PROJECT SEA DRAGON

CORE BREEDING CENTRE AND BROODSTOCK MATURATION CENTRE

EN02-MN4201

Water Quality Monitoring and Management Plan

Rev 1, 25-Feb-2020

Project and Document Details

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Signed: ....

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Terms and Abbreviations

µg/L	Micrograms per Litre, 1 µg = 1/million of 1 Litre, equivalent to parts per billion (ppb)
AWQG	The Australian Water Quality Guidelines, referring to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
DENR	Department of Environment and Natural Resources
DO	Dissolved oxygen
DoEE or the Commonwealth	Commonwealth Department of Environment and Energy
EA Act	Environmental Assessment Act 1982 (NT)
EC	Electrical Conductivity
EIMP	Environment Impact Monitoring Program
EIS, the EIS or the Project EIS	The Environmental Impact Statement (EIS) refers to the EIS documentation prepared for Stage 1 of the Legune Grow-out Facility
EMP	Environmental Management Plan
EMS	Environmental Management System
EPZ	Environmental Protection Zone
EVs	Environmental Values
FRP	Filterable Reactive Phosphorous
GDA	Geodetic datum of Australia. GDA94 is the current most up to date datum
Guideline Value	As per the AWQG (see above), a guideline value is 'a measurable quantity (threshold) or condition of an indicator for a specific community value below or above which we consider to be a low risk of unacceptable effects occurring '
JSEA	Job Safety and Environment Analysis
mg/L	Milligrams per Litre, 1 mg = 1/1000 of 1 Litre, equivalent to parts per million (ppm)
MNES	Matters of National Environmental Significance
NH_3	Ammonia
NOx	Oxides of Nitrogen (Nitrite + Nitrate)
NT EPA	Northern Territory Environment Protection Authority
NWQMS	National Water Quality Management Strategy
Phys-chem	Physical / Chemical analytes – dissolved oxygen, pH, solids, oxygen demand, and similar analytes, as opposed to biological, nutrients, etc.
QA/QC	Quality Assurance / Quality Control
Redox	Redox Potential
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WMPC Act	Waste Management and Pollution Control Act (NT)
WQMMP	This report, the Water Quality Monitoring and Management Plan

WQO	Water Quality Objective This term refers to objectives for water quality, described by the AWQGs as 'the guideline value or narrative statement for each selected indicator that should ensure the protection of all identified community values [previously environmental values]. In this document, this refers mostly to the Darwin Harbour WQOs (DNREAS, 2010).

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EXECUTIVE SUMMARY

This Water Quality Monitoring and Management Plan (WQMMP) has been developed for the Project Sea Dragon Core Breeding Centre (CBC) and Broodstock Maturation Centre (BMC) (the Project), located at Point Ceylon at Bynoe Harbour, on NT Portion Number 3192, Northern Territory. It has been prepared in response to the water quality related conditions of the Waste Discharge Licence (WDL242) as specified in Section 1.1 of this report.

The WQMMP has been developed to comply with statutory requirements, and to protect the water quality of receiving waters, such that ecological health, and the health, welfare and amenity of people are maintained. The plan addresses the following elements:

- Provides an overarching management scheme within which the WQMMP will operate, linked with the Project Sea Dragon Environmental Management System and the site Environmental Management Plan
- Describes specific Objectives and Targets for water quality management, and details discharge criteria, receiving water guideline values and impact assessment methodology to be followed
- Includes a risk assessment and derives management measures and controls based on that risk assessment
- Provides a detailed assessment of baseline data and the requirements for further monitoring
- Details baseline and operational monitoring programs, including:
  - Frequency, timing and duration
  - Parameters to be sampled and sampling methods
  - Scientifically robust methods for screening and analysis of data
  - Triggers, management and mitigation measures
  - Review, auditing and reporting requirements.

To ensure the plan is more easily implemented, while allowing for agency review, the report incorporates the key background and guidance information in the main report body, with the management strategies and monitoring plans to be implemented on the ground provided in Appendix A (water quality management, baseline water quality monitoring and operational water quality monitoring), the sampling methodology in Appendix B, and supporting data (including baseline data and review of guideline values) in the supporting report included in Appendix C.

1 INTRODUCTION

1.1 BACKGROUND

This Water Quality Monitoring and Management Plan (WQMMP) has been developed for the Project Sea Dragon Core Breeding Centre (CBC) and Broodstock Maturation Centre (BMC) (the Project), located at Point Ceylon at Bynoe Harbour, on NT Portion Number 3192, Northern Territory.

The Project involves the development of breeding program facilities, a seawater intake pipeline and settlement ponds and discharge infrastructure to Wheatley Creek.

The site location is shown in Figure 1-1, with Figure 1-2 showing the general site layout, including discharge location and receiving waters.

The WQMMP is required as part of the approved Waste Discharge Licence (WDL242) issued in accordance with the Water Act on 7 February 2018. The relevant WDL conditions are as follows:

34. *The licensee shall conduct a review of the baseline water quality monitoring program to inform suitable monitoring methodologies to develop site-specific trigger values and water quality objectives for management. The licensee shall enhance the baseline water quality monitoring program by:*
    - *34.1. increasing spatial representation of sites in Bynoe Harbour;*
    - *34.2. accounting for natural variation in receiving waters; and*
    - *34.3. including sediment sampling and biological indicators of nutrient impacts.*

    Based on the review, a revised monitoring program shall be peer reviewed by an appropriately qualified independent professional, and implemented, to the satisfaction of the NT EPA.

35. *The licensee shall review, and revise if necessary, the proposed interim site-specific water quality trigger values for Wheatley Creek. The review shall be based on the outcomes of the water quality monitoring program review provided for in condition 34, and be undertaken when a sufficient revised dataset is available. The review must:*
    - *34.1. consider the development of seasonal interim trigger values; and*
    - *34.2. be undertaken in consultation with the NT EPA*

36. *The licensee must submit a Water Quality Monitoring and Management Program to the administering agency in accordance with condition 39 of this licence.*

Additional elements to be addressed in this WQMMP are included in the WQMMP Checklist provided in the Supporting Report in Appendix C.

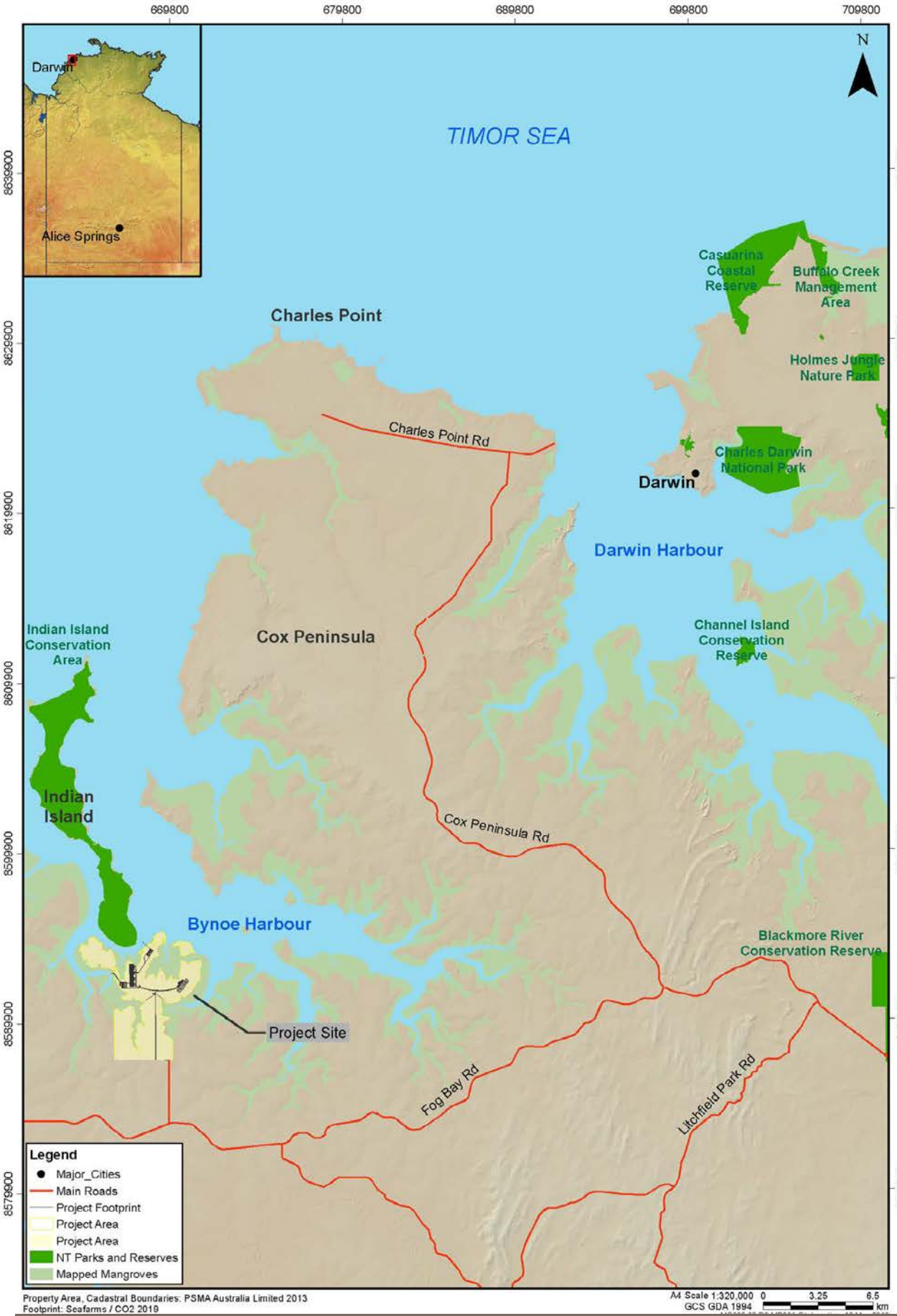

FIGURE 1-1 SITE LOCATION

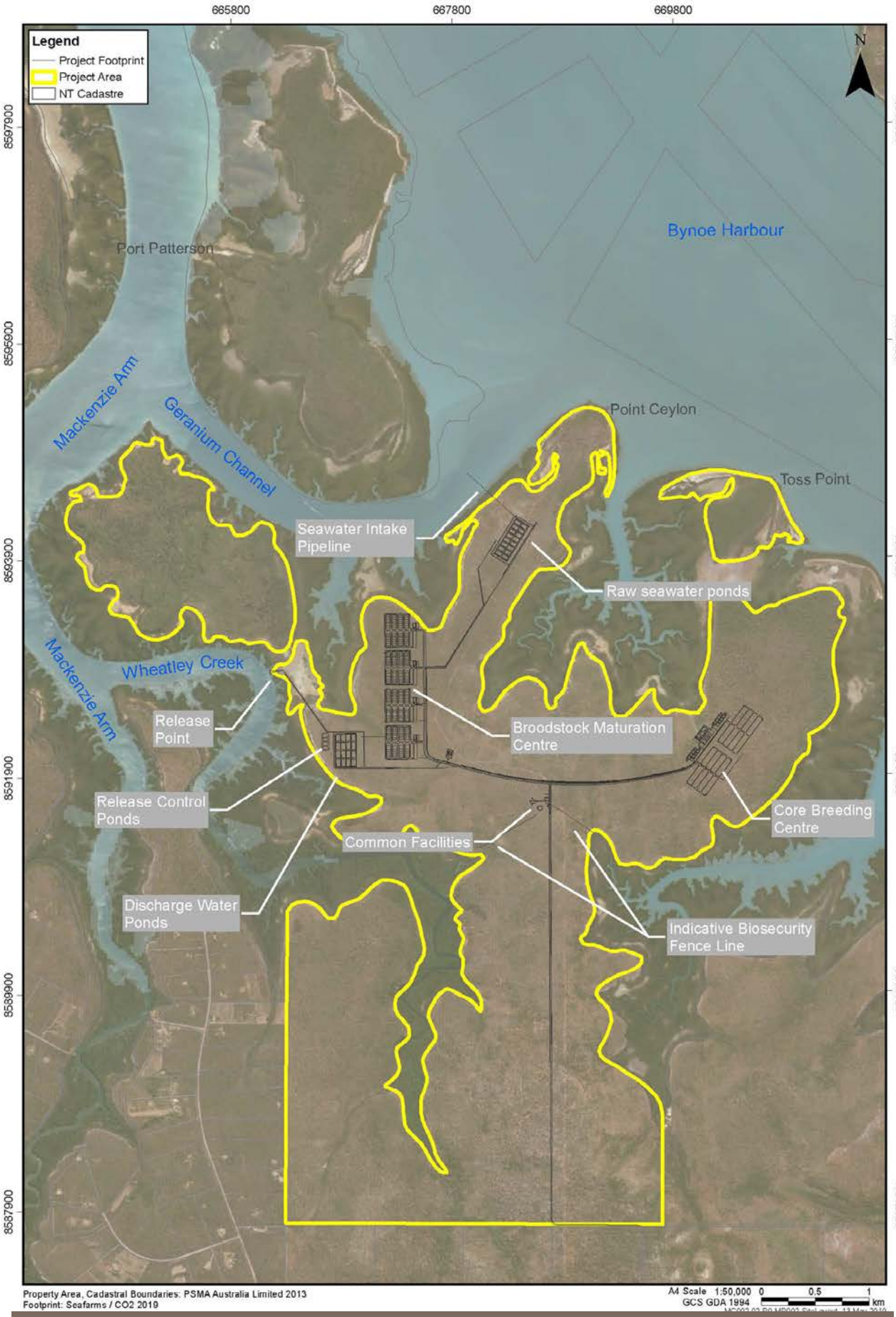

FIGURE 1-2 SITE LAYOUT

1.2 DOCUMENT SCOPE AND ORGANISATION

Project Sea Dragon has developed a Project Environmental Management System (EMS) guiding the overall environmental management across the Project and containing requirements and procedures common across all sites. Each component of the entire Project (e.g. hatchery, grow-out facility, CBC & BMC, etc.) in turn implements a site-specific Environmental Management Plan (EMP) to enable site specific implementation of the overarching EMS aims, objectives and targets.

This WQMMP sits under the site specific EMP and has been designed to meet required statutory requirements and the EMS Objectives and Targets by providing:

- Operational aims and objectives to be adopted in relation to water quality for discharges to the receiving environment
- Management strategies to be followed to manage and reduce impacts to water quality from Project operations.
- A monitoring program to determine whether significant changes in receiving waters occur due to Project discharges.

The document has been organised as follows:

- The main document body - general background (Introduction, Section 1), Objectives and Targets (Section 2), WQMMP development (Section 6), and supporting information (Legislative Requirements, Guidelines and Standards, Potential Risks and Impacts, Stakeholders and Consultation (Sections 3 – 5))
- The monitoring and management plans to be implemented – Appendix A, including overall management (including construction), and the baseline and operational monitoring plans
- Sampling methodology – Appendix B, and
- A supporting report in Appendix C, including Project Description, Existing Environment, Risk Assessment, Water quality data review and WQMMP approval conditions checklists.

2 OBJECTIVES AND TARGETS

The overall aim of this WQMMP is as follows:

> *Ensure that the water quality of receiving waters does not deteriorate due to site discharges, such that ecological health, and the health, welfare and amenity of people are maintained.*

Table 2-1 provides the overarching Objectives, Targets and Key Performance Indicators for this WQMMP against the above aim, incorporating specific Project approval requirements and standards (refer Section 3), and Environmental Values (EVs) for receiving waters (refer Appendix C).

TABLE 2-1 WQMMP OBJECTIVES AND TARGETS

Objectives	Targets	Key Performance Indicator
Undertake and complete works in compliance with statutory environmental requirements.	▪ No statutory infringements. ▪ No breaches of licence/approval conditions.	▪ Number of infringements. ▪ Number of breaches.
Protection of marine and estuarine aquatic ecosystems. Maintenance of the cultural and spiritual values of marine and estuarine waters, including ecosystems and biota. Protection of human consumers (fish species, crabs, etc.). Maintenance of suitable saline water supply quality for the Project.	**General** ▪ No complaints. **Construction** ▪ Relevant Management Strategies fully implemented. **Operation** *Discharge* ▪ Discharges comply with the discharge criteria in Appendix A3. *Receiving* waters ▪ Outside the initial mixing zone, receiving waters comply with the water quality guideline values in Appendix A3. ▪ Where exceedances of guideline values occur, impact monitoring shows that changes at impact sites are not significantly different from changes at control sites. ▪ No significant impacts to hydraulics and/or bathymetry or erosion due to Project discharges. *Intake waters* ▪ Intake water quality suitable to support aquaculture activities.	▪ Number of incidents or breaches. ▪ Number of complaints. ▪ Number of exceedances of discharge criteria or receiving water guideline values. ▪ Number of events showing impacts when compared to control sites. ▪ Spatial extent and timing of erosion and scour.
Collect sufficient data to characterise discharge and receiving water and reference site water quality.	▪ Minimum 12 months baseline data. ▪ Suitable coverage of tidal and seasonal variation – no strong bias.	▪ Length and number of baseline sampling events. ▪ Number of neap/spring, flood/ebb and wet/dry cycles covered at each site.

Objectives	Targets	Key Performance Indicator
Sample collection activities are safe, robust and repeatable.	▪ No workplace incidents. ▪ QA/QC procedures implemented. ▪ QA/QC checks validate program.	▪ Number of incidents. ▪ # of QA/QC samples collected compared to total # of samples collected (as %). ▪ Pass/fail for each sampling event.

3 LEGISLATIVE REQUIREMENTS, GUIDELINES AND STANDARDS

Key relevant Northern Territory Legislation for this WQMMP is as follows:

- *Environmental Assessment Act 1982* (EA Act), under which the Project Environmental Impact Statement (EIS) was assessed and approved
- *Fisheries Act*, relevant to protection of receiving waters fisheries values, relevant for cultural and recreational fisheries
- *Territory Parks and Wildlife Conservation Act 1976*, relevant to NT protected species
- *Waste Management and Pollution Control Act* (WMPC Act), which regulates most industry and individuals that conduct activities likely to cause pollution
- *Water Act 1992*, under which the WDL has been issued for the discharge to Wheatley Creek, and
- *Work Health and Safety Act*, under which the monitoring works will need to comply for personnel health and safety.

The supporting report in Appendix C outlines the relevant WDL conditions and a cross reference to where the condition is addressed.

Under Section 12 of the WMPC Act, all people who are engaging in an activity that is causing, or is likely to cause, pollution resulting in environmental harm must take all measures that are reasonable and practicable to prevent and reduce the amount of the waste. Under Section 14 of the WPMC Act, the NT EPA must be notified of incidents that cause or threaten to cause pollution.

The key guidelines utilised in the development of this WQMMP are as follows:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the Australian Water Quality Guidelines 2018, or AWQG) (ANZG, 2018)
- Australian guidelines for water quality monitoring and reporting (ANZECC & ARMCANZ, 2000b), and
- Queensland Monitoring and Sampling Manual (DES, 2018).

4 POTENTIAL RISKS AND IMPACTS

Information and data on the Project, the existing environment, and potential risks are provided in the supporting report in Appendix C. Based on this, the key potential water quality related risks to be managed are summarised in the sections below.

4.1 CONSTRUCTION

For construction, the potential impacts are related to vegetation clearing, earthworks, disturbance of acid sulfate soils and spills of chemicals, fuels or wastes. Potential impacts to water quality will therefore be related to sediment loss from the site, runoff of acidic waters from acid sulfate soil exposure and oxidation, and spills or leaks of fuels or chemicals to waters, including paints, concrete, etc.

4.2 OPERATIONS

During the operational phase, the primary potential impact to water quality is the discharge of aquaculture water into Wheatley Creek. The identified risks relate to exceedances of water quality guideline values (mainly from nutrients), increased scour and erosion and spills and leaks of fuels and other chemicals.

Additional potential impacts were identified relating to the intake of seawater (altered tidal characteristics, flow and erosion/scour rates), boat strike impacts to aquatic fauna and impingement of aquatic fauna in intake structures. These are not considered directly related to water quality management, but do relate to protection of receiving water ecology, and to provision of a suitable water supply for the Project.

The key actions affecting discharge into receiving waters have been identified as follows:

- Addition of feed to tanks, representing primarily nitrogen and phosphorous addition
- Growth and rearing of prawns including generation of prawn faeces, moults and mortalities
- Growth and control of algal biomass in tanks, and
- Spills and leaks.

The key potential water quality stressors are therefore related to nutrients, primary productivity indicators, solids levels (though expected to be lower than the existing environment) and potential additives (though no problematic constituents are proposed).

Spills and leaks are possible but are considered likely to be a lower order of risk.

The non-discharge potential stressors are:

- Direct impacts to aquatic flora and fauna (boat strike, impingement), and
- Changes to flow patterns, affecting erosion and scour rates, and potentially intake water quality.

Fauna related impacts are addressed in the fauna management strategy in the EMP and not further discussed in this WQMMP.

5 STAKEHOLDERS AND CONSULTATION

Discussions have been held with key Northern Territory Government agencies, particularly the NT EPA and NT DENR regarding the preparation of this plan.

A copy of this WQMMP will be provided to the NT DENR for review prior to implementation. Additional liaison will be required with the NT DENR in relation to data sharing between the department and Seafarms' operations.

6 WATER QUALITY MONITORING AND MANAGEMENT

6.1 OVERVIEW

This program has been prepared to test whether changes have occurred in receiving waters due to Project operations and to provide triggers to initiate corrective site actions to manage discharges to mitigate water quality impacts on receiving waters, if needed. The monitoring program is required to be able to characterise discharges, detect significant change in receiving waters, and determine whether that change is due to site operational discharges.

6.2 MANAGEMENT APPROACH

6.2.1 Management System

This WQMMP has been prepared as a sub-plan under the site EMP, which is a part of the overarching PSD EMS. The PSD EMS Manual (EN-MN4001) details general implementation including:

- Risk Assessment
- Relevant Legislation and Statutory Requirements
- Roles and Responsibilities
- Training and Awareness
- Communication
- Supplier and Sub-contractor Management
- Monitoring and Review
- Non-compliance and Corrective Action
- Complaints Management
- Documentation, Records and Reporting.

Site specific elements are incorporated into the site EMP, notably:

- Site specific risk assessment
- Roles and responsibilities, site communication requirements
- Monitoring, review and reporting.

6.2.2 Water quality management

The AWQG, part of the National Water Quality Management Strategy (NWQMS), defines the Water Quality Management Framework - a framework providing a logical process to be followed for the long-term management of receiving water/sediment quality. This process has been addressed as described below (from ANZG, 2018), with the detail largely provided in the supporting report included in Appendix C (referred to as the supporting report in this section).

The Water Quality Management Framework is a cyclical process and will be repeated as needed. In particular, the steps will be reviewed and revised as appropriate immediately prior to operations, and once the Project is operational, based on monitoring and assessment of receiving environment water quality against the guideline values.

Step 1 — Examine current understanding - To inform decisions at subsequent steps, develop conceptual models of how the waterway systems work, the issues they face and how to manage them.

- The supporting report provides background information on the system, including a brief description of the existing environment, and a detailed examination of existing water quality and biota associated with receiving waters (Sections 3, 4 and 7 of the supporting report).

Step 2 — Define community values and management goals: Establish or refine community values and more specific management goals (including level of protection) for the relevant waterways at stakeholder involvement workshops.

- Overarching management goals are defined in Section 2 of this report, with the specific aims identified at the start of each program in Appendix A in this report
- Section 5.1 of the supporting report establishes the Environmental Values relevant to the receiving waters for the Project, namely:
  - Marine and estuarine aquatic ecosystems
  - Recreation and aesthetics
  - primary industries (aquaculture).
- The relevant waters are defined as the Upper Estuarine waters of Wheatley Creek, flowing into the Upper to Mid-Estuarine waters of Mackenzie Arm, and the Mid-Estuarine waters of Geranium Creek and Bynoe Harbour, all defined as Slightly to Moderately disturbed waters (refer supporting report, Section 4.3)

Step 3 — Define relevant indicators: Select indicators for relevant pressures identified for the system, the associated stressors and the anticipated ecosystem receptors.

- Key indicators are developed in Section 6 – Risk Assessment – of the supporting report, which describes the key pressures (licensed discharge, potential spills and leaks, construction activities), stressors (nutrients, Chlorophyll a and trace metals, suspended solids, turbidity and dissolved oxygen), and ecosystem receptors (primary producers and zooplankton, benthic environments, community structure, mangroves and macroalgae).
- Based on this risk assessment, a range of indicators were chosen for monitoring, depending on the relevant pressure.

Step 4 — Determine water/sediment quality guideline values: Determine the water/sediment quality guideline values for each of the relevant indicators required to provide the desired level of protection (if applicable) for the management goals of relevant waterways.

Step 5 — Define draft water/sediment quality objectives: Use the guideline values or narrative statements chosen for each selected indicator as draft water/sediment quality objectives to ensure the protection of all identified community values and their management goals.

Step 6 — Assess if draft water/sediment quality objectives are met: Use measurements from monitoring of each relevant indicator to assess whether current water/sediment quality meets the draft water/sediment quality objectives.

- Existing local Water Quality Objectives (WQOs) exist for Darwin Harbour which have been slightly modified to adopt a set of interim water quality guideline values for receiving waters, following an

assessment of the available baseline data against these WQOs. This will be reviewed with additional baseline data.

- Discharge criteria were identified that could be met, and that would meet the water quality guideline values for receiving waters. The background levels and guideline values were used to re-assess the discharge criteria finding they remain suitable (Section 9 in the supporting report)
- Development of interim water quality guideline values, as well as discharge criteria, are discussed and provided in Section 9 in the supporting report, and Appendix A3 (Operational Water Quality Monitoring Program) in this report.

Step 7 — Consider additional indicators or refine water/sediment quality objectives: Assess the need to revise or add to the lines of evidence or indicators and the water/sediment quality guideline values.

- A detailed assessment of multiple receptors and lines of evidence was undertaken in the EIS (Volume 2, Chapter 2; Volume 2, Chapter 7; Volume 5, Appendix 9), and further in the supporting report, where Section 7 discusses the existing baseline dataset and need for additional / ongoing monitoring, and Section 6.3 outlines the key indicators based on an examination of pressures, stressors and receptors, in a multiple lines of evidence approach to water quality management

Step 8 — Consider alternative management strategies: Evaluate the effectiveness of current management strategies to address the identified water quality issues and recommend possible improvements. Improved or alternative management strategies are formulated, assessed and prioritised.

- A management strategy has been developed in Appendix A to this report, for which only the baseline monitoring has been implemented.
- The strategy includes adaptive management, including in Appendix A1, Review and Auditing and Corrective Actions, and Figure A1 showing the process figuratively.

Step 9 — Assess if water/sediment quality objectives are achievable: Use information gained from Steps 6 to 8 to assess whether the water/sediment quality objectives are achievable.

- An assessment against the Interim water quality guideline values was undertaken in the water quality modelling conducted in the EIS and SEIS, and this was confirmed through the re-assessment of the modelling results against the revised guideline values in Section 9 in the supporting report.
- Both assessments showed the receiving water quality could be met.
- Note that sediment quality is not assessed in the program as being compliant or otherwise, but instead is used in a weight of evidence approach to show deviation from a reference or baseline condition.

Step 10 — Implement agreed management strategy: Document and implement agreed management strategies, including, in some cases, a suitable and agreed adaptive management framework.

- The WQMMP (and associated supporting report) document the strategies and justifications as relevant, including an adaptive management framework and strategies. This is included within the larger Project Sea Dragon Environmental Management System and the site Environmental Management Plan.

6.3 MONITORING AND MANAGEMENT PROGRAMS

6.3.1 Program development

The following sections summarise the basic need for, and outline the approach taken, for baseline data collection, construction and operational phases. These have been developed to:

- Minimise the potential for off-site water quality impacts,
- Provide a framework for responding to monitoring results in a timely and effective manner, including additional monitoring, notification and reporting, and
- Provide management, contingency and reporting measures where water quality exceedances are identified.

Appendix A contains the programs. These have been provided as an overarching management strategy (Appendix A1), with the baseline monitoring program provided in Appendix A2 and the operational program in Appendix A3.

Monitoring programs have been designed to be practical and achievable for both wet and dry seasons, to be as simple and uncomplicated as possible, while still achieving suitable detection levels (power) and avoiding false positives and negatives, and to be as efficient and cost effective as practicable.

A multiple lines of evidence approach has been adopted, whereby data from multiple sources (water quality, sediment, mangroves) and analysis of different types (comparison to guideline values, control-impact control charting, before-after-control-impact statistical assessment, longitudinal charting) is used to support the analysis, provide early warning and build a more complete picture of the water quality related environment and potential impacts.

6.3.2 Water quality management program

The management program provided in Appendix A1 provides the overarching strategy for water quality management. It describes the required monitoring programs, management actions and escalation processes, and links to management actions to control discharges in response to water quality concerns. These link in turn to internal and external notification requirements.

It covers the pre-construction, construction and operational phases of the development, although construction phase activities relate primarily to implementing the appropriate construction management strategies from the site EMP. These include appropriate controls, monitoring and contingency measures and so do not require further specification within this WQMMP.

Monitoring and management for the operational phase has been based on the following points of control:

- CBC and BMC operations and monitoring, including site maintenance and water quality amelioration, water exchanges and fresh/saline supply
- The discharge point to Wheatley Creek, and
- Prawn growth, feed and stocking rates.

6.3.3 Baseline Data Collection

Water quality sampling has been undertaken over an extended period, with the supporting report in Appendix C providing an overview of the existing baseline dataset, including a gap analysis and determination of necessary monitoring to complete the baseline dataset.

The basic finding is that the existing data is broadly sufficient to indicate interim guideline values, but that additional baseline data collection prior to the commencement of construction and operation should continue to build the pre-operational discharge baseline dataset.

The Baseline program is included as Appendix A2.

6.3.4 Operational Phase Monitoring

The operational phase monitoring program is primarily related to the licenced releases to Wheatley Creek. As such, the program aims to:

- adequately characterise discharge water quality in comparison to prescribed discharge criteria for the Project
- provide early warning of the potential for detrimental changes in receiving water quality for action to prevent these changes occurring, and
- provide evidence of no impact or to detect change in receiving water quality, incorporating pre-development and reference site data.

Both the baseline and operational programs have been designed together to ensure effective comparison can be made between the baseline and the operational datasets. Operational monitoring has been specified for an initial 2-year impact assessment period, with the program being reviewed and refined to ensure it remains cost-effective, practical and focused, and that it is both sufficiently robust to detect changes at the stated level of precision, and suitable to provide for triggers and management measures to mitigate unexpected impacts.

7 REFERENCES

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

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APPENDIX A MANAGEMENT AND MONITORING PROGRAMS

A1 – WATER QUALITY MANAGEMENT

Table A1-1: Water Quality Management	
Phase	All phases
Timing	At all times and as noted in the frequencies described herein
Timeline	Construction to commence in the dry season, continuing for approximately 18 months. Operations will commence following construction.
Synopsis	A management program to implement water quality controls, monitoring programs and contingency responses to monitoring results.
Aim	Ensure that the water quality of receiving waters does not deteriorate due to site discharges, such that ecological health, and the health, welfare and amenity of people are maintained.
Objectives and Targets	Project Objectives and Targets from Section 2
Responsible Person	Construction: Construction Manager Operations: Site Manager
Actions / Mitigation Measures	**Construction** Implement the relevant construction phase strategies, including (but not limited to): ▪ Erosion and Sediment Control Strategy ▪ Acid Sulfate Soil Management Strategy ▪ Vegetation Management Strategy ▪ Waste Management Strategy, and ▪ Hazardous Materials Management Strategy. Undertake clearing and earthworks in the dry season, particularly in proximity to watercourses or estuarine areas, and ensure disturbed areas are appropriately stabilised prior to the next wet season. **Prior to Operations Commencing** Revisit and revise the Water Quality Management Framework process described in Section 6.2.2 based on the baseline (and any other available) data. Update this plan if required. Utilising the design and operational details, update this plan to include relevant actions and contingency measures to provide early warning of possible water quality issues and control water quality inside the farms (and other elements of the process).

Table A1-1: Water Quality Management	

	Signage is to be erected at least 20 business days prior to commencement of licensed activities in a prominent location at each public entrance to the premises that includes the waste discharge licence number (WDL242) and 24-hour emergency contact details. The signage is to be clear, legible and in English.
	
	Operations
	- Implement the operational monitoring and management program summarised in Figure A1-1.
	- Implement the following controls:
	  - Install adequate scour protection to ensure ongoing erosion and scour is minimised.
	  - Intake and Discharge pipelines, ponds:
	  - Install navigational markers to notify boaters of the location of the intake and discharge pipelines
	  - Maintain 500 mm freeboard in seawater storage and discharge settlement ponds at all times during normal operations.
	  - Maintain a fitted screen over the intake pipe to limit intake of aquatic fauna.
	- Intake:
	  - Intake of seawater from Geranium Creek to be preferenced toward mid to high tide
	- Discharge:
	  - Comply with the discharge criteria outlined in Appendix A3.
	  - Minimise discharge of wastes (i.e. improve water quality) by efficient water management - better feed conversion (less feed used), sufficient aeration (dissolved oxygen, reduce biochemical oxygen demand), water exchange rates and internal recycling, etc.
	  - All additives to the tanks to be selected based on suitability for release – no antibiotic, anti-parasitic or anti-fouling agents will be used.
	
	Prior to Stage 2 Operations
	Review and revise the Water Quality Management Framework process described in Section 6.2.2 based on the available data from Stage 1 Operations. Update this plan if required.
	Review the results of monitoring programs, including visual assessment, to determine the controls required for subsequent expansions of the Project. In particular:
	- Determine whether additional flow control structures are required to control release volumes and timing.

Monitoring	- Implement the monitoring programs outlined in the construction phase management strategies. - Implement the monitoring programs outlined in Appendices A2 (baseline monitoring) and A3 (operational monitoring) as summarised in Figure A1-1.
Review and Auditing	**Monitoring Results** - Each round, any monitoring data will be checked and entered into the dataset, with original field sheets scanned, and along with laboratory reports saved in a distinct electronic folder within the Project file system. - A review of the QA/QC result is also to be conducted each round. Should a QA/QC failure occur, review monitoring procedures and revise as necessary to ensure data integrity can be assured going forward.

Table A1-1: Water Quality Management	
	▪ 3-month result summaries of more frequent monitoring are to be reviewed quarterly when the results from the Environmental Impact Monitoring Program (EIMP) monitoring are available. ▪ The above review will include incidents, rectification works and whether these have been successful. **Program Review** ▪ Within the first year, following the first biological sampling round, a review of the sampling methods and sample sizes (for both sample unit – i.e. grab sample size, and sample size – the number of grab samples) shall be undertaken to ensure these are appropriate. ▪ Following the initial 2-year post-operational discharge monitoring program, a further review will be undertaken to refine the program, to maximise cost-effectiveness, practicality and ensure it remains focused on the key monitoring requirements for the Project. This will include an assessment of whether it is sufficiently robust to detect changes at the stated level of precision (i.e. suitable sample size, temporal and spatial replication, other relevant factors), and whether it adequately provides for triggers and actions to mitigate unexpected impacts. ▪ Determine seasonal guideline values at the 2-year review (or before if sufficient data is collected). Determine whether these are significantly different from the overall guideline values, and whether there is merit in meeting the aims of this WQMMP in using seasonal guideline values instead of (or as well as) overall guideline values. If so, these must be utilised in the assessment following the 2-year review period. ▪ Any failures of the monitoring program, rectification works and work procedures will trigger a review of this program. ▪ Any relevant changes in legislation, approvals or other factors will result in a review of the WQMMP. ▪ Site activities which alter the level of risk with respect to the WQMMP Objectives and Targets will require the risk assessment to be reviewed and revised if necessary, with consequent changes made to the WQMMP. **Audits and review** ▪ Conduct an internal review the water quality monitoring and management program, 2 years after implementation and every 2 years thereafter. ▪ A third-party review of the monitoring program will be completed each year for the first 2 years to ensure the program continues to be suitable to achieve its aims. ▪ EMS/EMP audits will include audits on the monitoring program and results. ▪ Changes to this WQMMP may be undertaken from time to time. Changes relating to water quality (guideline values, etc.) will only be undertaken based on a suitable length of data and made in consultation with an independent third-party reviewer. Any revisions to this plan must be communicated to the relevant approving agency prior to implementation.
Reporting	**WQMMP** This report is to be discussed, including the revised guideline values, with NT DENR prior to implementation. The report is to be submitted to the NT DENR prior to the 2020 Annual Return. **Monitoring** Prepare quarterly internal monitoring summary reports, summarising:

Table A1-1: Water Quality Management	
	▪ All monitoring data, particularly related to discharge and receiving water quality, exceedances and potential issues ▪ Recommended rectification measures (if any) or changes to the monitoring program An annual monitoring summary report shall be completed and submitted annually within 10 days of the anniversary date of the WDL (in accordance with conditions 32 and 33 of WDL242) summarising the preceding 12 months of monitoring. **Notification** The NT DENR is to be notified when discharges commence into Wheatley Creek, and again should discharges cease for any appreciable time. Any non-compliance, incident or potential incident will be recorded on the incident-complaint form in the EMP (or similar) and entered into the incident-complaint register for rectification and follow up. Non-compliance with discharge limits or other conditions of the WDL, or discharges resulting in potential or actual environmental harm or pollution are to be reported to the NT DENR and NT EPA within 24 hours of the event occurring, or otherwise as soon as becoming aware after the event. This notification is to include: ▪ the date and time of the non-compliance; ▪ the actual and potential causes and contributing factors to the non-compliance; ▪ the risk of environmental harm arising from the non-compliance; ▪ the action(s) that have or will be undertaken to mitigate any environmental harm arising from the non-compliance; ▪ corrective actions that have or will be undertaken to ensure the non-compliance does not reoccur; and ▪ if no action was taken, why no action was taken. **Maintain records and documentation** A copy of relevant reports, management plans, procedures, approvals and licences is to be maintained at the site, along with all relevant records showing compliance and non-compliance events, and provided to authorised officers on request.
Corrective Actions	Corrective Action Triggers: 1. Guideline values shown in Figure A1-1 are exceeded. 2. Water quality impacts from construction activities – excessive erosion and sedimentation, acidic runoff, etc. 3. Injury or harm to fresh or marine biota – e.g. fish kills, dead or dying marine fauna, boat strike, visible signs of disease or injury 4. Excessive erosion at intake or discharge locations 5. Exceedance of discharge water quality criteria 6. Exceedance of receiving water quality guideline values or control-impact comparison assessments 7. Receipt of complaint in relation to the discharge of wastewater

Table A1-1: Water Quality Management	
	Corrective Actions: 1. Follow escalation and responses outlined in Figure A1-1 2. Implement controls and contingency responses in the relevant construction phase plans 3. Implement the fauna management strategy for marine biota where required 4. Instigate bank stabilisation works to protect against erosion, implement additional control methods as needed 5. Follow the procedures in Figure A1-1. Also initiate immediate follow up investigation of: - The results - are they representative, have any errors occurred at the laboratory or during sampling? - Re-test the sample (if sufficient sample remains with the lab), or re-sample and investigate potential sources of exceedances - In the event of genuine exceedances, undertake mitigation works, inside the facility (or other source), or alter discharges. This may include cessation of discharges if necessary. - If required, install a diffuse discharge system to aid dilution within receiving waters. 6. As for 5 above. 7. Review the complaint and contact the complainant to discuss. If this cannot be simply resolved, determine in accordance with Social Impact and/or Cultural Heritage Management Strategies All incidents where further action is required, including additional monitoring, contingency or mitigation measures, are to be recorded on an incident form, in the incident register, and actions assigned. Monitoring of actions are to be undertaken to ensure they are addressed in a timely manner and within the timeframes stipulated. Should the contingency measures not achieve rectification, additional controls, or even cessation of discharge, will be required as appropriate.

