Water Quality Monitoring Plan

Humpty Doo Barramundi Pty Ltd

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ACRONYMS AND ABBREVIATIONS

AEP	annual exceedance probability
AI	Adelaide Intake – water intake point from Adelaide River
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	acid sulfate soils
BOD	biochemical oxygen demand
Chl-a	chlorophyll-a
DENR	Department of Environment and Natural Resources (Northern Territory)
DO	dissolved oxygen
DP	Discharge Point
DP1	Discharge Point 1
DP2	Discharge Point 2
EC	electrical conductivity
EMP	Environmental Management Plan
EPL	Environment Protection Licence
FRP	filterable reactive phosphorus
HDB	Humpty Doo Barramundi Pty Ltd
HDPE	High Density Polyethylene
NATA	National Association of Testing Authorities
NOx	nitrate NO_3 + nitrite NO_2
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NOI	Notice of Intent
PASS	potential acid sulfate soils
QA/QC	quality assurance, quality control
S1N	Stage 1 Nursery
SSTV	site specific trigger value
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
WMPC Act	*Waste Management and Pollution Control Act* (Northern Territory)
WQMP	Water Quality Monitoring Plan

1 INTRODUCTION

Humpty Doo Barramundi Pty Ltd (HDB) is a privately owned and operated family business producing premium saltwater barramundi fish for markets across Australia and overseas. This Water Quality Monitoring Plan (WQMP) outlines the environmental water quality monitoring undertaken at the HDB farm located at Middle Point, approximately 58 km east of Darwin on the Adelaide River floodplain (Figure 1-1). The main purpose of this WQMP is to ensure that water discharges from farm operations do not impact the receiving waters of the Adelaide River or downstream environments.

The current system of header ponds (for gravity flows), production (grow-out) ponds, and wastewater wetland treatment ponds allows for the constant recycling of water from the wetland treatment system back into the header and production ponds, and minimises the need for discharge to, or refilling from, the Adelaide River. Discharges mostly occur only during the peak of the wet season, when release of water from the farm is required to prevent overtopping of ponds.

Commercial operations started with the North Farm in 1993, then South Farm (operating since late 2016), and East Farm (12 ponds operating since late 2019, and a further 11 ponds planned for construction in late 2020; see Figure 1-2). The total area of production ponds (North, South and East Farms combined), is 45 ha. This includes the remaining East Farm production ponds to be constructed late 2020. The total area of wetland treatment system servicing the production ponds is 63 ha, i.e. the area of wetland treatment system is around 1.4 times the area of production ponds.

The HDB farm also has a Stage 1 Nursery (fingerlings up to 1 g), Stage 2 Nursery (fish between 1 and 30 g), and recently completed in early 2020, Stage 3 Nursery (fish between 30 and 200 g). Each of these nurseries utilises a wetland wastewater treatment pond system; negating the need to constantly extract from, or discharge to, the Adelaide River. Once juvenile fish are large enough, they are transferred to the production ponds for grow out.

The Middle Point farm does not include a hatchery. Fingerlings are brought in from interstate, or from the hatchery HDB are currently developing at Channel Island on Darwin Harbour. Note this WQMP does not include the HDB hatchery facility.

It takes around 24 months to grow the barramundi from fingerlings to an average harvest size of >3 kg. Once harvested, fish are transferred into large bins with an ice-brine slurry, where they are euthanised by cold shock. They are then sorted and packed. Only chilled whole fish are dispatched from the farm; no filleting or processing of fish occurs on site.

Supporting infrastructure at the farm includes a packing shed, offices, feed shed and workshop (Figure 1-2).

1.1 Purpose

HDB is licenced under the Northern Territory (NT) *Waste Management and Pollution Control Act* (WMPC Act). The NT Environment Protection Authority (NT EPA) has issued HDB an Environment Protection Licence (EPL239) to allow the collection, transport, storage, recycling, treatment and disposal of a 'listed waste'; the listed waste being 'animal effluent and residues' i.e. fish waste. The main activity undertaken in this regard is the treatment of wastewater from the barramundi production ponds in wetland treatment systems. Most of the time, the treated wastewater is recycled back into the production ponds, but on occasions requires discharge to the Adelaide River.

HDB must maintain and implement a WQMP as per condition 8 of EPL239.

1.2 Scope

This WQMP applies to the three farms (North, South and East Farms) and three nurseries (Stage 1, 2 and 3) at the Middle Point HDB Farm, and includes:

- Monitoring locations
- Sampling frequency
- Parameters measured
- Sampling methods
- Assessment criteria used for analysing results and triggering corrective actions if required.

1.3 WQMP updates

This WQMP version (Revision 2) is an update to the previous version issued December 2017. The main purpose of this update is to allow amendment of EPL239 to include the recently developed East Farm and changes to the discharge point for the South Farm.

