m. The result is a flow error of 1400% simply by virtue of the vegetation changing the hydraulic relationship of the spillway.

Figure 5 - End of wet season vegetation growth along the spillway

Figure 6 presents the raw logged pond water level data against a corrected dataset where the effects of elevated pond levels from vegetation build-up have been removed. The corrected dataset represents a more accurate record of the theoretical pond water levels had there been no interference from vegetation along the spillway. The corrected dataset is by no means an exact indication of what pond levels would have been, but a closer picture after removal of the build-up signatures in the data.

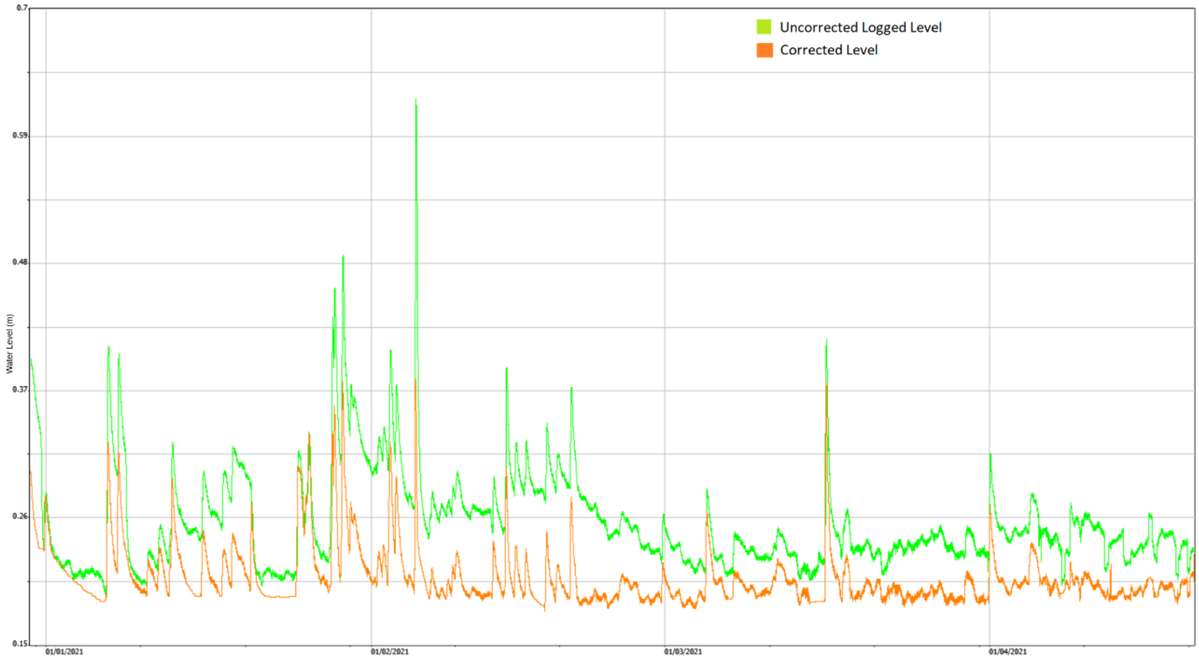


Figure 6 - Corrected and Raw logged pond level data

Based on the corrected level data total flow over the spillway for the 2020-21 year is calculated as approximately 900,000 m^3 (900 ML). This figure potentially has a 25% error by virtue of the method employed to correct the data, as well as the available logged data at time of writing not encompassing the entirety of wet season flows.

A significant proportion of the annual discharge would have been from the eastern freshwater runoff which entered the pond due to the breached diversion channel. The actual percentage is unknown as no data on such runoff were collected. Estimations may be possible based on an assessment of catchment areas.

Issues & Recommendations

1. Vegetation growth and debris affecting spillway to pond hydraulic relationship.

   The vegetation growth along the spillway, as well as any debris build-up on the fence line has shown to significantly impact on the pond water level and therefore the quality of any calculated spillway flow via the rating table. A programme of vegetation management and routine cleaning of the fence line and spillway would need to be implemented to improve the logged water levels of the pond, particularly if a need for increased accuracy is required.

   In absence of this, the current approach of using pond levels and the presented rating table to compute flows is inadequate and an alternative approach would be required. Unfortunately, the layout of the site and confounding effects of the diversion channel make an alternative approach difficult to implement without significant investment in additional data collection and physical changes to the spillway and/or downstream gully. Some ideas have been identified and can be discussed if required.

2. Diversion channel improvements
   Whilst the breach of the diversion channel eliminated the need to account separately for the eastern freshwater runoff during rating development, it did obviously contribute significantly to the total annual discharge from the pond. The section of spillway allocated to the diversion channel is small and definitely a constriction point, even in the absence of debris build-up on the fence exacerbating the problem. Physical enlargement of the diversion channel discharge point is needed, and consideration should be made in any works to improving measurements of pond discharges.

3. Manual staff gauge readings
   Very few manual records were kept over the 2020-21 wet season of water levels in the pond. It is generally good practice to record manual reading of the staff gauge so such data can be used to validate the logged data, as well as act as a backup in case the pressure sensor fails.

4. Increased data collection frequency
   Data from the level logger should be collected and reviewed at various times throughout the wet season. If the sensor fails for any reason the amount of data lost will be directly proportional to the length of time between checks. By increasing the frequency of check on the instrument such data loss can be minimised.

5. Resurvey of staff gauge
   The wetting and drying of the soil will cause the gauge to move over time. Depending on the amount of movement the water level will be in error to the rating and incorrect flows derived. The gauge should be surveyed at least once a year against the benchmark and adjusted if necessary, to ensure the rating table remains valid. The gauge was checked last on 29/4/21 and differed from installation by only 2mm.

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