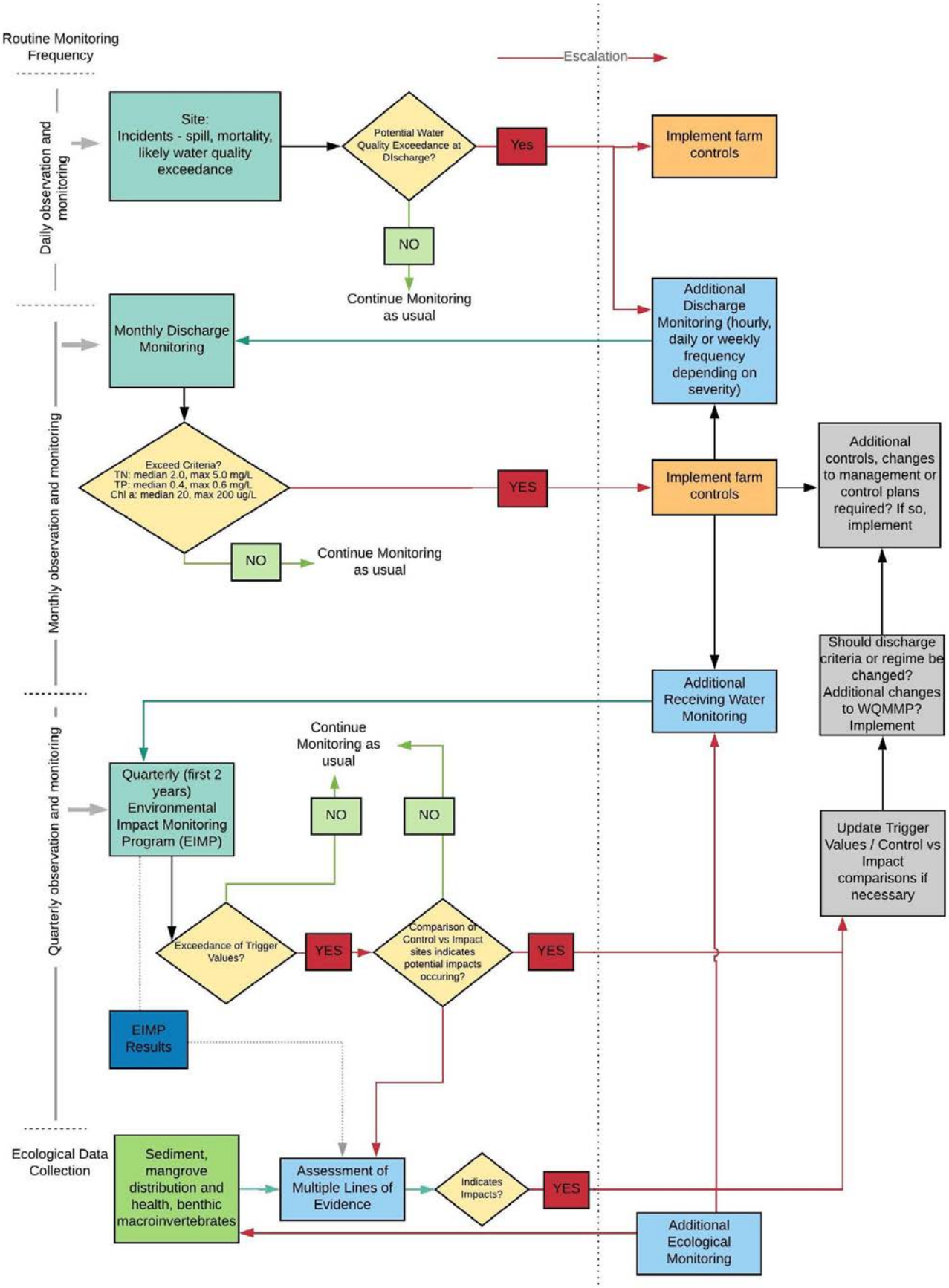

FIGURE A1-1 OPERATIONAL MONITORING AND MANAGEMENT DECISION TREE

A2 – BASELINE WATER QUALITY MONITORING PROGRAM

Table A2-1: Water Quality Management	
Phase	Pre-operational continuing up until operational discharges commence.
Synopsis	Baseline data collection to further build the existing baseline dataset to ensure longer term trends and seasonal variation in water quality is properly captured and to ensure sufficient power for any future detailed statistical assessment if required. Monitoring will continue through the baseline period through to the first discharge.
Aim	Continue to expand the baseline dataset, targeting key operational monitoring sites and parameters, in a way that is practical and cost effective and minimizes risk to samplers.
Objectives and Targets	Project Objectives and Targets from Section 2
Sampling Methods	Monitoring methods to be employed are as follows: ▪ Grab sampling from ~30cm depth in the water column, according to the methods outlined in AS/NZS 5667.1 - Water quality - Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples and the sampling methods summarised in Appendix B. ▪ Sediment sampling to be undertaken in accordance with *AS/NZS 5667.12 – Water quality—Sampling, Part 12: Guidance on sampling of bottom sediments*, Simpson & Batley (2016) and a sediment core of 2 cm depth, and recommendations 2 and 3 of Munksard (2013). ▪ Seagrass assessment to be conducted using methods comparable with DES (2018) to target seagrass density and species present. ▪ Mangrove assessments will utilise multi-spectral imagery / NDVI metrics to assess extent, health and intactness, with ground truthing to confirm findings, comparable to DES (2018) – refer to Cardno (2013) and others as needed.
Triggers and Escalation Procedures	Ongoing monitoring results will be incorporated into the baseline data set, with guideline values recalculated each round. The program will be assessed, and frequency increased if deemed appropriate where: ▪ The data indicates a departure from the current interim guideline values by >10%, and ▪ The computed guideline values (i.e. statistics) do not appear to be converging over time to a stable value, and ▪ The remaining timeframes before operations indicate the current monitoring may not achieve stable data for setting guideline values.
Management and Contingency Measures	Baseline monitoring is to follow the above elements and protocols, with sample collection, storage, transport, analysis, QA/QC, data management and analysis summarised in Appendix B.

Table A2-2: Baseline Water Quality Monitoring Program									
System	Wheatley Creek Sites		Mackenzie Arm Sites			Control Sites			
Classification	Impact	Impact	Control	Impact	Impact	Control	Control	Control	Control
Site Code	WC01	WCDS1	MA01	MA02	MA03	BH01	VI01	MI01	MI02
Description	Upstream	Downstream of mixing zone	Upstream	Junction with Wheatley Creek	Downstream	Bynoe Harbour Main Channel	Vigilant Inlet upper estuary	Milne Inlet upstream	Milne Inlet downstream
Latitude, Longitude (GDA 94) (refer Figure A2-1)	-12.7417 130.5300	-12.7236 130.5289	-12.7560 130.5145	-12.7229 130.5125	-12.7022 130.5180	-12.6882 130.5572	-12.7403 130.5752	-12.7696 130.6241	-12.7327 130.6326
Frequency and Timing	Water quality — Collect a total of at least 24 samples at the long term monitoring sites (BH01, MA03, WCDS1), and sample the other sites each round, prior to operational discharges commencing, on a quarterly or monthly basis, aiming for no overall bias in terms of tides or season. *Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.*								
Duration	Commence additional sampling after approval of this WQMMP. Baseline dataset finishes on first discharge into Wheatley Creek from Project operations (monitoring continues under the operational EIMP).								
Water Quality Assessment									
Monitoring at the designated locations each round for: ▪ pH, EC, DO, Temp, Turbidity, TSS ▪ Nutrients: N – NH_3, NO_2, NO_3, NOx, TKN, TN; P – FRP, TP; TOC (allow for saline effects – utilise saline water methods, LORs to achieve AWQG / Darwin WQO limits where able to do so ▪ Chlorophyll a. Monitoring at least three times during the baseline program for: ▪ Total and dissolved metals (Al, An, As, B, Be, Cd, Co, Cr, Cu, Fe, Pb, Hg, Mn, Mb, Ni, Se, Ag, Sn, U, V, Zn) - by ICP/MS, saline water, LORs to achieve AWQG guideline values where able to do so. Investigate and where practicable utilise remotely sensed water quality data for Chlorophyll a, turbidity and suspended solids to extend the dataset for these analytes. Analyse data for TP, FRP and DO and determine whether the existing dataset will be sufficient, given issues with historically collected data. Where required, implement additional water quality monitoring to obtain data sufficient to set local guideline values.								

EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; TSS = Total Suspended Solids: TDS = Total Dissolved Solids; N = Nitrogen; P = Phosphorous; NH3 = Ammonia; NOx = Oxides of Nitrogen; TKN = Total Kjeldahl Nitrogen; TN = Total Nitrogen; FRP = Filterable Reactive Phosphorous; TP = Total Phosphorous; TOC = Total Organic Carbon

Table A2-3: Baseline Sediment and Ecological Monitoring Program										
System	Wheatley Creek Sites		Mackenzie Arm Sites			Control Sites				
Classification	Impact	Impact	Control	Impact	Impact	Control	Control	Control	Control	Comparison
Site Code	WC01	WCDS1	MA01	MA02	MA03	BH01	VI01	MI01	MI02	#67
Description	Upstream	Downstream of mixing zone	Upstream	Junction with Wheatley Creek	Downstream	Bynoe Harbour Main Channel	Vigilant Inlet upper estuary	Milne Inlet upstream	Milne Inlet downstream	Upstream
Latitude, Longitude (GDA 94) (Fig A2-1)	-12.7417 130.5300	-12.7236 130.5289	-12.7560 130.5145	-12.7229 130.5125	-12.7022 130.5180	-12.6882 130.5572	-12.7403 130.5752	-12.7696 130.6241	-12.7327 130.6326	-12.7417 130.5300
Sampling*	All	All	All	All	All	All	All	All	All	Sd, MI, Sg
Frequency and Timing	Benthic macroinvertebrates	At least 3 events prior to operational discharges commencing								
	Benthic habitat	At least once prior to operational discharges commencing								
	Seagrass	At least twice, once per season (Wet, dry) prior to operational discharges commencing								
	Mangroves	2 wet and 2 dry satellite imagery analyses, with at least one ground-truthed prior to operational discharge commencing								
	Sediment	At least 2 events prior to operational discharges commencing								
	Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.									
Duration	Commence additional sampling after approval of this WQMMP. Baseline dataset finishes on first discharge into Wheatley Creek from Project operations (monitoring continues under the operational EIMP).									
Sampling Parameters / Requirements										
Sediment	▪ Sediment Particle Sizing ▪ Total Nitrogen and Phosphorous ▪ Total Metals (Al, An, As, B, Be, Cd, Co, Cr, Cu, Fe, Pb, Hg, Mn, Mb, Ni, Se, Ag, Sn, U, V, Zn) ▪ pH, Redox Potential, TOC					**Mangroves**	▪ Mangrove coverage / distribution / health from available satellite or aerial imagery. ▪ Ground-truthing in representative locations, particularly Wheatley Creek. Include sampling for δ15N signatures.			
Benthic Macro-invertebrates	▪ Benthic macro-invertebrates, collected from the same sites as the sediment samples. ▪ Abundance and Taxonomic richness					**Seagrass**	▪ Undertake visual assessment of intertidal areas for presence of seagrasses. ▪ Where possible locate sites in proximity to the water quality monitoring locations. ▪ Provide baseline presence / density, and identification of representative samples to species. ▪ Include macroalgae cover observations where seagrass are identified			
Benthic Habitat Mapping	▪ Undertake baseline benthic habitat mapping for intake and discharge locations prior to construction in these areas commencing ▪ Incorporate benthic observations (by video or observation of intertidal areas) into baseline water monitoring ▪ Compile benthic data collected during baseline investigations and update the existing habitat mapping where appropriate									

* Sd = Sediment; MI = Macroinvertebrates; Sg = Seagrass; All = Sediment, Macroinvertebrates, mangroves and seagrass

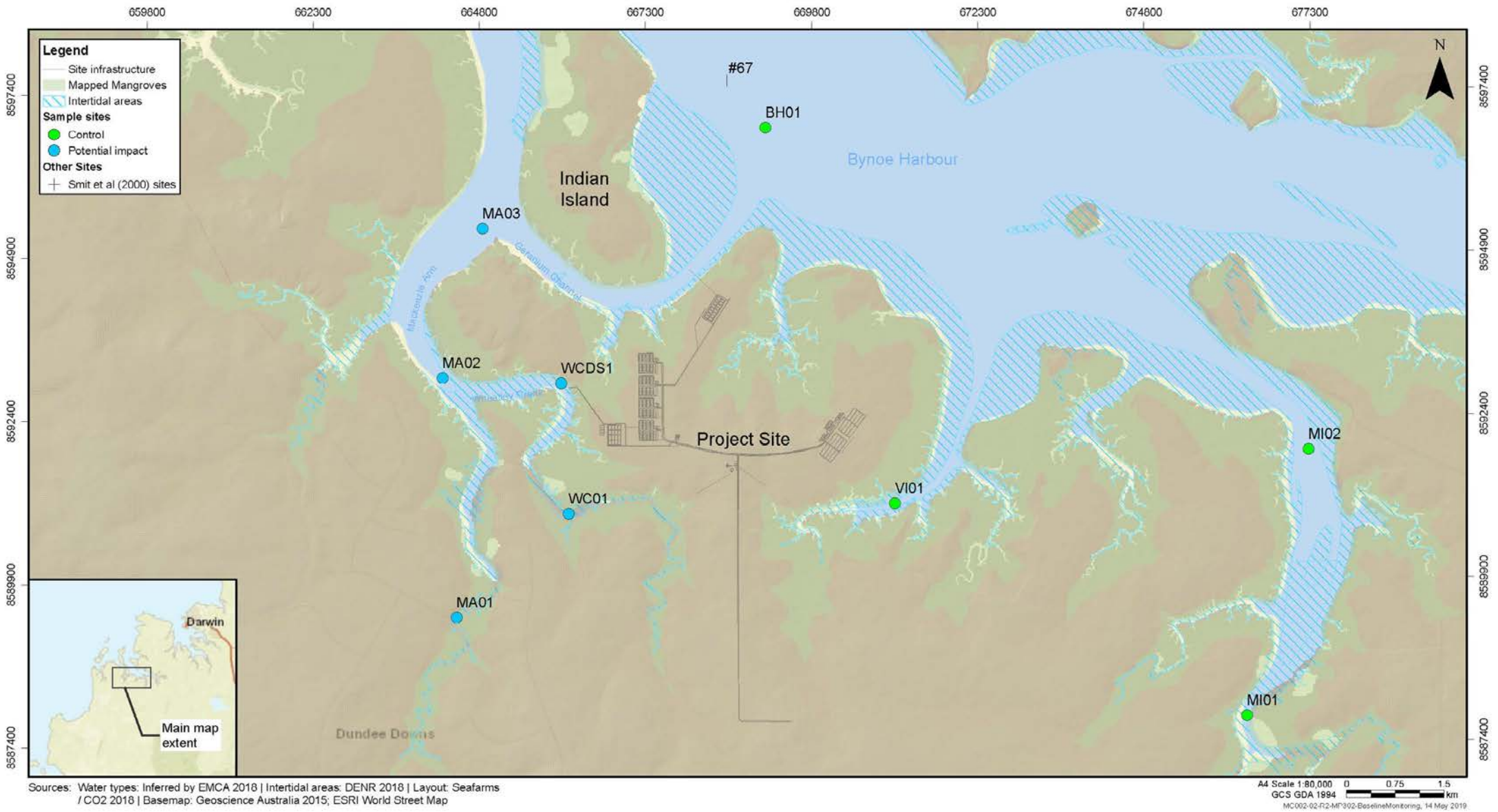

FIGURE A2-1 BASELINE SAMPLING LOCATIONS

A3 – OPERATIONAL WATER QUALITY MONITORING PROGRAM

Table A3-1: Operational Water Quality Monitoring Program – General	
Phase	Operations – commences once operational discharges into Wheatley Creek commence
Synopsis	An operational water quality monitoring program, involving two tiers of monitoring – 1) regular intake and discharge monitoring, and 2) less frequent EIMP monitoring. The EIMP includes impact and control sites in Wheatley Creek, Mackenzie Arm, Bynoe Harbour and two nearby inlets.
Aim	Undertake monitoring to provide both evidence of licence compliance / no impact, and to provide early warning to trigger management actions to minimise or avoid impacts on receiving waters.
Objectives and Targets	Project Objectives and Targets from Section 2
Sampling Methods	Monitoring methods to be employed are as follows: ▪ Water quality grab sampling from ~30cm depth in the water column, according to the methods outlined in AS/NZS 5667.1 - Water quality - Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples and the sampling methods summarised in Appendix B. ▪ Continuous flow recording shall be installed for recording the timing and volume of discharges. ▪ Sediment sampling to be undertaken in accordance with *AS/NZS 5667.12 – Water quality—Sampling, Part 12: Guidance on sampling of bottom sediments*, Simpson & Batley (2016) and a sediment core of 2 cm depth, and recommendations 2 and 3 of Munksard (2013). ▪ Ecological assessment to be conducted using: Seagrass and macroinvertebrates – methods comparable with DES (2018), with seagrass monitoring to target seagrass density and species present and macroinvertebrates for abundance and taxonomic richness; Mangroves – remote sensing assessment of coverage, intactness and health, coupled with ground-truthing where required.
Management and Contingency Measures	Monitoring is to follow the above elements and protocols, with sample collection, storage, transport, analysis, QA/QC, data management and analysis summarised in Appendix B. The decision tree in Figure A1-1 summarises the monitoring and escalation procedures. Appendix A1 provides the key water quality management and contingency measures to be adopted.

Table A3-2: Operational Water Quality Monitoring Program - Discharge Monitoring				
System	Discharge to Wheatley Creek			
Classification	Discharge			
Site Code	DP1			
Latitude, Longitude (GDA 94) (refer Figure A2-1)	Monitoring of waters representative of discharge into Wheatley Creek.			
Frequency and Timing	Flow Continuous monitoring of flow volumes, rates and events. Daily visual observation until continuous monitoring is in place Water quality Monthly *Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.*			
Duration	On first discharge to receiving waters. To continue for the life of the Project.			
Parameters to sample		**Discharge Criteria**		
		Median	**Annual Average**	**Maximum**
Flow	Volume (kL/day)	-	Stage 1: ≤3ML/day Stage 2: ≤12.5ML/day	-
	Timing	From mid to high tide, staged over two discharge cycles per day		
In-situ	pH, EC, DO, Temp, Turbidity	-	-	-
	Free Chlorine Residual*	-	-	<0.01mg/L
Phys-Chem	TSS (mg/L)	-	-	-
Nutrients	TN (mg/L)	≤2.0	-	≤5.0
	TP (mg/L)	≤0.4	-	≤0.6
Biological	Chlorophyll a (µg/L)	≤20	-	≤200
Other	Visual	No floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter.		
	Odour	Shall not cause or generate odours which would adversely affect the use of surrounding waters		

EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; TSS = Total Suspended Solids; TN = Total Nitrogen; TP = Total Phosphorous
* where chlorine use in the facility provides the potential for elevated free chlorine levels in the discharge

Table A3-3: Operational Water Quality Monitoring Program - Intake Monitoring	
System	Filtrate Discharge to Geranium Creek (from intake filters)
Classification	Discharge
Site Code	IN2
Latitude, Longitude (GDA 94) (refer Figure A2-1)	In vicinity of filtrate discharge point
Frequency and Timing	Water quality Monthly, visual monitoring on each visit to intake location *Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.*
Duration	On first intake and discharge of filtrate to Geranium Creek, to continue for duration of the Project.
Parameters to sample	**Criteria**
Water Quality	**Filtrate Discharge Criteria** Visual observation for sediment plumes – if a sediment plume extends >50m from the discharge point and persists for >1h, instigate investigation, including monitoring inside and outside the plume for: ▪ pH, turbidity, total suspended solids Where the results exceed the water quality criteria (refer Mid-Estuary values in EIMP Program below) with a difference > 10% between inside and outside an exceedance will be considered to have occurred.

Table A3-4: Operational Water Quality Monitoring Program - EIMP – Water Quality										
System	Wheatley Creek Sites			Mackenzie Arm Sites			Control Sites			
Classification	Impact	Impact	Impact	Control	Impact	Potential Impact	Control	Control	Control	Control
Site Code	WC01	WCUS1	WCDS1	MA01	MA02	MA03	BH01	VI01	MI01	MI02
Description	Upstream	Upstream of mixing zone	Downstream of mixing zone	Upstream	Junction with Wheatley Creek	Downstream	Bynoe Harbour, Main Channel	Vigilant Inlet upper estuary	Milne Inlet, upstream	Milne Inlet, downstream
Latitude, Longitude (GDA 94) (refer Figure A2-1)	-12.7417 130.5300	-12.7255 130.5299	-12.7236 130.5289	-12.7560 130.5145	-12.7229 130.5125	-12.7022 130.5180	-12.6882 130.5572	-12.7403 130.5752	-12.7696 130.6241	-12.7327 130.6326
Frequency and Timing	2-monthly for first 2 years: three (3) during the wet season, and three (3) during the dry season per year. Collect data as close as practicable in time on each sampling event, aiming as far as reasonable and practicable for the same tidal regime at each site. *Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.*									
Duration	On initiation of operational discharge. To continue for the life of the Project. Review of frequency, sites, etc. after first 2 years.									

Parameters to sample	**Guideline Values**		**Assessment Approach**
	Mid-Estuary	**Upper Estuary**	
pH	7.0 - 8.5	6.0 - 8.5	Compare nutrient results with guideline values. If these are exceeded, undertake additional assessment to determine the cause of the exceedance. Undertake screening level comparisons of Impact vs Control sites. Where screening level assessment indicates possible impact, undertake more detailed statistical assessment using Before-After-Control-Impact comparisons (by suitably experienced person). Select parameters that are useful in these comparisons. As a minimum: - TN, TP, Chlorophyll a At the end of each of the first and the second year's monitoring, compare the actual results with the predicted results from the EIS modelling. This will be used as another line of evidence in the assessment above, as part of the MLE approach adopted.
DO	80 – 100% Sat	80 – 100% Sat	
EC, Temp	-	-	
Turbidity (NTU)	≤3.9	≤8.1	
TSS (mg/L)	≤20		
TN (mg/L)	≤0.270	≤0.300	
NH_3 (mg/L)	≤0.020	≤0.020	
NO_x (mg/L)	≤0.020	≤0.020	
NO_2, NO_3, TKN (mg/L)	-	-	
TP (mg/L)	≤0.05	≤0.06	
FRP (mg/L)	≤0.005	≤0.010	
Chlorophyll a (µg/L)	≤2	≤4	
Visual	No floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter caused by the Project. Discharge shall not cause algal blooms, cause mortality of fish or other aquatic organisms in the receiving waters.		
Odour	Discharge shall not cause or generate odours which would adversely affect the use of surrounding waters.		

EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; TSS = Total Suspended Solids; NH_3 = Ammonia; NOx = Oxides of Nitrogen; TKN = Total Kjeldahl Nitrogen; TN = Total Nitrogen; FRP = Filterable Reactive Phosphorous; TP = Total Phosphorous

Table A3-5: Operational Water Quality Monitoring Program - EIMP – Sediment and Ecological Monitoring										
System	Wheatley Creek Sites			Mackenzie Arm Sites			Control Sites			
Classification	Impact	Impact	Impact	Control	Impact	Potential Impact	Control	Control	Control	Control
Site Code	WC01	WCUS1	WCDS1	MA01	MA02	MA03	BH01	VI01	MI01	MI02
Description	Upstream	Upstream of mixing zone	Downstream of mixing zone	Upstream	Junction with Wheatley Creek	Downstream	Bynoe Harbour, Main Channel	Vigilant Inlet upper estuary	Milne Inlet, upstream	Milne Inlet, downstream
Latitude, Longitude (GDA 94) (refer Figure A2-1)	-12.7417 130.5300	-12.7255 130.5299	-12.7236 130.5289	-12.7560 130.5145	-12.7229 130.5125	-12.7022 130.5180	-12.6882 130.5572	-12.7403 130.5752	-12.7696 130.6241	-12.7327 130.6326
Frequency and Timing	Sediment: Every 2 years Mangroves: Remote sensing data assessment, and ground truthing every 6 years Benthic macroinvertebrates: Annual (in the dry season) for the first 2 years, then every 6 years *Note: sample frequency may be changed due to health and safety concerns, and at no time should sampling be conducted if it is not considered safe – e.g. extreme weather, high crocodile risk, large / dangerous tides, etc.*									
Duration	On initiation of operational discharge. To continue for the life of the Project. Review of frequency, sites, etc. after first 2 years.									

Sampling Parameters / Requirements		**Assessment Approach**
Sediment	Sediment Sizing Total Nitrogen and Phosphorous pH, Redox Potential, TOC, total Aluminium	Make comparisons to data from past years. Generally, a departure of >1 standard deviations in the data that indicates impact requires further investigation to determine whether an ecologically significant impact is occurring due to site operations.
Benthic Macro-invertebrates	Abundance and Taxonomic richness	
Mangroves	Mangrove coverage / distribution / health from available satellite or aerial imagery Mangrove community composition and health at sites adjacent to EIMP monitoring sites	
Seagrass	Seagrass density and species present	
Benthic Habitat	Undertake post-discharge habitat mapping after 1 year and again after 2 years, particularly of intake and discharge locations. Compare pre-discharge benthic habitat mapping, with post-discharge habitat mapping areas and utilised in the weight of evidence approach to determining potential impacts	

TOC = Total Organic Carbon

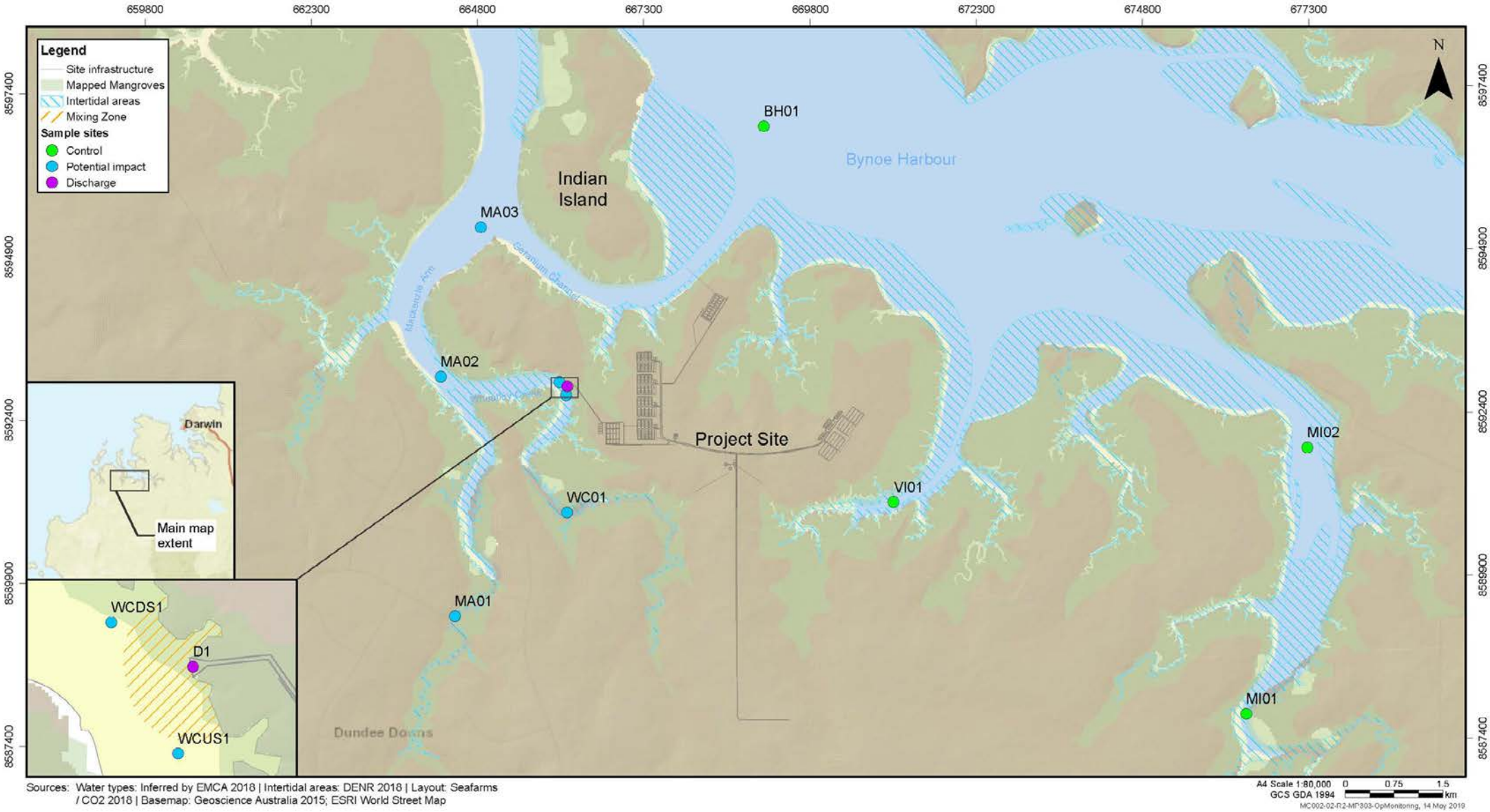

FIGURE A3-1 OPERATIONAL SAMPLING LOCATIONS

APPENDIX B SAMPLING METHODOLOGY

B1 – INTRODUCTION

B1.1 MONITORING REQUIREMENTS

The procedures outlined in this section of the WQMMP are intended to summarise the key requirements for undertaking the sampling programs outlined in this document, and to include Project specific elements as required.

At all times and for all events, suitably qualified and experienced personnel are required to undertake the works, including planning, sampling, sample preparation and analysis, data review and analysis, and subsequent actions. All personnel involved in the program are to be familiar with the more detailed monitoring methodologies outlined in the following sections.

B1.2 MONITORING COORDINATOR

Ensure a person is nominated on site as the responsible person for the monitoring program – the Monitoring Coordinator. This person will be responsible for sampling equipment, materials, events and review, and will be the primary contact for monitoring related matters

B1.3 RELEVANT STANDARDS

The following standards are to be followed during the monitoring program unless as amended in Appendix A, including for planning, carrying out the monitoring, and for guidance on subsequent assessment and analysis:

- AS/NZS 5667.1:1998 Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples
- AS/NZS 5667.9:1998 Water quality - Sampling - Guidance on sampling from marine waters
- AS/NZS 5667.12:1999 Water quality - Sampling - Guidance on sampling of bottom sediments
- Simpson & Batley (2016) and Munksard (2013).

The following may also be useful:

- The Queensland Monitoring and Sampling Manual (DES, 2018)
- The Western Australian Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs, Department of Water, January 2009.
- AS/NZS 5667.6:1998 Water quality - Sampling - Guidance on sampling of rivers and streams.

B1.4 REVIEW

The monitoring standards and methods are to be reviewed by an experienced and suitably qualified person prior to carrying out the first round of sampling. Ongoing review is to be undertaken, triggered by:

- Any health and safety incidents during sampling, or potential incidents that could occur during sampling (near miss, crocodile sighting, etc.)
- Any failure in the monitoring program – e.g. QA/QC failure, inappropriate equipment, missed sample sites or wrong locations, etc., and
- Any exceedance of water quality criteria not identified or communicated immediately as part of the monitoring program.

B2 – PREPARATION

B2.1 GENERAL

The following outlines the general process to be followed when preparing to undertake field sampling/monitoring:

1. The monitoring coordinator is to organise all sampling events or be aware of all monitoring events to be undertaken and have measures in place to ensure each is undertaken effectively.
2. Ensure that personnel understand:
   - how to sample (are they suitably qualified and experienced?)
   - where to sample
   - how many samples are required and how many bottles to be filled at each site
   - what parameters are being sampled for
   - what and how many QA/QC samples are required
   - what if any quality limits there are for the sites – what are the implications of an exceedance of water quality criteria?
3. Organise the laboratory for the analysis, understand holding time requirements and organise transportation (courier or other)
4. Collect the required sample containers plus spare containers for contingencies (1.5 – 2 x required) – this includes primary and QA/QC samples
5. Undertake calibration of any monitoring meters or probes and record on calibration sheet
6. Ensure all required equipment has been gathered and is in working order
7. Ensure safety equipment has been included, including PPE. Monitoring to be undertaken by two persons minimum in areas with potential crocodile presence.
8. Ensure other Project colleagues are aware of the sampling – maintain equipment to enable constant communication – mobile phone, satellite, etc. Equipment must be waterproof or contained in waterproof container.

Ongoing examination of rainfall (both forecast and actual) should also be undertaken, particularly in regard to determining the start or end of wet seasons. In addition, tide details are to be checked prior to each sampling event to ensure the sampling will be safe and (where relevant) water will be present.

B2.2 SEAGRASS MONITORING

Seagrass monitoring will be conducted using the safest methods practicable for the exercise, such as photography / video or ROV. These surveys will be undertaken by suitably experienced and qualified persons, likely external operators, who will provide for all health and safety and monitoring requirements.

B2.3 EQUIPMENT AND MATERIALS

B2.3.1 Water Quality and Sediments

The following equipment should be gathered for each water quality sampling event:

- Sample collection and compositing (if required) equipment
- Eskies for storage of samples & ice, ice bricks (refrigeration equipment may be utilised as an alternative)
- Monitoring data folder:
- field testing sheet for required site(s) x3
- Blank field testing sheet x3
- Blank sample submission / chain of custody form x 2
- Site specific sample submission / chain of custody form x 2
- deionised water and squeeze bottle(s)
- permanent marker (fine tipped) for labelling bottles
- 2 x lead pencils and sharpener for recording field data
- Latex gloves
- glad bags
- tissues (disposable for drying equipment)
- Large laminated sample site location map
- Camera
- GPS
- This WQMMP
- Additional optional equipment (if required):
- Pipettes if required for complete filling of small bottles containing preservative
- measuring tape for measuring distance or depth

B2.3.2 Other Surveys

Equipment for other surveys will depend on the requirements of the survey – for example seagrass surveys. A similar checklist should be prepared for these surveys prior to undertaking field work.

B2.4 METER CALIBRATION

All meters and probes to be used in monitoring should be calibrated prior to every sampling run, and again after each sampling round. Errors and corrections are to be noted on the results sheets where they result in significant changes to the results (as a first estimate, >10% change). If practicable, retest samples (on an additional collected bottle) or recollect samples.

A standard calibration form will be utilised, with a copy scanned and maintained within the monitoring documentation on-site (electronic is suitable), and a hard copy maintained with the sampling equipment, swapped out each time the equipment is calibrated.

For each calibration session, the date and name of the person calibrating the equipment should be entered, as well as details of the success or failure of calibration.

All buffers and standards are to be kept as recommended by the supplier (generally a cool dark place), and replaced before their use-by date

B2.5 SAMPLE CONTAINERS

A primary sample collection container may be used for sample collection, dispensing the required volume into other pre-prepared sample bottles, or the sample bottles may be used directly.

Sample bottles for analysis will be obtained from the NATA accredited testing laboratory prior to sampling, based on the analytes to be measured. Where containers include preservatives, these should be filled from a primary container and must not be tipped upside down, to avoid loss of the preservative.

B3 – PERSONAL SAFETY

Prior to undertaking any sampling, a detailed risk assessment and management process must be completed (JSEA or similar). All works must comply with the relevant NT WorkSafe requirements.

In general, all personnel undertaking sampling should be prepared for the potential risks involved in sampling. Personnel are required to wear appropriate protective clothing and abide by any applicable safety plans. Safety gear includes:

- Sun protection – hat, long sleeved shirts, long pants
- Stable and secure shoes (steel capped may not be required, must be stable in sampling environments, possibly muddy areas)
- Glasses – sunglasses are likely to be useful, but safety glasses (tinted or otherwise) should be worn when filling or sampling in containers involving acid preservatives
- Orange or yellow safety vest

Other considerations include remaining aware of your surroundings, and areas that could contain hazards (crocodiles, unstable banks, etc.) will require as a minimum one observer in addition to the sampler. Always ensure that heavy machinery operators near samplers are aware of the sampling team. Ensure footing is secure when sampling, especially over rapidly moving waters or drainage channels near inlets.

A constant communication link to others is required at all times - mobile phone, satellite phone or radio communications as available. All sampling trips are to be monitored by a person not on the field trip, with routine check in times organised prior to the sampling being undertaken. These check-in check-out procedures are to be undertaken as follows:

1. Advise supervision personnel of planned sampling trip, including proposed start and finish times and check-in timing, and ensure they will be available during this period
2. Check-in on leaving site (farms or other safe location) and ensure a reply is received before leaving
3. Check-in regularly during sampling – suggest every 1 – 2 hours. Supervisor to reply to show that check-in was received
4. Check-out on arriving back at site. Ensure a reply is received.

Depending on the methods used, a simple text message may be suitable for the above. Check-in check-out times and details should be recorded and stored with the sampling documentation for each trip.