Changes to this WQMP since the last version comprise the following:

- Inclusion of East Farm details and new monitoring and discharge sites: EF DP and EF CE DP
- Change of the monitoring site name from K/J DP to SF DP (South Farm Discharge Point) given that water flowing to this point derives from the South Farm wetland treatment system and not just the K/J Series production ponds. The site was originally named this because it is located near the K/J Series production ponds.
- The Adelaide River Upstream (ARUS) site has been moved approximately 200 m further upstream to ensure it is well upstream of EF DP.
- A change to the discharge point for the South Farm. Previously, discharge from the SF DP flowed into a drainage line that reported to DP2 where it discharged into the Adelaide River. Discharge from SF DP now flows along the channel that leads to AI, where it discharges into the Adelaide River
- Change to the requirement that all monitoring sites must be sampled weekly (or at least once) during a discharge event. Only the sites that relate to the discharge point are required to be sampled weekly (or at least once) during a discharge event. For example, if only the North Farm is discharging, only the North Farm monitoring sites (A DP, B/C DP, E/F DP and DP1) and the Adelaide River sites (ARUS, ARDS) need to be sampled.
- Change to the requirement that sites be sampled monthly. Sampling is now only undertaken during discharge to ensure Adelaide River water quality is not being impacted. This reduction in monitoring is justified given monthly monitoring has been undertaken consistently since August 2016; equating to almost 600 samples; when the weekly discharge sampling is included. The three Adelaide River sites have been sampled at least monthly since August 2016; resulting in a vast database of background river water quality data, including seasonal changes. The North Farm sites and Stage 2 Nursery have also been monitored monthly since August 2016. The South Farm sites have been monitored monthly since December 2016, and the Stage 1 Nursery since May 2017.

1.4 Legal requirements, standards and guidelines

This WQMP has been developed in accordance with the following:

- Requirements of EPL239, issued 6 June 2018, expires 5 June 2023; in particular, *Attachment A: Monitoring Program*, and Conditions 29 to 36.
- ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.
- ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

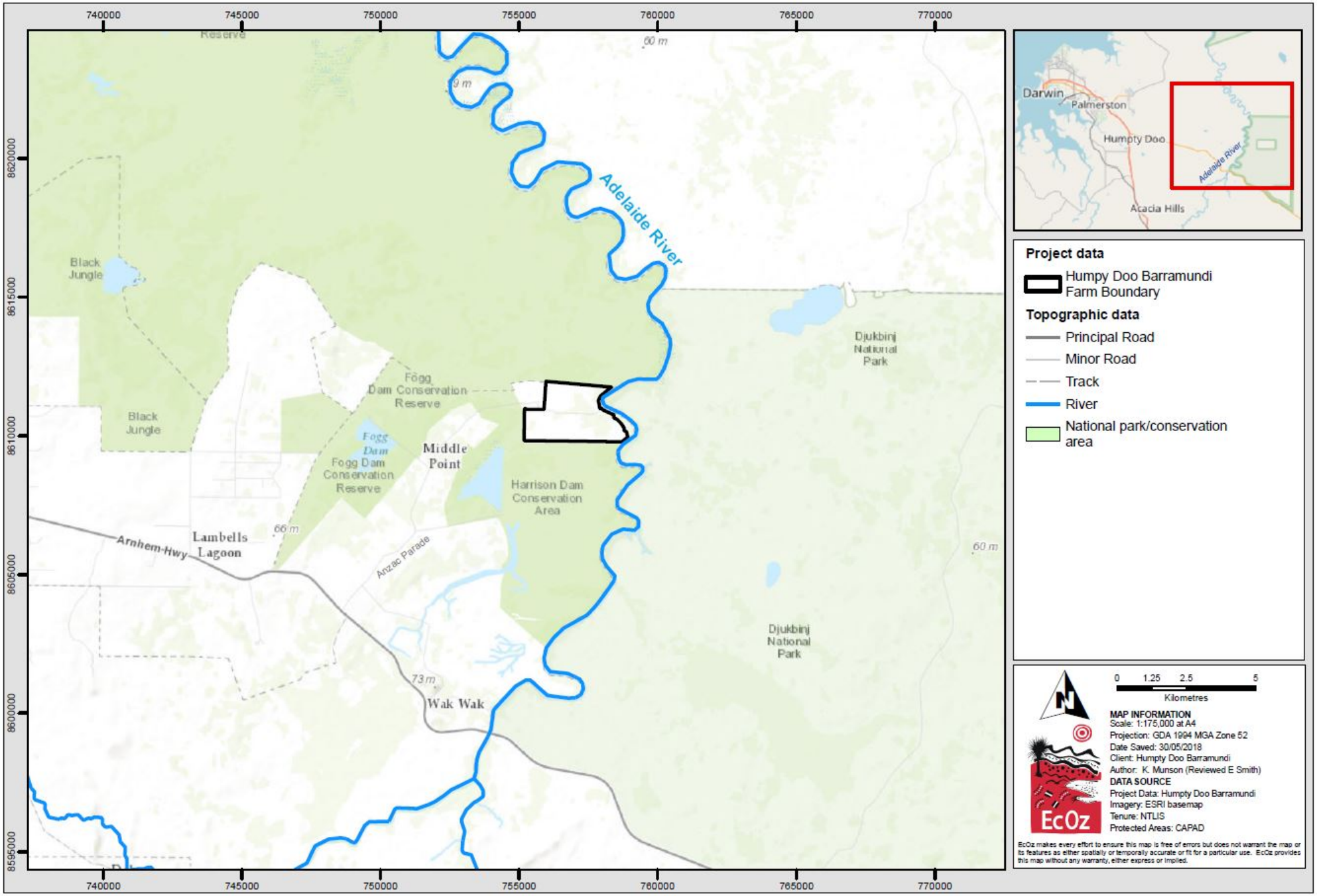

Figure 1-1. Location map.

