Water Quality Monitoring Program

For: Proof of the Concept
Domesticated High Health Tiger Prawn Program

Australia's National Science Agency

Location: 13 Muramats Road, East Arm, Darwin, NT

Prepared By: CSIRO
Date: 04/11/2025

Contents

Acronyms and Technical Words

AAPA – Aboriginal Areas Protection Authority
A statutory body in the Northern Territory responsible for protecting Aboriginal sacred sites by issuing permits for works that may affect these culturally significant areas.

ARC – Aquaculture Research Centre
CSIRO have plans to develop an Aquaculture Research Centre within the NT. The project will provide detailed information for such a project.

BOD5 (BOD)– Biological Oxygen Demand (5-day)
A measure of the amount of oxygen consumed by microorganisms in the water as they break down organic material over a five-day period. It's used to assess the level of organic pollution in the water.

Chl-a – Chlorophyll-a
A pigment found in plants and algae, used as an indicator of algal biomass in water. High levels of chlorophyll-a suggest excessive algal growth, which can be caused by nutrient pollution.

CRAS – Closed Recirculating Aquaculture Systems
A sustainable aquaculture method where water is continuously filtered and reused within the system, minimising the need for external water exchange and allowing precise control of water quality.

DRP – Dissolved Reactive Phosphorus
A form of phosphorus in water that is readily available for uptake by plants and algae. It's an important indicator for assessing nutrient levels and potential for eutrophication (excessive algae growth) (also known as filterable phosphorous).

E. coli (*Escherichia coli*) - E. coli is a key microbial indicator under the ANZECC (2000) guidelines for assessing primary contact recreational water quality and effluent discharge compliance.

Enterococci - Enterococci counts are required for estuarine and marine receiving environments under ANZECC (2000) and NT EPA guidance, providing a reliable measure of microbiological water quality.

HH – High Health
A term used to describe animals, such as Black Tiger prawns, that are bred and maintained in a controlled environment free from specific diseases or pathogens, ensuring healthier stock for aquaculture.

Multicyclone Filters
A pre-filtration device that uses centrifugal force to remove larger particles from water. It reduces the load on finer filtration systems by spinning water rapidly, causing sediment and waste to settle out before it enters the main filtration system.

NATA – National Association of Testing Authorities
An accreditation body in Australia that ensures laboratories and testing facilities meet stringent quality standards. Samples analysed by a NATA-certified laboratory meet the regulatory requirements for accuracy and reliability.

NH3-N – Ammonia-Nitrogen
A form of nitrogen found in ammonia, which can be toxic to aquatic organisms at high concentrations. Monitoring NH3-N is crucial for maintaining water quality in aquaculture systems.

NO2 – Nitrite
An intermediate compound in the nitrogen cycle. High concentrations of nitrite can be toxic to aquatic life.

NO3 – Nitrate
A nitrogen compound that serves as a nutrient for plants but in excess can lead to water quality issues such as algal blooms.

NT EPA – Northern Territory Environment Protection Authority
The regulatory body responsible for environmental management and protection in the Northern Territory, including oversight of waste discharge, pollution control, and environmental compliance.

RAS – Recirculating Aquaculture System
A water-efficient aquaculture method where water is continuously treated and reused within a closed-loop system. RAS units include mechanical and biological filtration, oxygenation, and disinfection components, allowing precise control of water quality and minimising the need for external water exchange.

RAS Skids (Recirculating Aquaculture System Skids)
A compact, modular unit that integrates key RAS components—such as pumps, filters, UV systems, and oxygenation—onto a single frame or platform. Skids are designed for efficient installation and maintenance of closed-loop aquaculture systems.

TN – Total Nitrogen
A measure of all forms of nitrogen (organic and inorganic) in water. Nitrogen is an essential nutrient but in excess can contribute to water pollution and eutrophication.

TP – Total Phosphorus
A measure of all forms of phosphorus (organic and inorganic) in water, used to assess the overall nutrient load and potential impact on water quality.

Turbidity (NTU) – Nephelometric Turbidity Units
A measure of the cloudiness or haziness of water caused by suspended particles. High turbidity can reduce light penetration and affect aquatic life.

UV Treatment – Ultraviolet Treatment
A water treatment process that uses ultraviolet light to kill or inactivate pathogens, bacteria, and viruses in water by disrupting their DNA, making them unable to reproduce or cause infection.

WDL – Waste Discharge Licence
A licence required under the Water Act 1992 for activities involving the discharge of waste into water bodies. The WDL ensures that discharges meet environmental standards and protect water quality, particularly in sensitive areas like Darwin Harbour.

WSSV – White Spot Syndrome Virus
A highly contagious viral pathogen that affects prawns and other crustaceans.

Contact Information for this project

Table 1: Contact details of nominated responsible person for this project

Name	Email	Phone
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1 Introduction

This document serves as the Water Quality Management Plan (WQMP) for the CSIRO Proof of Concept Domesticated Prawn programme located at East Arm and is intended for submission to Northern Territory Environmental Protection Agency (EPA).

The project, located at the East Arm site (13 Muramats Road, Darwin, NT), aims to establish a sustainable, High Health (HH) breeding program for Black Tiger prawns, with the goal of developing a domesticated population that is Specific Pathogen-Free (SPF) for targeted pathogens.

It will utilise existing commercial technologies currently deployed at CSIRO Bribie Island (Queensland). These technologies will be refined within an NT setting in response to the increased temperature of the region.

In alignment with the Darwin Harbour Water Quality Objectives (WQOs) established by the Northern Territory Environment Protection Authority (NT EPA), this WQMP provides comprehensive details on project objectives, operational procedures, biosecurity protocols, and environmental management strategies.

This document includes sections intended for integration into the Waste Discharge Licence (WDL) application, which will be submitted to NT EPA. Following WDL approval, relevant sections will be incorporated into the Environmental Management Plan (EMP), further promoting regulatory compliance and environmental stewardship for the site.

2 Overview

CSIRO seeks to establish an aquaculture project at 13 Muramats Road, East Arm, Darwin, NT.

This site, fully developed and located within an industrial area, zoned DV (Development), is leased from Mr. Barry Sandford, and is being conducted to advance the production of domesticated, High Health (HH) Black Tiger prawns (*Penaeus monodon*), a key initiative for sustainable aquaculture in Northern Australia. The project will utilise Closed Recirculating Aquaculture Systems (CRAS) wherever possible to maximise water efficiency and biosecurity.