Responsibility of samplers:

- Arrange check-in check-out procedures prior to leaving for sampling, including person(s) for supervision, escalation procedures, timing (e.g. every 2 hours, or set times)
- Ensure check-ins and check-out is provided as agreed – suggest alarm reminder
- Do not undertake works if unsafe to do so, or if you are unsure it is safe.

Responsibility of supervisor:

- Should the samplers not make contact as agreed, attempt to contact shortly after the agreed time
- If contact cannot be made within a suitable pre-agreed time (suggest 30 minutes), advise HSE supervisor, site manager or others as appropriate. Continue trying to make contact

- If no contact is forthcoming send out another team to locate the samplers. This may require a road vehicle, 4WD, boat or helicopter as fits the sampling occasion.
- If no contact can be made, and samplers cannot be located, contact the NT emergency services. Site management and emergency services to liaise on location/rescue operations as required.

B4 – SAMPLE COLLECTION AND ANALYSIS

B4.1 SAMPLE COLLECTION

The most important thing to accomplish with any sampling is to obtain a REPRESENTATIVE SAMPLE. The tests on the sample will give a number for a parameter, intended to represent the value of that parameter at that time and that location. Therefore, always sample with this in mind, and always take care of samples prior to testing with this in mind, to avoid bias, contamination or other influences.

Samples will be collected from each site generally into a larger clean sample container prior to being dispensed into pre-prepared and laboratory supplied sample bottles, some of which will contain preservatives. The primary sample container will be pre-rinsed and decontaminated prior to sampling at each site, preferably by:

- Rinsing with deionised water (fill, wash and empty 3 x) followed if possible by a similar procedure using sample waters, or
- Where this is not possible, pre-prepared primary containers will be used for each site.

Sample collection will target ~30cm depth in the water column at each site, being careful to avoid (where possible) collecting the surface itself (to avoid collecting floating debris, etc.). The volume of sample collected will be sufficient to allow for the required analysis, including replicate testing where appropriate.

The required method, volume and bottles will be confirmed with the testing laboratory prior to sampling commencing. Further details on the sampling for specific analytes can be found in the Queensland Monitoring and Sampling Manual (DEHP, 2013).

Photographs of each sampling site, including key observations, should be taken and stored for each sampling event.

B4.2 SAMPLE LABELLING

Each sample bottle for analysis will be labelled (preferably pre-labelled prior to filling) with the sample site ID, date and time, project ID/name and sampler initials. A water proof permanent marker will be utilised for labelling of sample containers.

B4.3 IN-SITU MEASUREMENTS

Measurements of field parameters will be undertaken using pre-calibrated portable field equipment, either by dipping sensors into the waterbody directly (to ~30cm depth), or by testing in a collected sample container. Due to safety concerns, testing within a previously collected sample container is preferred.

The testing procedure includes collection of the sample, testing by immersing the sensors in the sample as soon as possible after collection, and recording the results from each sensor. Different sensors may require different measurement methods and shall be undertaken according to the manufacturers documentation. For example, dissolved oxygen requires continuous gentle stirring of the sensor until the reading stabilises, to avoid oxygen depletion near the sensor head.

The sample used for in-situ testing should not be used to fill containers for subsequent laboratory analysis, since this risks contamination of the sample.

B4.4 LABORATORY ANALYSIS

A NATA accredited laboratory will be utilised for all analysis other than in-situ field measurements. All analyses will be undertaken after consultation with the testing laboratory, to ensure that laboratory limits of reporting for each analyte are below the water quality guideline values.

B4.5 QA/QC SAMPLES

Each sample round will include sufficient Quality Assurance/Quality Control (QA/QC) samples to allow the procedures and methods of collection to be verified. QA/QC testing will be undertaken as per AS5667.1.1998 by a NATA accredited laboratory.

Replicate sampling will be conducted as part of the sampling program to assess the sampling variability or error rate, at a rate of 1 per 10 samples collected. This is another sample collected at the same site, using the same methods. Replicates should be labelled DupA, DupB, etc., with the site recorded on the sampling documentation. However, the laboratory should not be advised which site this relates to.

B4.6 SAMPLE STORAGE, TRANSPORT AND TRACKING

Collected and labelled sample containers will be placed immediately on ice, with select samples potentially requiring freezing. Typically, this will be into an esky, which will be labelled with information required by the laboratory and include a copy of the Sample Submission / Chain of Custody form.

The Sample Submission / Chain of Custody is best filled out prior to sampling, or immediately after sampling is conducted, according to the requirements of the testing laboratory. This will contain the sample IDs, tests to be performed, sampling date and time, contact details of the monitoring coordinator and sampler, and similar details. A copy of this form should be emailed to the testing laboratory along with the anticipated time of arrival of the samples.

Samples will be stored and transported so as to comply with the holding times and methods detailed by the laboratory. When transported in eskies, clear labelling of details of the receiving laboratory and the sending company and contact (monitoring coordinator) is required, along with security seals on the lid of the esky (these are signed by the sender, and tear if removed, making tampering obvious on receipt at the laboratory).

The monitoring coordinator is responsible for the ownership and tracking of samples collected and will maintain a sample register on the site. This will include the samples collected (sample ID), date and time of collection, description of and number of containers (utilise laboratory abbreviations where available), site ID where taken, sampler, and details of any handover of samples.

When samples are taken from the site or handed to any third party, this must be acknowledged and signed by the sampling coordinator, with evidence provided from the collector (a signature, receipt, or similar). This must continue up until handover to the testing laboratory, who will sign and advise of receipt of the samples (usually on the supplied Sample Submission / Chain of Custody).

B4.7 DOCUMENTATION AND RECORDS

The following documentation is required for each sampling event, with copies maintained in a central register or location (both hardcopy and electronic):

- Sampling sheets – these detail the date, time, location and observations from each site sampled, including the type and number of samples collected, QA/QC samples, etc. Pencil is preferred over pens, since any wetting of the sampling sheets will not run if written in pencil
- Sample collection / Chain of Custody forms

- Calibration Sheets
- Sample Collection Register
- Laboratory documentation and results for each round
- Consolidated sampling data.

When the results for each round are received (including field in-situ data), the data is to be reviewed and a QA/QC assessment conducted to determine how reliable the data is. Any issues are to be followed up immediately as appropriate.

Assessment of the data against discharge criteria and receiving water guideline values / control-impact comparisons is to be conducted as soon as possible after receipt of the data, with exceedances escalated as required by the findings.

All data should be combined into a consolidated data set for ongoing analysis. Specialist databases are available, however a simple excel spreadsheet version is quite suitable for this purpose.

APPENDIX C SUPPORTING REPORT

PROJECT SEA DRAGON

CORE BREEDING CENTRE AND BROODSTOCK MATURATION CENTRE

EN02-MN4201

Supporting Report to the WQMMP

Rev 1, 25-Feb-2020

Project and Document Details

Proponent:	Project Sea Dragon Pty Ltd ACN: 604 936 192
Project Title:	Project Sea Dragon Core Breeding Centre and Broodstock Maturation Centre
Location:	Bynoe Harour, Northern Territory NT Portion 3192
Report Title:	Supporting Report to the WQMMP
Document Ref:	EN02-MN4201

Document Control

Revision	Description	Author/Amended By	Date
0	Final for independent review	Marc Walker	29-May-2019
1	Amended final based on peer review comments	Marc Walker	25-Feb-2020

Approved for release by: Rod Dyer, Seafarms Limited
Dallas Donovan, Seafarms Limited

Terms and Abbreviations

µg/L	Micrograms per Litre, 1 µg = 1/million of 1 Litre, equivalent to parts per billion (ppb)
ASS	Acid Sulfate Soils
AWQG	The Australian Water Quality Guidelines, referring to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000a)
BACI	Before-After, Control-Impact
BMC	Broodstock Maturation Centre
CBC	Core Breeding Centre
DENR	Northern Territory Department of Environment and Natural Resources
DGV	Default Guideline Value
DHWQOs	Darwin Harbour Water Quality Objectives
DO	Dissolved oxygen
EC	Electrical Conductivity
EIS, or the Project EIS	The Environmental Impact Statement (EIS) refers to the EIS documentation prepared for the CBC and BMC Project (Seafarms, 2016)
EMP	Environmental Management Plan
EMS	Environmental Management System
EVs	Environmental Values
FRP	Filterable Reactive Phosphorous
GA	Geoscience Australia
Guideline Value	As per the AWQG (see above), a guideline value is 'a measurable quantity (threshold) or condition of an indicator for a specific community value below or above which we consider to be a low risk of unacceptable effects occurring '
HDPE	high-density polyethylene
LOR	Limit of Reporting
mg/L	Milligrams per Litre, 1 mg = 1/1000 of 1 Litre, equivalent to parts per million (ppm)
NATA	National Association of Testing Authorities
NO_2	Nitrite
NO_3	Nitrate
NO_x	Oxides of Nitrogen (Nitrite + Nitrate)
NT	Northern Territory
NTU	Nephelometric Turbidity Unit
NWQMS	National Water Quality Management Strategy
QWQG	The Queensland Water Quality Guidelines, DEHP (2009)
Redox	Redox Potential
SE	Standard Error
SEIS	Supplementary Environmental Impact Statement (Seafarms, 2017)
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen

TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
WQMMP	Water Quality Monitoring and Management Plan
WQO	Water Quality Objective This term refers to objectives for water quality, described by the AWQGs as 'the guideline value or narrative statement for each selected indicator that should ensure the protection of all identified community values [previously environmental values]. In this document, this refers mostly to the Darwin Harbour WQOs (DNREAS, 2010).

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ATTACHMENTS

1 INTRODUCTION

This document provides supporting information used in the development of the Core Breeding Centre (CBC) and Broodstock Maturation Centre (BMC) Water Quality Monitoring and Management Plan (WQMMP), for the purposes of assessment of the WQMMP by agencies and to provide background information used to develop the plan.

It contains a brief description of the Project, relevant aspects of the existing environment, the Project risk assessment as it relates to water quality and the water quality review conducted for the Project, which includes baseline data assessment, identification of receiving waters, environmental values, discharge criteria and guideline values, and impact assessment methodology. Further detail on background elements including the project description and numerical modelling is provided in the Draft Environmental Impact Statement (the EIS) (Seafarms, 2016) and the Supplementary Environmental Impact Statement (the SEIS) (Seafarms, 2017).

A checklist against the relevant approval and licensing conditions is provided in Appendix A, along with cross-references to where these are addressed.

Following approval, this document will be merged into the site Environmental Management Plan, and will be appropriately referenced in the WQMMP, to ensure no duplication occurs within the Project Environmental Management System (EMS) and to provide a streamlined working system of documents for use on the site.

2 PROJECT DESCRIPTION

Project Sea Dragon is a large-scale, integrated, land-based prawn aquaculture project in northern Australia designed to produce high-quality, year-round reliable volumes of Black Tiger prawns (Penaeus monodon) for export markets.

It is a staged development of up to 10,000ha of production ponds, with the development of a series of facilities across northern Australia, including:

- The Grow-out Facility, Stage 1 of which involves 1,120ha of ponds over 3 farms
- Quarantine, Founder Stock Facility and Back-up Breeding Centre located at Exmouth (WA)
- Breeding Program (Core Breeding Centre and Broodstock Maturation Centre) - located at Point Ceylon at Bynoe Harbour (NT), the subject of this WQMMP
- Hatchery Site – located at Gunn Point
- Processing Plant – proposed to be located near Kununurra in Western Australia (WA), and
- Export Facilities – proposed to be located at either or both Wyndham and Darwin.

This WQMMP has been prepared for the CBC and BMC (the Project). The Project involves the development of breeding program facilities, a seawater intake pipeline and settlement ponds, and discharge infrastructure to Wheatley Creek.

The site Environmental Management Plan (EMP) describes the construction and operational works at the site in more detail. Figure 2-1 shows the site location and Figure 2-2 shows the general site layout, including discharge location and receiving waters.

In relation to operational water quality impacts, the essential site components include:

- Intake of seawater via a pipeline extending out approximately 300m into Geranium Channel
- Addition of prawn feed
- Growth and rearing of prawns
- Water exchange resulting in discharge to Wheatley Creek
- Water discharges first to a series of cascading settlement ponds and then into Wheatley Creek.

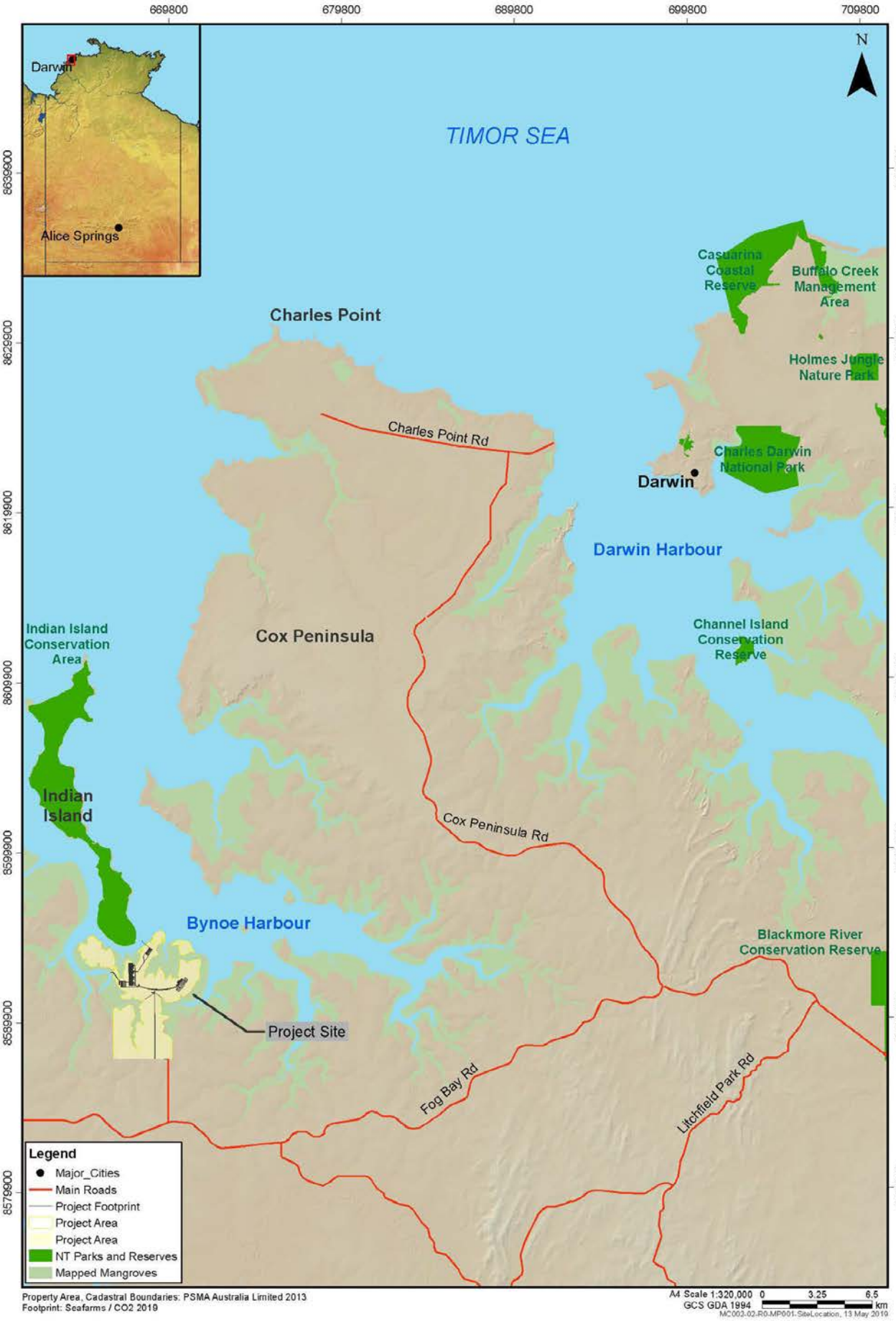

FIGURE 2-1 SITE LOCATION

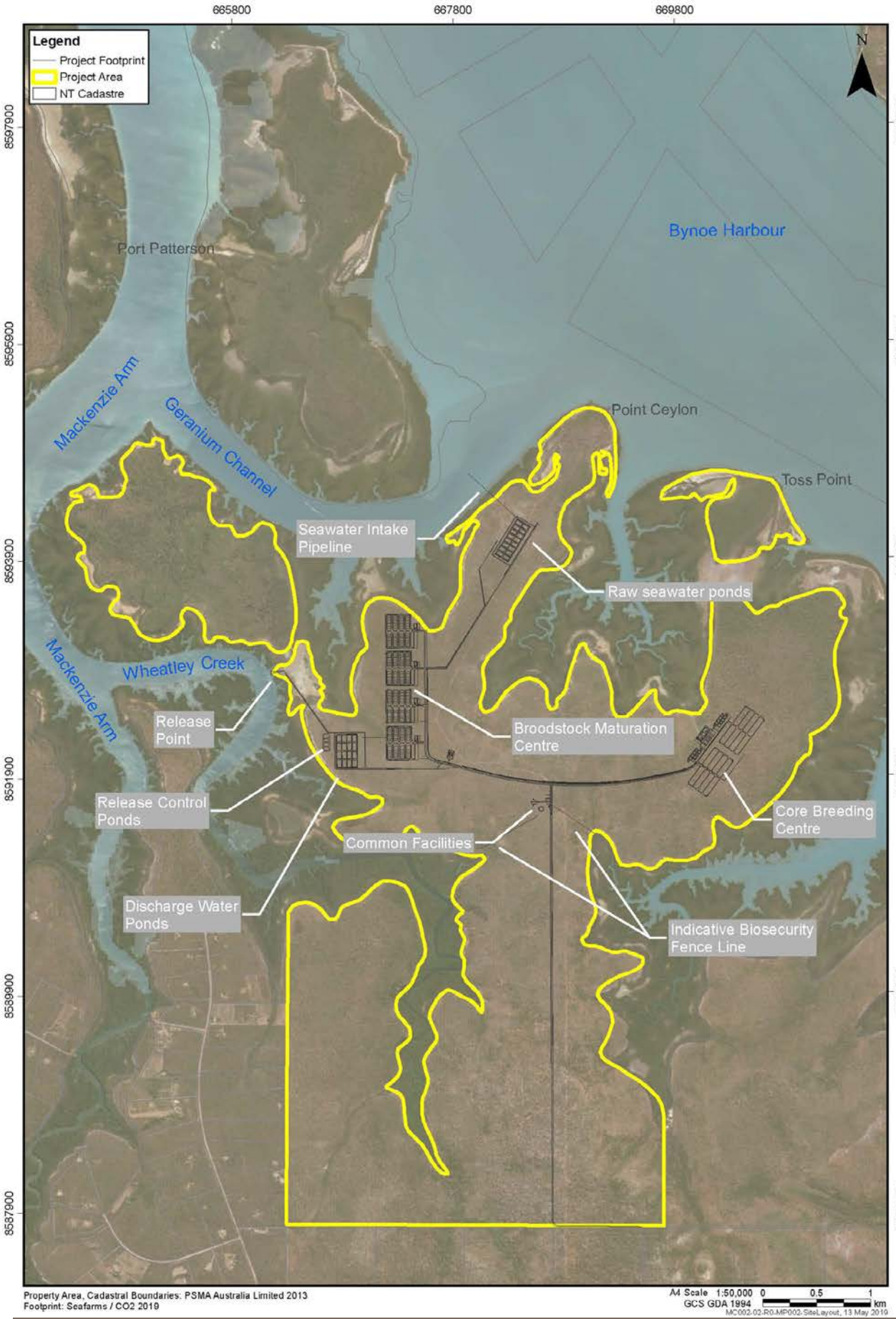

FIGURE 2-2 SITE LAYOUT

3 EXISTING ENVIRONMENT

The sections below summarise the key existing environmental elements relevant to this WQMMP. Further detail on these and the broader environment are detailed in the EIS and SEIS.

3.1 PROTECTED MATTERS

The Project site is bordered by Bynoe Harbour and surrounding estuary systems. There are two significant features identified in proximity to the site; however, neither will be impacted by construction or operational activities. These include:

- Indian Island Conservation Area, located 2 km to the north-east of the Project area (a high conservation value area because of its relatively undisturbed state, and as an important breeding habitats for turtles)
- the Finniss River coastal floodplain, approximately 15 km to the south of the Project

The coastal environment is (by design) in close proximity to the Project. However, direct disturbance to these areas will be minimal, limited to the immediate vicinity of the intake and outlet pipelines, with intake and outfall pipelines and inlet/outlet works sited and buried/fixed to avoid impacts to coastal processes.

The Project area is identified as a storm surge zone, with low lying areas around the perimeter of Portion 3192 subject to both primary and secondary storm surge. However, the CBC, BMC and administration and accommodation compound have all been located out of the primary and secondary storm surge zones.

Other nearby sites or features that will not be impacted by the Project, but that were considered include:

- Litchfield National Park, located approximately 50 km to the south-east of the Project area
- Commonwealth or Northern Territory marine parks or reserves, with the nearest over 50 km to the north-west
- World Heritage Properties and National Heritage Places, the nearest of which is Kakadu National Park, over 150 km to the east.

No public or private reserves are located within or near the Project area, and the area is not designated as a conservation zone under a planning scheme.

3.2 CLIMATE

The climate at Bynoe Harbour is described as tropical monsoon with a hot and dry season from April to September and a hot and humid wet season from October to March. The wet season is typified by high temperatures, high humidity and significant rainfall events, with most rain falling between December and March. The dry season is characterised by low humidity, warm temperatures and little or no rainfall.

Statistics developed by the BoM indicate that a cyclone occurs around Point Ceylon once every 2 – 3 years. However, wider climatic weather patterns have an impact on cyclone frequency, with more cyclones occurring during La Niña cycles when the frequency could be expected to be closer to 2 every 3 years (BoM 2017). Tropical cyclones risk results from extreme winds, extreme waves, storm surge and intense rainfall.

3.3 MARINE ENVIRONMENT AND HYDROLOGY

The Project site is located on a peninsula on the southern shore of Bynoe Harbour, classified as a drowned river valley estuary (or ria shoreline). The estuary is macro-tidal, with a maximum tidal range of 7.6 m. The entrance to Bynoe Harbour from the Timor Sea is located at the northern end of Indian Island, although water also flows into Bynoe Harbour via Port Patterson and the Geranium Channel to the west of Indian Island. A number of small tidal creeks and bays are present along the shore of Bynoe Harbour.

Wheatley Creek flows along the western side of the peninsula that the site is located on, and an unnamed creek flows along the eastern side. Wheatley Creek feeds into Mackenzie Arm, which flows into the Geranium Channel. The unnamed creek on the eastern side flows into Vigilant Inlet, which feeds into Bynoe Harbour.

Review of limited historical aerial images and site observations indicate that the shoreline at Point Ceylon appears to be relatively stable. There are no recent erosion scarps or areas of vegetation loss on the Point which would suggest ongoing erosion. On the southern side of Indian Island, however, there is some evidence that erosion may be occurring. The main flow path of Geranium Channel in this area is closer to the shore of Indian Island and steep banks to the low water level can be observed. In addition, during recent onsite observations, dead and dying mangroves were noted as having collapsed into the waterway.

The proposed operation includes the intake of seawater from the entrance of Geranium Channel via a 300m long pipeline, and the release of discharge waters into Wheatley Creek. Wheatley Creek is approximately 9.5km long from the confluence at Mackenzie Arm to the upstream end of the mangrove habitat and is fed by ephemeral streams. Stream flows are distinctly seasonal and concentrated during the wet season.

Placement of the intake pipe on the bed will result in minor and localised changes to the bathymetry in deeper water, due to scour and deposition. More significant changes could be observed in the intertidal region where sediments are more mobile.

The release outlet in Wheatley Creek is likely to also involve some removal and disturbance of vegetation, and there may be some visual disturbance owing to the construction of the intake pipe in an area with low level of development, however, minimal impact is expected upon coastal values in the area.

Discharged flow has the potential to cause scour of the bed and or bank within Wheatley Creek, however flows will be low compared with tidal currents. Stage 1 will be operated, and observations/measurements undertaken, with a view to designing a weir control structure in later stages if required to control scour and manage timing/mixing of discharge waters.

The macro tidal environment within Bynoe Harbour and Wheatley Creek means that the potential changes to the tidal water levels and currents by the intake or release are low. During a single tide, the intake pipe will remove 0.0002% of the tidal prism from Bynoe Harbour during a spring tide and 0.006% during a neap tide. This is unlikely to have any impact on tidal water levels or currents.

The release into Wheatley Creek represents an addition of 0.1% and 0.55% of the creek tidal prism for spring and neap tides respectively. Again, this is considered unlikely to have any impact on tidal waters or currents.

High tidal currents will also necessitate the anchoring of the intake pipe to the bed to prevent damage through movement. Modelling of the local conditions and requirements will determine whether the pipe is placed on the seabed surface or requires partial or full subterranean burial.

The catchments around Bynoe Harbour are ungauged and relatively small in size. The Wheatley Creek catchment is approximately 33 km^2. The total catchment for Bynoe Harbour is approximately 1,000 km^2, including Turnball Bay. Wheatley Creek and Mackenzie Arm catchments include areas of rural residential development, with approximately 7% of the Wheatley Creek and 12% of the western Mackenzie Arm catchment (i.e. west of the waterline) described as residential in the DENR *2008 Land Use Mapping Project of*

the Northern Territory. Cumulatively, this represents ~10% of the land area draining into these two waterways in proximity to the Project.

The shoreline of Point Ceylon and Wheatley Creek is characterised by mangrove forest that lines the tidal boundaries and grows in fine sediments. The mangrove community has remained relatively intact as a result of limited foreshore development and provides a significant resource for various stages of marine life (Brocklehurst and Edmeades, 2003). There are approximately 24,000 ha of mangroves in Bynoe Harbour, with *Ceriops tagal* forest the most widespread mangrove community of the region (Brocklehurst and Edmeades, 2003). Mangrove extent in the vicinity of the Project is shown on Figure 3-1 below.

Surveys of Bynoe Harbour and Darwin Harbour undertaken by Chatto (2003, 2006) recorded shorebirds and waterbirds around most of the coastline. The highest densities of shorebirds and waterbirds however, were recorded in the islands off Bynoe Harbour (most notably on Bare Sand Island) and on the coast to the east of Darwin (Bare Sand Island is located 24 km to the north-west of the Project Area).

3.4 BENTHIC HABITAT

In Bynoe Harbour main channel sediments consist primarily of sandy gravels and gravels, while the lateral channel banks consist mainly of mud and sand flats with occasional rocky outcrops and rocky/coral reef (Smit et al, 2000). Sponges and soft corals dominate reef benthos of Bynoe Harbour, together with hard corals of the genus Turbinaria (Smit et al, 2000).

Site observations undertaken by Water Technology personnel during bathymetric surveys identified that a large rocky outcrop extends over 450 m offshore from Point Ceylon, adjacent to the site. This is completely exposed during low tide and inundated during high tides. The adjacent intertidal platform was observed to be a combination of sandy material intermixed with finer silts (near mangroves) and cobble and rock beds. Later visual inspections by helicopter (CO2 Australia, pers. comm, 2019) indicated this continuous rocky platform had broken up with some rocky areas on shore, and a residual harder rock island offshore. This comprised rock and mud/silt and appeared subject to strong tidal currents.

Data from Smit et al (2000) was used by GeoOceans (2011) to infer the sediment type in the region of the site, which provided for approximate substrate boundaries (although they did broadly conform to the observations by Watertech, 2016a). Sampling conducted in 2019 by ECOz Environmental (unpublished data), involving video and camera grabs at sampling sites, and both sediment and macroinvertebrate sampling, broadly confirm the substrate describe above and shown in Figure 3-1.

Seagrass mapping undertaken by DENR in Bynoe Harbour indicates that the closest seagrass beds are located 16km from the Project Area, to the north of Indian Island. Smit et al. (2000) reported that seagrass beds were present in the intertidal–subtidal interface and in the very shallow subtidal areas of Bynoe Harbour, including patchy seagrass near Point Ceylon. Seagrass species that have been recorded in the Bynoe Harbour region include *Halophila decipiens*, *Halodule uninervis*, and *Enhalus acoroides* (Smit et al, 2000 and references cited therein). More recent studies in the greater region did not extend to Bynoe Harbour. However, the dominant Halophila/Halodule genera recorded by Smit et al. (2000) are comparable to those found in the region (Seafarms, 2016).

Site observations do not indicate presence of any of these previously described beds within the proposed Project area (Watertech, 2016a). In particular, sampling conducted in 2019 by ECOz Environmental (unpublished data), involving video and camera grabs and sediment sampling found only two very sparse and patchy occurrences of seagrass in proximity to the Project site, both within Mackenzie Arm (at the confluence with Wheatley Creek and one site upstream), and none within Wheatley Creek or further downstream in Mackenzie Arm, where current velocities are higher.

Enesar (2006) observed numerous burrows in bottom sediments in proximity to the Project site, indicating 'abundant animal life', although no macroscopic plants were observed due to 'the high attenuation of light in the muddy estuarine waters', describing sediments as typical of largely undisturbed mangrove estuarine environments. Macroinvertebrate sampling by Enesar (2006) indicated no obvious signs of existing impacts on macrobenthic communities, with communities being generally diverse with low levels of faunal dominance.

Infrastructure proposed for the marine environment includes the water intake pipe in the main channel of Bynoe Harbour, and the discharge to Wheatley Creek. The intake pipe is located in approximately 10 m water depth in an area characterised by sand/gravel substrate and associated benthic fauna. The proposed Wheatley Creek discharge point is located in approximately 3-7 m water depth in a highly variable area with a combination of rock, mud, clay and sand (Watertech, 2016).

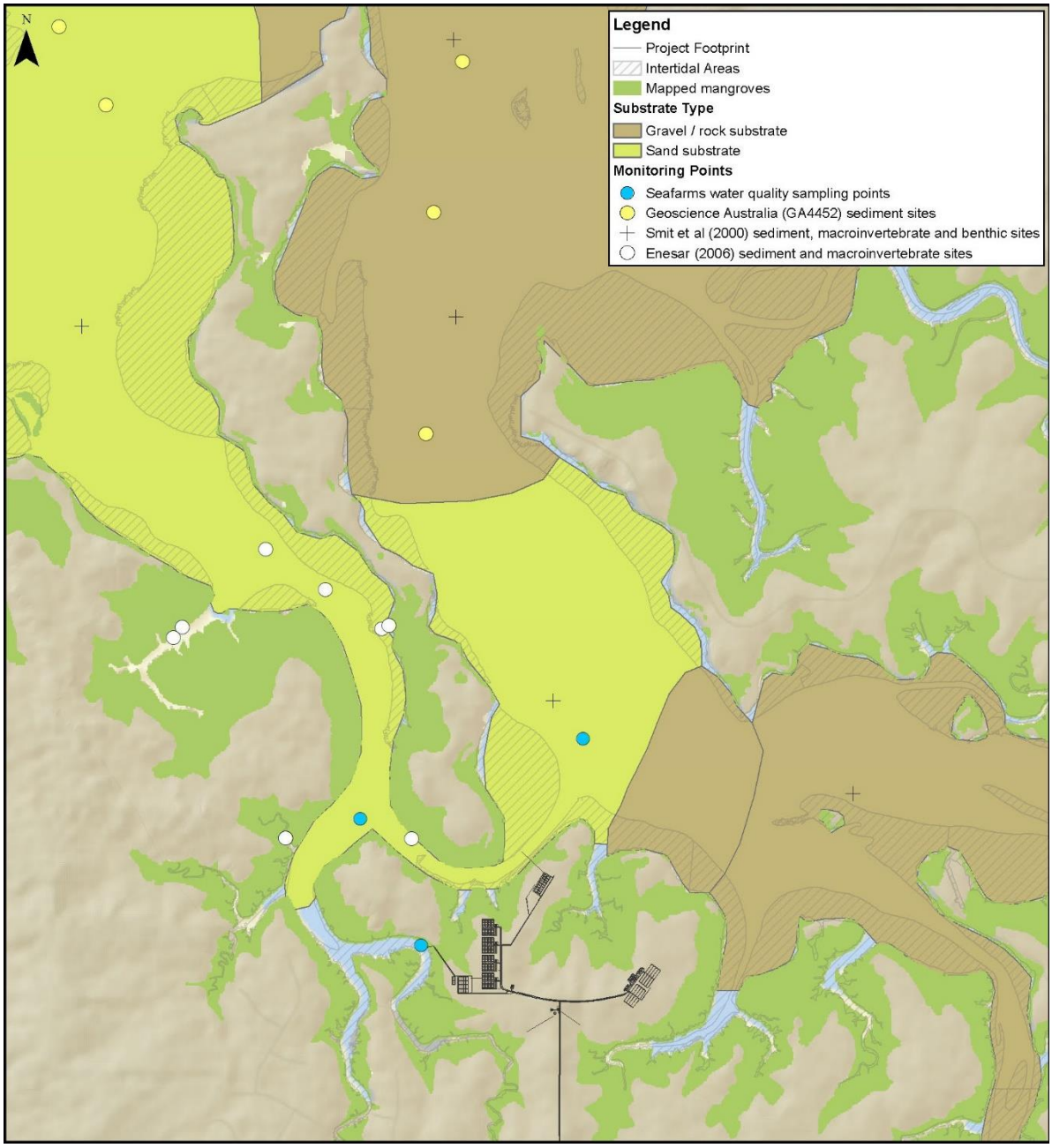

FIGURE 3-1 BENTHIC SITES AND INFERRED SEDIMENT TYPES

3.5 WATER QUALITY

Previous water quality assessments of Bynoe Harbour and Port Patterson (EcOz, 2003 and Enesar, 2006 in Watertech, 2016a) indicated that there are few potential sources of pollution in the area and that water quality is relatively undisturbed. The few potential sources of pollution include a rural block subdivision south of the site which includes some small-scale agriculture, the Crab Claw resort approximately 7km to the east, and the Paspaley Pearling Company oyster beds which are located just north of Point Ceylon and adjacent to the proposed intake point. In Darwin Harbour, Smith (2009) notes that urban and rural runoff is estimated to have increased nutrient loads by 1.7 and 5.9 times for nitrogen and phosphorous loads, respectively, indicating that the existing subdivisions may provide substantial sources of pollutants, particularly as they grow.

In November 2015 PSD commenced a sampling program to establish existing water quality conditions within the receiving environment and its associated waterways. Monthly samples have been taken and a range of physiochemical parameters have been measured including hydrocarbons, BTEX, heavy metals, organochlorine pesticides and nutrients. This is discussed in more detail in Section 7.

Based on this monitoring data (other data is sparse at best), water quality levels at all sites are relatively consistent with values available from the literature in the general region.

The potential impacts of the proposed release into Wheatley Creek were assessed via the formulation, application and interpretation of a calibrated, near and far field, two-dimensional hydrodynamic and advection dispersion modelling tool built using the MIKE 21 Flexible Mesh hydrodynamic model. This is described in more detail in the Draft EIS, Part B, Chapter 11.

The numerical modelling was based on a conservative tracer, which allowed the dilution and dispersion of the effluent to be understood. This conservative approach allows for a worst-case assessment of dispersion, not allowing for uptake (biological or physico-chemical), deposition, settlement or entrainment, or turbulent dispersion associated with, for example, depth varying flow around river bends. In addition, the maximum proposed licenced limits were adopted as release concentrations, rather than the expected mean values.

The modelling found that water quality was compliant with the proposed interim water quality guidelines for total nitrogen, and marginally exceed the total phosphorus guideline value in the dry season. This shows that, at the full capacity of the Project (11,000 m^3/day release) and at a conservative licence condition of 2 mg/L total nitrogen and 0.4 mg/L total phosphorous (noting that the effluent quality is expected to be better than these levels), this would cause at worst case localised and modest increases in nutrient levels in these areas.

When the additional effect of initial mixing, biological assimilation and particulate matter deposition is taken into account, it is considered unlikely that the proposed release will have significant water quality, or water quality related ecological impacts to Wheatley Creek, Geranium Channel or any other waterways in the Bynoe Harbour area.

Receiving waters potentially affected by the Project for the purposes of this WQMMP are defined in Section 4. A detailed review of the baseline program is provided in Section 7, including a determination of the suitability of this data to support the adoption of water quality guideline values for impact assessment.

4 RECEIVING WATERS

4.1 POTENTIAL IMPACT AREA

The Project discharge is located within the waters of Wheatley Creek, which enters Mackenzie Arm and then Geranium Channel flowing around the southern end of Indian Island into Bynoe Harbour.

Numerical modelling by Water Technology as part of the EIS process (Watertech, 2016a) undertook dispersion modelling for the discharge, using a conservative tracer (no loss, uptake or change) and assuming a constant discharge. The modelling found that total nitrogen and phosphorous increases were low, at around 0.06mg/L and 0.013mg/L respectively and dropping to 0.005mg/L and 0.002mg/L respectively downstream near the confluence of Mackenzie Arm and Geranium Channel.

These latter levels are essentially un-detectable, since they are below the ultra-trace detection levels used by ALS Laboratories (a NATA accredited laboratory) of 0.01mg/L for nitrogen and 0.005mg/L for phosphorous. For bioavailable nutrient forms, detection limits are 0.001mg/L for both oxides of nitrogen (NO_x) and Filterable Reactive Phosphorous (FRP). Baseline data has found that NO_x varies between about 10 – 20% (at most) of total nitrogen, while FRP was likely at worst between 2 – 4% (FRP was characterised by many non-detects). Fortune (2015) similarly found that FRP represented a minimal proportion of the total phosphorous pool and that the dissolved organic fraction of total nitrogen was dominant (NO_x is the inorganic fraction). Taking these ratios into account, NO_x and FRP would both be below ultra-trace detection levels.

As such, areas dropping to the above low levels would be considered outside of the potential impact area. Based on the modelled extent of total nitrogen and total phosphorous concentration gradients (see as Figure 11-26 in Appendix A to the SEIS), the potential impact area is therefore identified as the area extending upstream in Wheatley Creek and Mackenzie Arm and downstream to the confluence of Mackenzie Arm and Geranium Channel. This area is shown in Figure 4-1.

Note that this is anticipated to be larger than any actual impact zone, based on the conservative nature of the modelling which:

- assumed that the nutrient levels in the discharge were at the proposed licence limits, which is unlikely at all times,
- did not consider biological assimilation of dissolved nutrients, and
- did not consider the settling of particulate components in the discharge within the waters of Wheatley Creek and Geranium Channel.

Ongoing operational monitoring may be able to refine this potential impact area, and a review of such must be undertaken at least after the first 2 years of operational discharge monitoring.