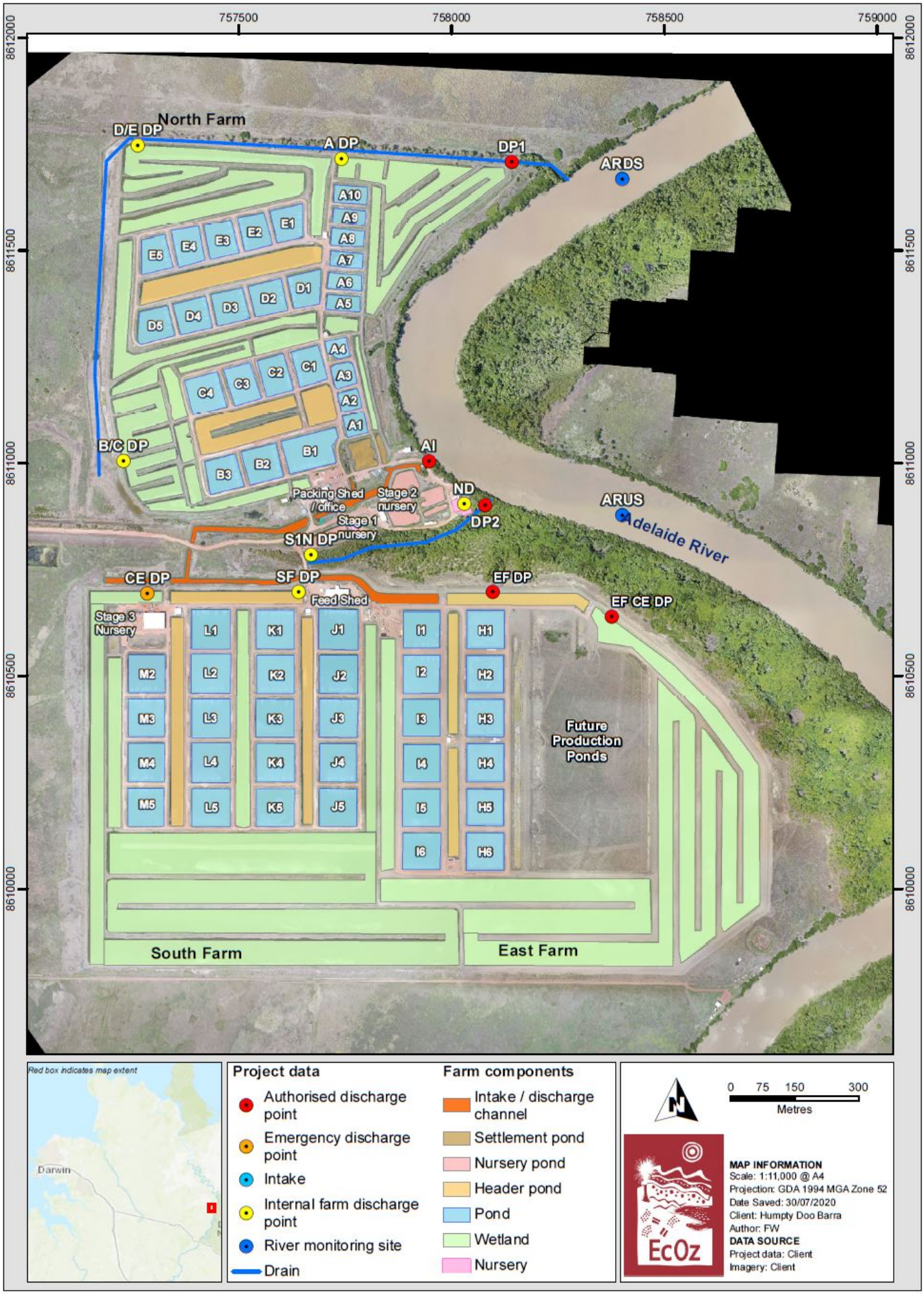

Figure 1-2. Map of farm pond layout, discharge monitoring points and receiving waterways.

1.5 Barramundi farm operation overview

Figure 1-2 shows the HDB Middle Point farm layout. This currently includes the:

- **North Farm** covering an area of approximately 60 ha, comprising 26 production (grow-out) ponds, 3 associated header ponds (for gravity flows), and 3 wetland treatment systems.
- **South Farm** covering an area of approximately 70 ha, comprising 19 production ponds, 3 associated header ponds, and a very large dedicated wetland treatment system.
- **East Farm** covering an area of approximately 68 ha, which currently includes 12 production ponds, 3 header ponds, and a very large dedicated wetland treatment system. More production ponds (11) and associated header ponds will be installed within the East Farm area in late 2020.