Although the East Arm site is located within an industrial zone extensively modified by activities such as the continuous dredging of East Arm, Darwin Harbour, and nearby industrial operations, it is bordered to the east by mangroves. Mangroves are ecologically significant, playing a critical role in supporting biodiversity, stabilising coastal areas, and serving as nurseries for marine life. While the surrounding environment includes these important mangrove ecosystems, the East Arm site itself is fully developed and lacks any natural features of ecological sensitivity.

The industrial setting and existing infrastructure make this site an optimal location for the project, enabling CSIRO to refine Closed Recirculating Aquaculture Systems (CRAS) technology for prawn breeding programs, and minimise potential environmental impact. Furthermore, the project aims to support the development of a larger Aquaculture Research Centre (ARC) which may be developed with key stakeholders such as NT Fisheries at a later date on another site, contributing to the long-term goal of establishing a commercially viable and environmentally sustainable prawn farming industry across Northern Australia.

By leveraging the modified nature of the East Arm site and its alignment with industrial zoning, the project seeks to balance development objectives with the protection of adjacent ecologically sensitive areas, such as mangroves. Monitoring and management plans have been developed to ensure that these ecosystems remain unaffected by the project's activities.

Cultural and Heritage Significance
Located on Larrakia Country, the East Arm site holds significant cultural heritage value, reflecting the deep connections of the Larrakia Peoples with the land and waters. CSIRO is committed to respecting and protecting cultural sites, artifacts, and features central to the Larrakia Peoples' identity.
Consultation will be conducted in accordance with the EMP.

Environmental and Ecological Context
The East Arm site, while industrially developed, is situated near ecologically sensitive areas supporting diverse marine and terrestrial species. The project prioritises preserving the region's natural biodiversity, minimising disruption, and preventing negative environmental impacts. Adhering to sustainable practices and water quality management will help maintain the balance of nearby ecosystems.

Community and Economic Context
The project has the potential to bring significant benefits to local and regional communities, potentially creating job opportunities, promoting economic growth, and supporting First Nations inclusion, notably through alignment with the planned Mapurlarri prawn project on Bathurst Island. By incorporating First Nations expertise, providing training, and supporting local employment, the project promotes sustainable development that aligns with both economic and cultural priorities, contributing positively to Northern Australia's aquaculture sector and local communities.

3 Legal requirements, standards, guidelines and Environmental context

The East Arm WQMP complies with key Northern Territory environmental legislation and guidelines, including:

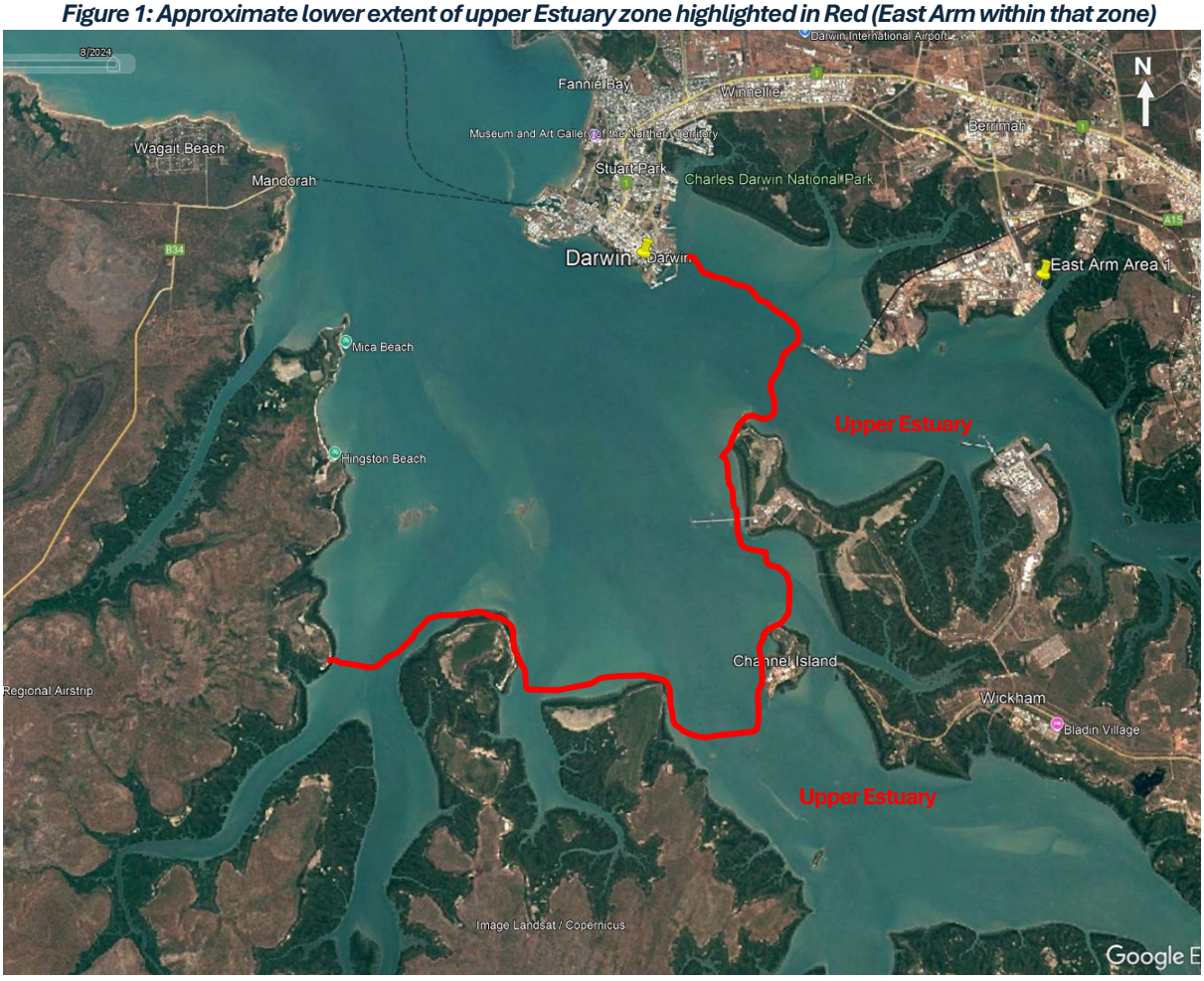
- **Waste Management and Pollution Control Act 1998 (WMPC Act)**: Establishes legal obligations for preventing pollution, managing waste, and protecting the environment.
- **Darwin Harbour Water Quality Objectives (WQOs)**: Sets benchmarks for maintaining estuarine and marine ecosystem health.
- **Australian/New 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).