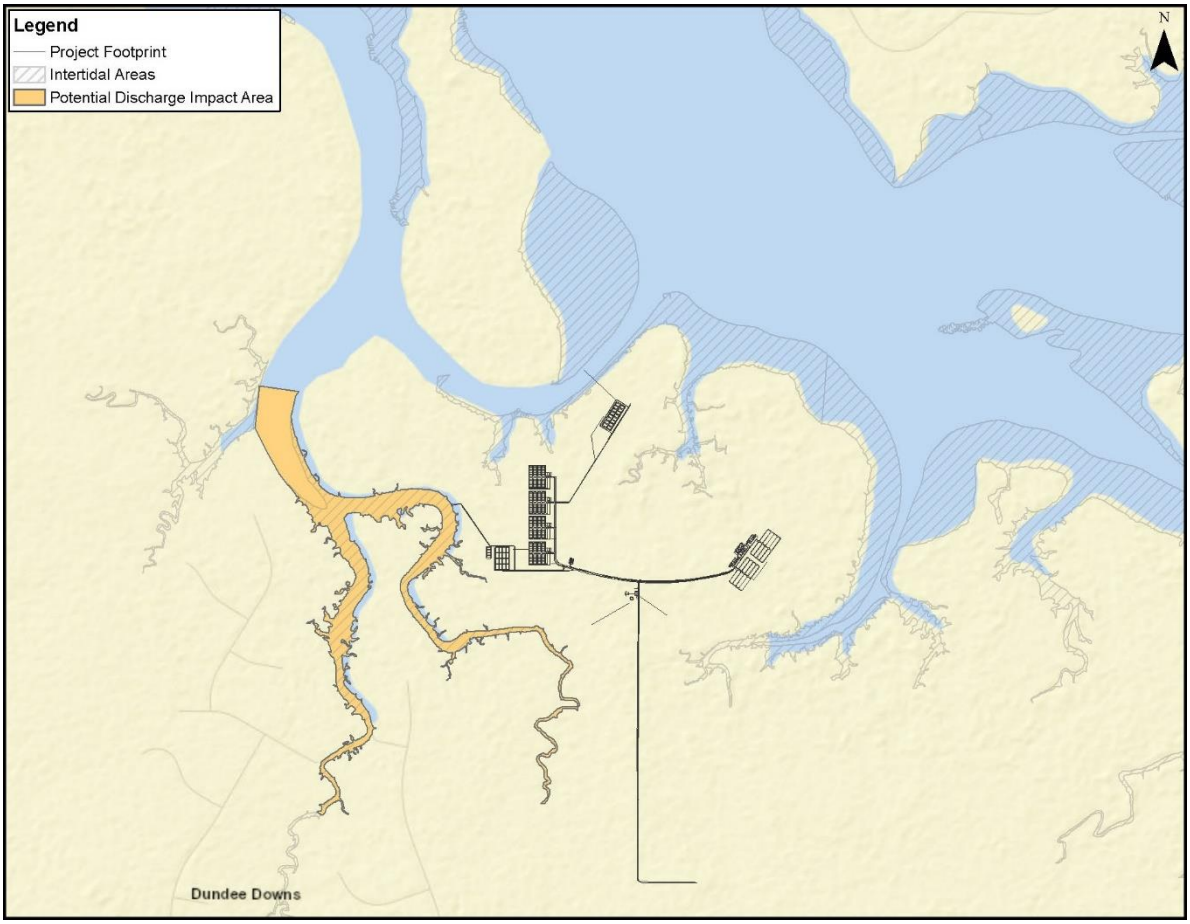

FIGURE 4-1 POTENTIAL DISCHARGE IMPACT AREA

4.2 WATER TYPES

As noted above, the receiving waters for the Project are the tidal creeks and waters of Bynoe Harbour – all estuarine systems. Within estuaries and coastal streams, water quality and the optimum water quality level can vary. As such, differentiating between these different systems is important in determining levels of protection and water quality guideline values, with the aim to define water types within which natural water quality is reasonably consistent.

Estuary systems have been classified in the Darwin Harbour region (DNREAS, 2010) as Upper, Mid and Outer Estuaries, which are defined as follows:

- Upper estuary zones: Upper most reaches of the estuary where hypersaline conditions may persist for short periods during the dry season and significant freshwater pulses prevail during the wet season where stratification (or saltwater wedges) may occur. Includes a series of tidally influenced creeks branching from the main body of the harbour and its estuarine arms. Significant flushing during the wet season and during tidal movement is experienced by these systems which in most cases are the first sites where catchment disturbance is detected. Considered poorly flushed, with residence times over 32 days.
- Mid estuary zones: Majority of the length of the estuary from below the upper estuary to near the mouth. Excludes smaller well flushed reach at mouth which typically has marine water quality. Greater mixing, with residence times between 14 and 32 days.
- Outer estuary zones: Coastal waters with some broader marine or ocean exchange. It includes shallower coastal waters or embayments. It also includes most downstream reaches of estuaries. Considerable

mixing with the ocean; residence times are less than 14 days; Salinity is indicative of marine waters, with the 80th percentile of seasonal salinity values >35ppt.

While residence times have not been calculated for these waters, given the close proximity of Bynoe Harbour to Darwin Harbour, and based on flow velocity and dispersion characteristics along with salinity data, water types can be determined for the receiving waters.

In comparison to the flushing zones identified for Darwin Harbour (DNREAS, 2010), the receiving waters in proximity to the Project would be considered as Mid or Upper Estuarine waters, with Outer Estuarine zones toward the mouth of Bynoe Harbour. Figure 2-12 from Watertech (2016a) shows that higher flow velocities are present within the main Bynoe Harbour channel and through Geranium Channel swinging around the bottom of Indian Island for peak Spring flood and ebb tide events, indicating these waters might all be considered Mid Estuarine.

Using the tracer dispersion characteristics from Figure 3-9 in Watertech (2016a) (repeated in Figure 4-2 below), it is evident that Wheatley Creek and the upper reaches of Mackenzie Arm exhibit less well flushed conditions, and so may be indicative more of Upper Estuarine waters than Mid-Estuarine waters. The boundary between the two is very similar to the limit of the intertidal zone in Mackenzie Arm, and this is therefore taken as the boundary in this system between Upper and Mid-Estuarine zones.

As confirmation, salinity data at each of the baseline monitoring sites (refer Figure 7-4 in Section 7.2.3) shows that H01 and BH03 located in the above defined Mid-Estuary zone are quite similar, with BH03 showing departure from the other two sites during the 2016-2017 wet season (lower salinity). The 80th percentile salinity results from the baseline data are ~40ppt in the dry season at all sites, and 31ppt at BH02 (Wheatley Creek) and 34ppt at the other two sites in the wet season. This indicates an increase in marine salinity due to evaporation and limited mixing with marine waters, with the influence of fresh runoff waters more pronounced at the Wheatley Creek site during the wet season.

Taken together, the above indicates a Mid-Estuarine designation for the waters of Bynoe Harbour, Geranium Creek and Mackenzie Arm up to the limits of the intertidal zone, with an Upper Estuarine zonation applying to Wheatley Creek and waters upstream of the mapped intertidal zone in Mackenzie Arm, as shown in Figure 4-3. This also shows several of the surrounding tidal creeks as Upper Estuarine waters – these are inferred from the intertidal areas and the shape of the proximate main channel.

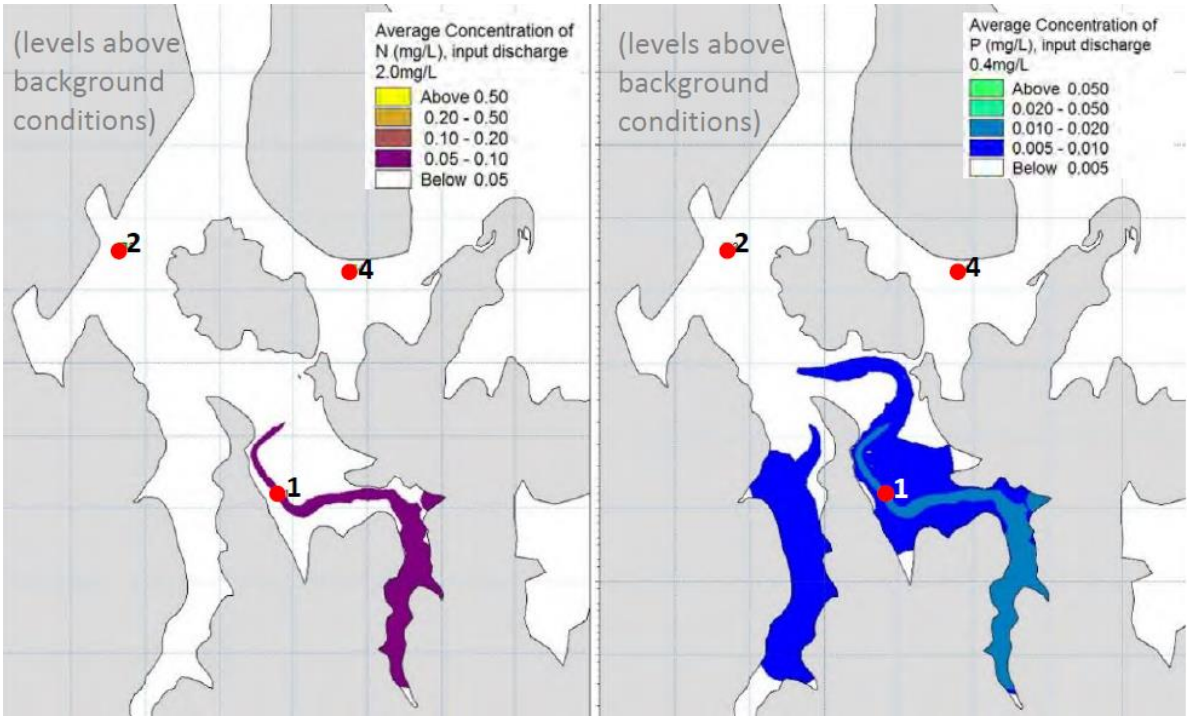

FIGURE 4-2 ADDITIONAL NITROGEN AND PHOSPHOROUS CONCENTRATIONS FROM WATERTECH (2016A)

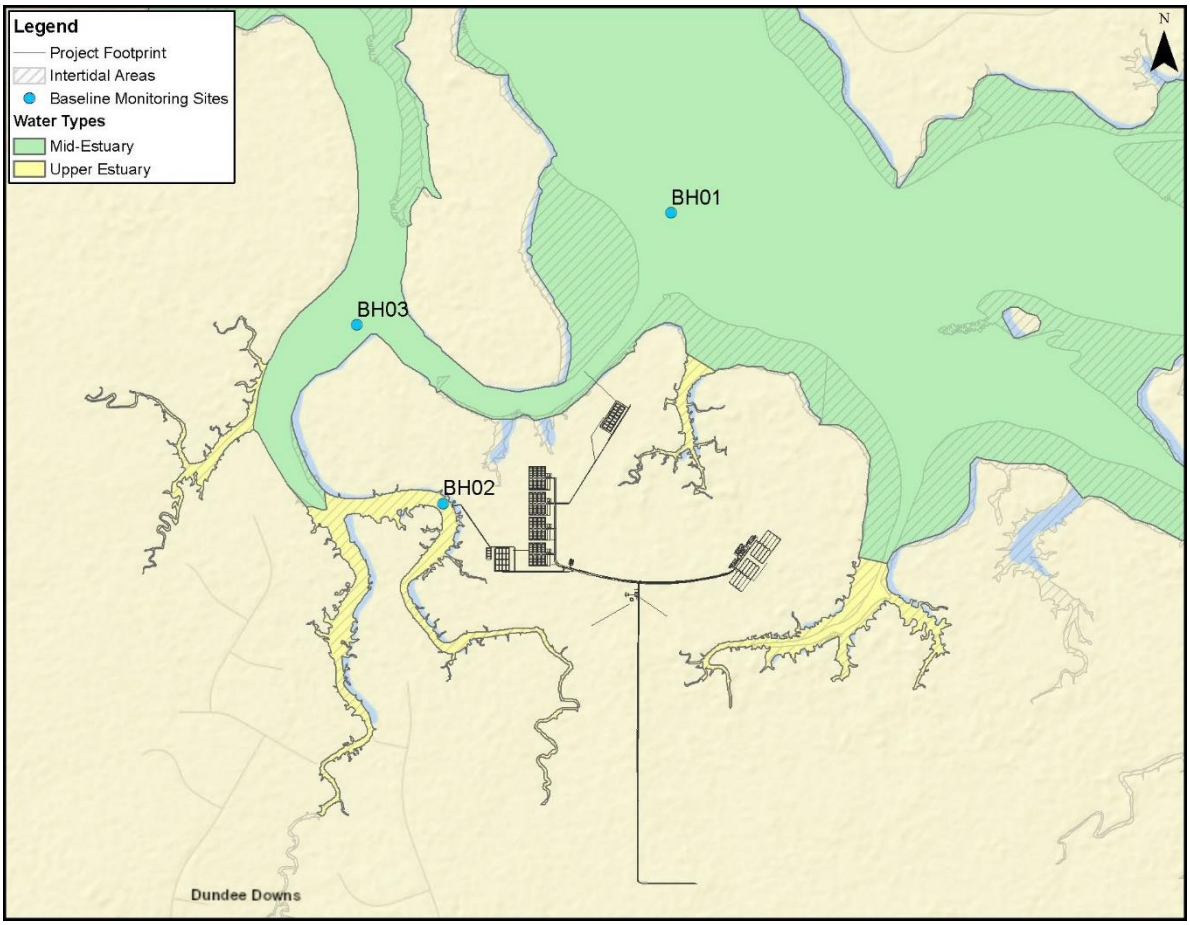

FIGURE 4-3 ASSUMED WATER TYPES IN PROXIMITY TO THE PROJECT SITE

4.3 LEVEL OF PROTECTION FOR RECEIVING WATERS

In order to define management goals and water quality guideline values, the level of protection for receiving waters needs to be determined, based on its ecosystem condition.

4.3.1 Ecosystem Condition

The AWQG (ANZG, 2018) recognise 3 levels of ecosystem condition:

1. High conservation or ecological value systems (condition 1 ecosystems)
2. Slightly to moderately disturbed systems (condition 2 ecosystems) and
3. Highly disturbed systems (condition 3 ecosystems).

Bynoe Harbour has been determined as clearly not a condition 3 ecosystem as part of the EIS/SEIS process. The definitions (from the AWQG) for condition 1 and condition 2 ecosystems, and comments on the definitions with reference to the receiving environment are provided below:

Condition 1 Ecosystem

Effectively unmodified or other highly valued ecosystems, typically (but not always) occurring in national parks and conservation reserves, or in remote and inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand entirely without some human influence, the ecological integrity of our high conservation or ecological value systems is regarded as 'intact'.

Condition 2 Ecosystem

Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained.

Freshwater systems would typically have slightly to moderately cleared catchments or reasonably intact riparian vegetation. For example, rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism.

Marine systems would typically have largely intact habitats and associated biological communities. For example, marine ecosystems lying immediately adjacent to metropolitan areas.

The marine ecosystem of Bynoe Harbour is in a healthy condition and ecosystem integrity is largely retained. It has, however, been affected to some degree by human activity. The area of Bynoe Harbour in proximity to the Project site has been subject to development, mainly in the form of rural residential subdivisions and the construction of associated infrastructure required to service these subdivisions including roads and boat ramps (around a 10% combined catchment area comprising residential areas – refer Section 3.3). Bynoe Harbour is also, given its proximity to Darwin, a popular recreational fishing and boating area and the Paspaley Pearling Company runs a number of oyster leases in the harbour. As such, while the ecosystem is in healthy condition, it is not entirely without some human influence and therefore the receiving waters for the Project are considered to meet the definition for a condition 2 ecosystem.

Furthermore, there is a precedence for this classification, as the proposed Marine Harvest Barramundi Fish Farm at Port Paterson (located within Bynoe Harbour) compared the results of water quality sampling in Bynoe Harbour to the AWQG guidelines for slightly to moderately disturbed (i.e. condition 2) ecosystems.

4.3.2 Level of Protection

For condition 2, Slightly to moderately disturbed systems, the AWQG states that the key management goal should be 'maintenance of biological diversity relative to a suitable reference condition', with the recommended levels of protection summarised below:

Biological indicators (field)

- Statistical decision criteria for detecting departure from reference condition (aiming for maintenance of biodiversity).
- Where reference condition is poorly characterised, include actions to increase the inferential strength of the monitoring program.

Physical and chemical stressors

- Preferable to use data on local biological effects to derive guideline values.
- If local biological effects data are unavailable, use local or regional reference site data to derive guideline values.
- Where local reference site data are not yet gathered, apply regional Default Guideline Values (DGVs).

Toxicants

- Preferable to use data on local biological effects, including direct toxicity assessment (DTA), to derive site-specific guideline values.
- For toxicants in water, apply 95% species protection DGVs, or 99% species protection for highly bioaccumulating toxicants, if local biological-effects data are unavailable.
- For toxicants in sediment, use the AWQG toxicant DGVs for sediment quality.

5 ENVIRONMENTAL VALUES AND WATER QUALITY GUIDELINES

5.1 ENVIRONMENTAL VALUES[1]

The overarching objective is essentially to ensure that Project operations do not negatively affect the Environmental Values (EVs) of the receiving environment. The receiving waters are identified as the Fog Bay Area and are subject to a Beneficial Use Declaration under the NT Water Act 1992 (Gazette No. G20, 27 May 1998), which lists the following beneficial uses for marine and estuarine waters:

- Aquatic ecosystem protection;
- Recreational water quality; and
- Aesthetics.

The equivalent Australian Water Quality Guideline (AWQG) EVs are:

- Marine and estuarine aquatic ecosystems
- Recreation and aesthetics

Given the proposed use, the following should be added:

- Primary industries (aquaculture).

5.2 WATER QUALITY GUIDELINE VALUES

As discussed in the EIS and SEIS, the Darwin Harbour Water Quality Objectives (DHWQOs – DNREAS, 2010) were adopted as interim guideline values for the purposes of assessing impacts from the Project, subject to further data collected from waters suitable to define local guideline values, or to confirm the above DHWQOs. As noted in Section 4.3 above, the key management goals relate to existing reference condition, as suitable for Slightly to Moderately disturbed systems, which is the same level of protection provided by the DHWQOs to Darwin Harbour.

The DHWQOs are designated under Part 7 of the NT Water Act as a local guideline level in accordance with the National Water Quality Management Strategy (NWQMS) and the AWQG (DENR, 2016), and are potentially suitable based on the close proximity and size of Darwin and Bynoe Harbours, although catchment sizes are smaller in Bynoe Harbour.

To determine their suitability, the data from the existing baseline program was compared to the DHWQOs based on the methods outlined in the Queensland Water Quality Guidelines (QWQGs, DES, 2018) to determine whether they should be rejected, or might be retained for use in the Project. This involves comparing the computed criteria (from 20th and 80th percentiles of the baseline data) with the guideline values (i.e. the DHWQOs, also based on 20th and 80th percentiles), taking into account an error margin calculated from the standard error. Where the error margin of the calculated guideline value includes the DHWQO, there is insufficient evidence to state that the two values are truly different (i.e. the DHWQO may be provisionally retained). The results are shown in Table 7-3, and discussed further in Section 7.2.3.

[1] These are now termed Community Values in ANZG (2018). The term Environmental Value has been retained herein to maintain consistency with the EMS and EMP for the Project, and previous correspondence and liaison with the NT Government and others.

The analysis shows that the calculated guideline values (based on 20th and 80th percentiles) were comparable to the DHWQOs with the exception of total suspended solids (DHWQO too low), total phosphorous (DHWQO too low), dissolved oxygen (measured values low – further investigation required) and filterable reactive phosphorous (limits of reporting too high – further monitoring required). No DHWQO for turbidity exists, however one might be developed from the baseline data if required.

An assessment of seasonal guideline values has also been made. Potential differences between calculated values were found as follows:

- Total Suspended Solids: Upper estuarine waters: Dry 34mg/L; Wet 15mg/L (overall 21.6mg/L)
- Ammonia: Upper estuarine waters: Dry <0.010mg/L; Wet 0.020mg/L (overall <0.010mg/L)
- Oxides of Nitrogen: Upper estuarine waters: Dry 0.026mg/L; Wet <0.020mg/L (overall 0.030mg/L)
- Total Nitrogen: Upper estuarine waters: Dry 0.200mg/L; Wet 0.316mg/L (overall 0.220mg/L)
- Total Phosphorous:
  - Upper estuarine waters: Dry 0.128mg/L; Wet 0.029mg/L (overall 0.060mg/L)
  - Mid-estuarine waters: Dry 0.086mg/L; Wet 0.027mg/L (overall 0.050mg/L)
- Chlorophyll a:
  - Upper estuarine waters: Dry 1.6µg/L; Wet 2.1µg/L (overall 2.1µg/L)
  - Mid-estuarine waters: Dry 1.7µg/L; Wet 2.7µg/L (overall 2.2µg/L)

The error margins involved make it difficult in some cases to determine if the above differences are real from a statistical perspective, and more data is required to determine if true seasonal guideline values should be adopted. The bias towards wet seasons may explain some of the above differences.

The current interim guideline values are summarised in Table 5-1. As described in Section 4.2, the waters to be affected by the Project are in the Upper Estuary zone, with control and possible impact sites as well as the intake monitoring point located in the Mid-Estuary zone.

TABLE 5-1 INTERIM RECEIVING WATER QUALITY GUIDELINE VALUES

Parameter	Mid-Estuary[1]	Upper Estuary[1]	Source / Comments
pH	7.0 - 8.5	6.0 - 8.5	DHWQO
Dissolved Oxygen (%Sat)	80 - 100		DHWQO - further investigation required
Turbidity (ntu)	≤3.9	≤8.1	Interim site specific guideline value
Total Suspended Solids (mg/L)	≤20		
Ammonia (mg/L)	≤0.020		DHWQO
Oxidised N (NO_x) (mg/L)	≤0.020		DHWQO
Filterable Reactive P (mg/L)	≤0.005	≤0.010	DHWQO - further investigation required
Total Phosphorous (mg/L)	≤0.050	≤0.060	Interim site specific guideline value
Total Nitrogen (mg/L)	≤0.270	≤0.300	DHWQO
Chlorophyll a (µg/L)	≤2	≤4	DHWQO

Table notes:
1 DHWQO values unless otherwise noted

6 RISK ASSESSMENT

6.1 RISK ASSESSMENT FRAMEWORK

A Project wide risk assessment was conducted for the Project, as outlined in the EIS. This risk assessment will continue to be utilised, reviewed and updated for the site as a whole, with water quality risks included in that process.

The methodology employed was a standard semi-quantitative risk assessment consistent with AS/NZS ISO 31000:2009 'Risk Management – Principles and Guidelines'. This incorporates an assessment of the potential risks (including general ecological values, threatened and migratory species, and marine and estuarine waters), determining the likelihood of an event occurring, and the consequence should the event occur. Risk ratings are derived for the unmitigated case (no controls), and following the controls proposed for the site.

Further information is provided in the EIS. A copy of the elements relevant to this WQMMP is included in Appendix B to this report, with the risk assessment framework described in the procedure included in Appendix C to this report.

6.2 OPERATIONAL DISCHARGES

6.2.1 Water quality

The EIS provided an assessment of the inputs to the breeding tanks and the resultant components of the discharge waters. These additions are identified as follows:

- filtered seawater, freshwater – discharged to Wheatley Creek, less evaporation
- Feed – this includes different diets for different life stages, but includes:
  - fresh feed – polychaetes, squid, pipis, scallops, beef or pork liver, frozen and delivered to site
  - microalgae grown in batch culture on site using standard enriched seawater algal culture media
  - the common brine shrimp Artemia cultured on site within the hatchery
  - Commercially available dry formulated feed (typically comprising fish meal, 23%; soya bean meal, 35%; whole wheat, 29%; other micronutrients, minerals, vitamins and stabilisers, 13%).

  These result in animal protein, microbial colonies, microalgae, mineralisation of nutrients, and trace minerals not taken up by prawn biomass within the water column. Probiotics (bacterial colonies) may be present but would be transformed into proteins (used as food by zooplankton and fish).
  - Feed additives, which typically comprise:
    - vitamin and mineral premixes: typically, <1% of the feed (GAA, 2006), containing trace amounts of vitamins and minerals, including iodine, selenium, cobalt, copper, zinc, iron, magnesium and manganese.
    - stabilisers: commonly wheat and wheat gluten.

  As noted in the Supplementary EIS, no antibiotics, anti-parasitics or anti-fouling agents will be in use.
- Chlorine for disinfection, rapidly breaking down to dissociated sodium chloride and oxygen
- Organic matter, including prawn faeces, uneaten food and dead algae and primary producers
- Freshwater used to washdown tanks and other culture related infrastructure, with chlorine and hydrochloric acid used as required during cleaning of infrastructure.

Available literature data, monitoring at existing Seafarms' Queensland sites and the data above indicates the following characteristics of prawn farm discharge waters, which would be broadly comparable for the Project discharge:

- Total nitrogen in prawn farm discharges has been found to vary between ~2 – 3.1 mg/L (Jackson et al, 2003; Jackson et al, 2004; Seafarms, pers.comm, 2017), dominated by particulate nitrogen (mostly phytoplankton and uneaten feed), with approximately 10% ammonium, 2% nitrate/ nitrite and 30% dissolved organic nitrogen (Burford et al. 2003). The median discharge concentration from the existing Cardwell farm site is 1.1mg/L, with the 80th percentile concentration at 1.5mg/L and maximum up to 2.8mg/L (EIS, Chapter 11), broadly consistent with the above data.
- Almost all (> 90%) of the total phosphorus in untreated effluent is in the particulate form (Preston et al, 2000), with a typical mean ranging from 0.22 – 0.28 mg/L (Jackson et al., 2004) in untreated discharge waters (i.e. prior to settlement), and even lower at Seafarms' Queensland sites (Seafarms, pers.comm, 2017). The EIS provides the median and 80th percentile results from the Cardwell site at 0.08mg/L and 0.11mg/L respectively, up to a maximum of 0.27mg/L (EIS, Chapter 11), again similar to the above results.
- Chlorophyll a, an indicator of algae and primary producers, varied between ~1.2 – 36 µg/L in discharge water, averaging 11.3 µg/L in Seafarms' Queensland sites.
- Discharge settlement ponds will be lined with HDPE liners and discharge will be via an enclosed HDPE pipeline. Given that the majority of the suspended load typically seen in prawn farm discharge waters (60 – 90%) is from eroded soils from pond and channel floor and banks (Preston et al, 2000), the resultant Project discharge load is expected to be low, comprised of largely particulate organic matter (nutrients, etc.).
- Due to the high level of aeration in ponds and pond conditioning, discharge dissolved oxygen is typically within suitable levels (>6mg/L), with pH remaining within the 6.5 – 8.7 criterion range for the North Queensland Seafarms' sites (Seafarms, pers.comm, 2017).
- Based on estimated composition of feeds, the level of trace metals added to the system in formulated feed, at <1% of the feed mass, would equate to a negligible concentration in discharge waters.

Levels of nutrients and total suspended solids are anticipated to be lower than that described above, since design for the Project has focussed on the following:

- maximisation of water re-use/recirculation
- use of settlement ponds to treat effluent
- optimisation of timing of discharge
- breeding efficiency (i.e. the genetic improvements from the domestication program mean that prawns grow faster and require less feed over time), and
- best practice for feed formulation (minimising marine ingredients - fish meal, fish oil).

6.2.2 Potential impacts

Of the above discharge characteristics, nutrient impacts have the greatest potential for impact. Dissolved inorganic nutrients (ammonium and nitrite / nitrate) may potentially increase primary production in the receiving environment, and at high concentrations may lead to harmful algal blooms and / or create anoxic conditions. Nutrient enrichment can also change the community composition of phytoplankton by altering nutrient ratios (Burford et al., 2003).

Phytoplankton and particulate organic matter from uneaten feed and facial material in the water column can increase the grazing activity of pelagic organisms such as zooplankton or bacterioplankton (Burford et al., 2003).

Particulate matter can also increase suspended solids concentrations in the water column, potentially increasing turbidity. In receiving environments that are less turbid than the discharge, increased turbidity can reduce light levels and decrease primary production. Upon settling to the substrate, suspended solids can also smother or change the community composition of benthic communities. However, as noted above, levels of suspended solids are likely to not be high in discharge waters.

Prawn pond discharge in northeast Queensland was found to:

- elevate nitrogen, phosphorus (bound to particles) and algal biomass near the discharge
- increase primary production near the discharge, with approximately 15% of the nitrogen transformed by the phytoplankton and approximately 10% of the nitrogen transformed by the microbial community within 2 km of the discharge
- increase denitrification near the discharge, removing approximately 6% of the nitrogen discharged
- increase zooplankton biomass, with high micro zooplankton grazing rates within 2 km of the discharge (likely to be feeding on phytoplankton and bacteria) and high mesozooplankton grazing rates further downstream (likely to be feeding on the microzooplankton derived from upstream)
- increase juvenile fish biomass at the discharge point (dominated by clupeids and engraulins), likely to be filter feeding particulate matter from the discharge
- favour filter feeding fish near the discharge and fish species that selectively fed on benthic epifauna and zooplankton further downstream
- provide a source of nitrogen for mangroves and macroalgae and
- have no obvious effect on sediment processes, possibly due to regular resuspension and removal downstream by the scouring action of strong spring tide currents and episodic rainfall events in this region (Burford et al. 2003).

These studies therefore carefully identified key processes and pathways associated with the 'bio-assimilation' in those environments.

Evidence from both CSIRO and James Cook University indicated that, notwithstanding the above observations, amongst the scientific community, the CSIRO and the universities, there is a very strong consensus that it is very difficult to find any impact of aquaculture on the Great Barrier Reef, notwithstanding localised changes. The Great Barrier Reef Marine Park Authority also outlined the differences in the receiving environments at different sites, especially contrasts between the Hinchinbrook Channel and Abbot Bay (Joint Standing Committee on Northern Australia, 2015). Thus the synthesis of the science undertaken is that any impact of prawn farming activity, if observed, is very localised.

6.3 ECOSYSTEM STRESSORS AND INDICATORS

Section 6.2 and Appendix B discuss and summarise the key risks and stressors relevant to the Project and receiving water quality. The key pressures relevant to water quality are discharges from construction activities and spills, and from site discharges of spent aquaculture water. The key stressors can be summarised as follows:

Construction

- Disturbance of Acid Sulfate Soils (ASS) - discharge of acidic water, potentially with elevated metals, into marine environments, altering pH levels and changing water/sediment redox reactions (may affect release of metals, phosphorous); reduction in dissolved oxygen levels in receiving waters (acid reactions) impacting marine organisms; direct toxicity from spills and leaks
- Clearing and ground disturbance - loss of sediment from disturbed areas; reduction in dissolved oxygen where large quantities of oxygen demanding substances enter receiving waters; direct toxicity from spills and leaks

Operation

- Spent aquaculture water discharges:
- Elevated nutrients and organic matter, potentially raising nutrient levels in receiving waters, leading to changes in biodiversity, community structure, enhanced primary production and grazer activity (algae, zooplankton and bacterioplankton), increased oxygen demand leading to reduced dissolved oxygen in receiving waters, and changes to marine plant communities
- Algae discharged from prawn growing tanks
- Disinfection products - disinfection of raceways and washwaters may be undertaken using chlorine compounds
- Filtrate Discharge from intake structure – elevated turbidity and suspended solids, altered pH in discharge from intake filters (back into near-intake waters)

Spills or leaks

- Direct toxic effects of fuels, oils, chemicals, etc.
- Indirect effects, including changes to pH (affects water chemistry, release of metals and phosphorous); oxygen demanding substances reducing oxygen, affecting organisms directly.

Since activities associated with construction (acid sulfate soils, clearing and ground disturbance) and spills or leaks are specifically addressed elsewhere in the Environmental Management Plan for the site, only the effect of prawn farm discharges is further addressed in this report.

Table 6-1 provides the key indicators chosen to assess site discharges and the above stressors. These have been selected to provide multiple lines of evidence (MLE) in the assessment of water quality impacts against each key stressor identified for the Project.

TABLE 6-1 INDICATOR SELECTION

Indicators		Stressor(s)	Type
Discharge Concentrations and Loads (Pressure)	Flow Nutrients (N & P), Chlorophyll a Suspended solids, turbidity	Nutrients, algae and solids load in discharges	Early warning Direct measure of nutrients and algae in discharges Direct measure of solids load in discharges, and
Discharge visual (pressure)	Visible oils, slicks, surface sheens	Indicators of pollution	Early warning
Receiving waters physico-chemical water quality (Stressor)	Nutrients (N & P) Chlorophyll a	Nutrients, algae in discharges, and resultant elevated primary productivity	Early warning, longer term water quality changes Indicator of primary productivity
	Suspended solids, turbidity	Algae and solids load in discharges Solids load in filtrate return	
	Dissolved Oxygen	Oxygen demanding substances and interactions	Early warning
	Chlorination - free chlorine, redox potential	Disinfection products in discharges (when used)	Early warning
	pH, temperature, salinity/conductivity	General indicators – may also be indicative of chemical reactions, relationships	Early warning Support other indicators and analysis
	Dissolved metals (Al, An, As, B, Be, Cd, Co, Cr, Cu, Fe, Pb, Hg, Mn, Mb, Ni, Se, Ag, Sn, U, V, Zn)	Provide baseline metals concentrations in receiving waters – if needed for comparison with toxicity / pollutant monitoring during operations	Pollution indicator, indicator of changes in receiving waters chemistry, tracer for altered inputs to receiving waters
Receiving waters visual (Stressor)	Visible oils, slicks, surface sheens	Indicators of pollution	Early warning
Ecological Health (Ecosystem receptors)	Mangrove intactness/extent, community composition, review of satellite imagery, δ15N signatures	Ecosystem health indicator of impacts from discharge quality and quantity	Biodiversity indicator Indicator of nutrient dispersal / uptake in receiving environment
	Benthic Macroinvertebrates - abundance and taxonomic richness	Ecosystem health indicator of increased nutrients from discharges	Biodiversity indicator
	Seagrass – presence, type, density	Ecosystem health indicator of increased	Biodiversity indicator

Indicators		Stressor(s)	Type
		nutrients from discharges	
	Sediment quality/chemistry – nutrients (N & P), total organic carbon, redox potential, pH, grain size, total metals (Al, An, As, B, Be, Cd, Co, Cr, Cu, Fe, Pb, Hg, Mn, Mb, Ni, Se, Ag, Sn, U, V, Zn)	Nutrients, organic matter in discharges, changes in sediment chemistry Total organic carbon, grain size and total aluminium provide means to normalise results Total metals indicate changes in sediment chemistry and release/uptake in sediments	Indicator of longer-term trends in nutrient / organic matter movement and sediment chemistry changes / accumulation

Based on Table 6-1, the following monitoring program would be undertaken, initially as a 2-year program, after which a review would be undertaken and the program revised if necessary:

Discharge monitoring:

- In-situ: pH, EC, DO, turbidity
- Phys-chem: TSS. TDS can be estimated from EC for the purposes of discharge monitoring
- Nutrients – TN and TP (given that the speciation of nutrients is likely to remain relatively constant)
- Biological - Chlorophyll a
- Other – visual indicators and odour.

Baseline/operational phase receiving environment monitoring:

- In-situ: pH, EC, DO, turbidity
- Phys-chem: TSS. TDS can be estimated from EC for the purposes of receiving waters monitoring
- Nutrients:
  - Nitrogen species (NH_4, NO_x, TKN, TN) and phosphorous species (FRP, TP)
  - Review need for speciation after initial 2 year operational monitoring program
- Biological - Chlorophyll a
- Other – visual indicators and odour
- Sediment sampling:
  - Sediment sizing, TN, TP
  - pH, redox potential, TOC
  - Total metals, including aluminium
- Ecological - mangrove ecological health and extent, benthic macroinvertebrates, seagrass observation (where present).

6.4 CONSIDERATION OF LABORATORY HOLDING TIMES

The analytes listed above generally have a reasonable holding time limit with laboratories, allowing for the samples to reasonably be transported to Darwin labs (for further transport to Brisbane, Melbourne or Sydney facilities) within the required time limits from this site. The analytes with potential issues due to short holding times, along with the recommended solution (after discussions with ALS Environmental, Australia), are as follows:

- pH, dissolved oxygen, turbidity, free chlorine, redox potential: these require testing in the field or on recently collected samples, as the holding times are quite short (~6 hours for pH, dissolved oxygen should be measured on fresh samples only, turbidity ~2 days, redox and free chlorine may also change quickly) – field measurement with field instrumentation will be used.
- Nitrate (NO_3), Nitrite (NO_2): the holding time for standard analysis is 2 days; however, with ultra-trace methods, as long as the sample bottles are frozen after collection, the holding time can be extended to 4 days. Given the low levels within the harbour these methods should be used regardless.
- Filterable Reactive Phosphorous: the holding times may limit standard sample collection methods, however alternative methods may be utilised to extend the holding times, including field filtering and potentially freezing (depending on the laboratory).
- Chlorophyll a: the standard holding time for Chlorophyll a is relatively short (~ 2 days), however this can be extended to 28 days or more by filtering and freezing the filter paper (i.e. the residue) in foil to exclude light.

Alternative methods are suitable, as long as they meet the method requirements of the NATA accredited testing laboratory.

7 BASELINE DATA REVIEW

7.1 OVERVIEW

The site is located on a peninsula on the southern shore of Bynoe Harbour, a macrotidal estuary located approximately 30km southwest of Darwin Harbour. Only limited previous water quality data was available for this location, limited to one sampling event in 2005 of physico-chemical and some nutrient and chlorophyll a in Mackenzie Arm and Port Patterson (Enesar, 2006) and some temperature and salinity data from the nearby pearl leases from 2002 to 2011 (though data is sporadic) and several sediment samples in the vicinity of the Project site. As such, a monthly water quality monitoring program was initiated by Seafarms in proximity to the site.

Water quality sampling has included a number of sites in proximity to the Project site, and representative of waters potentially affected by the proposed discharge. This data is shown in Appendix D, and includes a suite of physico-chemical and nutrient parameters along with Chlorophyll a. Toxicants (total and dissolved metals, hydrocarbons and pesticides) were measured on two occasions.

Sediment sampling has been conducted by Enesar (2006) on one occasion in 2005 (redox and particle size analysis, benthic macroinvertebrates), and at a number of sites within Bynoe Harbour and extending seawards by Siwabessy et al (2016) and GeoOceans (2011) (physico-chemical and particle size).