The flow system design of all three farms is essentially the same, where water flows from the header ponds, to the production ponds, then through the wetland treatment system. Once treated through the wetlands, the water is of sufficient quality for return to the header ponds for reuse in the production ponds. This minimises the need for discharge to, or refilling from, the Adelaide River. Water can be recirculated indefinitely, and discharge to the Adelaide River is usually limited to the peak of the wet season to prevent ponds overtopping, or occasionally during the dry season when topping-up the ponds to maintain optimal salinity for fish health.

The flow system design at HDB also means that all discharges (when required) are via the wetland treatment systems; no wastewater is discharged direct from the production ponds into the Adelaide River.

The HDB farm also includes a Stage 1 Nursery (fingerlings up to 1 g), Stage 2 Nursery (fish between 1 and 30 g), and recently completed in early 2020, Stage 3 Nursery (fish between 30 and 200 g). Once juvenile fish are large enough, they are transferred to the production ponds for grow out. Each of these nurseries utilises a wetland treatment system; negating the need to constantly extract from, or discharge to, the Adelaide River. Occasional discharges are required to prevent the wetland treatment ponds overtopping during the peak of the wet season, and to allow maintenance and upgrades of infrastructure (on average once per year).

Water required to top-up farm ponds and nursery tanks is pumped from the Adelaide River from the point shown in Figure 1-2 as ‘AI’ (Adelaide Intake).

1.5.1 North Farm Discharge

The North Farm has three groupings of production ponds linked to three separate wetland water treatment systems as described below (see also Figure 1-2):

- Ponds A5 to A10 are linked to the north-eastern wetland treatment system, which discharges into the perimeter drain at ‘A Discharge Point’ (A DP).
- Ponds B1 to B3, C1 to C4, and A1 to A4 are linked to the south-western wetland system, which discharges into the perimeter drain at ‘B/C Discharge Point’ (B/C DP).
- Ponds D1 to D5 and E1 to E5 are linked to the north-western treatment system, which discharges into the perimeter drain at ‘D/E Discharge Point’ (D/E DP).

Discharge from the North Farm is via ‘Discharge Point 1’ (DP1); see Figure 1-2. When the wetland water treatment systems overflow, they release water into a perimeter drain that flows to DP1. At DP1, water is directed into two pipes that run through an embankment. On the other side of this embankment, the water discharges into a very short tidal creek linked to the Adelaide River. An automated flow meter installed at DP1 accurately records the volumes of discharge.

1.5.2 South Farm Discharge

In the South Farm, the 19 production ponds are numbered J1 to J5, K1 to K5, L1 to L5 and M2 to M5 and all these flow into the single large wetland water treatment system. The Stage 3 Nursery also utilises this wetland treatment system. Once water reaches the end of the wetland treatment system, it is pumped back into the header pond. When discharging, an operator-controlled valve at SF DP (see Figure 1-2) is opened, and water from this header pond is released through a pipe in the earthen bank into a drainage channel. This water then flows to discharge point AI where it enters the Adelaide River.

An automated flow meter is installed at SF DP to accurately measure the volumes of discharge leaving the South Farm.

An additional discharge point CE DP, is located where the wetland treatment system for the South Farm discharges into the drainage channel (leading to AI) during extreme flood events, if required, when the capacity of SF DP is exceeded. Discharge volumes from CE DP would be measured manually if discharge was to occur.

1.5.3 East Farm Discharge

The East Farm (once fully complete) comprises 23 production ponds numbered F2 to F6, G1 to G6, H1, to H6, and I1 to I6. Ponds H1 to H6 and I1 to I6 were completed in 2019, and F2 to F6 and G1 to G6 are scheduled for completion in late 2020. The wetland water treatment system to service all 23 ponds is already fully constructed and operating. Once water reaches the end of this wetland treatment system, it is pumped back into the header pond.

When discharging, an operator-controlled value at EF DP (see Figure 1-2) is opened, and water from this header pond is released through pipes in the earthen bank into the mangroves that line the Adelaide River. An automated flow meter is installed at EF DP to accurately measure the volumes of discharge leaving the South Farm.

An additional discharge point EF CE DP, is located where the wetland treatment system for the East Farm discharges during extreme flood events into the mangroves lining the Adelaide River, if required, when the capacity of EF DP is exceeded. Discharge volumes from EF CE DP would be measured manually if discharge was to occur.

1.5.4 Nursery Discharge

Discharges from the Stage 1 Nursery and Stage 2 Nursery report to DP2 prior to flowing into the Adelaide River (Figure 1-2). Water from the Stage 2 Nursery is released via a PVC pipe connected directly to the nursery into the drainage line just upstream of where it meets the Adelaide River (i.e. discharge point ND).

Water from the Stage 1 Nursery wetland treatment system discharges into the drainage line at ‘S1N DP’, from where it flows down to DP2, and into the Adelaide River.

Discharge volume from the Stage 1 and Stage 2 nurseries is monitored manually by measuring the time it takes to fill a 20 L bucket to obtain a flow rate (usually around 5 L/sec) and multiplying this by the period of discharge (usually no longer than 48 hours).

Discharge from the Stage 3 Nursery is into the South Farm wetland treatment system, where any discharges are measured through the SF DP automated flow meter.