By adhering to these frameworks, the project ensures compliance with NT EPA requirements and contributes to sustainable aquaculture practices in Northern Australia.

3.1 Darwin Harbour Water Quality Objectives (DHWQOs)

This Water Quality Monitoring Program has been developed to meet the requirements of the Darwin Harbour Water Quality Objectives (WQOs), ensuring that the project aligns with established standards for protecting estuarine and marine ecosystems in the region. The WQOs provide specific guideline values for key water quality indicators across different zones within the harbour, categorised as the Upper Estuary, Mid Estuary, and Outer Estuary, with each zone tailored to address its unique environmental conditions.

Figure 1: Approximate lower extent of upper Estuary zone highlighted in Red (East Arm within that zone)



(based on image contained within the NTG Water Quality Objectives for the Darwin Harbour Region – Background Document February 2010)

For the Upper Estuary zone, which includes areas such as Hudson Creek and East Arm, the WQOs are as follows:

- **Dissolved Oxygen (% saturation): 80–100%**
- **Chlorophyll-a (µg/L): Less than 4**
- **NOx N (µg/L): Less than 20**
- **Ammonia as N (µg/L): Less than 20**
- **Filterable Reactive Phosphorus (µg/L): Less than 10**

These guideline values serve as benchmarks to assess and manage water quality, ensuring the protection of aquatic life and the health of the harbour's ecosystems.

The Department of Environment, Parks and Water Security publishes annual report cards, which provide maps delineating the nine reporting zones representing distinct physical environments within Darwin Harbour. These resources are invaluable for stakeholders to effectively monitor and manage water quality, particularly in ecologically sensitive areas like Hudson Creek and East Arm.

3.2 Environmental Context

The site has a mix of hard stand and gravel topped earth with stable coastal soils and provides access to year-round clean saline water, which is crucial for aquaculture.

Key Points regarding Geology and Hydrology

- Operations will not draw on and or release water to groundwater aquifers.
- CSIRO will utilise current infrastructure located at the site with no additional permanent structures to be developed.
- Water will be sourced from Hudson Creek, an offshoot creek of the East Arm of Darwin Harbour.
- There will be no additional stormwater and or diversion drains established.

3.3 Hydrology and Coastal and Marine Environments

Table 2: Climate, Rainfall and Temperature Darwin, Northern Territory

Month	Avg Max Temp (°C)	Avg Min Temp (°C)	Avg Rainfall (mm)	Avg Humidity (%)
January	31.8	25.3	426.2	79
February	31.4	25.3	369.5	81
March	31.8	25.0	315.7	80
April	32.6	24.1	101.5	74
May	32.0	21.8	21.7	67
June	30.6	19.6	1.6	63
July	30.6	19.3	1.0	61
August	31.2	20.5	3.1	61
September	32.2	23.0	15.3	66
October	33.2	25.0	71.7	72
November	33.3	26.0	140.5	76
December	32.5	26.0	252.2	78
Avg	**31.7 (°C)**	**23.5 (°C)**	**176 mm (2114 mm annual)**	**71.1%**

3.3.1 Hudson Creek Geology

The "**Geotechnical Investigations: East Arm Stage 1B and 2A Industrial Subdivision Incorporating Muramats Road Subdivision**" report (NT EPA.NT.gov.au) provides detailed insights into the soil composition of the East Arm area. The subsurface profile is generally characterised by marine sediments overlying weathered rock. Specifically, the investigation identified up to 1 metre of very soft marine mud or a combination of sand and mud in certain areas. In the southern part of the site, a mixture of marine mud, sand, and gravel-sized coral fragments was encountered.

Underlying these sediments, weathered rock formations, including phyllite and meta-siltstone, were observed. The depth of these overburden soils varies across the site, with some areas exhibiting up to 3.2 metres of overburden. These findings are crucial for informing construction practices, particularly concerning foundation design and earthworks, to ensure structural stability and environmental compliance.

3.3.2 Darwin Harbour Geology

The Darwin Harbour area is characterised by Permian siltstones and sandstones, which form the foundational bedrock of the region. During the Last Glacial Maximum (approximately 19,000 to 23,000 years ago), the harbour and adjacent areas were exposed to subaerial conditions due to lower sea levels, leading to significant geological formations and sediment deposits. (Researchgate.net)

3.3.3 Darwin Harbour Hydrology

Darwin Harbour experiences a monsoonal tropical climate with distinct wet and dry seasons. The wet season, from October to March, contributes the majority of the annual rainfall, leading to increased freshwater input into the harbour's tributaries, including Hudson Creek. The harbour is macrotidal, with tidal ranges reaching up to 7.8 meters, resulting in complex and strong tidal currents that influence water movement and sediment distribution within the estuarine systems.

The region's hydrology is also influenced by its extensive mangrove systems, which play a crucial role in nutrient cycling and provide habitats for various marine species. These mangroves contribute to the nitrogen-limited nature of the harbour, serving as primary producers and supporting the overall ecological balance. (CDU.edu.au).

3.3.4 Groundwater

As highlighted previously, the project will not draw on and or release to groundwater aquifers.

The "**Geotechnical Investigations: East Arm Stage 1B and 2A Industrial Subdivision Incorporating Muramats Road Subdivision**" report provides insights into the groundwater conditions of the East Arm area.

The investigation revealed that groundwater levels vary across the site, with depths ranging from approximately 2.5 to 4.0 metres below the existing ground surface. These fluctuations are influenced by tidal movements, given the site's proximity to Darwin Harbour. The report also notes that the groundwater is generally brackish, reflecting the saline conditions of the adjacent marine environment. (NT EPA.gov.au)

3.3.5 Flora and Fauna

This project will be primarily contained indoors, and all operations will occur on an area that has been cleared and developed for over 20 years.

The project acknowledges that the East Arm area supports a diverse range of flora and fauna, including extensive mangrove forests, intertidal mudflats, and seagrass beds, which provide critical habitats for

marine and bird species. Mangrove ecosystems play a key role in coastal stability and serve as breeding and nursery grounds for many fish and crustacean species.