This section provides an assessment of the data with respect to seasonal and tidal variation, and variation with depth, along with a gap analysis for the baseline monitoring program. Importantly, the focus of this section is to assess how representative the data is and identify biases in terms of deriving guideline values and comparing before and after impact data. Some limitations in the data are described, however quantifying the scale of a particular influence is not necessarily required and is not considered a limitation unless otherwise noted.

7.2 WATER QUALITY

7.2.1 Sample Effort and Seasonal Variation

The baseline sampling effort has so far covered 2 wet seasons and 1 dry season. Compared to the longer term climatic averages in Figure 7-1, one of these wet seasons was relatively dry (1,119mm, Nov 2015 to May 2016), and one particularly wet (2,484mm, Nov 2016 to May 2017) . Monthly rainfall totals during the wet season were below average for the 2015/2016 wet season, and for the 2016/2017 wet season generally average up to January 2017 and above the 90th percentile totals after. As such, monitoring has captured one drier and one wetter than average wet season. Figure 7-1 shows the long term average and 90th percentile rainfall and mean maximum temperature against the actual monthly values over the sampling period, as well as when the actual sampling events occurred in relation to this rainfall.

The available water quality data for the relevant sites is summarised in Table 7-1, which shows the sample sites, total number of sampling events, the number by season (wet and dry), the sample period and resultant interval, and the months where any additional data were taken.

While one sampling event is available in 2005 (Enesar, 2006), there is only 1 site close to the Project, and given the long time lag it has not been included here.

The actual onset of rainfall combined with the effect on water salinity was used to identify the start and end of the wet season for the monitoring period. This aimed to capture the true seasonal influences on the waterways, rather than the average calendar timing.

Most of the sites are weighted in favour of wet seasons, with 68% of samples taken in the wet season. The water quality data shown in Figure 7-4 to Figure Figure 7-13 show that seasons likely have an important impact on water quality. Seasonal influences are considered important in capturing an unbiased baseline data set and in determining pre- and post-development impacts. As such, additional dry season baseline sampling is required, with an aim to even out the wet season bias in the sampling.

The sample locations are shown in Figure 7-2.

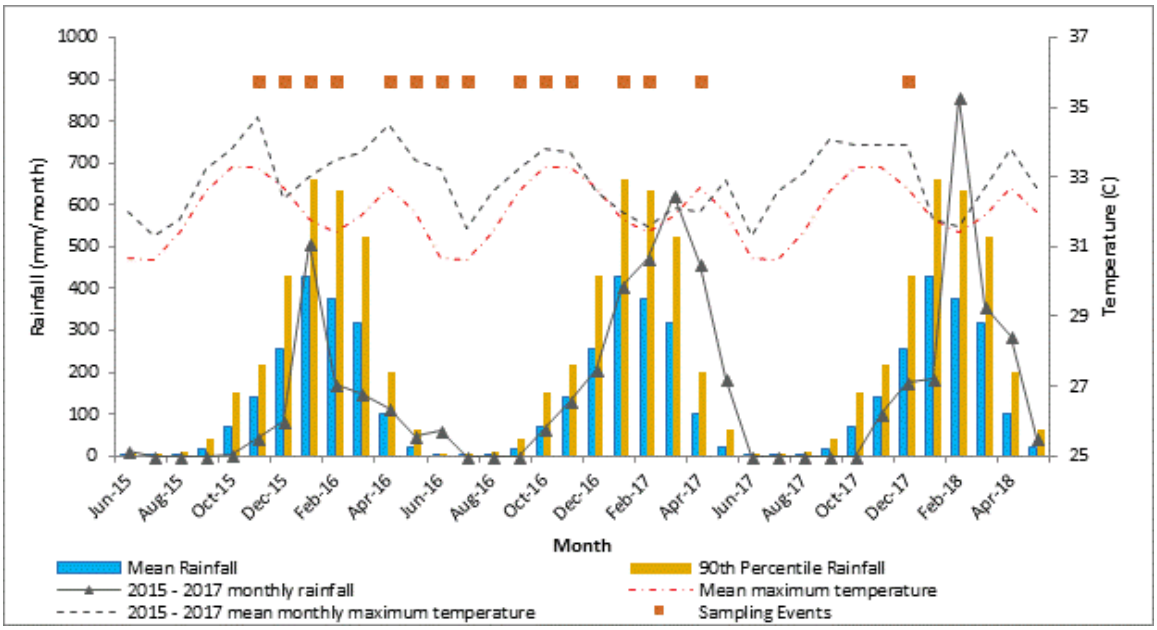

FIGURE 7-1 CLIMATE DATA COMPARED TO LONG TERM RECORDS

TABLE 7-1 SUMMARY OF SAMPLING EFFORT BY SITE

System	Site	Seasons			Additional Sampling Effort[1]	Sample Period	Sample Interval
		All	Wet	Dry			
Mid Estuary	BH01	16	10	6	Nov & Dec 2015: Toxicants – metals, hydrocarbons, pesticides Nov & Dec 2015: Alkalinity Dec 2015: Major cations & anions	Nov 15 – Dec 17	25 months (17 months to Apr-17, plus Dec-17)
	BH03	16	10	6			
Upper Estuary	BH02	16	10	6			
All		100%	63%	38%			

Table notes:
1 in addition to standard physico-chemical and nutrient/Chlorophyll a sampling

Sampling is currently short of the AWQG 24 data points (2-year monthly sampling regime), and marginally short of the QWQG 18 data points recommended for setting site specific guideline values. As can be seen, 63% of the sampling events were in the wet season, potentially biasing the results towards this season.

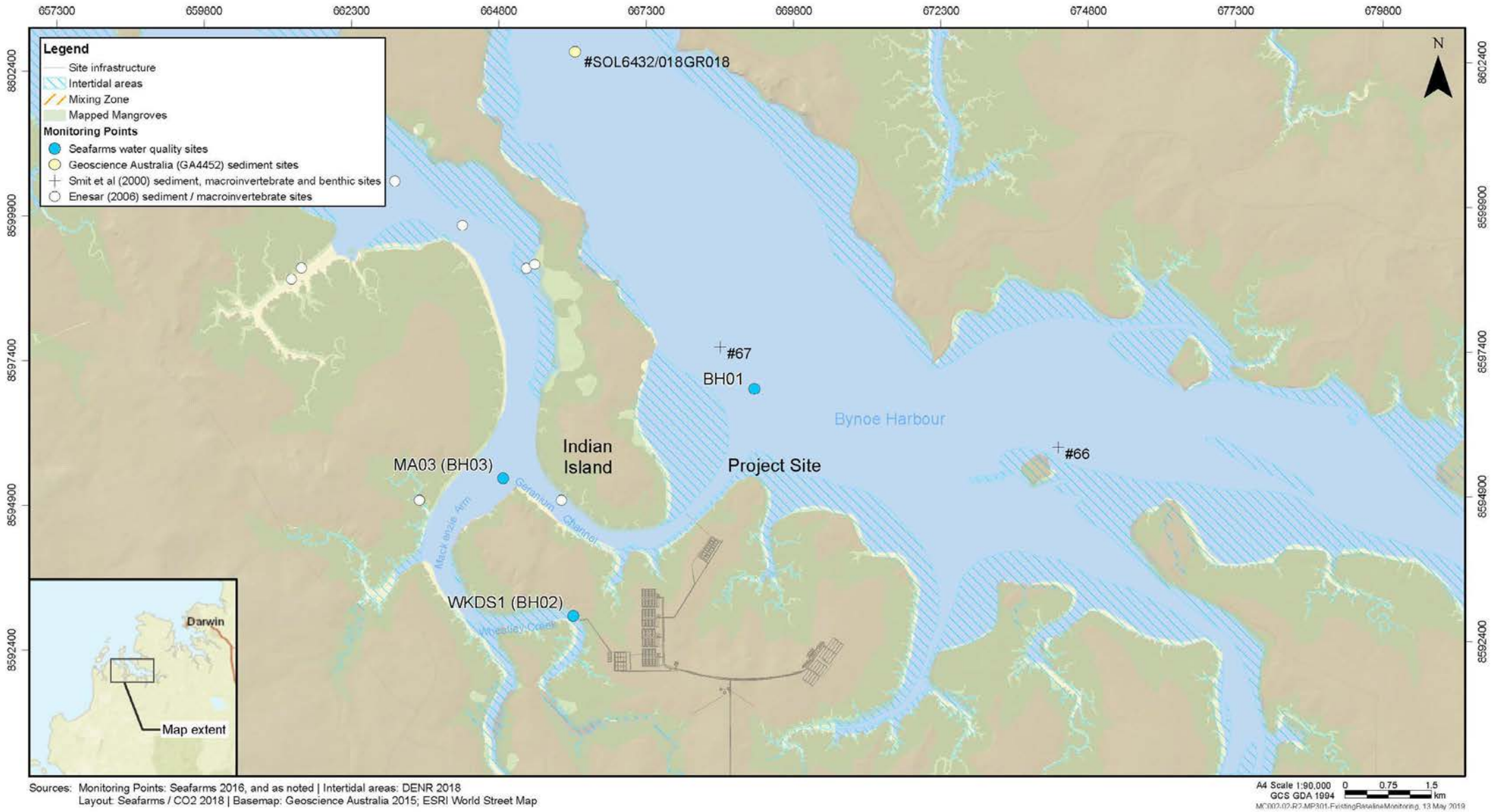

FIGURE 7-2 BASELINE SAMPLING LOCATIONS

7.2.2 Variation by tide and depth

Modelling conducted for the EIS (Watertech, 2016a) showed minimal variation in tidal height and phase between Burge Point, the proposed intake point and the discharge point in Wheatley Creek. Historical data for Burge Point was not readily available prior to 2018, however it was available for Charles Point Patches, off Darwin Harbour, which had essentially identical tidal phase, and similar tidal height. As such, this site was used to determine the tidal phase in relation to the date and time of sampling.

The sampling effort by lunar and diurnal tide cycles is shown in Table 7-2. As can be seen, half of the sampling events occurred during neap and during flood tides, with the remainder equally split between spring and transition (between spring and neap), and split 70:30 between ebb tides and highs respectively. However, in combination neap-ebb and inter-flood were most sampled (4 each, or 25% each), with the remainder ~2 or 12.5%.

TABLE 7-2 SAMPLING EFFORT BY TIDAL CYCLE

System	Site	Lunar Cycles*			Diurnal Cycles*			
		Neap	Spring	Transition	Flood	High	Ebb	Low
Mid Estuary	BH01	8	4	4	8	2	5	-
	BH03	8	4	4	8	2	5	-
Upper Estuary	BH02	8	4	4	8	2	5	-
	Flood: Ebb: High:	2 4 2	2 1 -	4 0 0				
All		50%	25%	25%	53%	13%	33%	0%

Table notes:
*discrepancies between lunar and diurnal cycles are due to a lack of times given for one Spring cycle event, resulting in unknown diurnal tide cycles for this event.

In the work completed for the EIS, Watertech (2016a) undertook continuous bed and surface salinity and temperature data collection in the vicinity of the proposed site during early December 2015, late January 2016 and mid-March 2016. Samples were collected across the flood and ebb tide, and during and after local rainfall. The impacts of the differing tidal states and rainfall appear to be minor and no pattern was observed in the measured data - very little vertical stratification within the waterbody was observed during the sampling occasions.

A similar assessment for the Legune Stage 1 Grow Out Facility was conducted, involving collection of water quality samples across tidal events and over a depth profile (see Seafarms, 2018). This similarly showed no appreciable impact from depth or tide on water quality results and given the above data from Watertech (2016a), a similar outcome is anticipated for this Project site.

As such, differences between diurnal tidal events are not expected to be significant.

Determining whether there are statistical differences between lunar cycles is compounded by differences between daily tidal cycles and seasons. Given that the bulk of the data has been collected during Neap cycles, further monitoring should be timed where practicable to capture more spring tide events, to provide a somewhat more balanced dataset.

7.2.3 Water Quality Results

The data from the baseline study has been summarised into Table 7-3, which includes medians and calculated guideline values using the 20th and 80th percentiles, along with estimates of error margins for comparison with the DHWQOs (using the standard error) after the QWQG approach. These are also shown graphically in Figure 7-3.

Graphs are also provided in Figure 7-3 showing the results for the key water quality parameters along with the relevant DHWQOs. Given the potential difference between wet and dry seasons, 10-day rainfall has been included on the plan, and wet seasons have been shown. The timing of wet seasons was determined based on salinity changes in receiving waters, as discussed further in Section 7.2.1.

The data shows that:

- Salinity was relatively stable during the dry season, at between 36 to 40ppt at all three sites. During the wet season, salinity dropped to as low as 12ppt at the BH02 Upper Estuarine site, while the Mid-estuarine sites dropped to 18 – 19 ppt. The 80th percentile statistics found no discernible difference between sites, however visually Figure 7-4 shows that the mid-estuarine sites were much more similar to each other, with the upper estuarine BH02 site departing from the other two on several occasions.
- Turbidity is below the DGV defined by the AWQGs of 20 NTU (none is given in the DHWQOs), and the results indicate the Mid-Estuarine sites (BH01, BH03) have lower turbidity (median ~3 NTU) than the Upper Estuarine site (BH02) (median ~5NTU). Turbidity appeared to drop through the dry season, with sporadic results during the wet seasons, possibly due to different effects of different sized storms immediately preceding sampling. The range was also larger in the upper estuarine BH02 site.
- Total suspended solids were above the DHWQO on 7 occasions at BH01 and BH03, and 9 occasions at BH02. The median of the BH01 and BH03 sites was below the DHWQO, although the error margin extended above, where the median and error range was above the DHWQO at BH02. Comparing the computed guideline values and the DHWQOs, it is evident that the DHWQO for total suspended solids are too low for the Project.

  The guideline value error range for mid-estuarine sites was above the criteria, however the error range for the upper estuarine guideline value was large, including the DHWQO (although the median range was much smaller). Together this indicates higher variability at the Wheatley Creek site, with the true statistic likely above the DHWQO.

  Similar to turbidity, total suspended solids appear to gradually drop during the dry season, before becoming more elevated during the start of the wet season.
- Ammonia appeared to respond to rainfall events with peaks generally, although not always, associated with rainfall. Results were compliant with the DHWQO criterion at all sites other than three occasions, all during the wet season:
  - January 2016, reaching 0.04 – 0.05mg/L (the DHWQO is 0.02mg/L) at all three sites
  - November 2016, at 0.05mg/L at BH01 only
  - February 2017, at 0.04mg/L at BH03 only

  However, the median (and 80th percentile) were below the DHWQO criterion at all three sites. Due the lack of data from limits of reporting issues, the lower limit of the 80th percentile error range could not be defined, and the actual upper error range is likely to be lower than shown. However, regardless, the calculated guideline values were at worst equal (mid-estuary) or lower than the DHWQO.

TABLE 7-3 COMPARISON OF BASELINE DATA WITH DARWIN HARBOUR WQOS

Parameter	LOR[6]	N	%ND[1]	Median*			Calculated Guideline Values #,[2]				DHWQOs[5]	
				BH01 (Mid Estuary)	BH02 (Upper Estuary)	BH03 (Mid Estuary)	BH01	BH03	Mid-Estuary[3]	Upper Estuary (BH02)	Mid-Estuary	Upper Estuary
pH	-	9	0%	7.9 ±0.1	7.8 ±0.1	7.9 ±0.1	7.9 - 8.1 (7.7 - 8.3)	7.7 - 8.1 (7.5 - 8.2)	7.6 – 8.0 (7.4 - 8.1)	7.6 – 8.0 (7.4 - 8.1)	7.0 - 8.5	6.0 - 8.5
Dissolved Oxygen (%Sat)	-	9	0%	Refer note 10							80 - 100	
Electrical Conductivity (µS/cm)	-	16	0%	53000 ±2600	48000 ±4400	54000 ±3400	55000 ±700	55200 ±700	55100 ±500	55200 ±1400	-	-
Salinity (as Total Dissolved Solids) (ppt)	-	16	0%	37 ±1.4	38 ±2.5	37.5 ±1.6	39 ±0.7	39 ±0.5	39 ±0.5	39 ±0.7	-	-
Turbidity (ntu)	-	15	0%	2.4 ±0.3	5.2 ±1.3	3.5 ±0.4	3.2 ±0.5	4.6 ±0.6	3.9 ±0.4	8.1 ±1.6	1 – 20[5]	
Total Suspended Solids (mg/L)	1	16	2%	7.9 ±2.9	15 ±3.7	9.7 ±2.1	23 ±8.0	17 ±6.3	20 ±5.8	21.6 ±18	10	
Ammonia (mg/L)[4]	0.010	16	63%	<0.010	<0.010	<0.010	<0.010 - 0.023	<0.010 - 0.021	<0.010 - 0.020	<0.010 - 0.017	0.020	
Oxidised Nitrogen (NO_x) (mg/L)	0.020	0	0%	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.030 ±0.012	0.020	
Filterable Reactive Phosphorous (mg/L)	0.005 - 0.05[7]	16	98%	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.005	0.010
Total Phosphorous (mg/L)	0.01 - 0.05[8]	16	52%	<0.050	<0.050	<0.050	<0.050 – 0.080	0.060 ±0.038	0.050 ±0.029	0.060 ±0.048	0.020	0.030
Total Nitrogen (mg/L)	0.1 - 0.2	16	31%	0.175 ±0.036	0.150 ±0.032	0.135 ±0.043	0.240 ±0.041	0.210 ±0.046	0.225 ±0.030	0.220 ±0.069	0.270	0.300
Chlorophyll a (µg/L)	1 – 5[9]	16	48%	1.1 ±0.2	1.0 ±0.3	1.0 ±0.4	1.9 ±0.9	2.5 ±0.6	2.2 ±0.6	2.1 ±0.4	2	4

Table notes:

* Compliance of median with DHWQOs: red indicates the median and the error range (median ± standard error (SE)) do not comply with the DHWQOs; purple indicates the error range (median ± SE) includes the area inside the compliance and non-compliance range – i.e. the true value could be compliant, or may not be compliant; orange indicates insufficient data (due to limits of reporting being too high). Green indicates the values are compliant with the DHWQO taking into account the SE range
# Acceptability of DHWQOs in comparison to calculated guideline values: Red indicates the error range does not include the DHWQO value, and exceeds the DHWQO value; Orange indicates the value exceeds the DHWQO, but the limit of reporting was too high to determine whether the statistic really complied
1 - % of the data below limits of reporting (ND = Non-Detects)
2 - Ranges show 20th to 80th percentiles, with the error margin in brackets representing the range: 20th percentile minus 1 standard error (SE) to the 80th percentile plus 1 SE. All other values are the 80th percentile ± 1 SE. All SE calculated using bootstrap methods in R. Non-detects were replaced with half the Limit of Reporting, as outlined in USEPA (2009) in Ofungwu (2014)
3 - The QWQGs recommend averaging the guideline values for the two sites (BH01, BH03) and then calculating standard error (SE) on these values. However, this ignores the underlying variability in the data. Instead, bootstrap methods were utilised whereby the average of the 80th percentile for the two sites was taken for each iteration, and the SE calculated on the resultant dataset.
4 - The 80th percentile for Ammonia is at the limit of reporting at all sites. With the standard error (SE), this results in a range extending below the limit of reporting (0.010mg/L). As such, only the range is provided with a lower limit at the limit of reporting.
5 - Values are the DHWQOs unless otherwise marked with the superscript '5' in which case they are from the AWQGs.
6 - LOR = Laboratory Limit of Reporting
7 – 62% were <0.005mg/L; 6% < 0.01mg/L and the rest (32%) <0.05mg/L. As such, 38% of the total results were below a limit of reporting that was higher than the DHWQO
8 – 88% were <0.05mg/, 8% were <0.02mg/L and the remainder (4%) were <0.01mg/L. With 52% non-detects, 46% of the total results were below a limit of reporting that was higher than the DHWQO
9 - 13% were <5µg/L; 43% <2µg/L and the rest (43%) <1µg/L. As such, 6% of the total results were below a limit of reporting that was higher than the DHWQO.
10 – the available data provides for low dissolved oxygen results for the bulk of the dataset. However, given the high value and well mixed nature of Bynoe Harbour, these are considered more likely to be erroneous (data from 2019 does not show such low results). As such, the data has not been used in this assessment (to be calculated following baseline assessment collection).

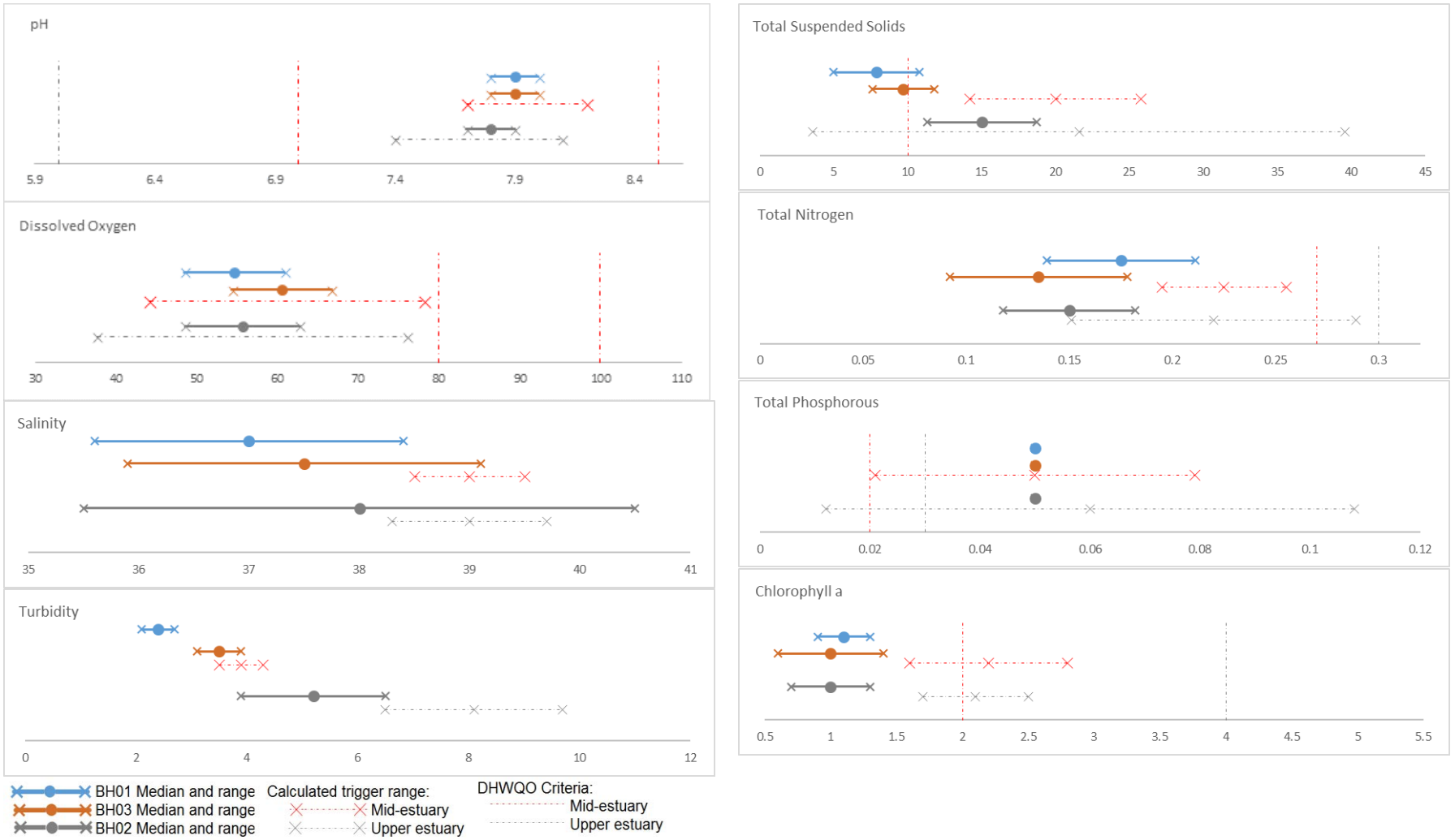

FIGURE 7-3 GRAPHICAL VIEW OF KEY WATER QUALITY STATISTICS

- Oxides of nitrogen (NO_x) showed a number of exceedances, all during the wet season other than June 2016 at BH01. There are some instances where first flush effects might be seen in the catchment, and it does appear that NO_x levels might be elevated during the wet seasons with lower levels during the dry.

  The 80th percentile data was less than the DHWQO in the mid-estuary (no error range available, due to limits of reporting issues), and included the DHWQO for the upper estuary, finding insufficient evidence of difference between the calculated vs DHWQO. Median values were <0.010 mg/L at all sites, indicating compliance with the DHWQO.

- Total Nitrogen varied over the sampling period, with elevated levels occurring in conjunction with rainfall events, indicating rainfall washoff impacts, as well as during occasions without any apparent rainfall influence. Total Nitrogen exceeded the DHWQO at all three sites on January 2017, with a single exceedance at each site, but on different occasions in December 2017 for BH01, May 2016 for BH02 and November 2015 for BH03. However, the medians were all below the criteria, including the error range.

  The 80th percentile range was also below the DHWQO at all sites, although not significantly so. Given the length of available dataset, the existing DHWQO is potentially still suitable for use at these sites.

- Filterable Reactive Phosphorous was not able to be assessed, since it was consistently below the limits of reporting (<0.05mg/L) but above the DHWQO value (0.02mg/L). On the one occasion when a result was obtained, it was below the DHWQO (0.005mg/L). Future sampling will need to utilise the correct methods for obtaining a suitable limit of reporting and additional monitoring may be required to obtain a long enough valid dataset.

- Total Phosphorous was lower in the wet season and higher in the dry, exceeding the DHWQO during the dry season and at a similar level to the DHWQO during the wet. There was 1 exceedance during the wet at BH01 and BH02 (both May 2016, 0.06mg/L) with 4 possible exceedances at BH01 during other wet season events (LOR > DHWQO). 2 exceedances were recorded at BH03 during the wet (0.03mg/L in January and 0.06mg/L in May 2016) with 4 possible exceedances at other wet season events (LOR > DHWQO).

  Median results were unable to be clearly defined due to limits of reporting issues, however given the available data are anticipated to be above the DHWQO value. The 80th percentile statistics were also above the DHWQO for the mid-estuary. The error range for the upper estuary guideline value included the DHWQO value, however the error range was quite large, and the estimated guideline value itself indicates that it too exceeds the DHWQO. As such, the DHWQO for total phosphorous is unlikely to be suitable for the Project receiving waters.

- Chlorophyll a shows a potential elevation during rainfall periods, with peaks associated with rainfall peaks, although one peak was recorded in June 2017, following a peak in total phosphorous and oxides of nitrogen in June 2016 accompanied by lower turbidity levels and no rainfall. A number of exceedances of the mid-estuarine criteria were recorded, with none at the BH02 upper estuarine site (levels were similar, with a higher DHWQO in upper estuarine sites). BH03 recorded 5 exceedances, with only 2 at BH01, likely reflecting the impacts from upstream waters at the BH03 site compared to the Bynoe Harbour main channel at BH01.

  Median results are compliant with the DHWQO, with the 80th percentile range including the mid-estuarine DHWQO at all sites indicating no statistical difference. The upper estuarine calculated range was below the DHWQO for upper estuarine waters.

- Dissolved Oxygen was generally below the DHWQOs, other than a marginal reading at BH03 in May 2016, and compliant results in December 2017. Given the nature of Bynoe Harbour (well mixed, good condition),

it is considered that these results are more likely to be errors, such as from the delay between sample collection and testing, improper calibration, or other similar issues.

- pH data is only available essentially for the 2016 dry season, the 2016/2017 wet season, and one sample in the 2017/2018 wet season. It appears that a general drop in pH might occur during a wet season, with levels increasing during the dry. Results were compliant other than one minor elevated result at BH01 in November 2016.

  Median results were fully compliant at all sites, and the calculated guideline values were within the DHWQO range at all sites, although with a much narrower range than the DHWQOs. Given the amount of data the calculated guideline values are based on and the general acceptability of this pH range within Australian waters, indications are that the DHWQO pH criteria are suitable for application at the Project site.

The results show that the sites complied with the relevant DHWQOs (i.e. the median was below the criteria) for all sites and all parameters with the exception of dissolved oxygen (low), total suspended solids (high) and potentially total phosphorous at the mid-estuarine sites (<0.05mg/L compared to 0.20mg/L limit).

Calculated 80th percentiles and error ranges supported the use of the DHWQOs for the Project for pH, ammonia, oxidised and total nitrogen at all sites, and for Chlorophyll a at the mid-estuarine sites.

Chlorophyll a at the upper estuarine BH02 site was below the DHWQO and indicated the mid-estuarine DHWQO might be suitable. Total suspended solids and total phosphorous guideline values appear to be elevated compared to the DHWQO. Further monitoring should be undertaken to determine whether alternative guideline values may apply.

Site specific guideline values may be needed for total suspended solids and total phosphorous, with further investigation required to determine if dissolved oxygen and filterable reactive phosphorous also truly deviate from the DHWQOs. Based on the results in Table 7-3, a guideline value for turbidity might also be applied, which would differ for mid and upper estuarine sites.