2 MONITORING PROGRAM

2.1 Sample site locations

Sample site locations are shown in Figure 1-2 and detailed below in Table 2-1. Monitoring locations comprise:

- Discharge point locations i.e. DP1, A DP, B/C DP, D/E DP, ND, S1N DP, SF DP, AI, CE DP, EF DP and EF CE DP. Note that DP2 cannot be safely accessed and this site is not sampled. Instead, the individual discharge points reporting to this site are sampled i.e. ND and S1N DP.
- Adelaide River water quality locations (i.e. ARUS and ARDS), used for determining any impacts on river water quality during discharge events. Note the context of the ARUS and ARDS sites is different depending on the tides at the time of sampling (i.e. the ARDS is "upstream" of the farm during an incoming tide).

All monitoring points are sign-posted except for the Adelaide River sites ARUS and ARDS.

Table 2-1. Monitoring location details.

Site ID	Site Name	Location	GPS Coordinates	
			Latitude	Longitude
DP1	Discharge Point 1	Point where drain along western and northern perimeter of North Farm discharges into the Adelaide River. This drain receives overflows from the wetland treatment systems for the North Farm via the internal discharge points B/C DP, D/E DP and A DP.	-12.54778	131.37553
DP2	Discharge Point 2	Point where drainage line discharges into the Adelaide River. This drainage line receives discharge from the Stage 1 Nursery via S1N DP and Stage 2 Nursery via ND. Note that DP2 cannot be safely accessed for sampling due to crocodile risk and the individual discharge points S1N DP and ND are instead monitored.	-12.55530	131.37485
SF DP	South Farm Discharge Point Note: Previously 'K/J DP'	Where South Farm treatment system discharges into channel that flows to AI and into Adelaide River.	-12.55694	131.37109
CE DP	Controlled Emergency Discharge Point for South Farm	Where South Farm treatment system discharges when flows exceed SF DP capacity. Discharges into same channel as SF DP.	-12.55706	131.36784
EF DP	East Farm Discharge Point	Where East Farm treatment system discharges into	-12.5569	131.37500

Site ID	Site Name	Location	GPS Coordinates	
			Latitude	Longitude
		mangroves lining Adelaide River.		
EF CE DP	East Farm Controlled Emergency Discharge Point	Where East Farm treatment system discharges into mangroves lining Adelaide River when flows exceed EF DP capacity.	-12.5574	131.37800
ND	Nursery Discharge	Stage 2 Nursery water prior to discharge into treatment ponds or to river when discharging via DP2.	-12.55506	131.37465
ARUS	Adelaide River Upstream Note: moved 200 m further upstream as of March 2020 to account for EF DP location	On Adelaide River, approx. 350 m upstream of DP2.	-12.5553	131.37800
ARDS	Adelaide River Downstream	On Adelaide River, approx. 150 m downstream of DP1.	-12.54811	131.37802
AI	Adelaide River Intake	Point where intake/out-take channel meets the Adelaide River. This channel receives discharge from the South Farm wetland treatment system via SF DP, and also CE DP during heavy rainfall when the capacity of SF DP is exceeded. This same channel is also the intake channel used to deliver water to the farm when pumping from the Adelaide River.	-12.55416	131.37390
A DP	A Ponds Discharge Point	Where A5 to A10 treatment ponds discharge into perimeter drain.	-12.54775	131.37199
B/C DP	B/C Ponds Discharge Point	Where B and C Series and A1 to A4 treatment ponds discharge into perimeter drain.	-12.55418	131.36731
D/E DP	D/E Ponds Discharge Point	Where D and E Series treatment ponds discharge into perimeter drain.	-12.54751	131.36757

2.2 Sampling frequency

The frequency of water quality sampling and flow volume measurements at each different monitoring site is provided in Table 2-2 below.

Table 2-2. Sampling frequency.

Site ID	WQ Sampling	Flow Volume
DP1	At least once when discharge from North Farm is occurring, or at least weekly if discharge longer than a week	Continuously during discharge via installed flow meter – real-time.
SF DP	At least once when discharge from South Farm is occurring, or at least weekly if discharge longer than a week	Continuously during discharge via installed flow meter – real-time.
CE DP	At least once when discharge from South Farm is occurring, or at least weekly if discharge longer than a week	Daily during discharge-measured manually
EF DP	At least once when discharge from East Farm is occurring, or at least weekly if discharge longer than a week	Continuously during discharge via installed flow meter – real-time.
EF CE DP	At least once when discharge from East Farm is occurring, or at least weekly if discharge longer than a week	Daily during discharge-measured manually
ND	At least once when discharge from Stage 2 Nursery is occurring, or at least weekly if discharge longer than a week	Daily during discharge-measured manually
ARUS	At least once each discharge, or at least weekly if discharge longer than a week	Not measured
ARDS	At least once each discharge, or at least weekly if discharge longer than a week	Not measured
AI	At least once each discharge, or at least weekly if discharge longer than a week	Not measured
A DP	At least once when discharge from North Farm is occurring, or at least weekly if discharge longer than a week	Not measured
B/C DP	At least once when discharge from North Farm is occurring, or at least weekly if discharge longer than a week	Not measured
D/E DP	At least once when discharge from North Farm is occurring, or at least weekly if discharge longer than a week	Not measured

2.3 Water quality parameters and assessment criteria

Table 2-3 lists the water quality parameters measured each time a site is sampled.