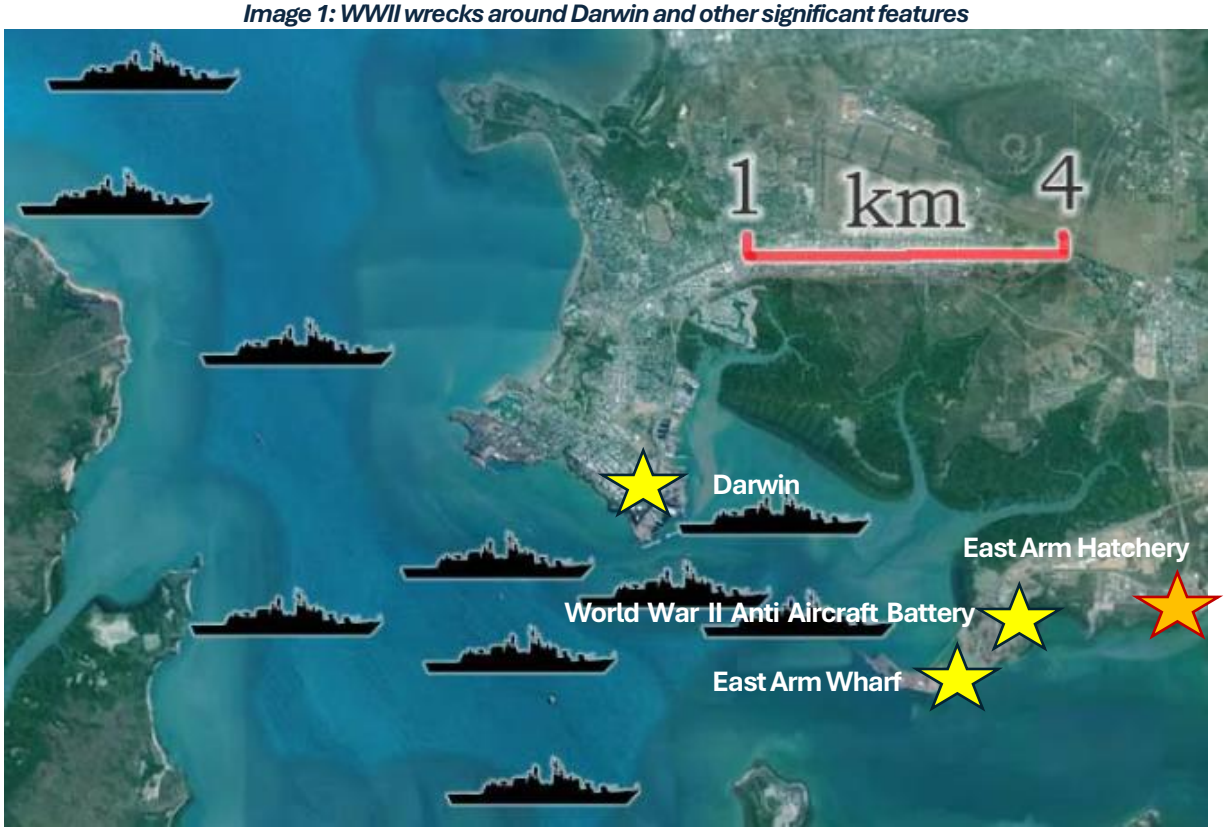
3.3.6 Significant sites or features (East Arm)

The East Arm area in Darwin, Northern Territory, is notable for several significant features and sites:

- **East Arm Wharf:** A deepwater port facility that serves as a critical hub for maritime trade in northern Australia (approximately 1.5kms from the site).
- **World War II Heritage Sites:** The area includes historical sites such as the WWII Quarantine Anti-Aircraft Battery Site, which is recognised for its unique design and historical significance.
- **Catalina Aircraft Wrecks:** The waters around East Arm contain wrecks of Catalina flying boats from World War II, serving as underwater cultural heritage sites.

None of these sites will be effected by this project.

Image 1: WWII wrecks around Darwin and other significant features



4 Site Details

4.1 Location:

The site location is shown in Image 1 and Image 2, with details summarised in Table 3 below:

Table 3: Site Details

Latitude	-12.4771922
Longitude	130.9294776
Datum	GDA94
Street address	13 Muramats Road, East Arm, Darwin, NT
Lot/Section number	Section 3245
Town/Hundred	Hundred of Bagot

4.2 Site Size:

13 Muramats Road is a multi-use location with sections of the site operated by various companies. The site has a total land area of **approximately five hectares.**

- CSIRO will lease two small sections of the site previously operated by Monsoon Aquatics.
- These areas will be known as: **East Arm Area 1** and **East Arm Area 2**.

4.3 East Arm Area 1:

Consists of a section of the 13 Muramats Rd site measuring 80 x 27m, or **2160m²**
It currently contains:

- A main site shed measuring 16 x 27m, or approximately **430m².**
- Attached Annex measuring 9 x 16m, or approximately **144m².**
- A demountable office.

4.4 East Arm Area 2:

Consists of a section of the 13 Muramats Rd site measuring 52 x 20m, or **1040m².**
It currently contains:

- Two shipping containers.
- An attached Annex between the shipping containers measuring 12 x 14m, or approximately **160m².**
- A demountable office.

4.5 Zoning

- The Site is zoned DV (development) – Similar to industry.
- As a research facility the land use is an "**undefined use**" and in this zone (and all zones) an Undefined use will be impact assessable and will require a development application.
- The site has received a Development Permit to operate at the site (see appendages)

4.5.1 Neighbouring Property Land Use:

The site is a multi-use facility with mechanics and pipeline construction facilities operating.

- The area is a multi-use "undefined use" with multiple freight and petroleum facilities nearby.