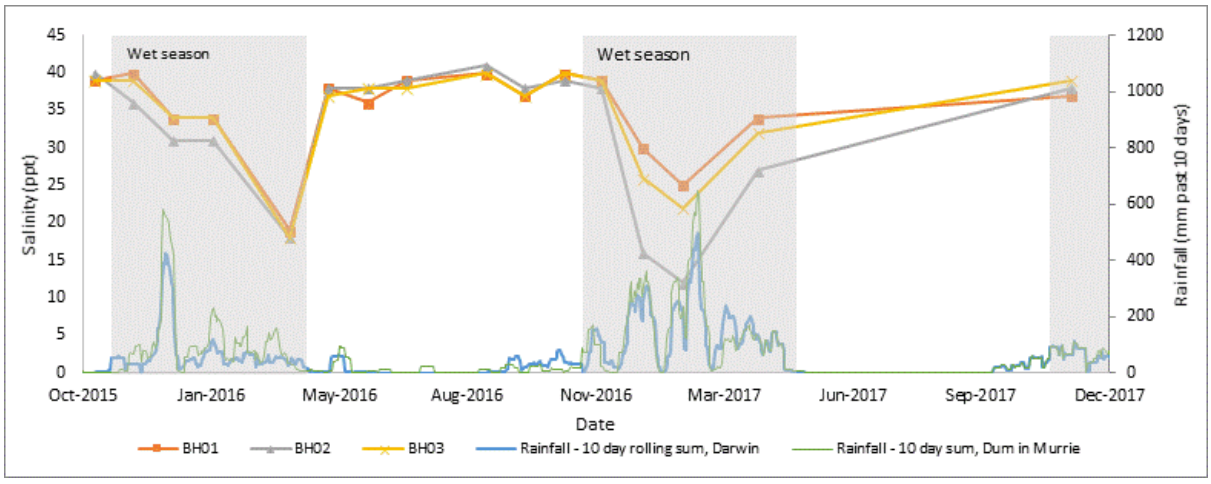

FIGURE 7-4 SALINITY 2015 – 2017 AT BASELINE SITES

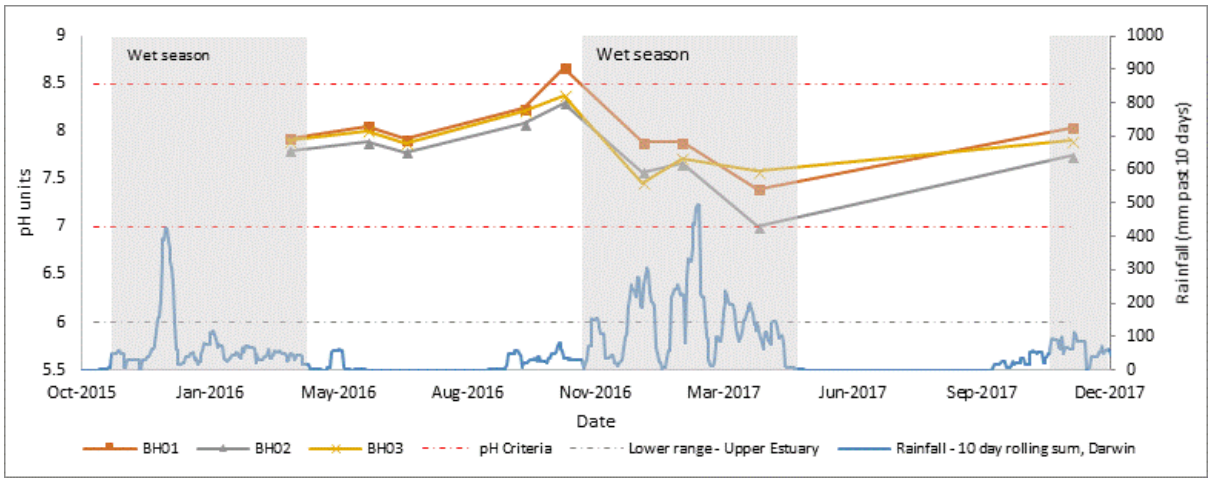

FIGURE 7-5 PH 2015 – 2017 AT BASELINE SITES

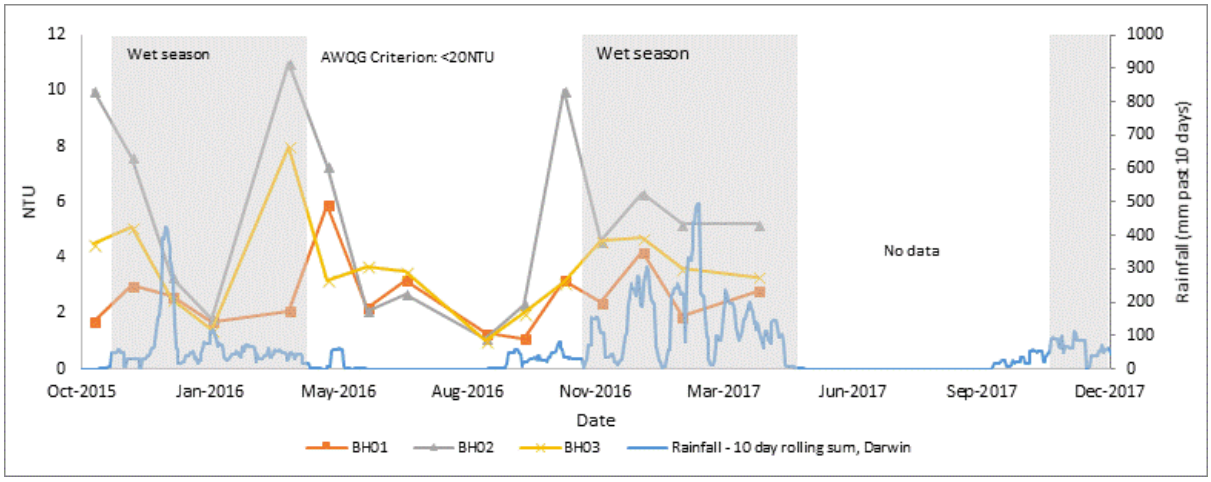

FIGURE 7-6 TURBIDITY 2015 – 2017 AT BASELINE SITES

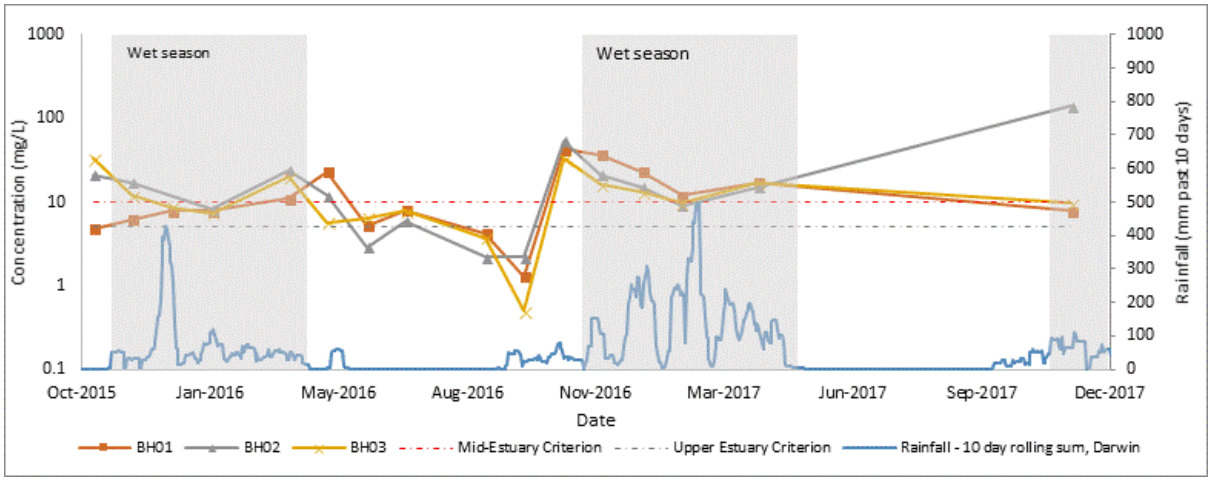

FIGURE 7-7 TOTAL SUSPENDED SOLIDS 2015 – 2017 AT BASELINE SITES

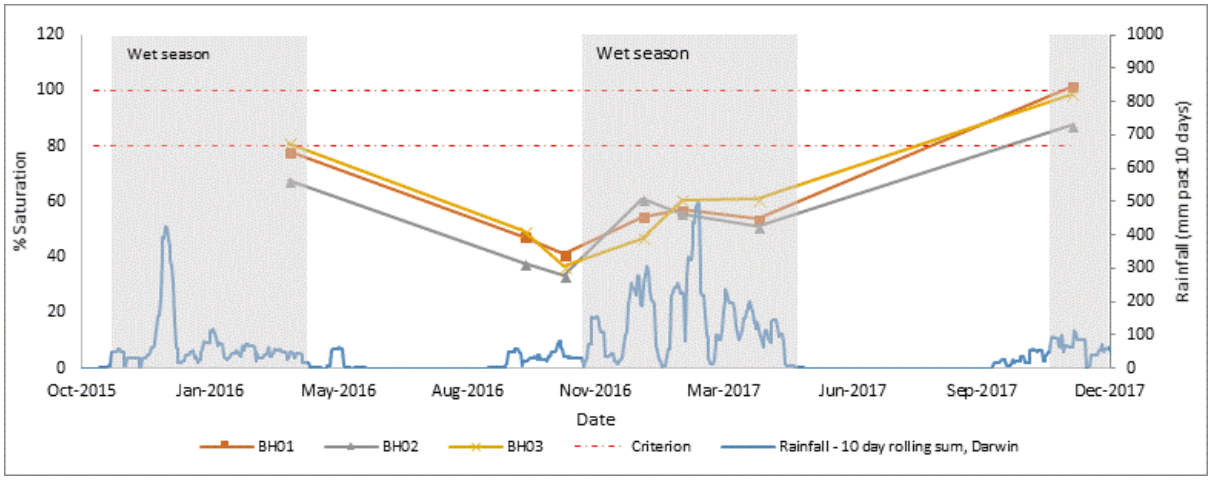

FIGURE 7-8 DISSOLVED OXYGEN 2015 – 2017 AT BASELINE SITES

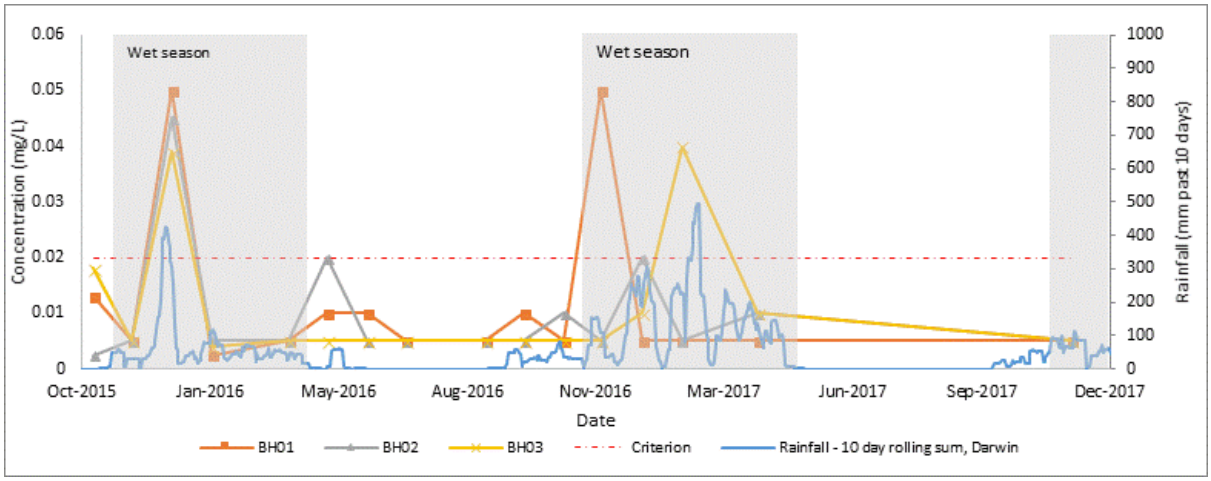

FIGURE 7-9 AMMONIA 2015 – 2017 AT SELECT SITES

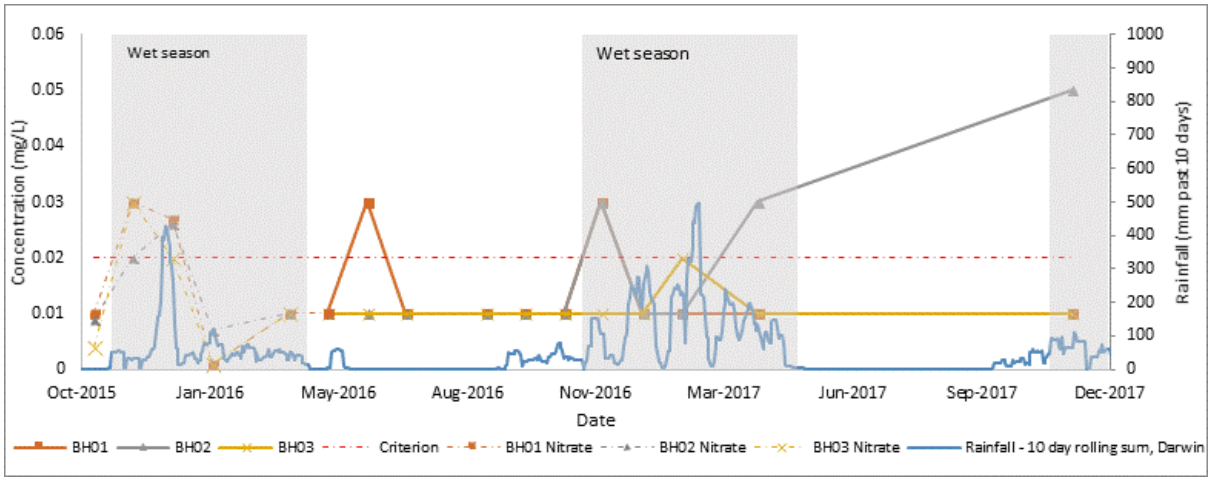

FIGURE 7-10 OXIDES OF NITROGEN (NOX) 2015 – 2017 AT SELECT SITES

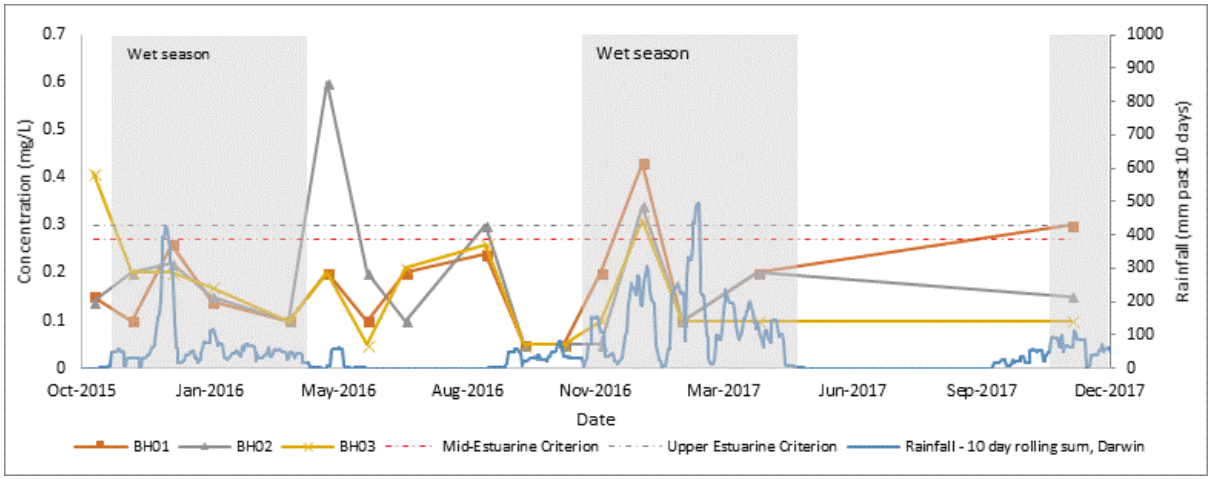

FIGURE 7-11 TOTAL NITROGEN 2015 – 2017 AT SELECT SITES

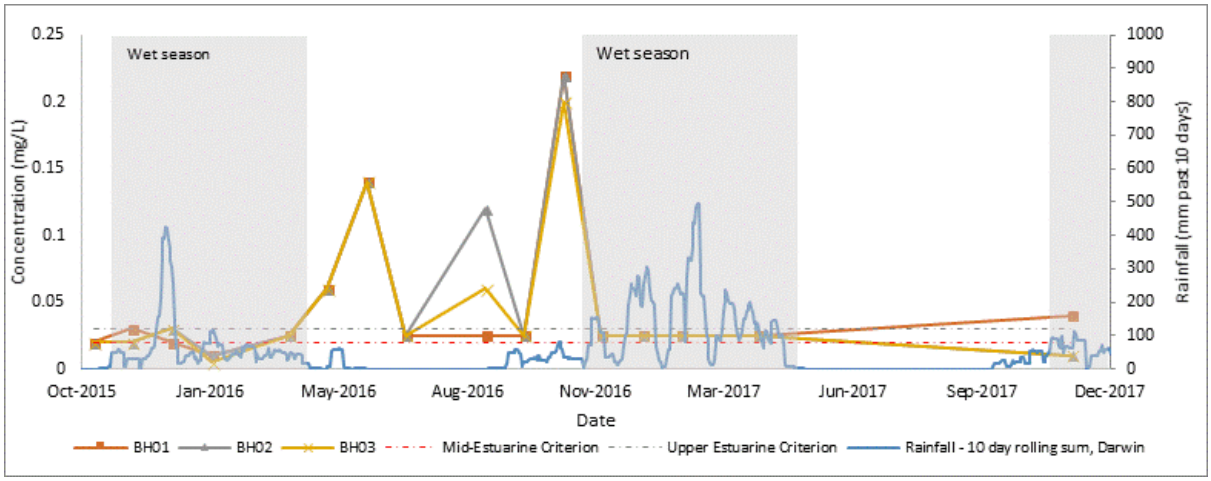

FIGURE 7-12 TOTAL PHOSPHOROUS 2015 – 2017 AT SELECT SITES

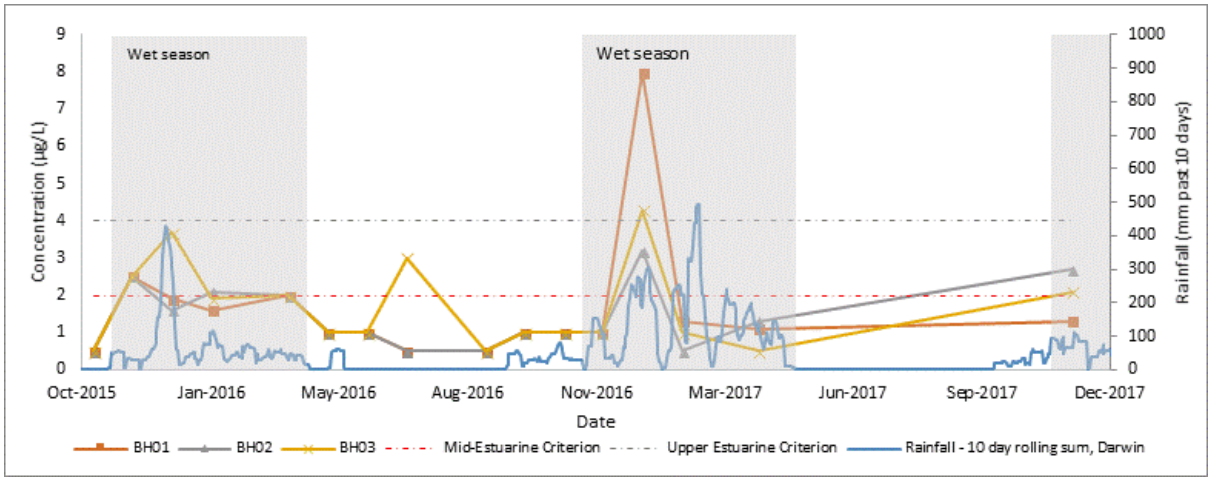

FIGURE 7-13 CHLOROPHYLL A 2015 – 2017 AT SELECT SITES

7.2.4 Toxicants

Sampling for hydrocarbons, pesticides and metals (total and dissolved) was conducted during November and December 2015. All hydrocarbon and pesticide results were below the limits of reporting. For heavy metals, only antimony, manganese and vanadium were clearly below the AWQG default guideline values (DGVs). Total metals levels above the low reliability marine DGVs were recorded for aluminium (2 sites in December 2015) and Boron (all sites and both occasions), and above the marine 95% species protection level for zinc (2 sites in both sampling events). For dissolved metals, all levels were below the limit of reporting other than boron (all above the low reliability marine value) and zinc (3 above the marine 95% level).

The remaining metals results were less than the limit of reporting, which was above the DGVs – therefore additional exceedances may have occurred that cannot be seen in the data. This included aluminium, arsenic, beryllium, cadmium, potentially chromium (limit of reporting > DGV for Cr VI but less than the DGV for Cr III), cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver and tin.

Toxicants assessment data from Darwin Harbour from 2002 – 2003 and 2010 – 2011 (French et al, 2015; Darwin Harbour monitoring sites G8155467, G8150138, G8155134), where the limits of reporting were below the DGVs was assessed, showed the following key results:

- All aluminium results were above the low reliability marine guideline value
- Total arsenic was elevated above the low reliability guideline value in 2002 – 2003, but below in later years, and no exceedances were found for dissolved arsenic
- Total chromium recorded two exceedances above the Cr III 95% marine guideline value in 2002 at the same site, with all results above the Cr VI 95% marine guideline value in 2002 – 2003. All results in 2010 – 2011 were below, and no exceedances were recorded for dissolved chromium
- Total copper, similarly to total chromium, was above the 95% marine guideline value in 2002 – 2003, but below in later years and in the dissolved fractions
- Total manganese recorded two results above the low reliability marine guideline value value in 2010 and 2011, with no dissolved fraction exceedances
- Zinc was generally below the 95% marine guideline value other than one marginal result at one site in 2002.

Results for cadmium, cobalt, lead and nickel were all below the guideline value, with all dissolved results (only available for 2010 – 2011) below the guideline values other than aluminium.

The above indicates that a number of metals are likely to be below the guideline values within Bynoe Harbour, particularly antimony, manganese and vanadium, with total cadmium, cobalt, lead and nickel likely to be low based on the Darwin Harbour results. Of the remaining metals, most of the dissolved fractions are likely to be below the guideline values based on both sets of data, with the exception of aluminium, boron and zinc, although both aluminium and zinc are based on low reliability guideline values.

To adequately demonstrate that elevated metals concentrations in receiving waters are not associated with Project discharges, additional baseline monitoring for both total and dissolved metals is required. This needs to incorporate laboratory limits of reporting that are equal or lower than the guideline values.

7.2.5 Summary

The 16 data points collected for the key indicators is below the 24 months recommended by the AWQG, although close to the 18 data points recommended by the QWQG. The QWQGs note that for the 20th and 80th percentile values, 'error values tend to level off at around 15–20 data values, suggesting this number of samples [i.e. 18] is sufficient to provide a reasonable estimate of the true percentile value'. They also state that 'percentile estimates based on eight or more samples could be used to derive interim guidelines on the understanding that further data would be collected and guideline values updated accordingly'. The baseline dataset currently has 16 data points for the critical parameters of total nitrogen and phosphorous and Chlorophyll a, slightly short of the recommended 18, but within the above range. Additional baseline monitoring should be conducted, and the guideline values reviewed, including for seasonal guideline values where appropriate.

The data is slightly biased towards wet seasons, with 63% of events in the wet, and biased towards neap (50%) and flood (53%), with spring and transitional periods being equally represented (25% each). The remaining diurnal patterns included ebb tides (33%) and high tides (13%). Given the available data, differences between diurnal tidal events are not expected to be significant, but the bias towards neap tides may require some balancing during remaining baseline sampling.

The physico-chemical and nutrient results show that the sites complied with the relevant DHWQOs (i.e. the median was below the criteria) for all sites and all parameters with the exception of dissolved oxygen (erroneous readings), total suspended solids (high) and potentially total phosphorous at the mid-estuarine sites (<0.05mg/L compared to 0.20mg/L limit). The laboratory limit of reporting was too high to determine filterable reactive phosphorous levels.

The calculated guideline values (based on 20th and 80th percentiles) were comparable to the DHWQOs with the exception of total suspended solids, total phosphorous, dissolved oxygen and filterable reactive phosphorous (which could not be determined). No DHWQO for turbidity exists, however one might be developed from the baseline data if required.

Two sampling events for toxicants (metals, hydrocarbons and pesticides) were conducted in late 2015, indicating low to no hydrocarbons and pesticides in receiving waters, as would be expected (refer Section 3.5). Metals results showed exceedances of the low reliability marine guideline values for aluminium and boron, and of the 95% marine trigger value for zinc, with limits of reporting for most other elements above the guideline values. Additional monitoring of metals is required.

In terms of before-after and control-impact comparisons, the above data would likely be suitable to determine some control-impact comparisons for mid-estuarine waters. Additional sites within Wheatley Creek, upstream in Mackenzie Arm and in comparable upper estuarine control sites would be preferable to provide for suitable pre-operational data.

7.3 SEDIMENT AND BENTHIC SAMPLING

7.3.1 Benthic Habitat

Few observations of benthic habitat have been made in the region of the Project site. Data from Smit, et al (2000) was used by GeoOceans (2011) to infer the sediment type in the region of the site, as shown in Figure 3-1, which shows predominantly sandy substrate with areas of rocky shelf and gravel. Watertech (2016a) observed that the adjacent intertidal platform comprised a combination of sandy material intermixed with finer silts (near mangroves) and cobble and rock beds, and Enesar (2006) described sediments in the area as 'soft, brown-grey mud', with the site located close to the Project within Geranium Channel comprised of sand over sand and mud, with coarse material including shell and pebbles present.

While habitat mapping data available from DLRM identifies the nearest seagrass meadows to be around 16km from the Project site (refer Figure 3-1), Smit et al (2000) reported patchy seagrass beds in the intertidal–subtidal interface and in the very shallow subtidal areas of Bynoe Harbour, including near Point Ceylon, and Enesar (2006) described seagrass as 'sparse and patchy in nature' in the Bynoe Harbour area. Seagrass species that have been recorded in the Bynoe Harbour region include *Halophila decipiens*, *Halodule uninervis*, and *Enhalus acoroides* (Smit et al, 2000 and references cited therein). Site observations do not indicate presence of any of these previously described meadows within the proposed Project area (Water Technology, 2016a), also confirmed by Enesar (2006) in proximity to the site.

Benthic macroinvertebrate assessment was conducted by Enesar (2006), who observed numerous burrows in bottom sediments in proximity to the Project site, although none in the Geranium Channel site close to the Project. No macroscopic plants were observed due to 'the high attenuation of light in the muddy estuarine waters'. Benthic infaunal analysis was conducted, finding no obvious signs of existing impacts on macrobenthic communities, and providing some nearby baseline data to draw from, noting animal and species numbers were consistently low at the subtidal site close to the Project. Another macrobenthic faunal sample was collected by Smit, et al (2000) near to the BH01 site.

Given the age of the above data (and the one sampling event in each case), its usefulness is likely limited other than to potentially indicate change over this long term period.

The intake pipe is located in Geranium Channel in an area likely characterised by sand substrate and associated benthic fauna. The proposed Wheatley Creek discharge point is located in approximately 3-7 m water depth in a highly variable area with a combination of rock, mud, clay and sand (Watertech, 2016a). Baseline benthic habitat mapping for these locations, along with suitable control-impact benthic macroinvertebrate monitoring locations, needs to be conducted prior to construction in these areas commencing.

While no substantial seagrass beds are anticipated, visual observations for seagrass presence and abundance in the locations noted by Smit et al (2000) should also be undertaken. As such, the baseline program needs to include these nearby sites, and the location and characterisation of representative areas around the Project area, and to include them in ongoing ecological impact monitoring should they be located.

In terms of macrobenthic communities, establishment of control-impact sites are required. Resampling of some of the nearby Enesar (2006) and Smit et al (2000) sites should be conducted to understand long term (~13 year) changes in the area.

7.3.2 Sediment

Some baseline sediment data is available, with one Geoscience Australia site (Siwabessy et al, 2016) located east of Indian Island within the Bynoe Harbour main channel (6.6km downstream of BH01); 3 sites by Smit et al (2000) stretching along the Bynoe Harbour main channel, from 5.2km upstream of BH02, to a site ~1km downstream and another 8.8km downstream from BH01, and several locations in proximity to the Project site by Enesar (2006). Siwabessy et al (2016) included testing for major, minor, trace and rare earth elements, organic and inorganic elements, with Smit et al (2000) including data on grain size and carbonate content. Enesar (2006) provided particle size analysis, visual observation information (mottling, gas bubbles, odour, colour) and redox potential.

Additional sediment sampling is warranted, both in some of the above locations and in areas closer to the proposed discharge point. Covering the above locations will enable comparison to the older data where results are similar, or indications of change over time where they are not.

7.4 MANGROVES

Brocklehurst and Edmeades (2003) undertook a mangrove assessment within Bynoe Harbour, including interpretation of aerial photography and ground truthing during the 1998 dry season. More recent work was undertaken by Cardno (2013) who prepared a Darwin Harbour region remote sensing baseline report, covering Darwin Harbour and Bynoe Harbour. This data and the methods employed can be used to compare mangrove cover and general community health in the areas in closest proximity to the Project should the need arise in the future, although based on the report results, additional satellite imagery may be required to fully cover the Bynoe Harbour area.

8 CONCEPTUAL MODEL

A conceptual model has been developed for the harbour and Wheatley Creek, using information from the EIS (Seafarms, 2017), the water technical reports (Watertech, 2016a; 2016b) and the marine fauna assessment (GHD, 2016). Key characteristics are as follows, with the important nutrient cycling processes summarised in Figure 8-1.

Bynoe Harbour

- A macro-tidal (semi-diurnal) tide dominated estuary with a maximum tidal range of 7.6 m, well mixed with very little vertical stratification.
- Total Bynoe Harbour catchment approximately 1,000km^2, including Turnball Bay. Runoff responsive to rainfall with low continuing baseflow ('peaky' behaviour).
- Salinity is primarily influenced by offshore salinity levels during the dry season, and catchment runoff during the wet season, with potential for salinity levels to increase upstream of the estuary system at the end of the dry.
- Shores vary between intertidal mangrove backed shorelines, rocky headlands and sand spits with sandy berm beaches. Relatively stable shoreline, with only small and isolated pockets of erosion or deposition.
- Main channel sediments consist primarily of sandy gravels and gravels, while the lateral channel banks consist mainly of mud and sand flats with the occasional rocky outcrops and rocky/coral reef.
- Sediments are delivered to Bynoe Harbour primarily during high rainfall and runoff events through the creeks, and either carried in suspension out of the harbour by the strong tidal currents or deposited in the mangrove forests along the shoreline. Bottom sediments have a high proportion of sandy and gravel material, while Port Patterson, located west of Indian Island, has a higher proportion of fines indicating a less energetic tidal regime.
- While moderate to high turbidity is common throughout the year due to strong currents and in response to large rainfall events, generally turbidity is moderate to low, particularly during the dry season.
- Nutrient inputs are expected to be relatively low from the terrestrial catchments and tend toward higher concentrations due to less flushing, dilution, and greater tidal resuspension and recycling during dry periods.
- Few potential sources of pollution, include a rural block subdivision south of the site (draining into Mackenzie Arm) which includes some small-scale agriculture, the Crab Claw resort approximately 7km to the east, and the Paspaley Pearling Company oyster beds which are located just north of Point Ceylon.
- Benthic communities dominated by sponges and soft corals on reef communities, together with hard corals of the genus *Turbinaria*. Recent video monitoring indicates limited benthic communities in proximity to the Project, as scattered individuals rather than dense communities.
- Benthic invertebrate communities are generally diverse with low levels of faunal dominance.
- The nearest seagrass meadows are located west of Indian Island, approximately 16km from the site. Seagrass beds are present in the intertidal – subtidal interface in the very shallow areas of the harbour, with patchy beds near Point Ceylon. Recent monitoring indicates at best very patchy occurrence of seagrass in proximity to the Project.
- Chlorophyll a levels are relatively low, with small peaks associated with rainfall events, indicating flushing of nutrients into the harbour.

- Concentrations of dissolved inorganic nitrogen are low as a proportion of total nitrogen, and both nitrogen and phosphorous are generally moderate to low.
- While filter feeders do exist, high channel currents limit suitable habitats in proximity to the Project.
- Migrant and resident shorebirds, fish and reptiles feed on macroinvertebrates – capturing carbon and nitrogen.
- No turtle nesting beaches at the Project site and immediate surrounds, with the closest 15km away at the northern end of Indian Island. Other migratory megafauna may be present at times, though the Project area is not mapped as a biologically important area for these species, and shore birds are not typically found feeding in large numbers in the channelised intertidal zones in proximity to the Project, although depositional broad intertidal flats do occur elsewhere within the harbour, which are more preferred feeding areas.
- Denitrification through the water column and sediment.

Point Ceylon and channels

- Tide dominated coastal creeks, ranging in depths from 8m below mean sea level in Geranium Channel, to 10m in the Mackenzie Arm main channel. Wheatley Creek varies between 7m at the connection to Mackenzie Arm to 5m below mean sea level at the release point, with pools and shallower sections at shallower than -3m AHD, indicating that sections may dry out during low tide.
- Small onshore catchment areas, with distinctly seasonal stream flows concentrated during the wet season. Mackenzie Arm catchment comprised of predominantly large rural residential properties with some small scale agriculture; Wheatley Creek predominantly mangrove forests and salt flats.
- Relatively shallow offshore areas from Point Ceylon with a large rocky reef present.
- Wheatley Creek has a highly variable bed and bank material, with a combination of rock, mud, clay and sand and with a relatively stable bankline.
- Extensive mangrove areas, between 50 – 300m wide along the creek.

In the wet season, water from the catchment is flushed into the estuarine receiving environment from heavy rainfall. This catchment run-off transports freshwater, sediment loads and detritus that have built up during the dry season. Within the freshwater and sediments, nutrients are transported and deposited further downstream. Low nutrients may limit primary productivity, as well as turbidity spikes during rainfall periods. However, nutrient levels in the water column do not fluctuate significantly with rainfall.

Figure 8-1 summarises the processes within the system relating to the key pressures and stressors from the Project identified in Section 6.3, and summarised in Table 6-1, namely:

- Increased nutrients, algae and solids load in discharges.
- Oxygen demanding substances and disinfection by-products in discharges.

Resultant elevated primary productivity, smothering and direct impacts, including lowered oxygen levels.

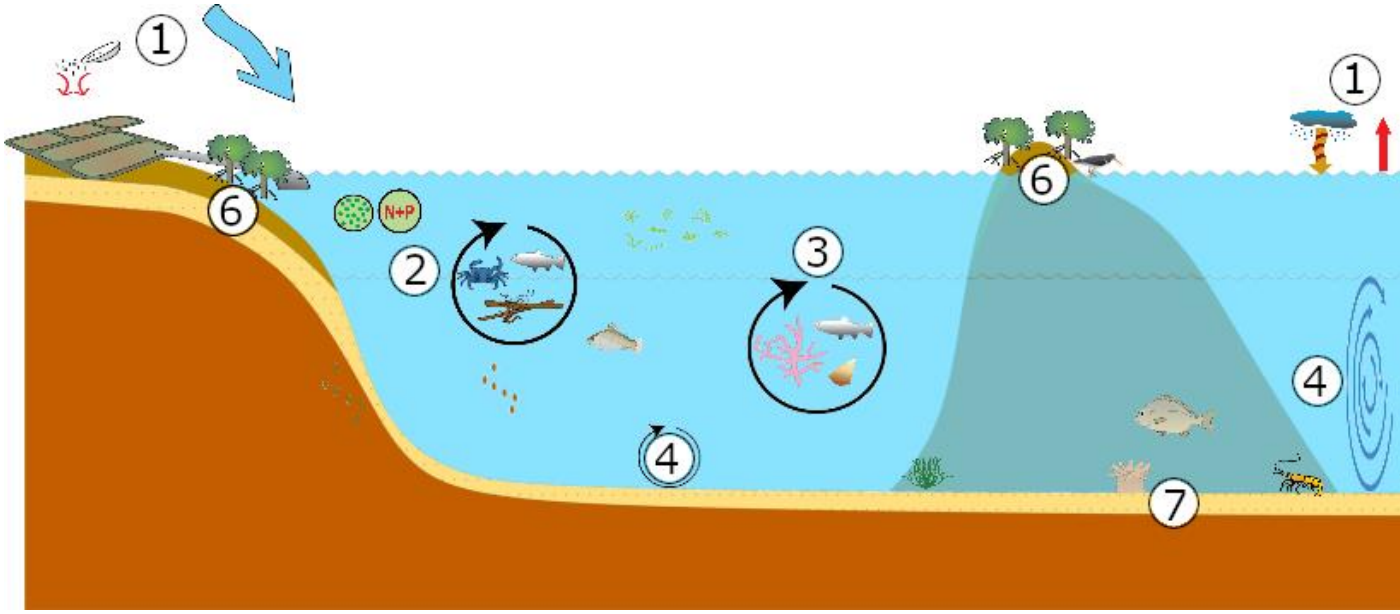

FIGURE 8-1 CONCEPTUAL MODEL OF ESTUARINE RECEIVING ENVIRONMENTS

1. Inputs of feed, algae and plankton food for prawns, chlorine for disinfection (settled and dissipates before release); catchment inputs of freshwater, terrigenous sediments and detritus in wet season; atmospheric deposition of nitrogen, and denitrification.
2. Discharge dominated by particulate N and P, phytoplankton and algae; minimal sediments, other than particulate organic matter; pH, DO within suitable ranges.

   Near the outfall, dissolved organic nutrients increase primary productivity; particulate organic matter and phytoplankton plus increased primary productivity increase pelagic zooplankton grazing; increased juvenile fish near outfall, favouring filter feeding fish; increased denitrification.

   Particulate organic matter (and solids) settle.

   Conversion of dissolved inorganic Nitrogen (DIN) to particulate Nitrogen (pN) in primary productivity (~25%), movement of N from particulate matter into detrital feeders, pelagic organisms.
3. Increased grazing of mesozooplankton downstream, feeding on microzooplankton; fish feedng on benthic organisms and zooplankton further downstream
4. High tidal velocities in channel resuspend sediments, and resuspend pN, some pN remineralisation to DIN; tides result in well mixed water column, no stratification (may be some higher salinity water develop upstream in the dry season, sink and move seaward under 'fresher' top waters, though significant mixing still likely)
5. Net export of nutrients and sediments to sea due to tidal movements; DIN reaching ocean assimilated by marine phytoplankton and converted into pN; Seagrass at mouth of harbour process N exported from the estuary
6. Deposition of finer sediments near shallow mangrove areas; resuspension of settled sediments, particularly fine sediments, in deeper areas, and net flushing from system; pN and DIN washed into intertidal areas. Some DIN converted to pN by benthic organisms, increasing productivity. N fixation from atmosphere; mangrove sediments a sink for DIN
7. High velocities in main channels, coarser substrate; sparse and scattered benthos in proximity to site;

9 DISCHARGE CRITERIA AND GUIDELINE VALUES

The discharge criteria were defined using licence conditions from existing prawn farms operated by Seafarms, and the EIS impact assessment was based on these and background levels developed from the baseline data available at the time. The assessment found compliance for total nitrogen and marginal exceedance for total phosphorous.

The modelling (refer Watertech, 2016a) relied on the following background and added concentrations for total nitrogen and total phosphorous and chlorophyll a:

- Total Nitrogen: background of 0.2mg/L based on median in receiving waters; increase due to discharges 0.06mg/L in Wheatley Creek and 0.005mg/L towards Geranium Channel
- Total Phosphorous: background of 0.02mg/L based on median in receiving waters; increase due to discharges 0.013mg/L in Wheatley Creek and 0.002mg/L towards Geranium Channel

Chlorophyll a was modelled by Watertech in a memorandum post-dating the EIS (Watertech, 2017) using a background of 1.0µg/L based on available data (median in receiving waters). The results showed an increase of 0.4µg/L in Wheatley Creek, reducing to 0.12µg/L in Mackenzie Arm. Note that Chlorophyll a relates to the discharge as an indicator of algal / primary production load into the receiving environment. The modelling did not set out to determine dynamic uptake, conversion, or effects of nutrients in the environment directly on Chlorophyll a levels.

A re-analysis of the complete dataset finds the following:

- Total Nitrogen: the median background level is 0.21mg/L in Wheatley Creek, and ~0.18mgL in mid-estuarine waters. With an additional 0.06mg/L in Wheatley Creek, this elevates the potential concentration to 0.27mg/L, below the DHWQO of 0.30mg/L. Towards Geranium Channel, the additional 0.005mg/L would increase it to 0.185mg/L, below the DHWQO of 0.27mg/L.
- Total Phosphorous: the median background level is <0.05mg/L. With an additional 0.02mg/L in Wheatley Creek, this elevates the potential concentration to <0.07mg/L, above the DHWQO of 0.030mg/L. However, it is close to the calculated guideline value from the baseline data of 0.060mg/L, and likely equal or lower if data below the limit of reporting were available. Towards Geranium Channel, the additional 0.002mg/L would increase it to <0.052mg/L. This is also above the DHWQO of 0.020mg/L, but similar to the calculated guideline value of 0.050mg/L in mid-estuarine waters, and again would likely equal or be lower when limits of reporting effects are removed. This matches the previous assessment's findings.
- Chlorophyll a: the median background level is 1µg/L. With an additional 0.4µg/L in Wheatley Creek, this elevates the potential concentration to 1.4µg/L, below the DHWQO of 4µg/L. Towards Geranium Channel, the additional 0.12µg/L would increase it to 1.12µg/L, below the DHWQO of 2µg/L.

As noted above, the elevated values for total phosphorous in relation to the DHWQOs are due to naturally higher total phosphorous levels in Bynoe Harbour waters compared to Darwin Harbour (refer Section 7.2.3) and the effect of the limit of reporting. Based on the available data, the discharge from the site would be expected to be below the revised guideline value in both areas assessed. Further baseline monitoring with lower limits of reporting needs to be undertaken to confirm background median concentrations.

Note that regardless of the above, the modelling is conservative, since:

- Increases in concentration were calculated for the worst case situation which was the dry season –in the wet season the additional flow and dilution increases in concentration will be of a lower magnitude, and

- All modelling has used conservative tracer assumptions. In reality, there will be deposition and decay processes occurring, which will further reduce the chances of guideline value exceedance.

The above indicates that the existing discharge criteria remain valid, which in turn confirms the discharge regime remains valid, and no changes are therefore required.

The proposed Project is anticipated to operate in much the same way as the existing Seafarms operations at Cardwell, Queensland, with similar processes, water quality and food requirements. Given Seafarms' experience in this area, there is every reason to assume that the proposed discharge criteria can be met.

In summary, given the dilution available and the findings from the numerical modelling, the discharge criteria adopted for the EIS are considered suitable to protect the existing values of the receiving waters through maintenance of existing water quality as per the AWQG. The discharge criteria adopted for the WQMMP are provided in Table 9-1.

TABLE 9-1 DISCHARGE CRITERIA

Parameter	Median	Maximum
Total Nitrogen (mg/L)	2.0	5.0
Total Phosphorus (mg/L)	0.4	0.6
Chlorophyll a (µg/L)	20	200

9.1 CHLORINE RESIDUAL

The EIS and SEIS discussed testing of discharge waters to determine when remaining chlorine residual from disinfection processes in the facility had broken down such that no free chlorine is detectable. A marine low reliability value for total residual chlorine of 0.003mg/L has been nominated in the AWQGs, although this relates to receiving waters rather than discharges.

The above level is also well below the normal detectable level, and on-site measurement (rather than lab-based measurement) will be required, with a resolution of perhaps 0.01 - 0.1mg/L. Given the available dilution in the receiving environment, a level of <0.1mg/L (i.e. non-detectable in a standard test kit) would be expected to be a suitable 'non-detect' level and is adopted for the purposes of the WQMMP.

10 MONITORING PROGRAM DESIGN

10.1 OVERVIEW

The previous sections have defined the receiving waters, provided the interim guideline values for the Project, and an overview of the existing data including assessing the need for further or ongoing monitoring. The EIS and SEIS program provided for water quality analysis as well as indicator monitoring of benthic macroinvertebrate communities, distribution and ecological health of mangrove communities, δ15N signature of mangroves and sediment quality as extended indicators of estuarine and marine water quality.

Based on the review provided in Section 7.2, a baseline monitoring program up to the start of operations followed by an initial 2-year post-operational discharge validation study is proposed. The operational program will compare the EIS impact assessment with the monitoring data, in context with the baseline data (including revised interim guideline values), including water quality, sediment quality, benthic macroinvertebrates and mangrove health assessment, adopting a multiple lines of evidence (MLOE) approach to assessing departure from natural conditions. Based on this initial 2-year study, a review of the evidence will be conducted, and monitoring revised as required to suit the findings and conditions to ensure it remains cost-effective, practical and focused. An early review will be conducted of the biological sampling data (within the first year) to ensure the sampling methods and sample sizes (for both sample unit – i.e. grab sample size, and sample size – the number of grab samples) are appropriate.

This section outlines the sites to be sampled, parameters to be tested and the proposed data analysis to be adopted for both the baseline and the operational phase monitoring programs.

10.2 SELECTION OF SITES

10.2.1 Operational Monitoring Sites

Watertech (2016b) provided near-field modelling within Wheatley Creek nominating a small mixing zone located 100m either side (up and downstream) of the discharge point and identifying locations along Wheatley Creek where predictions of water quality were made. Given the hydrology in the vicinity of the discharge, a gradient type monitoring program has been adopted, with sites chosen either side of the discharge, upstream and downstream of the discharge, and to reflect the water types in proximity to the Project.

Control or reference sites were chosen in areas nearby that are as similar as practicable, however are not impacted by the Project discharge.

The following monitoring sites are proposed:

Discharge

- DP1: At the discharge location, representative of waters discharging to Wheatley Creek

Wheatley Creek – impact sites

- WCDS1: Existing site BH02 located 100m downstream of the discharge – i.e. just outside the mixing zone
- WCUS1: 100m upstream just outside the 100m mixing zone
- WC01: At the Watertech (2016b) nearfield modelled Point 1 located 2.3km upstream from the discharge point

Mackenzie Arm – potential impact sites

- MA01: approximately 4km upstream of the Wheatley Creek / Mackenzie Arm confluence, representing the upstream limit of the Watertech (2016a, b) modelled plume

- MA02: Watertech (2016b) nearfield modelled Point 17 located 2km downstream from the discharge point, at the confluence of Wheatley Creek and Mackenzie Arm
- MA03: Existing site BH03, located at the Mackenzie Arm / Geranium Channel confluence. Located as a comparison with the baseline monitoring, and to confirm no impact at this location (as predicted by the modelling).

Control Sites:

- BH01: Existing BH01 site within the main Bynoe Harbour channel
- VI01: Located in the upstream tidal waters draining to Vigilant Inlet immediately west of the Project, representative of a catchment similar to Wheatley Creek to capture natural change in nearby estuarine waters
- MI01: upstream in Milne Inlet (upper estuarine waters), a nearby inlet to capture change in waters similar to upstream Mackenzie Arm, and impacts from rural residential areas not impacted by the Project
- MI02: downstream in Milne Inlet (mid-estuarine waters) (refer MI01 above). Representative of mid-estuarine waters and provides a gradient between upstream (MI01) and downstream (this site) to compare to Mackenzie Arm sites

The control and impact monitoring sites are shown in Figure 10-1. Green points are control sites, and blue are potential impact sites.