Table 2-3 also lists the assessment criteria used in compliance reporting to the NT EPA. The assessment criteria are the site specific trigger values (SSTVs) calculated in accordance with the ANZECC 2000 methodology, as per Condition 48 of EPL239. These values are based on the 80th percentile of reference data comprising at least 2-years' worth of monthly monitoring data from the Adelaide River sites (where samples were collected in the absence of any discharge from the farm). The derivation of these SSTVs is presented in the report *EPL239 Amendment Application, Site Specific Trigger Values*, prepared for HDB by EcOz, and submitted to the NT EPA on 25 September 2018.

Table 2-3. Water quality parameters measured and assessment criteria.
AR – assess against the quality of Adelaide River upstream location at time of sampling.

Parameters	Units	Assessment Criteria
Physical Parameters (measured in-situ)		
pH	pH units	7.2 – 8.2
Temperature	°C	Not applicable
Dissolved Oxygen (DO)	%saturation	AR
Electrical Conductivity (EC)	µS/cm	AR
Turbidity	NTU	AR
Flow	(kL/day	Not applicable
Laboratory Parameters		
Ammonia (NH_3) as N	mg/L	0.06
Nitrate (NO_3) as N	mg/L	0.41
Nitrite (NO_2) as N	mg/L	0.005
NO_3 + NO_2 (NOx) as N	mg/L	0.41
Total Kjeldahl Nitrogen (TKN) as N	mg/L	Not applicable
Total Nitrogen (TN) as N	mg/L	1.00
Total Phosphorus (TN) as P	mg/L	0.13
Filterable Reactive Phosphorus as P (FRP)	mg/L	0.04
Chlorophyll-a	µg/L	2
Biological Oxygen Demand (BOD)	mg/L	1.00
Other information recorded		
GPS Coordinates – although these are well established for each specified sampling site and samples are collected from same site coordinates each sampling round – all sites signposted except ARUS and ARDS		
Date and Time		
Sampler/s name		
Tide (high/low/spring/neap/incoming/outgoing)		
Any comments relating to site condition – e.g. any visible pollutants, scrum, water colour, clarity, water plants/algae, dead fish, any odours		

2.4 Notifications and compliance reporting

The following EPL239 conditions outline the compliance reporting requirements most relevant to water quality monitoring:

2.4.1 Discharge notifications

Conditions 27 and 28: *The licensee must as soon as practicable notify the NT EPA, by emailing waste@nt.gov.au, when a discharge begins, and ceases, via an authorised discharge point.*

2.4.2 Non-compliance notifications

Conditions 40 and 41: *The licensee must notify the NT EPA of any non-compliance with this licence by completing the Non-Compliance Notification via NT EPA Online (or by emailing waste@nt.gov.au), as soon as practicable after (and in any case within 24 hours after) first becoming aware of the non-compliance.*

In relation to the above, **Condition 39** defines a non-compliance with the licence includes:

> *39.1 an exceedance of a trigger value at the compliance point, as specified in Attachment A* (i.e. the assessment criteria listed in Table 2-3 above)*, on three consecutive sampling occasions;*
>
> *39.2 an exceedance of three times or more a trigger value at the compliance point, as specified in Attachment A, on a single sampling occasion;*
>
> *39.3 when Electrical Conductivity, Turbidity and Dissolved Oxygen at the compliance point exceed, in accordance with Attachment A, on three consecutive sampling occasions, the ambient water quality of the Adelaide River upstream monitoring point; and*
>
> *39.4 when Electrical Conductivity, Turbidity and Dissolved Oxygen at the compliance point exceed, in accordance with Attachment A, on a single occasion where the parameter measures greater than or equal to three times the ambient water quality of the Adelaide River upstream monitoring point.*

2.4.3 Monthly discharge report

Condition 43: *The licensee must submit to the NT EPA, a Monthly Discharge Report for each month a discharge occurs, by emailing waste@nt.gov.au. The Monthly Discharge Report is due on the last business day of the following month and must include:*

> *43.1 water quality data for all authorised discharge points, monitoring points and the compliance point;*
>
> *43.2 the concentration of nutrients, Biological Oxygen Demand and chlorophyll-a in the discharge water;*
>
> *43.3 flow data, discharge volumes and discharge times; and*
>
> *43.4 surface water quality management actions taken in the event of a trigger value exceedance at the compliance point.*

2.4.4 Annual Monitoring Report

Condition 45: *The licensee must complete and provide to the NT EPA a Monitoring Report, as prescribed by this licence, in accordance with the reporting schedule specified in Table 4.*

Table 4 - Reporting Schedule:

Reporting Period	Report Due Date
01 August 2017 - 31 March 2018	31 May 2018
01 April 2018 - 31 March 2019	30 April 2019
01 April 2019 - 31 March 2020	30 April 2020
01 April 2020 - 31 March 2021	30 April 2021
01 April 2021 - 31 March 2022	30 April 2022
01 April 2022 - 31 March 2023	30 April 2023

Condition 46 specifies that the licensee must ensure that each Monitoring Report:

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

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

46.3 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

46.4 includes an assessment of environmental impact from the activity

3 METHODOLOGY, SAFETY, TRAINING AND QUALITY ASSURANCE

3.1 Sampling methods

All sampling is undertaken in accordance with 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 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 on Water Quality Sampling – *Part 10: Guidance on sampling of waste waters* (AN/NZS 5667.10:1998), Standards Australia, New South Wales.
- ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

  ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

Sampling involves the following steps:

1. Recording of site name, GPS coordinates, sampler/s name, date and time, tide, and any notable site conditions such as visible pollutants, scrum, water colour, clarity, water plants/algae, dead fish, odour.
2. Measurement of physical parameters in-situ (pH, temperature, EC, DO, turbidity,) using hand-held YSI water quality meters calibrated immediately prior to mobilisation to site. Physical parameters are measured directly in the water body, if possible, depending on safe access.
3. Collection of water into laboratory-supplied sample bottles for sending to the NATA accredited laboratory for analysis. Water for laboratory analysis is collected directly into the bottles, if possible, depending on safe access, or if the bottle contains preservative, decanted from a non-preserved laboratory bottle. If safe access is not possible, water is collected for analysis using a laboratory-supplied bottle on an extendable pole. The three river samples ARDS, AI and ARUS are sampled using a drone to avoid crocodile safety risks.
4. Samples will be collected from approximately 0.3 m below the water surface. When collecting samples from flowing water bodies, the sample must be collected a reasonable distance from the water's edge and facing into the flow direction, keeping hands and all sample equipment downstream to prevent contamination.

Sampling equipment required for each monitoring round includes:

- Copy of this WQMP
- Maps of monitoring site locations
- Site Coordinates
- GPS (handheld) and spare batteries
- Folder/clipboard, Field Data Sheets (see Appendix A), enough for all sites plus spares; all printed on waterproof paper
- Laboratory Chain of Custody (COC) forms (See Appendix B)
- Stationary: Pens / pencils, permanent markers (xylene-free) for completing sample bottle labelling
- Sample containers obtained from a NATA accredited Laboratory as per Table 3-1 below. Enough for all sample sites, QA/QC samples and some spares
- YSI field water quality meters (pH, EC, temperature, DO, Turbidity) calibrated immediately prior to mobilising to site
- Plastic jugs
- Sample pole
- Eskies with frozen ice bricks; enough for the entire days' worth of samples
- Camera fully charged
- Decon 90 solution mixed with deionised water (1:20) and Plastic tub to clean equipment between samples
- Disposable powder-free gloves
- PPE
- Garbage bag for general waste generated during sampling
- Communications equipment (e.g. mobile/satellite phone, radio, EPIRB)

Table 3-1. Sample container and volume requirements

Container Type (preservation noted if required)	Test Parameter(s)
500 mL plastic	BOD, NO2, NO3
60 mL plastic ULTRATRACE	Reactive P
1,000 mL opaque plastic	Chlorophyll a
60 mL plastic (H2SO4 acid preservative)	TN, TP, NOx, TKN

3.2 Quality assurance, quality control (QA/QC) summary

The quality, accuracy and representativeness of samples and analytical results are assured given the following:

- All sampling will be carried out under the guidance of suitable qualified and experienced personnel.
- The standard Pro-Forma Field Data Sheet in Appendix A will be used to ensure that all required field data is collected.
- The laboratories analysing samples have stringent internal QA/QC procedures in accordance with their NATA accreditation.

- To prevent contamination of samples during field collection the following controls procedures will be implemented:
    - Sampling personnel will wear powder-free disposable gloves (a new pair for each site)
    - Samples will be collected into laboratory-supplied, pre-preserved containers
    - All equipment that is re-used (e.g. sampling jugs and water quality meters) will be rinsed with Decon 90 and deionised water between sample sites
    - Wherever possible, samples will be collected directly into laboratory sample containers negating the need to clean equipment between samples, e.g sample goes directly into bottles from surface water bodies
    - When filling sample containers, whilst the lid is off, the lid will not be placed edge-down in contact with any surfaces, and nothing will be allowed to contact the opening of the bottle
    - All sampling equipment will be kept downstream of where samples are collected in surface water bodies
- Samples will be labelled on sample bottles, and in all laboratory documentation and results according to the standard site IDs.
- Once collected, samples will be kept cool in eskies with frozen ice-bricks until drop off at the laboratory, after which they will be kept refrigerated <4°C until analysed. Ice is not to be used in eskies as melted ice can contaminate the samples.
- All samples will be delivered to the nominated laboratories to allow for analysis to be undertaken within holding times (see Table 3-2 below). The shortest holding time is two days for BOD, NO2, NO3, Reactive Phosphorus, and chlorophyll-a. In order to allow samples to be delivered to interstate laboratories and meet holding times, samples with these parameters will need to be delivered to the Darwin-based laboratory shopfront by 3 pm each day and not on a Friday, Saturday or Sunday. As such, sampling will need to start early (7.30 am) and be completed before 2:00 pm on (Mon/Tues/Wed/Thurs) to allow time for samples to be relinquished. If sampling is not completed before Thursday, it will need to be finished the following Monday.
- Strict chain of custody (COC) procedures and documentation will be maintained. COC form provided in Appendix B.