Image 2: Area 1 & 2, 13 Muramats Road

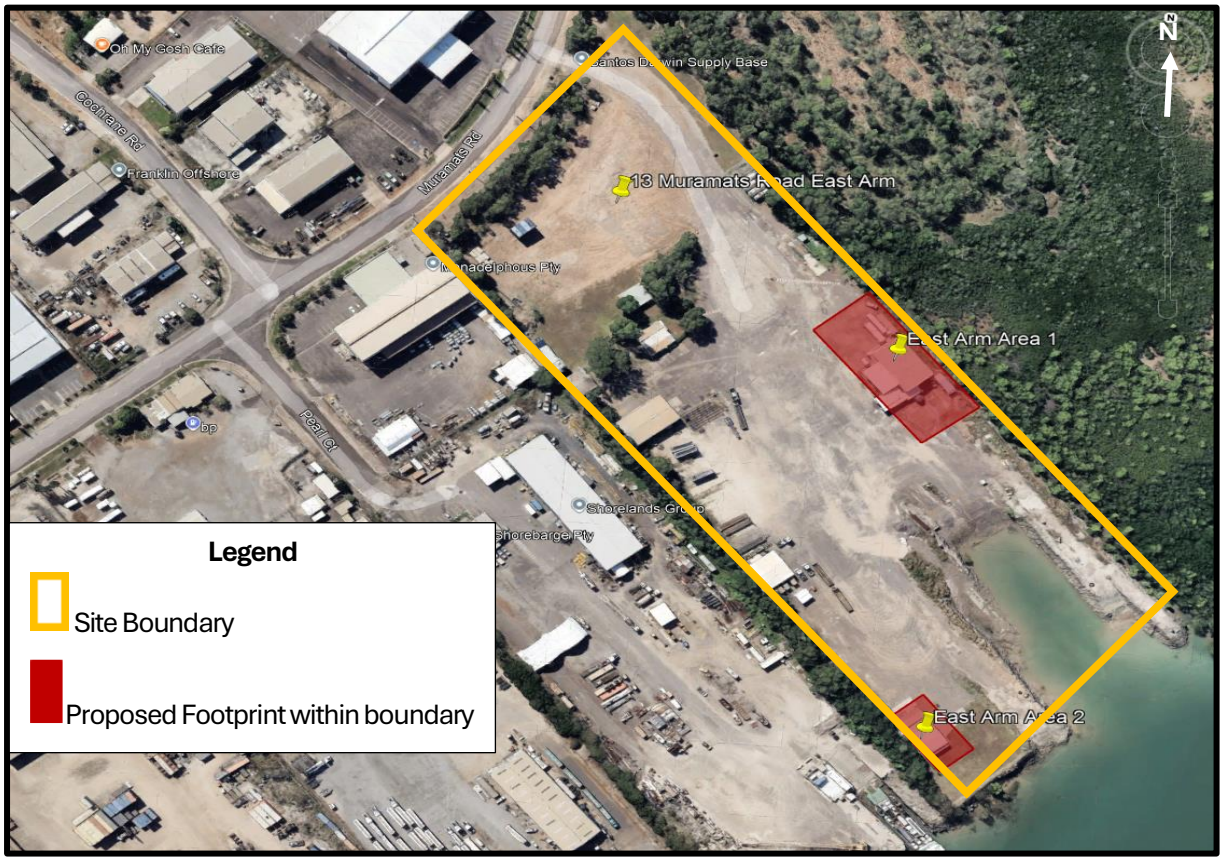


Image 3: Extraction and discharge points

5 Water Quality Monitoring Program

CSIRO's monitoring program is designed to meet project, regulatory (Waste Management and Pollution Control Act 1998), and public requirements while managing costs. The program will assess the low volume discharge into the Darwin estuary through controlled weekly internal analysis of discharge water quality characteristics and volumes, supplemented by laboratory analysis to generate an accurate nutrient budget.

5.1 Water Extraction

Water for the site will be extracted from two locations known as Extraction Point 1 (EP1) and Extraction Point 2 (EP2) (see table 4). Water extraction will occur during periods when the rising tide exceeds 4.5 metres. Previous site operators Monsoon Aquatics have provided feedback that this is when the clearest water is available from Hudson Creek. **See Image 3** for location of Water extraction points.

Table 4: Water Extraction locations

Site ID	Site Name	Coordinates		Rationale
		Latitude	longitude	
EP 1	Extraction Point 1	-12.478103°	130.931231°	Existing extraction point and will supply water to East Arm Area 1
EP 2	Extraction Point 2	-12.479023°	130.930406°	To supply water to East Arm Area 2

5.2 Discharge Points

Discharge will occur during outgoing tides to ensure minimal influence to the environment upstream of the facility and to maximise immediate dilution with the tidal flow exiting Hudson Creek. Discharge Points will be located directly adjacent to water extraction points (**see table 5**). See **image 3** (previous page) for location of Discharge Points.

Table 5: Discharge Point locations

Site ID	Site Name	Coordinates		Rationale
		Latitude	longitude	
DP 1	Discharge Point 1	-12.478115°	130.931248°	Access is available to this area and pipework already exists.
DP 2	Discharge Point 2	-12.479041°	130.930422°	Access is available to this area, and it is in close proximity to East Arm area 2

5.3 Monitoring Sites

Sampling will be conducted at the two discharge sampling points (discharge sampling point 1 and discharge sampling point 2) and at two additional sites in Hudson Creek to assess upstream and downstream water quality during discharge events. (see image 4 following page)

Table 6: Monitoring Sites details

Site ID	Site Name	Coordinates		Rationale
		Latitude	longitude	
HCMPUS	Hudson Creek Monitoring Point Upstream	-12.477814°	130.933201°	Upstream of both Discharge Points
HCMPDS	Hudson Creek Monitoring Point Downstream	-12.482976°	130.927911°	500m Downstream of both Discharge Points
DSP1	Discharge Sampling Point 1	-12.477872°	130.931036°	Located on discharge pipe, prior to any dilution. Also, a safe sampling point
DSP2	Discharge Sampling Point 2	-12.478834°	130.930214°	Located on discharge pipe, prior to any dilution. Also, a safe sampling point

Image 4: Monitoring points– Highlighting two onsite discharge sampling points, the upstream and downstream monitoring points