The above design provides:

- Direct comparison to the extent of the Watertech (2016a, b) modelling predictions, including predicted concentrations and the predicted mixing zone
- Longitudinal gradients in water quality along Wheatley Creek, and along Mackenzie Arm, providing an indication of mixing within both systems. The MA03 (BH03) site provides for a no-impact test before waters enter Geranium Channel and Bynoe Harbour proper, as predicted by the modelling
- Sites within both upper and mid-estuary waters, including control sites
- Control sites which aim to explain changes in the potential impact sites due to:
  - Regional changes within Bynoe Harbour waters at the BH01 site
  - Changes within similar tidal inlets to Wheatley Creek and Mackenzie Arm, including the presence of rural residential areas.

Observations for seagrass can be made at the same locations, with mangrove monitoring sites located as required to provide suitable ground truthing of remote sensing data within Wheatley Creek. Macroinvertebrate sampling should be conducted at all of the Wheatley Creek and Mackenzie Arm sites, possibly adjusted to obtain better habitat, plus the three control sites in the inlets to the west. Sites should be chosen to provide similar comparison sites at control and impact locations in terms of water type, depth and sediment type.

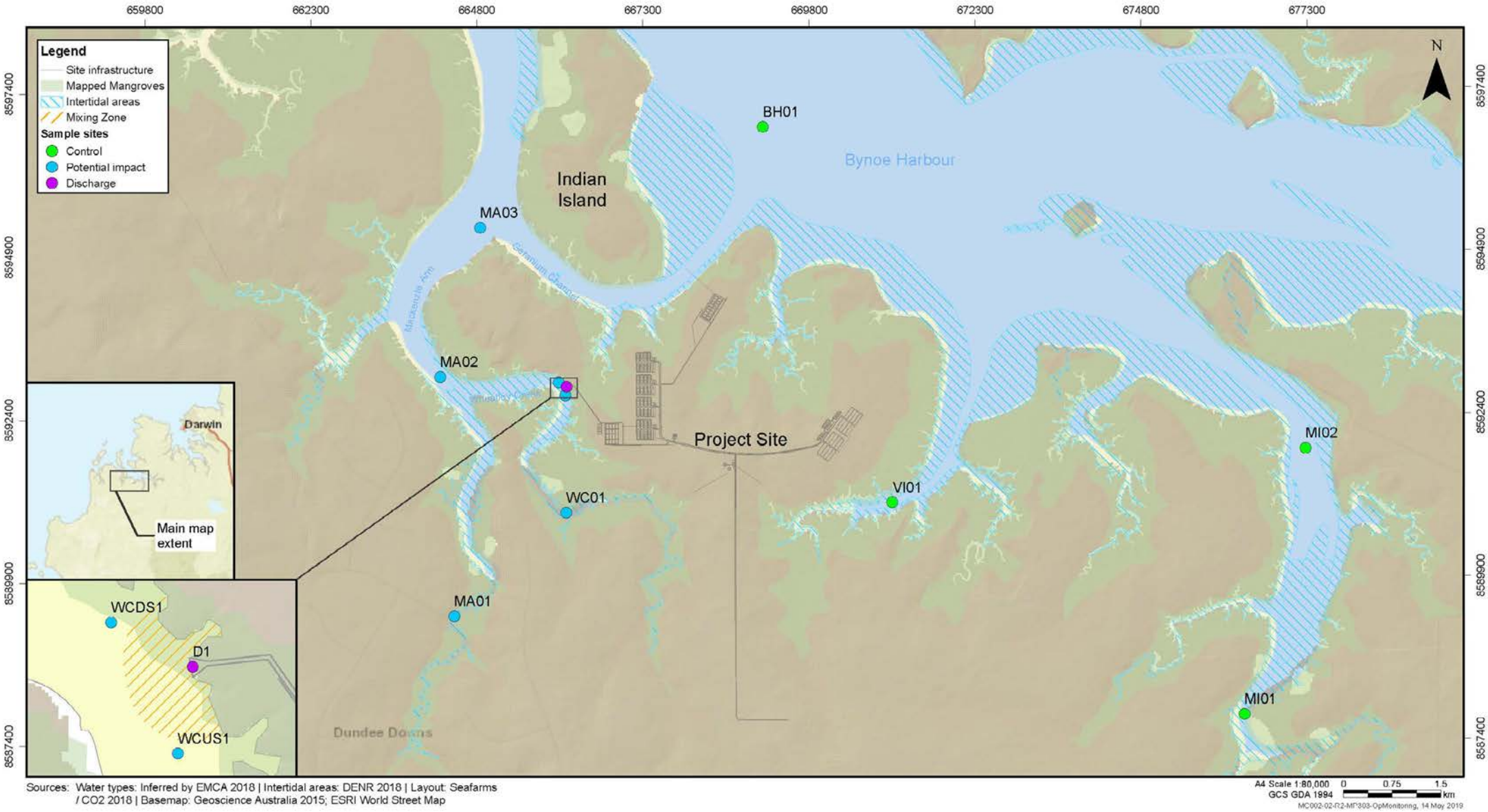

FIGURE 10-1 WATER QUALITY MONITORING SITES

10.2.2 Baseline monitoring sites

Of the above sites, the upstream / downstream mixing zone sites can be represented by one site only – the WCDS1 site, which corresponds to the existing and long-term monitoring site BH02. An additional sediment / benthic check site is proposed, coinciding with a site sampled by Smit et al (2000), and located near to BH01 (included as a comparison of existing conditions against that survey).

10.3 DATA ANALYSIS

The program design and the data analysis is based on a BACI type design, where before-after data is compared, and control-impact data offers the ability to determine whether changes are likely due to Project operations, or wider changes in the aquatic environment.

A two stage approach to analysis is adopted for water quality:

1. Comparison of the results of each sampling event and the median of the previous year's results against guideline values, using control charting approaches as outlined in the AWQG.
2. Where guideline values are exceeded, comparison of the deviation from the median for control sites vs impact sites, aiming to identify trending departure from baseline indicative of Project impacts.

The control charting approaches outlined in the AWQG for both comparison to guideline values and control-impact sites are to be adopted. An example of these charts for total nitrogen is shown in Figure 10-2, where the control site is BH01, and the impact site BH03. As can be seen, the BH03 data is below the guideline value other than in November 2015 and January 2017, with the site compliant during the whole period, based on the median result. Control and impact sites are comparable other than in November 2015 and May 2016, with sites returning to agreement after each of these events. In May 2016, where BH03 was above the criterion, both control and impact sites showed a peak, indicating broader effects in the region rather than a particular impact in Mackenzie Arm alone.

Based on the cumulative departure graph, both sites are aligned following the initial few months of data.

One would expect that the departure from median would not diverge differently between the two sites over time, as seen in these graphs. During operations, should the median exceed the criteria (i.e. exceedance between pre- and post-impact detected), and the control and impact sites diverge, this would be indicative of an impact from the Project requiring more detailed assessment and implementation (if required) of controls.

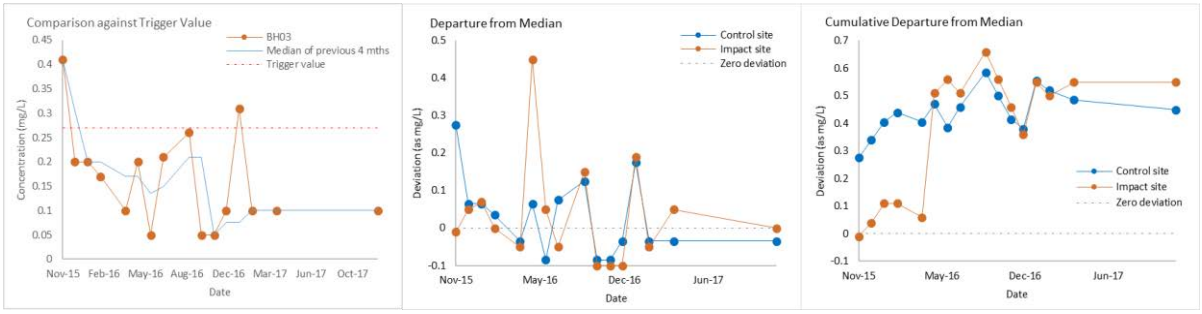

FIGURE 10-2 EXAMPLE OF CONTROL CHARTS – TOTAL NITROGEN

Other supporting analysis that might be considered includes general descriptive and exploratory statistics and graphical techniques, including gradient charts (concentration compared to the guideline values along Wheatley Creek and Mackenzie Arm) and robust regression[2] of impact sites against control sites. From a

[2] linear regression that involves weighting outliers to counter the effect these have on the regression, obtaining a 'truer' regression against the bulk of the population of samples.

statistical perspective, where the true median has not shifted due to site discharges, in 7 samples (refer to discussion of frequency in Section 10.4) one would expect a high chance of 1 or 2 results being above the criteria (probability 64%), but the chance of getting 3 or more above the criteria is only about 14%, and 4 or more (i.e. median is above criteria) less than 5%, providing an indication of expected exceedance numbers. This will be a quick and simple trigger for undertaking additional statistical review and weight of evidence assessment - i.e. sustained departure of trend from reference sites, >3 exceedances per year).

These triggers will be refined with completion of the baseline data collection, and refinement of guideline values and variation in monitored parameters.

Due to the influence of left censored data (< detection limit), statistics must explicitly incorporate measures that deal with censored data (for further reference, refer to Helsel, 2012).

10.4 MONITORING FREQUENCY

As noted in Section 7.2.5 ongoing baseline sampling for water quality is required, aiming for a total of at least a total of 24 data points at the long term monitoring sites (BH01, MA03, WCDS1), without bias towards wet/dry, or ebb/flood tides[3].

Collection of benthic macroinvertebrate samples should aim to collect a total of at least 3 pre-operational discharge samples for comparison with a similar number of post-operational discharge samples during the first two years. During the first round, some sites may need to be moved due to inappropriate locations or substrate.

Sediment sampling should also be undertaken when macroinvertebrate samples are taken. Mangrove satellite data will be collected and ground truthing assessment field work conducted prior to construction commencing. This should be repeated at the end of two years after post-operational discharges commence.

For operational monitoring, the Type I and Type II error rates were analysed against the variation in the baseline data. The proposed analysis approach discussed in Section 10.3 follows that identified in the AWQGs of comparing the 80th percentile of the reference site to the test site (i.e. pre/post discharge, and control/impact sites). For the simple case of comparison of a median at a test site to a guideline value, the probability of exceeding the guideline value where there is no difference post-discharge is 20% for one sample. Using binomial probabilities with p = 0.2 and sample size of 5 (1 sample followed by 4 quarterly samples over a year) gives p ~ 0.05 (a suitable Type I error rate).

Should the actual median increase so as to be equal to the guideline value (i.e. previous 80th percentile), then this probability changes to p = 0.5 of exceedance each round, and an overall power of 50%, based on the probability alone and irrespective of sample size. Using total phosphorous levels at the discharge location (measured during the baseline monitoring), the true median would need to increase to ~0.100mg/L for a power of 80%, an effect size of 0.09mg/L, or 1.5 standard deviations. To reduce the detection level, and improve on trend analysis, the sampling could be increased to 2-monthly, in which case 7 samples would be collected over 1 year. This would provide for an effect size of 0.075mg/L, or 1.3 standard deviations. Where the discharge meets the discharge criteria (i.e. that found to be suitable in modelling works), then this is expected to be sufficient. Should it exceed, more frequent monitoring of receiving waters would be required to ensure no impacts have occurred, effectively increasing the statistical power to detect change at a lower detection limit.

[3] Data from the other sites will be used to inform pre- and post- discharge differences, however water quality objectives can be set from these three points

If instead a comparison of group differences is made, using lognormal distributions (which the data fits), the Type I error rate is in the order of p = 0.01, and the power afforded is ~80% at an effect size of 1.1 standard deviations.

Overall, this sample size is suitable to detect trends overall departure of a suitably small magnitude, with sufficient power and without undue risk of false triggering.

Note that trend analysis described in Section 10.3 provides for better detection of trends as they are occurring, including comparison with environmental effects (rainfall, other variables) and clustering of non-conforming values which can indicate a potential problem before collection of the full year's data.

Based on the above, during operations a 2-monthly monitoring frequency will be adopted for the initial 2-year assessment period and reviewed after this period.

Following the initial 2-year monitoring period, ongoing monitoring frequency would be reviewed, however the nominal frequency (depending on the review results) would be:

- Water quality: quarterly (2 wet and 2 dry samples each year)
- Mangrove health assessment: satellite assessment every 6 years, with confirmatory ground based assessments (coincides with the below sampling)
- Sediment sampling: every 2 years
- Benthic macroinvertebrate sampling: every 6 years (coinciding with the sediment sampling).

11 ADDITIONAL BASELINE DATA REQUIREMENTS

The assessment provided in the previous sections indicates the following baseline monitoring should be conducted prior to operational discharges:

- Water quality monitoring at the nominated sites, with an aim to collect additional samples to total at least 24 sample points at the existing BH01, BH02 (now WCDS1) and BH03 (now MA03) sites (the other sites will collect as many samples as practicable along with the above three sites). Sampling should be unbiased in terms of season and tides (ebb, flood, spring and neap) with an aim to result in approximately equal representation of the different cycles to achieve an overall randomised sampling effort.
- To extend the amount of data collected, investigate and where practicable utilise remotely sensed water quality data for Chlorophyll a, turbidity and suspended solids.
- Once some of the additional baseline data has been collected for those parameters with high non-detects in the existing dataset, a re-analysis of the data is to be conducted using statistical techniques if required to better treat non-detects, and determine whether further data is required for these parameters – of particular interest are total phosphorous and filterable reactive phosphorous.
- Dissolved oxygen also needs further monitoring to determine how meaningful the existing baseline dataset is and confirm whether they are likely to be in error. Following this assessment, further baseline data collection requirements are to be determined and added to the program.
- Undertake at least 3 rounds of analysis for total and dissolved metals prior to operations commencing.
- Laboratory methods selected to ensure limits of reporting are low enough to provide meaningful data.
- Undertake at least 3 macroinvertebrate sampling events at each of the proposed monitoring points.
- Collect at least 2 more sediment samples from for sediment chemical analysis in the vicinity of each of the water quality sampling sites.
- Undertake seagrass assessment to locate potential seagrass beds for baseline and post-operational discharge comparison monitoring, including a visual observation of intertidal areas (e.g. by helicopter), and a visual assessment of the benthic environment in the vicinity of the proposed sampling sites, at least once prior to operational discharge commencing.
- Obtain remote sensing data and determine mangrove extent, intactness and health in the area of the proposed monitoring points. Undertake ground truthing in representative locations along Wheatley Creek at least once prior to operational discharge commencing.
- Determine seasonal guideline values at the 2 year review (or before if sufficient data is collected). Determine whether these are significantly different from the overall guideline values, and whether there is merit in meeting the aims of this WQMMP in using seasonal guideline values instead of (or as well as) overall guideline values. If so, these must be utilised in the assessment following the 2-year review period.

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APPENDIX A WQMMP REQUIREMENTS CHECKLIST

TABLE A1. KEY NT AND COMMONWEALTH APPROVAL CONDITIONS / RECOMMENDATIONS

#[1]	Condition Text	Cross Reference
NT Waste Discharge Licence (WDL242239, 7 February 2018)		
Responsibilities of licensee		
	Except as expressly provided for in this licence, the licensee must not: • cause environmental harm either directly or indirectly; • allow waste to come into contact with water; or • allow water to be polluted.	WQMMP Section 2 – key aim and objectives are protection of receiving water quality.
	Without limiting the conditions of this licence, in conducting the activity, the licensee must do all things reasonable and practicable to: • prevent or minimise the likelihood of pollution occurring as a result of, or in connection with, the activity; • prevent or minimise the likelihood of environmental harm occurring as a result of, or in connection with, the activity;	WQMMP Section 2 – key aim and objectives are protection of receiving water quality. WQMMP Appendix A1.
	• effectively respond to pollution and the risk of pollution occurring as a result of, or in connection with, the activity; • effectively respond to environmental harm and the risk of environmental harm occurring as a result of or in connection with the activity; and	WQMMP Appendices A1 and A3, Figure A1-1. These outline the monitoring and response mechanisms.
	• as far as practicable: - avoid and reduce waste produced as a result of, or in connection with the activity; - increase the re-use and recycling of waste; - effectively manage waste disposal; and • apply the principles of ecologically sustainable development.	EMP C9 Waste Management Strategy - Actions / Mitigation Measures - implement the waste hierarchy (waste hierarchy provided)
General		
1	The licensee must ensure the contact details recorded with the administering agency for this licence are correct at all times.	To be updated as required.
2	The licensee must at all times have a 24 hour emergency contact.	EMS Communication EMP Key Contacts WQMMP Appendix A1 (Actions / Mitigation Measures).
3	The licensee must notify the administering agency prior to making any operational change that will cause, or is likely to cause, an increase in the potential for environmental harm.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Provision of information to Agencies WQMMP Appendix A1 (Reporting).
4	The licensee must, 20 business days prior to commencement of licensed activities, cause clear and legible signage, in English, to be displayed in a prominent location at each public entrance to the premises that includes the following details: 4.1. waste discharge licence number issued under the Water Act; and 4.2. 24 hour emergency contact details.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Project Signage WQMMP Appendix A1 (Actions / Mitigation Measures).
5	The licensee must cause a copy of this licence to be available: 5.1. for inspection by any person, in hard copy form, at the premises; and 5.2. on the licensee's website	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Project Reports and Licenses WQMMP Appendix A1 (Reporting).
6	The licensee must provide to the administering agency, within 10 business days of a request, a copy of any document, monitoring data or other information in relation to the activity, in the format requested by the administering agency.	WQMMP Appendix A1 (Reporting).

#[1]	Condition Text	Cross Reference
7	All notices, reports, documents or other correspondence required to be provided as a condition of this licence, unless otherwise specified as a condition of this licence, must be provided in electronic form by emailing the document to waste@nt.gov.au	EMP Key Contacts
8	The administering agency may require the licensee to revise or amend and resubmit any document provided to the administering agency during the period of this licence. Where the administering agency requires a document to be resubmitted, the licensee must submit it to the administering agency by the date specified by the administering agency.	Noted.
9	The licensee must, for the duration of this licence, implement, maintain and follow a Consultation and Communication Plan which includes a strategy for communicating with persons who are likely to have a real interest in, or be affected by, the activity.	Communications are outlined in the EMS and Site EMP.
10	The licensee must maintain a Complaint Log for all complaints received by the licensee in relation to the activity.	EMS Complaints Management WQMMP Appendix A1 (reporting).
11	The licensee must ensure that the Complaint Log includes, for each complaint received by the licensee, the following information: 11.1. the person to whom the complaint was made; 11.2. the person responsible for managing the complaint; 11.3. the date and time the complaint was reported; 11.4. the date and time of the event(s) that led to the complaint; 11.5. the contact details of the complainant if known, or where no details are provided a note to that effect; 11.6. the nature of the complaint; 11.7. the nature of event(s) giving rise to the complaint; 11.8. prevailing weather conditions at the time (where relevant to the complaint) 11.9. the action taken in relation to the complaint, including any follow-up contact with the complainant; and 11.10. if no action was taken, why no action was taken.	EMS Complaints Management, Incident-Complaint form The incident form, part of the EMS, contains this information.
Early Surrender of Licence		
12	Any reports, records or other information required or able to be provided by the licensee under this licence must be submitted to the administering agency prior to the licensee surrendering the licence. If the date on which a report, record or other information is required falls after the date the licensee requests to surrender this license, the licensee must provide the report, record or information as far as possible using data available to the licensee up to and including the date the request to surrender the licence is made.	Noted.
Operational		
13	The licensee must, without limiting any other condition of this licence, in conducting the activity do all things reasonable and practicable to ensure the activity does not adversely affect Wheatley Creek.	The target is to protect the receiving waters (Wheatley Creek), which in turn will protect Mackenzie Arm and Bynoe Harbour. This is reflected in Objectives and Targets (WQMMP Section 2), and in the monitoring sites selected (Section 10.2 of the WQMMP-SR, WQMMP Appendix A3).
14	The licensee must ensure any plant and equipment used by the licensee in conducting the activity: 14.1. is reasonably fit for the purpose and use to which it is put; 14.2. is maintained; and	Personnel 'fit for work requirements' are outlined in the EMS - Training and Awareness.

#[1]	Condition Text	Cross Reference
	14.3. is operated by a person trained to use the plant and equipment.	
Discharges		
15	This licence authorises discharge to Wheatley Creek from the Authorised Discharge Point as identified in Table 1. Table 1 - Authorised Discharge Authorised Discharge Point: Discharge Point 1 (DP1) Description: Discharge Point 1 (DP1) receives wastewater from a series of settlement ponds (Stage 1) and release control ponds (Stage 2 onwards) via a discharge release channel (DRC) into Wheatley Creek at DP1. DP1 is located on the bank of Wheatley Creek on the eastern boundary of NT Portion 3192 (the Premises). It is located approximately 1.4 km from the confluence of Mackenzie Arm. Wastewater will be released into Wheatley Creek over an embankment which is flooded at high tide. Rip rap or a rock mattress will be placed up to the low tide mark to ensure no scourina of the salt flat. Location: Latitude: -12.72425:4° Longitude: 129.289151 °	Shown in Figure 1-2 in the WQMMP and Figure 2-1 in the WQMMP-SR. Location identified in the WQMMP Appendix A3.
16	The licensee must, prior to discharge from the authorised discharge point, install a device to measure and record each discharge event at DP1. The device must record: 16.1. the time the discharge commenced and the duration of the discharge; 16.2. the discharge rate of flow; and 16.3. the discharge volume.	WQMMP Appendix A3 (Frequency and Timing, Sampling Methods).
17	The licensee must, in the event that water quality objectives cannot be met, install a diffuse discharge system to aid dilution	WQMMP Appendix A1 (Corrective Actions, 5)
18	The licensee must, until such time that condition 16 is fulfilled, conduct daily visual observations to identify and record the status of discharge at DP1. Discharge events noted during these daily observations should record: 18.1. the time the discharge commenced and duration of discharge; and 18.2. the total estimated discharge volume per discharge event.	WQMMP Appendix A3 (Frequency and Timing, Sampling Methods).
19	The licensee must ensure that the discharge from all discharge events at DP1 listed in Table 1 does not: 19.1. contain any floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter; 19.2. cause or generate odours which would adversely affect the use of surrounding waters; 19.3. cause algal blooms in the receiving water; 19.4. cause mortality of fish or other aquatic organisms; or 19.5. cause adverse effects on plants.	WQMMP Appendix A3 (Discharge Criteria, guideline values and Assessment Approach). The EIMP provides for monitoring of chlorophyll a and ecological health.
20	The licensee must ensure that the authorised discharge: 20.1. does not exceed the limits specified in Table 2; 20.2. is restricted to an annual average daily discharge rate of: • 3 ML/day during Stage 1 operations; and • 12.5 ML/day during Stage 2 operations; and 20.3. only occurs at mid to high tide, staged over two discharge cycles per day in line with semi-diurnal tides to maximise dispersion and mixing. Table 2 - Discharge Limits Median Maximum Total nitrogen (mg/L) 2.0 5.0 Total phosphorous (mg/L) 0.4 0.6 Chlorophyll a (µg/L) 20 200	WQMMP Appendix A3 (Discharge Criteria).

#[1]	Condition Text	Cross Reference
21	The licensee must as soon as practicable notify the administering agency when discharges commence at the Authorised Discharge identified in Table 1.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Provision of information to Agencies WQMMP Appendix A1 (Reporting).
22	The licensee must as soon as practicable notify the administering agency when discharges cease at the Authorised Discharge identified in Table 1.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Provision of information to Agencies WQMMP Appendix A1 (Reporting).
Recording and Reporting		
23	The licensee must, as soon as practicable and where possible within 24 hours, notify the administering agency when monitoring results for Authorised Discharge Point 1 exceed the wastewater quality parameters in condition 20:	EMP E1 Contingency Response Plan - Notification WQMMP Appendix A1 (Reporting).
23.1	the licensee must conduct monitoring in accordance with conditions 19 and 20.	WQMMP Appendix A3.
24	The licensee must ensure that the notification includes the following information: 24.1. when the exceedance was detected and by who; 24.2. the date and time of the exceedance; 24.3. the actual and potential causes and contributing factors to the exceedance; 24.4. the risk of environmental harm arising from the exceedance; 24.5. the action(s) that have or will be undertaken to address the exceedance and/or environmental harm; and 24.6. if no action was taken, why no action was taken.	EMS - Non-conformance and corrective action EMP E1 Contingency Response Plan - Notification WQMMP Appendix A1 (Reporting)
25	The licensee must keep records of all non-compliances with this licence. These records must be adequate to enable the licensee to comply with the non-compliance notification conditions of this licence.	EMS - Records WQMMP Appendix A1 (Reporting).
26	The licensee must notify the administering agency of any non-compliance with this licence as soon as practicable after (and in any case within 24 hours after) first becoming aware of the noncompliance.	EMP E1 Contingency Response Plan - Notification WQMMP Appendix A1 (Reporting).
27	The licensee must include in the notification of non-compliance the following information: 26.1. when the non-compliance was detected and by whom; 26.2. the date and time of the non-compliance; 26.3. the actual and potential causes and contributing factors to the non-compliance; 26.4. the risk of environmental harm arising from the non-compliance; 26.5. the action(s) that have or will be undertaken to mitigate any environmental harm arising from the non-compliance; 26.6. corrective actions that have or will be undertaken to ensure the non-compliance does not reoccur; and 26.7. if no action was taken, why no action was taken.	EMP E1 Contingency Response Plan - Notification WQMMP Appendix A1 (Reporting).
28	The licensee must as soon as practicable provide monitoring data relating to a discharge via an Authorised Discharge identified in Table 1 to the administering agency when that Authorised Discharge ceases discharging.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Provision of information to Agencies WQMMP Appendix A1 (Reporting).

#[1]	Condition Text	Cross Reference
29	The licensee must immediately and in any case within 24 hours notify the administering agency of any potential or actual environmental harm or pollution.	EMP E1 Contingency Response Plan - Notification WQMMP Appendix A1 (Reporting).
30	The licensee must comply with the requirements of section 14 of the WMPC Act.	Incorporated into Objectives and Targets (WQMMP Section 2), Legislative requirements (WQMMP Section 3) and reporting / notification requirements (WQMMP Appendix A1).
31	The licensee must submit a completed Annual Return within 20 business days after each anniversary date of this licence, which relates to the preceding 12 month period.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Annual Reporting WQMMP Appendix A1 (Reporting).
32	The licensee must complete and provide to the administering agency a Monitoring report within 10 business days after each anniversary date of this licence.	EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Annual Reporting WQMMP Appendix A1 (Reporting).
33	The licensee must ensure that the Monitoring Report: 32.1. is prepared in accordance with the requirements of the NT EPA 'Guideline for Reporting on Environmental Monitoring'; 32.2. includes a tabulation of all monitoring data required as a condition of this licence; 32.3. provides an update on the development of site specific trigger values; 32.4. outlines measures to assess net load released from Discharge Point 1; and 32.5. includes specific dates for full implementation of each measure detailed in the Monitoring report.	WQMMP Appendix A1 (Reporting).
Performance Improvement		
34	The licensee shall conduct a review of the baseline water quality monitoring program to inform suitable monitoring methodologies to develop site-specific trigger values and water quality objectives for management. The licensee shall enhance the baseline water quality monitoring program by: 34.1. increasing spatial representation of sites in Bynoe Harbour; 34.2. accounting for natural variation in receiving waters; and 34.3. including sediment sampling and biological indicators of nutrient impacts. Based on the review, a revised monitoring program shall be peer reviewed by an appropriatelyqualified independent professional, and implemented, to the satisfaction of the NT EPA.	Section 7 in the WQMMP-SR provides a review of existing data. The WQMMP provides the revised program, including additional sites, and taking into account natural variation, sediment sampling and biological indicators. Independent review advice is provided in Appendix E to the WQMMP-SR.
35	The licensee shall review, and revise if necessary, the proposed interim site-specific water quality trigger values for Wheatley Creek. The review shall be based on the outcomes of the water quality monitoring program review provided for in condition 34, and be undertaken when a sufficient revised dataset is available. The review must: 34.1. consider the development of seasonal interim trigger values; and 34.2. be undertaken in consultation with the NT EPA.	A review and revision of the guideline values for the receiving waters is provided in Sections 5 and 8 in the WQMMP-SR.

#[1]	Condition Text	Cross Reference
36	The licensee must submit a Water Quality Monitoring and Management Program to the administering agency in accordance with condition 39 of this licence.	This WQMMP
37	The licensee must submit an Emergency Response Plan to the administering authority that addresses procedures for responding to emergencies associated with the-activity that may cause environmental harm.	The WQMMP includes procedures for monitoring and triggers for further management – refer to the WQMMP Appendices A1 and A3. Emergency Response Plan to be prepared by Seafarms
38	The licensee must implement an auditable Environmental Management Plan (EMP) that provides for effective management of the actual and potential impacts resulting from carrying out the licensed activity, and facilitates and demonstrates compliance with this licence. The EMP must include measures: 38.1. for continuous improvement in environmental management practices and environmental performance; 38.2. to apply best practice to the management of wastewater treatment and discharges to the maximum extent achievable; 38.3. to manage foreseeable environmental risks and hazards for non-routine situations including corrective responses to prevent and mitigate environmental harm, including a contingency plan for shut down for maintenance or other reasons; and 38.4. must be prepared in consideration of the NT EPA Guideline for the Preparation of an Environmental Management Plan; 38.5. be certified by a person with the experience and qualifications to be able to assess the environmental risks associated with carrying out the licensed activity and to assess the adequacy of the EMP to facilitate compliance with the conditions of this licence; 38.6. be provided to the administering agency with the qualified person's written certified review of the current EMP, within 20 business days prior to the planned commencement of licensed activities; and 38.7. not be implemented or amended in a way that contravenes or is inconsistent with any condition of this licence.	The overall Project is managed under an EMS, with an EMP implemented for the site. The EMS/EMP has been designed to comply with these conditions. A statement of certification is provided in the EMP. The WQMMP has been prepared in relation to the water quality aspects of the Project.
39	The licensee must submit documents referred to in conditions 33, 35, 36, 37, and 38 by the 2020 Annual Return due date.	Included in EMP Appendix D - EN-01-RG-EM1101b Monitoring and Review Register - Project reports and licences Annual return requirements relevant to this WQMMP are included in the WQMMP Appendix A1 (Reporting).

APPENDIX B RISK ASSESSMENT

B1 – RISK ASSESSMENT

Tables B1-1 and B1-2 provide an extract of the Project risk assessment as it relates to marine and estuarine water quality management. This was based on the procedures outlined in EN-PR-EM0201 Risk Management (included as Appendix C).

TABLE B1-1 EXTRACT FROM PROJECT RISK ASSESSMENT – WATER QUALITY (CONSTRUCTION PHASE)

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
Vegetation clearance during the construction phase	Marine and Estuarine Waters	Sediment run-off enters waterways and decreases water quality	3	3	M	▪ Minimise vegetation clearance to the smallest extent possible. ▪ Clearly mark out limits of clearing and individuals to retain. ▪ Avoid land clearing during the wet season. ▪ Adhere to buffer widths recommended by the NT Land Clearing Guidelines where possible, with regard to riparian vegetation in drainage lines. ▪ Install structures that would manage water flow and capture sediment downstream of development. ▪ Stage clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with the erosion and sediment control plan. ▪ Rehabilitate/stabilise cleared land as soon as possible after works have been completed. ▪ Develop and implement vegetation clearing subplans which include areas not to be cleared (no-go ▪ areas) and make all workers aware of them through environmental management plan and site ▪ work briefings.	2	2	L	

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						▪ No laydown areas or material storage in close proximity to riparian areas. ▪ Limit earthworks to necessary areas only. ▪ Ongoing monitoring of erosion and rehabilitation success post construction.				
Artificial lighting during construction and operations	Conservation significant species	Disturbance to turtles and nesting habits	1	3	L	▪ Manage the spill of lights (if required) into marine areas via use of directional lighting. ▪ Lighting to be limited to only that which is essential. ▪ Lighting to be installed low in the vertical plane and using the lowest intensity practicable. ▪ If required for vessels, lighting is to be restricted as far as practicable, whilst maintaining lighting required in accordance with navigation and vessel safety standards	1	3	L	Given that turtles do not nest within the Project area or adjacent habitats (the nearest nesting beach is located 15 km from the Project area), it is unlikely that artificial light, if required for construction, would interfere with navigation to nesting beaches or hatchling behaviour or, therefore, their breeding success and population longevity.
Construction and operation of seawater intake pipeline	Conservation significant species	Mortality or injury of marine megafauna species (e.g. via boat strike) during construction of intake and outfall structures	2	2	L	▪ Visual surveillance for megafauna during all vessel movements ▪ Use of reduced speed to avoid collision interaction as needed ▪ If practicable, timing of works to be undertaken outside of breeding or migration periods	2	3	L	There is potential for vessels involved in the construction activities to strike or entangle marine fauna including cetaceans, fish and marine reptiles. The main collision risk associated with the activities is construction vessels colliding with slow moving/surface basking marine turtles. While the potential exists for

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										interference with marine fauna from vessel movements during the activity, impacts will be localised and relatively short lived, being confined to the duration of the activity.
		Noise and vibration, particularly from boat use, results in disturbance to threatened and migratory marine megafauna.	3	2	L	▪ Limit vessel use as far as possible ▪ If practicable, timing of works to be undertaken outside of breeding or migration periods	3	1	L	The noise emitted during construction has the potential to cause behavioural changes (e.g. swimming away from the area) by marine fauna, with the most sensitive species being cetaceans. Any behavioural impact caused by the vessel noise is likely to be localised and temporary, with marine species expected to resume normal behavioural patterns in the waters surrounding the Project area in a short time-frame. Threatened and migratory species expected to resume normal behavioural patterns following the cessation of works.
		Loss of seagrass habitat	2	3	M	▪ Minimise construction corridor where possible.	2	1	VL	Habitat mapping data available from DENR identifies the nearest seagrass meadows to be over 200 km from the Project site.

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										However, it has been reported that seagrass beds are present in the intertidal–subtidal areas and in the very shallow subtidal areas of Bynoe Harbour, including patchy seagrass beds near Point Ceylon. Disturbance to any seagrass habitat will be isolated and temporary. It is expected that habitats within the construction corridor will regenerate after construction. Disturbance to the corridor during operations is unlikely.
		Physical entrapment of fauna in the intake valve	3	2	M	A fixed screen will be installed over all intake valves.	1	2	L	
	General Ecological Values		3	1	L		3	1	L	
	Marine and Estuarine Waters	Increased turbidity causing decreased water quality.	5	3	H	Once pipe anchoring design is determined, ensure control measures appropriate to that construction technique are included in the EMP to manage and mitigated the potential turbidity during construction	2	2	L	The local hydrodynamics, seabed and subsurface geotechnology will determine the pipeline anchoring design. The plan is to use either or both concrete collar anchor blocks strapped to the pipe or a weighted geo-tech matting to
		Alternation of seabed or bathymetry due to impacts to local	2	2	L	Complete hydrodynamic modelling and geotechnical studies to determine suitable alignment and placement of pipeline. Ensure anchoring suitable for tidal forces.	2	1	VL	

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		hydrodynamics from the pipeline placement								retain the pipe in its alignment. Piling is a last resort for securing the pipe location and hence is unlikely to be used. The objective of the design will be determined by the requirements to ensure that pipeline is correctly anchored and imiting lateral movement. Disturbance will be temporary and during the construction phase only with no ongoing disturbance required post installation. The existing environment is naturally turbid and high in sediment solids.
Construction and operation of discharge water release infrastructure	Marine and Estuarine Waters	Erosion of the banks along Wheatley Creek from release point.	4	3	M	▪ Siting and designing the release point infrastructure to be resilient to potential climate change risks ▪ Ensure appropriate scouring protection is considered in the design phase and accounts for extreme weather events.	2	1	VL	The existing environment is naturally turbid and high in sediment solids. The temporary disturbance during construction is unlikely to pose long-term impacts.
	General Ecological Values	Loss of mangrove habitat	5	2	M	▪ Minimise footprint to as small as practicable.	2	2	L	The small size of the footprint is unlikely to result in significant impacts relative to the extensive mangrove forest that exists

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						▪ Ensure stability of the site post-construction to permit rehabilitation of the construction area.				along Wheatley Creek and more widely in the region. A small area of mangroves will be cleared for the construction of the discharge water release point. The point of release has been selected to specifically minimise the number of individual mangroves that require clearing. The release point has been designed to maintain stability regardless of pressures such as tidal movement, storm surge and other climatic changes. Ongoing and post-event monitoring of the site (to assess stabilisation and sediment movement) will be included in the Environmental Management Plan.
Generation and dispersion of dust emissions from site establishment, vegetation clearing, earthworks.	Marine and Estuarine Waters	Dust emissions result in increased levels of dust deposition which leads to changes in water quality.	4	1	M	▪ Weather reports will be checked daily to enable action to be taken immediately if conditions change. ▪ A site 'shut down and cover up' policy will be implemented during periods of extreme weather conditions.	3	1	L	

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
Undertaking earthworks in potential acid sulphate soils (PASS) risk areas.	Marine and Estuarine Waters	Disturbance of ASS results in the generation of acid leachate which acidifies runoff and leads to changes in water quality in receiving waters.	1	2	L	▪ ASS management plan to be developed and implemented prior to the commencement of construction. ▪ Geo-technical investigations for any excavations into potential ASS. ▪ Final design to be modified if required to avoid any disturbance. For example, the seawater intake pipeline could be laid on the surface in the intertidal zone (potential PASS area) and armoured for protection and stability rather than be trenched. ▪ Avoid disturbance and oxidation of ASS or ensure disturbed ASS have sufficient neutralising capacity to permanently avoid oxidation (adding lime if necessary).	1	2	L	Acid sulfate soils can be associated with areas of mangroves. The Project footprint only extends into areas of mangrove for the construction of the seawater intake and discharge water release infrastructure. A detailed geotechnical investigation will be undertaken to determine is PASS will be likely to be encountered in construction. Final designs will be modified if required to avoid any disturbance. All other work and infrastructure is located above the 5m AHD which is considered low risk for PASS. A site-wide ASS Management Plan will be developed prior to construction commencing.
Accidental spills or leaks of contaminants such as fuel, oils, chemicals or liquid waste.	Marine and Estuarine Waters	Contaminants enter surrounding waterways and lead to changes in water	3	2	M	▪ Spill kits and spill management controls utilised at all storage and transfer points. ▪ All chemical and hazardous waste disposed appropriately offsite through a licence commercial contractor.	1	2	L	Chemical and fuel storage and transfer points are located away from sensitive receptors such was waterways. With mitigation and management measures in

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		quality in receiving water body.				▪ Training in incident/notification and spill management to be provided to staff. ▪ Chemical register to be maintained for the Project site.				place, such as bunding, spills are unlikely and procedures are in place to rectify them immediately.
Release of discharge water into Wheatley Creek	Marine and Estuarine Waters	Reduction in water quality in Wheatley Creek and Bynoe Harbour (as assessed by Water Tech - Appendix 17) [Watertech, 2016a, b]	3	3	M	▪ Installation of settlement ponds that permit the settlement of nutrient rich sediments from the water column before release. ▪ Maximising holding in the settlement ponds to optimise biological uptake of nutrients before release. ▪ Controlling release of discharge water to periods between mid to high tides only to increase dilution. ▪ Monthly water quality monitoring of Wheatley Creek and Bynoe Harbour prior to any release of discharge water to determine background water quality parameters of the receiving environment. ▪ Ensure a waste discharge licence, under the Water Act, in place prior to any release of water. ▪ Adherence to Environmental Code of Practice for Australian Prawn Farmers. ▪ Monitoring all discharge waters pre-release to confirm adherence to discharge license conditions; with no release of waters that breach conditions and	1	3	L	Monitoring is currently occurring and will continue to collect at least 12 months' pre-construction baseline data across two seasons to support ability to determine site specific guideline values. Hydrodynamic numerical modelling of the dilution and dispersion of the pond effluent discharge water planned to be discharged to Wheatley Creek was undertaken to inform the assessment of potential impacts upon the receiving environment, and to identify the optimum location and timing for water discharge. Modelling of planned discharge indicates that these risks are able to be managed if the facility is designed and operated in accordance with best practice

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						adoption of additional treatment controls where required to support adherence to license conditions - Monitoring of waters within the predicted Wheatley Creek mixing zone and control areas to confirm no impacts on water quality and confirm modelling mixing zone relevance to operational conditions - Staging delivery with release restricted to approximately 2,200 m^3/day at Stage 1 with review of relevance of management conditions undertaken following collection and analysis of 9 months of Stage 1 environmental monitoring data - Restricting maximum development release volume to approximately 11,000 m^3 per day unless additional review of relevance of environmental controls is undertaken to confirm prescribed controls are adequate - Feeding strategies to be planned and managed to optimise Food Conversion Rates, productivity and minimise the associated nutrient levels in discharge water. - Providing ability in the facility design for discharge waters to be diverted to holding ponds and, if required, disposed of onsite or licensed waste facilities if waters are				and site requirements. A site specific operational Environment Management Plan will be developed to support adherence to these environmental controls. It is considered likely that there will be some change in community structure of phytoplankton, bacteria and invertebrates within the initial mixing zone, which is conservatively predicted to extend for around 750 m upstream and 750 m downstream of the proposed release point. These three are considered to be the primary mechanism for controlling nutrient concentrations in creeks receiving shrimp farm effluent. However, it is considered unlikely that this would lead to significant impacts on the mangrove community of the Wheatley Creek, or on the larger organisms, such as marine fauna.