Table 3-2. Sample holding times

Parameter	Holding Time
Biochemical Oxygen Demand	2 Days
Chlorophyll-a	2 Days
Nitrite NO2	2 Days
Nitrate NO3	2 Days
Reactive Phosphorus	2 Days
Total Nitrogen	28 Days
Total Phosphorus	28 Days
Total Kjeldahl Nitrogen	28 Days
Ammonia NH3	28 Days
Nitrate + Nitrite NOx	28 Days

3.3 Reporting and record-keeping

Field data and laboratory data will be entered into the *HDB Water Quality Database* and any required data interpretation, assessment and reporting will be completed by the end of the month.

Samples will be submitted to a NATA accredited laboratory with a “standard” turn-around-time, which is estimated at 5 - 7 business days for the particular suite of analysis requested. Sample batches will be submitted to the laboratory on a daily basis during the sampling campaign, therefore results from the first day of sampling will be received first etc.

All laboratory results and laboratory documentation will be kept on file i.e chain of custody (COC) forms, certificate of analysis (COA), sample receipt notifications (SRN) and QA/QC documentation.

All Field Data Sheets will be scanned and filed upon completion of each sampling round. All site photos and other relevant sampling information will also be filed.

APPENDIX A PRO-FORMA FIELD DATA SHEET

Humpty Doo BARRAMUNDI
premium fish, wild Territory

EcOz

Surface Water Field Data Sheet

Project Number: *EZ19118*
Project Name: *Humpty Doo Barra Water Monitoring 2019-2020*
Sampling Date: 11-03-2020

Sampling Undertaken: Surface water grab samples
Sampler/s: *Andrew Lewis*
Location: *Humpty Doo Barra Farm – Middle Point*

EcOz Environmental Consultants

Site ID:	Time	Tide	Temp	pH	EC	TDS	Sal	DO	ORP	Turbidity
	24 hr	High/outgoing/ Low/Incoming	(°C)	pH units	(µS or mS / cm) Please specify units	(g or mg /l) Please specify units	(ppt)	(%sat)	(mV)	NTU
Northing:										
Easting:										

Comments (visible pollutants, notable flora/fauna etc)

Site ID:	Time	Tide	Temp	pH	EC	TDS	Sal	DO	ORP	Turbidity
	24 hr	High/outgoing/ Low/Incoming	(°C)	pH units	(µS or mS / cm) Please specify units	(g or mg /l) Please specify units	(ppt)	(%sat)	(mV)	NTU
Northing:										
Easting:										

Comments (visible pollutants, notable flora/fauna etc)

Site ID:	Time	Tide	Temp	pH	EC	TDS	Sal	DO	ORP	Turbidity
	24 hr	High/outgoing/ Low/Incoming	(°C)	pH units	(µS or mS / cm) Please specify units	(g or mg /l) Please specify units	(ppt)	(%sat)	(mV)	NTU
Northing:										
Easting:										

Comments (visible pollutants, notable flora/fauna etc)

APPENDIX B LABORATORY CHAIN OF CUSTODY FORM

Humpty Doo BARRAMUNDI
premium fish, wild Territory

EcOz

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5800 E: gladstone@alsglobal.com
MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304 Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: EcOz Environmental Consultants	TURNAROUND REQUIREMENTS :	X Standard TAT (List due date):	FOR LABORATORY USE ONLY (Circle)
OFFICE: Darwin	(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)	☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact? Yes No N/A
PROJECT: EZ19118 Humpty Doo Barra DATE: 11/03/2020	ALS QUOTE NO.: SY/476/16 V2 Humpty Doo Barra Quote	COC SEQUENCE NUMBER (Circle)	Free ice / frozen ice bricks present upon receipt? Yes No N/A
ORDER NUMBER: EZ19118		COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: Emma Smith	CONTACT PH: 08 8981 1100	OP: 1 2 3 4 5 6 7	Other comment:

SAMPLER: Andrew Lewis	SAMPLER MOBILE: 0410478875	RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY: / RECEIVED BY:
COC emailed to ALS? (YES / NO)	EDD FORMAT (or default):			
Email Reports to: emma.smith@ecoz.com.au; andrew.lewis@ecoz.com.au		DATE/TIME:	DATE/TIME:	DATE/TIME: / DATE/TIME:
Email Invoice to: eocz@ecoz.com.au, emma.smith@ecoz.com.au				

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).											Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	Chlorophyll-a	BOD	Suspended Solids (High Level)	Phosphorus - Reactive as P - ULTRATRACE	NT-S Total Nitrogen, TKN, NOx, NO2, NO3, NH3, Total Phosphorus							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	CE DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	K/J DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	S1N DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	ND	11/03/2020	W	P, SP	4	X	X	X	X	X							
	B/C DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	D/E DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	A DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	DP1	11/03/2020	W	P, SP	4	X	X	X	X	X							
	ARDS	11/03/2020	W	P, SP	4	X	X	X	X	X							
	AI	11/03/2020	W	P, SP	4	X	X	X	X	X							
	ARUS	11/03/2020	W	P, SP	4	X	X	X	X	X							
	EF DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
	EF CE DP	11/03/2020	W	P, SP	4	X	X	X	X	X							
				TOTAL	52												

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VS = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

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