Image 5: Conceptual Site Model East Arm

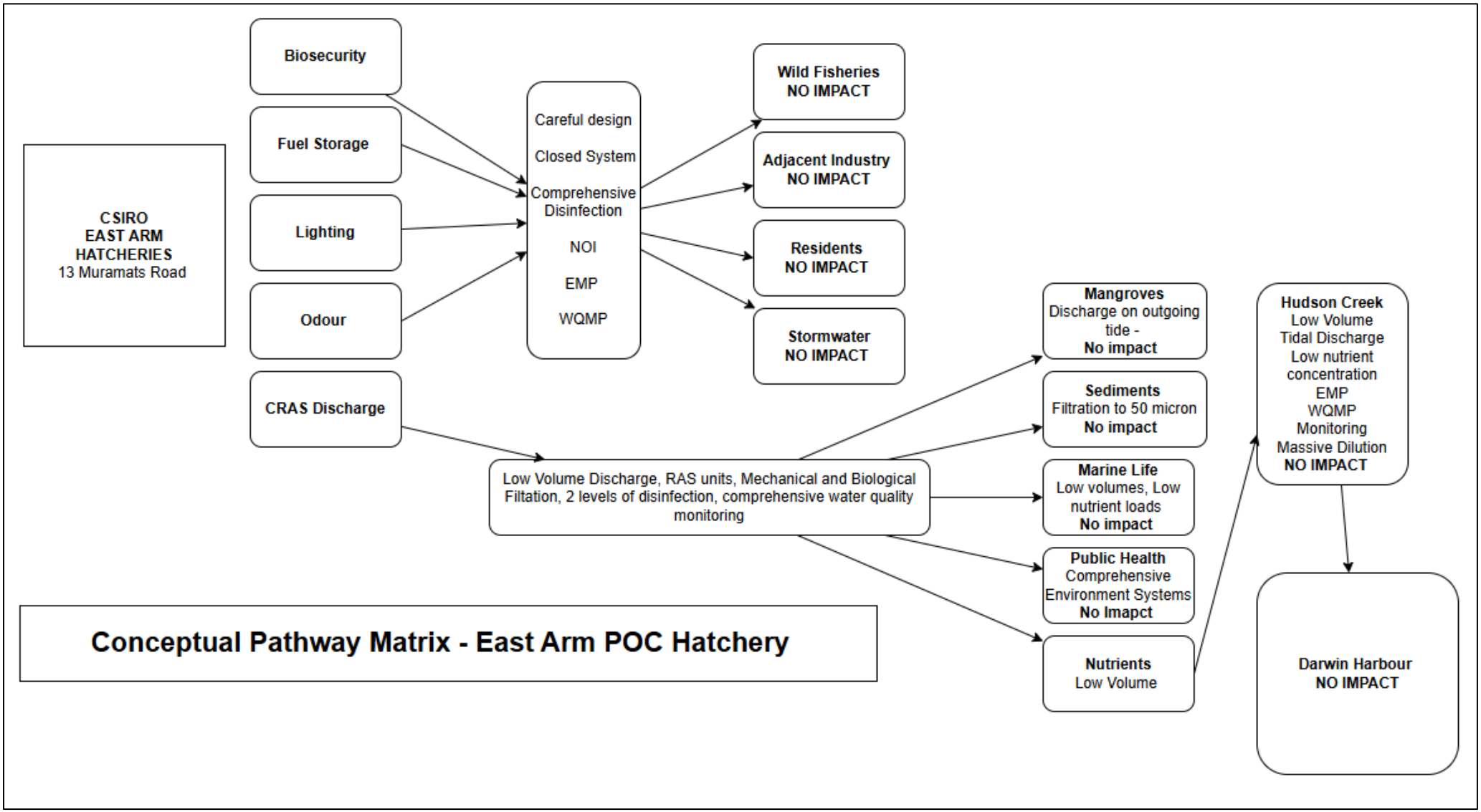
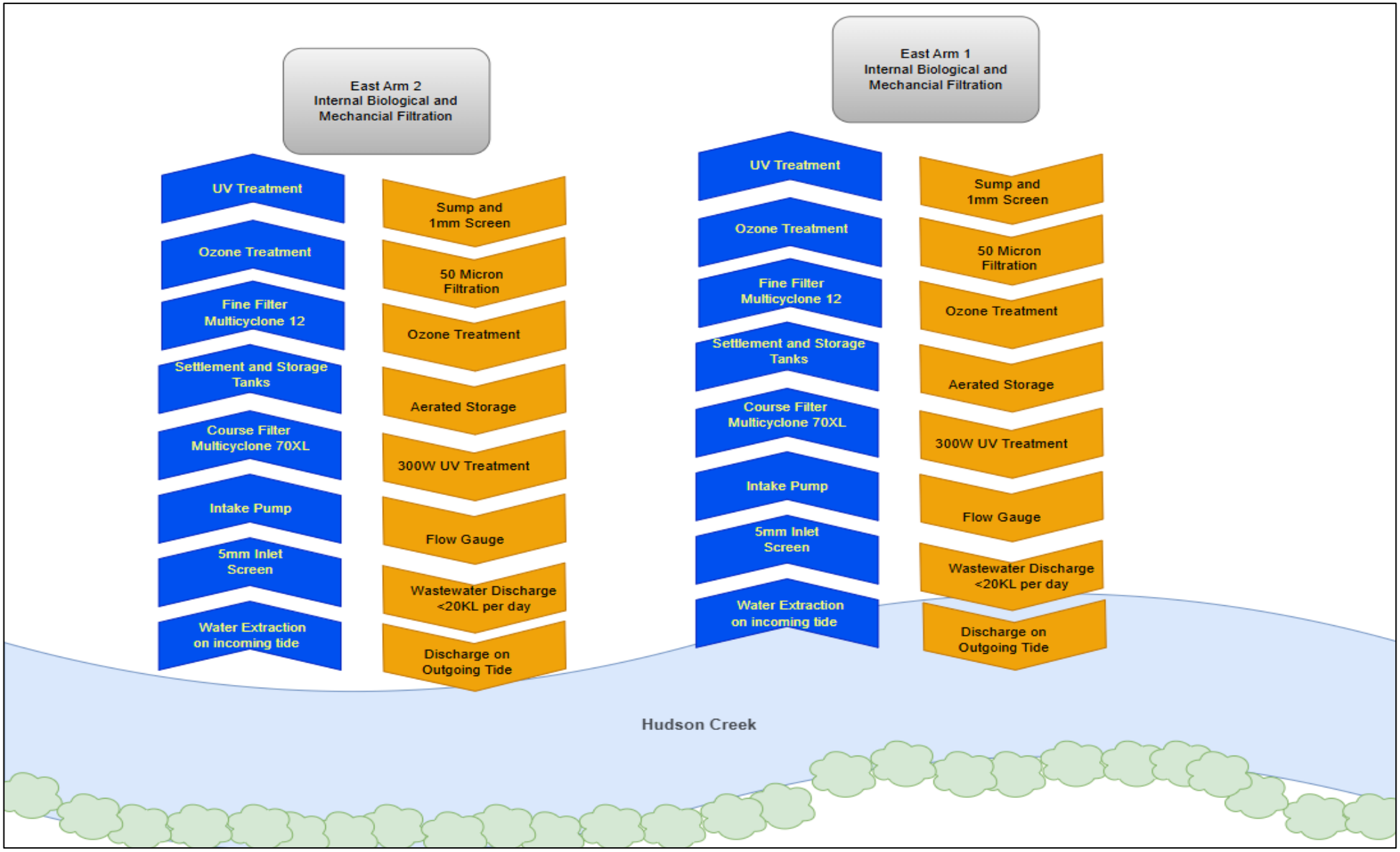


Image 6: Process Flow Diagram East Arm



5.4 Field and Laboratory Analysis and Sampling Frequency

5.4.1 Field Analysis Frequency

CSIRO proposes conducting weekly field analysis using onsite monitoring equipment to assess key water quality parameters at the **Discharge Sampling Point 1** (DSP 1) and **Discharge Sampling Point 2** (DSP 2).

Samples will be collected weekly (if discharge occurred during that week) from purpose-built sampling points (taps/valves) within the discharge pipes before release, ensuring the analysis accurately reflects the actual characteristics of the discharge without dilution from external sources. This approach provides a precise assessment of the discharge composition and the characteristics of the wastestream.

All field analysis will use calibrated water analysis units that meet industry standards, ensuring reliable, accurate, and consistent results.

Monthly laboratory testing of the discharge sites will complement this onsite monitoring, offering higher detection sensitivity to verify results and provide a more detailed nutrient profile.

5.4.1.1 Parameters

Field analysis will be conducted weekly for the following parameters:

- Temperature (C)
- Flow (KL weekly total)
- pH (Units)
- Dissolved Oxygen (DO)
- Salinity (ppt)
- Turbidity (NTU)
- Chlorophyll a (PE RFU)
- Alkalinity (mg/L)
- Ammonia (NH3-N)
- Calcium (mg/L)
- Magnesium (mg/L)
- Nitrate (mg/L)
- Nitrite (mg/L)
- Phosphate (mg/L)

All results will be securely stored in the CSIRO database and summarised in annual reports with information available to EPA on request.

5.4.2 Laboratory Analysis Frequency

CSIRO proposes conducting monthly laboratory sampling, with analysis performed by a NATA-certified laboratory to assess key components of the discharge and its potential impact on the receiving waterway. Samples will be collected from purpose-built sampling valves within the discharge pipes before reaching the discharge point, as well as from two designated locations in Hudson Creek (**see image 4**).

CSIRO recommends an adaptive approach to laboratory sampling, allowing for the adjustment of parameters based on relevance to environmental outcomes. Parameters that do not provide significant environmental insights may be phased out, while additional parameters may be included as needed, particularly if recommended by regulatory bodies. This flexibility allows the program to remain efficient and responsive to evolving environmental and regulatory needs.

This integrated monitoring approach ensures transparency and accuracy in reporting, aligning with CSIRO's commitment to environmental stewardship and regulatory compliance.

If changes are made to the monitoring parameters (post approval from EPA post a formal request), this WQMP and the EMP would be amended and submitted to the NT EPA for the corresponding licence amendment.

5.4.3 Monthly Laboratory Sampling and Analysis

Monthly sampling and analysis will include the following parameters:

- pH (Lab)
- Filterable Reactive Phosphorous (FRP)
- Total Phosphorous (TP)
- Total Nitrogen (TN)
- NH3-N (mg/L)
- NOx (mg/L)
- Chlorophyll-a (chl-a)
- Total Suspended Solids (TSS)
- *E. coli*
- *Enterococci*

All results from laboratory analysis will be securely stored in the CSIRO database and summarised in monthly and annual reports.

Table 7: Suggested Monitoring Program East Arm (WQMP)

		Monitoring Points				
	Site Code	**DSPEA1** [1]	**DSPEA2** [2]	**HCMPUS** [3]	**Compliance Point - HCMPDS** [4]	
	Latitude	-12.477872°	-12.478911°	-12.477814°	-12.482976°	
	Longitude	130.931036°	130.930258°	130.933201°	130.927911°	
Parameter	**Units**	**Sampling Frequency (W=Weekly) (M=Monthly)**			**Trigger Values**	
Field Parameters						
Flow	KL	W	W	Not applicable	NA	Not applicable
pH (Field tested)	pH units	W	W	M	<7 or >8.5	M [c]
Temp	°C	W	W	M	NA	M [c]
Salinity	ppt	W	W	M	NA	M [c]
Turbidity	NTU	W	W	M	20 [a]	M [c]
Dissolved Oxygen (DO)	% or mg/L	W	W	M	<80 or >100	M [c]
Chlorophyll-a (chl-a)	mg/L	W	W	M	NA	M [c]
Calcium	mg/L	W	W	M	NA	M [c]
Magnesium	mg/L	W	W	M	NA	M [c]
Ammonia (NH3-N)	mg/L	W	W	M	NA	M [c]
Nitrite (NO_2)	mg/L	W	W	M	NA	M [c]
Nitrate (NO_3)	mg/L	W	W	M	NA	M [c]
Alkalinity	mg/L	W	W	M	NA	M [c]
Phosphate	mg/L	W	W	M	NA	M [c]
Laboratory Parameters						
pH (Lab)	pH units	M	M	M	<7.0 or >8.5 [b]	M [c]
Filterable Reactive Phosphorous (DRP)	mg/L	M	M	M	>0.010 [b]	M [c]
Total Phosphorous (TP)	mg/L	M	M	M	>0.020 [b]	M [c]
Total Nitrogen (TN)	mg/L	M	M	M	>0.250 [b]	M [c]
Ammonia (NH3-N)	mg/L	M	M	M	>0.020 [b]	M [c]
NOx	mg/L	M	M	M	>0.020 [b]	M [c]
Chlorophyll-a (chl-a)	mg/L	M	M	M	>0.002 [b]	M [c]
Total Suspended Solids	mg/L	M	M	M	>0.010 [b]	M [c]
E. coli	CFU/100ml or MPN/100ml	M	M	M	≥200 [b]	M [c]
Enterococci		M	M	M	≥50 [b]	M [c]

Note: Trigger Values have been adopted from the Darwin Harbour Water Quality Objectives.

Trigger values apply to Hudson Creek Monitoring Point Down Stream only and not on the undiluted discharge.

Trigger Values will not be assumed to be exceeded if exceedance has also occurred at the Hudson Creek Monitoring Point Upstream (HCMP US).

6 Sampling Procedures – Reporting

Sampling will be conducted by experienced, suitably qualified staff.

6.1 Field Sampling Procedures

6.1.1 Preparation and Calibration

To ensure accuracy and prevent contamination, calibrate and clean all sampling equipment before use. (Calibration protocols and procedures will be discussed in detail within the EMP for the project).

- Collect the Weekly Field Sampling sheet from the front office and review it to understand sampling points and required equipment.
- Clean all probes according to the manufacturer's instructions.
- Review the calibration log for handheld units. If required, calibrate units as per manufacturer instructions.
- Label two sampling containers with the site identifiers:
- DSP EA1 (Discharge Point East Arm 1), Outlet pipe from main building.
- DSP EA2 (Discharge Point East Arm 2), Outlet pipe from Hangar building.

6.1.2 Sample Collection

- Check the Flow Monitor and record the total flow. (Subtract last week's figure to determine the weekly total.)
- Use the purpose-built sampling taps at DSP EA1 and DSP EA2 to collect water samples directly from the discharge pipes, avoiding dilution or contamination.
- To prevent air exposure that may alter results, fill containers fully and avoid air bubbles.

6.1.3 Field Measurements

Use portable YSI ProQuarto units with calibrated sensors to conduct in-situ measurements for the following parameters:

- Temperature,
- Dissolved Oxygen,
- Salinity
- Turbidity
- Chlorophyll-a

Record the time and location on the sampling sheet.

To collect the field measurements:

- Rinse a clean jug, with wastewater to be sampled, three times before collecting the sample.
- Introduce the probe in the jug. Record field readings upon stabilisation of all field parameters. In the field sheets, also note any relevant field observations (e.g. water colour, odour, presence of solids in sample, etc.)
- Repeat the previous steps at each monitoring site.

6.1.4 Onsite lab/Field Measurements

CSIRO will utilise its onsite laboratory water testing equipment (Waterlink, Spin-touch photometry) to analyse the remaining parameters that cannot be analysed using hand-held units.

Bottled samples DSP EA1 and DSP EA2 (Discharge Point East Arm 2), will be taken to the onsite lab for analyse of the following parameters:

- Alkalinity
- Ammonia
- Nitrate
- Nitrite
- Calcium
- Magnesium
- Phosphate

On completion, sampling container/jug/bucket – must be undergo decontamination as per protocols.

6.1.5 Field Data Documentation

- Enter sample results in the field sampling data spreadsheet, noting all parameters, calibration details, and any observations that may affect results.
- Compare current results with previous data and trigger values to identify any unusual result. If an outlier is found, resample to confirm accuracy before finalising the data.

6.2 Laboratory Sampling Procedures

Sample Collection will be conducted during discharge on an Outgoing tide. Discharge must cease two hours prior to the change of tide.

- Ensure wastewater tanks are discharging.
- Ensure Field sampling has been completed and Flow measurements recorded.

6.2.1 Discharge Laboratory Sampling

- Use the purpose-built sampling taps at **DSP EA1** and **DSP EA2** to collect water samples directly from the discharge pipes, avoiding dilution or contamination.
- To prevent air exposure that may alter results, fill laboratory sampling containers fully and avoid air bubbles.
- Place samples in esky.

6.2.2 Environmental Monitoring Laboratory Sampling

Due to the sampling sites within Hudson Creek, either a sampling drone and or boat will be used for access.

- **HCMP US** (Hudson Creek upstream of Discharge Point EA1) needs to be collected on an outgoing tide, whilst site discharge is occurring and 2 hours prior to low tide.
- **HCMP DS** (Hudson Creek downstream monitoring point) needs to be collected post one hour of beginning of discharge from **DSP EA1** and or **DSP EA2** during an outgoing tide and 2 hours prior to low tide.

Fill NATA labelled sampling bottles fully and avoid air bubbles.

- Record the time and location on the sampling sheet.
- Note tide information on sampling sheet.
- Place Bottles into refrigerator for delivery to NATA lab transport company.

6.3 Laboratory Data Documentation

Laboratory data will be stored within the CSIRO database and will be utilised to generate Reports or Reviews as per conditions found within the WDL. Laboratory Analytical Reports, Chain of Custody and any other documentation regarding the analysis, transport and receipt of laboratory samples will be stored within CSIRO's database and supplied to regulatory authorities on request.

6.4 Field Sampling Equipment

All field sampling equipment will be calibrated and maintained according to the suppliers specifications and calibration records will maintained by CSIRO and made available to regulators on request.

6.5 Reporting

CSIRO suggests that annual reports be generated and submitted to NT fisheries and NT EPA to provide clarity of operations. CSIRO also suggests that the Water Quality monitoring program be reassessed after two years of operations to refine the program to focus on any areas of concern and to refine ongoing costs with focus concentrated on key parameters and or desirable information

6.6 Trigger Values Exceedance

The site will operate to the conditions contained within the WDL and therefore this section will be reviewed post the issuing of that document. However, the principles of how Trigger Value Exceedances will be managed are noted below.

Any exceedance of Trigger Values will prompt immediate notification to the EPA. If the exceedance is suspected to be related to site operations, CSIRO will initiate additional weekly laboratory analyses until levels return to compliance. Additionally, CSIRO will investigate and modify procedures accordingly to prevent the recurrence of the incident.

7 Final Summary

The East Arm Water Quality Monitoring Program for the Proof of Concept (POC) Specific Pathogen-Free (SPF) Black Tiger Prawn project is designed to ensure compliance with the Northern Territory's environmental regulations and the Darwin Harbour Water Quality Objectives (WQOs). This monitoring program outlines the key methodologies for field and laboratory sampling, data analysis, and reporting protocols essential for safeguarding the surrounding estuarine and marine ecosystems.

Key components include:

Site-Specific Context: The East Arm site, situated within an industrial zone on Larrakia Country, reflects both cultural significance and environmental sensitivity. By leveraging closed recirculating aquaculture systems (CRAS) and adopting sustainable practices, the project aims to minimise impacts on local biodiversity and water quality.

Monitoring Framework: Regular weekly field analyses are conducted using on-site equipment, complemented by monthly laboratory analyses through a NATA-certified facility. This two-tiered approach ensures real-time insights into water quality parameters meeting both regulatory and project-specific requirements.

Trigger and Compliance Mechanisms: Trigger values derived from the Darwin Harbour WQOs guide the monitoring of potential nutrient loading and ecological impacts. Any exceedances initiate immediate notification and corrective actions in coordination with NT EPA, reinforcing the project's commitment to environmental compliance.

Transparent Reporting: Annual reports will summarise field and laboratory data, with comprehensive tables and graphical representations of key parameters. These reports are designed for submission to the NT EPA and stakeholders, fostering transparency and building trust in the program's environmental stewardship.

Overall, this monitoring program is a foundational aspect of CSIRO’s efforts to establish a sustainable, pathogen-free aquaculture model that aligns with both environmental and community expectations. Through adaptive management, cultural respect, and rigorous data-driven practices, the program supports a model for responsible aquaculture development within Northern Australia.