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						known to contain chemical agents or similar that would breach discharge license conditions or harm the environment				Initial stage will be considerably smaller than the ultimate flow of 11,000 m^3 per day estimated as full capacity release. This will provide ample opportunity to better understand background water quality and associated mangrove processes and also for further investigations of the dilution and decay of materials within the earlier stages of the release to Wheatley Creek to confirm the observations and conclusions of the studies that have underpinned this risk assessment.
		Increase in water levels within Wheatley Creek affecting survivorship of aquatic and riparian vegetation.	3	2	M	Provision and implementation of an adaptive management plan (including monitoring, discharge water, environmental objectives)	2	2	L	
Prawns escaping the CMC or BMC	General Ecological Values	Prawns entering the natural environs breeding with wild populations or creating disease risk.	2	3	M	Using mesh covering of all facility discharge pipes to avoid release of any escapee prawns Implement Biosecurity Management Plan to maintain disease-free operations.	1	3	L	Maintaining the biosecurity of the site is critical to the success of the Project. A Biosecurity Management Plan will detail biosecurity measures and

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						▪ Specific Pathogen Free animals only used in the production system ▪ In the event of a disease outbreak within the production system, any diseased prawns identified will be euthanized and disposed of either through incineration or offsite at a licenced facility				monitoring that is to be implemented. The biosecurity strategy for Project Sea Dragon is premised upon developing a domesticated and selectively bred population of animals that have been screened for a suite of known pathogens, satisfying the Specific Pathogen Free' condition. Unscreened prawns will not be used within the production system. Mesh will be affixed to all points of exit (such as the discharge water channels) to ensure that no prawns are able to escape the facility. In the rare event that a prawn escapes then survival is not considered possible in the 'hostile' environment of the discharge water channels.
Extreme weather event	Marine and Estuarine Waters	Pond overtop/fail leads to large amount of untreated, nutrient and sediment	1	3	L	▪ Ensure freeboard that ensures no overtopping during rainfall event. ▪ All infrastructure located above 5 m AHD.	1	3	L	Ponds are designed such that there is negligible risk of wall failure. Ponds are connected in a series to neighbouring ponds

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		enriched water leaving site								and discharge can only occur via the release channel. A 500 mm freeboard has been included in the pond design. Storm tide modelling was completed for the Bynoe Harbour and Darwin area by Systems Engineering Australia Pty Ltd (SEA, 2006). The study provided a prediction of existing storm tide levels for a number of return periods. It identified that the storm surge for a 1 in 100-year event in 2010 was 3.7 m AHD and would increase to 4.1 m AHD in 2050. The 4.1 m AHD contour line has been used as the basis for site planning to ensure that all infrastructure is located outside of storm surge impact areas.
Wastewater from non-process associated activities	Marine and Estuarine Waters	Contamination of water resources from waste water disposal to the environment	3	2	M	▪ Sewage managed onsite via septic tank and only treated water discharge to ground via absorption trench ▪ Maintain capacity in the septic tanks for the number of personnel onsite ▪ Wastewater from to vehicle wash-downs directed to the septic tanks	2	2	L	

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						▪ First flush capture from all bunded areas treated as hazardous waste				
Sediments from discharge water settlement ponds	Soils	Contamination of surrounding waterways and lead to changes in water quality in receiving water body.	4	3	H	▪ Drying area to be located away from sensitive areas. ▪ Regeneration of native species encouraged to stabilise topsoil once spread. ▪ Implementation of Victoria EPA 'Guidelines for Environmental Management Bio solids Land Application'	3	3	M	
Rainwater capture	Marine and Estuarine Waters	Reduction in overland flow into small tidal creeks and estuarine environment during rainfall event.	1	3	L	▪	1	3	L	The total roof catchment area for full scale development is estimated to be 2.8 hectares. The total Project site area is 1,997 hectares. The area which rainfall is captured accounts for 0.14 % of the site area. Therefore, rainfall capture is estimated to divert 0.14% of rainfall that would contribute to overland flow to creeks, channels And the soil profile in the absence of development on site.

APPENDIX C EN-PR-EM0201 RISK MANAGEMENT

PROJECT SEA DRAGON

EN-PR-EM0201

RISK MANAGEMENT FRAMEWORK

Rev: A, 28-Sep-2017

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1 INTRODUCTION

1.1 PURPOSE

This procedure provides a description of the environmental risk management framework adopted for the Project Sea Dragon Environmental Management System (EMS). This framework incorporates the identification and analysis of Project environmental risks, and allows for mitigation to be developed consistent with the level of risk.

The framework has been developed to be consistent with AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines.

1.2 SCOPE

The environmental risk management framework aims to identify, analyse and provide mitigation for risks which threaten the achievement of the Project Environmental Objectives and Targets. This is undertaken through a risk assessment process described in this procedure.

2 RISK ASSESSMENT METHODS

The risk assessment process adopted is a standard semi-quantitative approach consistent with AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines. This is shown in Figure 1 and described in more detail in Sections 2.1 to 2.5.

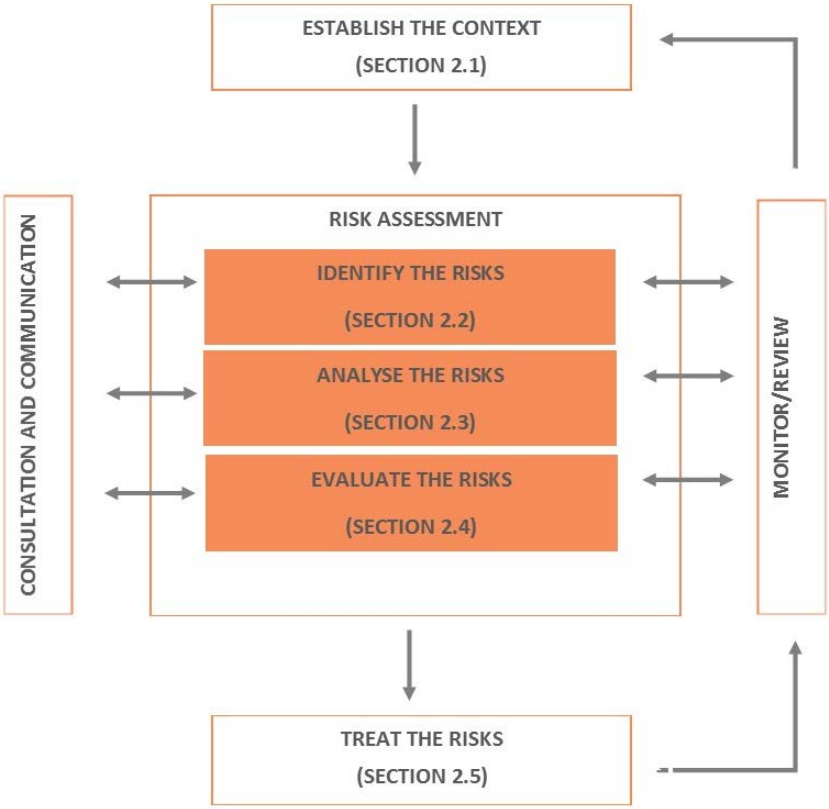

FIGURE 1 RISK ASSESSMENT PROCESS

2.1 CONTEXT ESTABLISHMENT

The first step in the risk assessment process involved establishing the context of the environmental risks. The context of the environmental risks is determined by the environmental setting of the particular element of the Project being assessed – at a corporate level, on a site by site basis, or for specific activities. On a site or activity basis, this would include a detailed description of the environment in which it is located, typically provided in the Environmental Management Plan.

2.2 RISK IDENTIFICATION

The next step in the risk assessment process involved the identification of potential environmental risks associated with the Project. This should be undertaken as part of a risk assessment workshop with the key environmental, engineering, management and technical specialists involved in the Project.

The risk identification process involves the identification of risks to the achievement of the Project Objectives and Targets. Given the nature of environmental risk assessment, this will typically identify impacts on environmental values, referred to in this procedure as 'consequence aspects', broadly categorised as:

- general ecological values
- threatened and migratory species
- historic and cultural heritage
- amenity
- land
- marine and estuarine waters
- freshwater streams, rivers and wetlands
- groundwater
- air quality
- human health and safety
- traffic and transport

Risks to the achievement of Project Objectives and Targets are systematically identified taking into consideration the full range of Project activities during each phase of the Project (e.g. construction and operations, product life cycle). Any risks to achieving Objectives and Targets which rely on risks of environmental impacts are assessed in relation the consequence aspects listed above.

2.3 RISK ANALYSIS

Once all the potential risks have been identified, initial risk ratings are assessed by assigning a level of consequence in accordance with consequence criteria for the Project (Table 1) and a level of likelihood in accordance with likelihood descriptors (Table 2). The initial risk rating considers the consequence and likelihood of the event occurring without any control measures in place. Following risk treatment (i.e. the implementation of control strategies - Section 2.5) the consequence and likelihood of the event occurring is reassessed.

Consequence criteria (Table 1) have been developed for each of the consequence aspects list in Section 2.2 and ranged on a scale of magnitude from ‘very low’ to ‘very high’. Magnitude was considered as a function of the size of the impact, the spatial area affected and expected recovery time.

The level of likelihood (Table 2) has also been determined based upon the probability of occurrence, within the context of reasonable timeframes and frequencies given the nature of the anticipated Project life. For many of the risks identified, the conditional probability of the risk occurring was taken into account - the probability of an event occurring given another event has already occurred.

TABLE 1 CONSEQUENCE SCALE

Consequence aspect	Consequences				
	Very Low	Low	Moderate	High	Very High
General Ecological Values	Insignificant or imperceptible effects.	Minor local resource and/or habitat modification and/or local short-term decrease in abundance of some species with no lasting effect on local population.	Moderate local resource and/or habitat modification and/or local long-term decrease in abundance of some species resulting in some permanent change to community structure.	Moderate resource and/or habitat modification and/or regional decrease in abundance of some species resulting in some changes to community structure.	Substantial regional resource and/or habitat modification and/or loss of numerous species resulting in the dominance of only a few species.
Threatened and Migratory Species	Minor local habitat modification and/or lifecycle disruption for a listed species No discernible decrease in size of populations of conservation significant fauna species.	Moderate local habitat modification and/or lifecycle disruption for a listed species. Minor local decrease in size of populations of species of conservation significance.	Substantial local habitat modification and/or lifecycle disruption for a listed species. Moderate lasting decrease in size of populations of conservation significant species.	Moderate widespread habitat modification and/or lifecycle disruption for a listed species. Substantial local decrease in size of populations of conservation significant species.	Substantial widespread habitat modification and/or lifecycle disruption for a listed species. Moderate or substantial widespread decrease in size of populations of conservation significant species.
Historic and Cultural Heritage	Insignificant impact to site or item of cultural significance.	Reparable minor impact to site or item of cultural significance.	Reparable major damage to site or item of cultural significance.	Irreparable minor damage to site or item of cultural significance.	Irreparable major damage to sites of cultural significance or sacred value.
Amenity	**Visual:** Changes to landscape as a result of the Project are barely noticeable from key vantage points, publicly accessible areas and areas of significance.	**Visual:** Changes to landscape as a result of the Project are visible only from nearby key vantage points, publicly accessible areas and areas of significance, and only occupy	**Visual:** Changes to landscape as a result of the Project are visible from most key vantage points, publicly accessible areas and areas of significance, and only occupy	**Visual:** Changes to landscape as a result of the Project are visible, occupy a large proportion of the viewshed and may intrude upon the visual amenity of key vantage points, publicly accessible	**Visual:** Changes to landscape as a result of the Project are clearly visible, numerous, continuous and widespread and are likely to be viewed from a number of key vantage points, publicly

Consequence aspect	Consequences				
	Very Low	Low	Moderate	High	Very High
	Noise: Negligible noise level increase at closest affected receiver	a small proportion of the viewshed. **Noise:** Marginal noise level increase at closest affected receiver	a small proportion of the viewshed. **Noise:** Moderate noise level increase at closest affected receiver	areas and areas of significance across a variety of landscape. **Noise:** Appreciable noise level increase at closest affected receiver.	accessible areas and areas of significance across the landscape. **Noise:** Significant noise level increase at closest affected receiver.
Land	Impacts are localised and confined to near surface soils and are short-term. Easily rectified with no long term impacts.	Localised and medium-term reversible impact. May take up to 1 year to remediate.	Major localised impact or widespread lower impact. Remediation may take months to years.	Impact most likely affecting large areas and/or deep soil profiles leaving long term residual damage. Requires long-term recovery. May take years for full remediation to a point suitable for beneficial uses commensurate with current land uses.	Impact most likely affecting large areas and/or deep soil profiles leaving major residual damage. Requires long-term recovery. May take decades to achieve full remediation to a point suitable for beneficial uses commensurate with current land uses.
Marine and Estuarine Waters	**Quality:** Minimal near source (at point of discharge) eutrophication, or other water quality change with no significant loss of quality. **Quantity:** Short term minor change in quantity. **Seabed changes:** Insignificant change in bathymetry as a direct result of project activities.	**Quality:** Local short-term eutrophication or other water quality change above approved Water Quality Objectives. **Quantity:** Long term minor change in quantity. **Seabed changes**: Near-source and minor changes in bathymetry as a result of project activities.	**Quality:** Local long-term eutrophication or other water quality change above approved Water Quality Objectives. Short term local changes to water quality as a result of discharge or spillage of chemical or toxicants. **Quantity:** Moderate change in quantity.	**Quality:** Widespread long-term eutrophication or other water quality change above approved Water Quality Objectives. Short term widespread changes to water quality as a result of discharge or spillage of chemical or toxicants **Quantity:** Short term major or long term moderate changes in quantity.	**Quality:** Long term widespread changes to water quality as a result of discharge or spillage of chemical or toxicants **Quantity:** Long term major changes in quantity. **Seabed changes:** Widespread and substantial changes in bathymetry as a result of project activities.

Consequence aspect	Consequences				
	Very Low	Low	Moderate	High	Very High
			Seabed changes: Local and minor changes in bathymetry as a result of project activities.	**Seabed changes**: Local and substantial changes in bathymetry as a result of project activities.	
Freshwater streams, rivers and wetlands	**Quality:** Minimal contamination or change with no significant loss of quality. **Quantity:** Short term minor change in quantity. **Hydrology**: Insignificant alteration of existing hydrology.	**Quality:** Localised minor short term reduction in water quality. Local contamination or change that can be immediately remediated. **Quantity:** Long term minor change in quantity. **Hydrology**: Localised minor changes to existing hydrology.	**Quality:** Localised, minor long term; or widespread, minor short term; reduction in water quality. Remediation may take weeks. **Quantity:** Moderate change in quantity. **Hydrology:** Localised major or widespread minor changes to existing hydrology.	**Quality:** Localised, major long term; or widespread, major short term; reduction in water quality. Remediation may take months. **Quantity:** Short term major or long term moderate changes in quantity. **Hydrology:** Widespread major changes to existing hydrology.	**Quality:** Widespread major long term reduction in water quality. Remediation may take years. **Quantity:** Long term major changes in quantity. **Hydrology:** Major changes to existing hydrology on a catchment level.
Groundwater	**Quality:** Impacts are localised and confined to near source and are short-term. Easily rectified with no long term impacts. No impact on beneficial uses or ecological values. **Drawdown:** Insignificant effect.	**Quality:** Localised and medium-term, low level reversible impact. May take up to 1 year to remediate. No impact on beneficial uses or ecological values. **Drawdown:** Near-source minor change in recharge patterns within sub-catchments.	**Quality:** Major localised impact or widespread lower impact. Remediation may take months to years. No impact on beneficial uses or ecological values. **Drawdown:** Near-source major change in recharge patterns within sub-catchments.	**Quality:** Large volumes of or deep-seated contaminants requiring long-term recovery. May take years for full remediation. **Drawdown:** Local major changes in recharge patterns within sub-catchments.	**Quality:** Large volumes of or deep-seated contaminants requiring long-term recovery. May take decades for full remediation. **Drawdown:** Widespread major changes in recharge patterns.

Consequence aspect	Consequences				
	Very Low	Low	Moderate	High	Very High
Air Quality	No measurable air quality impacts or exceedance of air quality standards	Near source, short-term, and approaching exceedance of air quality standards	Near source, minor, long-term, or widespread minor short term or minor exceedance of air quality standards	Widespread, major, short-term exceedance of air quality standards	Regional long term change in air quality or exceedance of air quality standards
Human Health and Safety	Low level short term subjective inconvenience or symptoms. Typically first aid and no medical treatment.	Reversible / minor injuries requiring medical treatment, but does not lead to restricted duties. Typically a medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.

TABLE 2 LIKELIHOOD CLASSIFICATION

	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Frequency Interval (multiple events)	1/100 years	1/10 – 1/100 years	1/year – 1/10 years	2/years – 1/year	>2/year
Probability (single events)	<0.1%	0.1%-1%	1%-10%	10%-25%	>25%

2.4 RISK EVALUATION

Once the consequence criteria and level of likelihood had been assigned to each identified risk, the overall risk level is evaluated by using the risk matrix provided in Table 3.

TABLE 3 RISK ASSESSMENT CLASSIFICATION MATRIX

Likelihood	**Consequences**				
	1 – Very Low	**2 – Low**	**3 – Moderate**	**4 – High**	**5 – Very High**
5 – Almost Certain	Medium	Medium	High	Extreme	Extreme
4 - Likely	Medium	Medium	Medium	High	Extreme
3 – Possible	Low	Medium	Medium	Medium	High
2 – Unlikely	Very Low	Low	Medium	Medium	Medium
1 – Rare	Very Low	Low	Low	Medium	Medium

A brief description of each overall possible risk classification is provided below.

Extreme

A ranking of very high represents an unacceptable risk, which is usually critical in nature in terms of consequences (e.g. extensive and long term environmental damage) and is considered possible to almost certain to occur. Such risks significantly exceed the risk acceptance threshold and require comprehensive control measures, and additional urgent and immediate attention towards the identification and implementation of measures necessary to reduce the level of risk.

High

High risks typically relate to significant to critical consequences (e.g. a major amount of environmental damage) that are rated as possible to almost certain to occur. These are also likely to exceed the risk acceptance threshold, and although proactive control measures are usually planned or implemented, a very close monitoring regime and additional actions towards achieving further risk reduction is required.

Medium

As suggested by the classification, medium level risks span a group of risk combinations varying from relatively low consequence / high likelihood to mid-level consequence / likelihood to relatively high consequence / low likelihood scenarios. These risks are likely to require active monitoring as they are effectively positioned on the risk acceptance threshold.

Low

Low risks are below the risk acceptance threshold and although they may require additional monitoring in certain cases, are not considered to require active management. In general such risks represent relatively low likelihood, and low to mid-level consequence scenarios.

Very Low

Very Low risks are below the risk acceptance threshold and would, at the most, require additional monitoring and in many cases would not require active management. These risks can include unlikely to rare events with minor consequences, and in essence relate to situations around very low probabilities of relatively minor impacts occurring.

2.5 RISK TREATMENT

Control measures were developed to further reduce the risk. The risk is then reassessed using the processes outlined in Sections 2.3 and 2.4 to confirm the effectiveness of these control measures. This second rating is known as the residual risk rating and is used as the final risk rating.

The control measures are then required to be implemented, through the development of or incorporation into specific procedures and environmental management plans.

3 RISK REGISTER

A risk register is to be established to document the findings of the risk assessment process. The risk register contains details of the source of impact, the potential consequences and control measures that will be implemented. This will be developed for each site as a minimum as document EN-0X-RG-EM0201 where 0X defines the site identification number.

APPENDIX D BASELINE WATER QUALITY DATA

TABLE D1 BASELINE DATA

Site	Date	DO	EC	TDS	pH	Turb	TSS	NH_4	NO_x	FRP	TN	TP	Chl a	Season	Tide
BH01	1/11/2015	-	55000	39	-	1.7	4.8	0.013	-	<0.05	0.15	0.02	<1	Dry	inter, flood
BH01	1/12/2015	-	53000	40	-	3	6.2	<0.01	-	<0.05	0.1	0.03	<5	Dry	spring, flood
BH01	30/06/2016	-	55000	36	8.06	2.2	5.2	0.01	0.03	<0.005	0.1	0.14	1	Dry	neap, ebb
BH01	1/07/2016	-	55000	39	7.92	3.2	8	<0.01	<0.02	<0.005	0.2	<0.05	<1	Dry	neap, flood
BH01	1/09/2016	-	57000	40		1.3	4.2	<0.01	<0.02	<0.05	0.24	<0.05	<1	Dry	neap, high
BH01	1/10/2016	47.3	56000	37	8.24	1.1	1.3	0.01	<0.02	<0.005	<0.1	<0.05	<2	Dry	neap, high
BH01	1/11/2016	41	55000	40	8.67	3.2	43	<0.01	<0.02	<0.005	<0.1	0.22	<2	Dry	neap, ebb
BH01	30/11/2016	-	54000	39	-	2.4	37	0.05	0.03	0.005	0.2	<0.05	<2	Dry	spring, ebb
BH01	1/12/2017	101.5	-	37	8.04	-	7.8	<0.01	<0.02	<0.005	0.3	0.04	1.3	Dry	inter, flood
BH01	1/01/2016	-	48000	34	-	2.6	7.8	0.05	-	<0.05	0.26	0.02	1.9	Wet	spring
BH01	1/02/2016	-	51000	34	-	1.7	7.8	<0.005	-	<0.01	0.14	0.01	1.6	Wet	spring, flood
BH01	1/04/2016	77.9	28000	19	7.93	2.1	11	<0.01	-	<0.05	<0.2	<0.05	2	Wet	inter, flood
BH01	1/05/2016	-	48000	38	-	5.9	23	0.01	<0.02	<0.005	0.2	0.06	1	Wet	inter, flood
BH01	1/01/2017	54.6	46000	30	7.89	4.2	23	<0.01	<0.02	<0.005	0.43	<0.05	8	Wet	neap, flood
BH01	1/02/2017	57.1	40000	25	7.89	1.9	12	<0.01	<0.02	<0.005	<0.2	<0.05	1.3	Wet	neap, ebb
BH01	1/04/2017	53.7	45000	34	7.4	2.8	17	<0.01	<0.02	<0.005	0.2	<0.05	1.1	Wet	neap, ebb
BH02	1/11/2015	-	55000	40	-	10	21	<0.005	-	<0.05	0.14	0.02	<1	Dry	inter, flood
BH02	1/12/2015	-	54000	36	-	7.6	17	<0.01	-	<0.05	0.2	0.02	<5	Dry	spring, flood
BH02	30/06/2016	-	56000	38	7.89	2.1	2.9	<0.01	<0.02	<0.005	0.2	0.14	1	Dry	neap, ebb
BH02	1/07/2016	-	56000	39	7.78	2.7	5.9	<0.01	<0.02	<0.005	0.1	<0.05	<1	Dry	neap, flood
BH02	1/09/2016	-	58000	41	-	1.1	2.2	<0.01	<0.02	<0.05	0.3	0.12	<1	Dry	neap, high
BH02	1/10/2016	37.8	55000	38	8.08	2.3	2.2	<0.01	<0.02	<0.005	<0.1	<0.05	<2	Dry	neap, high
BH02	1/11/2016	33.2	53000	39	8.3	10	54	0.01	<0.02	<0.005	<0.1	0.22	<2	Dry	neap, ebb
BH02	30/11/2016	-	45000	38	-	4.6	21	<0.01	0.03	<0.005	<0.1	<0.05	<2	Dry	spring, ebb
BH02	1/12/2017	87.5	-	38	7.74	-	140	<0.01	0.05	<0.005	0.15	<0.02	2.7	Dry	inter, flood
BH02	1/01/2016	-	45000	31	-	3.3	-	0.045	-	<0.05	0.22	0.03	1.6	Wet	spring
BH02	1/02/2016	-	48000	31	-	1.8	8.1	0.005	-	<0.01	0.15	0.01	2.1	Wet	spring, flood
BH02	1/04/2016	67.4	27000	18	7.8	11	24	<0.01	-	<0.05	<0.2	<0.05	2	Wet	inter, flood

Site	Date	DO	EC	TDS	pH	Turb	TSS	NH_4	NO_x	FRP	TN	TP	Chl a	Season	Tide
BH02	1/05/2016	-	48000	38	-	7.3	12	0.02	<0.02	<0.005	0.6	0.06	1	Wet	inter, flood
BH02	1/01/2017	61	27000	16	7.57	6.3	15	0.02	<0.02	<0.005	0.34	<0.05	3.2	Wet	neap, flood
BH02	1/02/2017	55.6	18000	12	7.66	5.2	9	<0.01	<0.02	<0.005	<0.2	<0.05	<1	Wet	neap, ebb
BH02	1/04/2017	51	36000	27	7	5.2	15	0.01	0.03	<0.005	0.2	<0.05	1.3	Wet	neap, ebb
BH03	1/11/2015	-	55000	39	-	4.5	33	0.018	-	<0.05	0.41	0.02	<1	Dry	inter, flood
BH03	1/12/2015	-	55000	39		5.1	12	<0.01	-	<0.05	0.2	0.02	<5	Dry	spring, flood
BH03	30/06/2016	-	55000	38	8.01	3.7	6.4	<0.01	<0.02	<0.005	<0.1	0.14	1	Dry	neap, ebb
BH03	1/07/2016	-	56000	38	7.88	3.5	7.9	<0.01	<0.02	<0.005	0.21	<0.05	3	Dry	neap, flood
BH03	1/09/2016	-	57000	40	-	1	3.7	<0.01	<0.02	<0.05	0.26	0.06	<1	Dry	neap, high
BH03	1/10/2016	49.2	56000	37	8.22	2	<1	<0.01	<0.02	<0.005	<0.1	<0.05	<2	Dry	neap, high
BH03	1/11/2016	36.6	55000	40	8.38	3.1	33	<0.01	<0.02	<0.005	<0.1	0.2	<2	Dry	neap, ebb
BH03	30/11/2016	-	54000	39	-	4.6	16	<0.01	<0.02	<0.005	0.1	<0.05	<2	Dry	spring, ebb
BH03	1/12/2017	98.7	-	39	7.9		9.6	<0.01	<0.02	<0.005	0.1	<0.02	2.1	Dry	inter, flood
BH03	1/01/2016	-	48000	34	-	2.5	8.7	0.039	-	<0.05	0.2	0.03	3.7	Wet	spring
BH03	1/02/2016	-	50000	34	-	1.4	7.3	0.004	-	<0.01	0.17	<0.01	1.9	Wet	spring, flood
BH03	1/04/2016	80.9	28000	18	7.9	8	20	<0.01	-	<0.05	<0.2	<0.05	2	Wet	inter, flood
BH03	1/05/2016	-	46000	37	-	3.2	5.7	<0.01	<0.02	<0.005	0.2	0.06	1	Wet	inter, flood
BH03	1/01/2017	46.7	41000	26	7.46	4.7	13	0.01	<0.02	<0.005	0.31	<0.05	4.3	Wet	neap, flood
BH03	1/02/2017	60.5	35000	22	7.72	3.6	9.7	0.04	0.02	<0.005	<0.2	<0.05	<2	Wet	neap, ebb
BH03	1/04/2017	60.9	42000	32	7.58	3.3	17	0.01	<0.02	<0.005	<0.2	<0.05	<1	Wet	neap, ebb

Table notes:

EC = Electrical Conductivity (µS/cm); TDS = Total Dissolved Solids (mg/L); pH (pH units); Turb = Turbidity (NTU); TSS = Total Suspended Solids (mg/L); NH_4 = Ammonia N (mg/L); NO_x = Oxides of Nitrogen (NO_2 + NO_3) (mg/L); FRP = Filterable Reactive Phosphorous (mg/L); TN = Total Nitrogen (mg/L); TP = Total Phosphorous (mg/L); Chl a = Chlorophyll a (µg/L).

APPENDIX E INDEPENDENT REVIEWER ADVICE

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Our Ref: DLR: L.B23779.001.Peer review

2 March 2020

CO2
Level 2, 12 Browning St
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QLD 4101

Attention: Kate McBean

Dear Kate

RE: INDEPENDENT PEER REVIEW - WATER QUALITY MONITORING AND MANAGEMENT PLAN FOR THE BYNOE CORE BREEDING CENTRE AND BROODSTOCK MATURATION CENTRE

Background

The author, Dr Darren Richardson, was engaged by CO2 to provide an Independent Peer Review of the Water Quality Monitoring and Management Plan (WQMMP) developed for *Project Sea Dragon, Core breeding centre and broodstock maturation centre*. The WQMMP was prepared by CO2 and Seafarms.

The Peer Review was conducted in two stages:

- Stage 1 - An initial review of the draft WQMMP report:
  - Draft Water Quality Monitoring and Management Plan EN02-MN4201, Rev 0, dated 29 May 2019
  - Supporting Report to the WQMMP EN02-MN4201, Rev 0, dated 29 May 2019.
- Stage 2a - A review of the updated WQMMP responding to the Stage 1 review:
  - Water Quality Monitoring and Management Plan EN02-MN4201, Rev 1, dated 11 November 2019
  - Supporting Report EN-01-EM002, Rev 1, dated 11 November 2019.
- Stage 2b - A review of the final WQMMP responding to the Stage 2a review:
  - Water Quality Monitoring and Management Plan EN02-MN4201, Rev 1, dated 25 February 2020

This report consolidates the findings of the peer review, which will be included as part of the WQMMP documentation.

Basis for the Review

This review responds to requirements set out in the *Northern Territory Environmental Protection Authority (EPA) Assessment Report 81*[1], specifically Recommendation 3 which states:

"In consultation with the NT EPA, the Proponent shall enhance the baseline water quality monitoring program by:

- *increasing spatial representation of sites in Bynoe Harbour*

[1] https://ntepa.nt.gov.au/__data/assets/pdf_file/0008/410795/assessment_report_sea_dragon_core_breeding_centre.PDF

- *accounting for natural variation in receiving waters*
- *including sediment sampling and biological indicators of nutrient impacts.*

The water quality monitoring program should be peer reviewed by an appropriately-qualified independent professional, and implemented to the satisfaction of the NT EPA".

Summary

The conclusions drawn from the review process are provided below. In summary, the reviewer is satisfied that the WQMMP is fit for purpose and all review comments are now closed.

Stage 1 Review Findings

Table 1 and 2 presents the findings of the Stage 1 review, and the proponent's responses to the issues raised. In summary, the Stage 1 review raised queries/comments regarding the following elements:

- linkages between pressures and ecosystem condition
- the management review process and philosophy, and management responses
- methodology and monitoring program design
- the location of sensitive receptors and how this was considered in the monitoring program design
- reasons for anomalous data for several indicators.

The draft WQMMP was updated to address these issues, which was re-assessed in Stage 2.

Stage 2 Consolidated Review Findings

The updated WQMMP documents (Revision 1) were reviewed in the context of:

- amendments to the WQMMP in response to the Stage 1 review
- issues identified in NT EPA Assessment Report 81.

Most issues raised in the Stage 1 were satisfactorily addressed and are now closed. Additional comments were provided regarding the following:

- Comment 12 – suggested re-phrasing re. replicate sample analysis
- Comment 13 - the reviewer had queries regarding (i) statements in the WQMMP regarding benthic substrates and sediment size fractions derived from catchment runoff; and (ii) whether algae blooms occur in the harbour
- Comment 17 – the potential presence of seagrass meadows in the harbour
- Comment 37 – clarifications regarding modelling of chlorophyll.

The WQMMP documents were subsequently updated (Revision 1 – 25 February 2020). The above points were satisfactorily addressed and therefore closed.

Yours Faithfully
BMT

Dr Darren Richardson
Senior Principal Scientist

Table 1 Stage 1 and 2 review findings and proponent responses on main report draft water quality monitoring and management plan EN02-MN4201

Comment	Section no.	Comment	Recommendation	PSD Response (28/11/2019) and Changes in Rev 1	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses and bold)
(1)	6	No conceptual model provided. See comment (13).	Refer to comment (13).	A conceptual model has been developed, in Section 8 to the supporting report, similar to that developed for the Legune WQMMP	Closed	-
(2)	6.2.2	There are many inter-changeable terms to describe numerical guideline values (guideline values, trigger values, water quality objectives), which can be confusing. ANZG (2018) adopts the term guideline values for numerical values for indicators used to assess water quality risk (equivalent to the "trigger value" in ANZECC (2000))	Please address.	Where relevant we have replaced terms with the term 'guideline values', except in the following instances: - the Darwin Harbour Water Quality Objectives set by the NT Government - Discharge criteria instead of discharge triggers - Default Guideline Values (DGVs) for AWQG default guideline values. The terms and abbreviations has been updated to include definitions for Water Quality Objectives and guideline values.	Closed	-
(3)	6.2.2	The ANZG (2018) framework is a cyclical process and the steps should be re-visited once the farm is operational and monitoring is undertaken to assess receiving environment water quality against the guideline values.	Please add note.	The following note has been added at the start of this section: 'The Water Quality Management Framework is a cyclical process and will be repeated as needed. In particular, the steps will be reviewed and revised as appropriate immediately prior to operations, and once the Project is operational, based on monitoring and assessment of receiving environment water quality against the guideline values.' In Appendix A1, in Actions/Mitigation Measures, added a pre-operational requirement to: 'Revisit and revise the Water Quality Management Framework process described in Section 6.2.2 based on the baseline (and any other available) data. Update this plan if required' A similar requirement added to the Pre-Stage 2 Operations: 'Review and revise the Water Quality Management Framework process described in Section 6.2.2 based on the available data from Stage 1 Operations. Update this plan if required'	Closed	Closed
(4)	6.2.2 - also Appendix A2	This section refers to power analysis, but no such results are presented here or in the supporting documentation.	Please address.	Power analysis is not referred to here, however we assume these are the sections referred to: - Section 6.3.1 states 'Monitoring programs have been designed to be practical and achievable for both wet and dry seasons, to be as simple and uncomplicated as possible, while still achieving suitable detection levels (power) and avoiding false positives and negatives, and to be as efficient and cost effective as practicable' - Table A2-1 which states that 'Baseline data collection to further build the existing baseline dataset to ensure longer term trends and seasonal variation in water quality is properly captured and to ensure sufficient power for any future detailed statistical assessment if required.' The term power was used in the statistical sense of minimising Type II errors (while minimising Type I errors as stated above), but was not referring to a particular power analysis. Instead, the approach has been to adopt standard monitoring and compliance assessment practices in terms of setting reference data (i.e. 20th and 80th percentiles) and comparing annual medians to this reference data. Essentially this results in an effect size of between the median and 80th percentile, which equates to approximately 1 standard deviation - the default for ecologically conservative decisions in the AWQGs. A minimum baseline dataset was defined based on achievement of at least 24 data points over >2 years for the three longest monitored sites.	(A) Section # referred to be reviewer was erroneous. (B) Reviewer supports: (i) the use of 20th/80th percentile reference site data as GVs, and (ii) comparison of test site 50th percentile test to reference site guideline values. Reviewer agrees with comments regarding effect size, which is consistent with ANZECC (2000). The sample size (and duration of sampling) reference site data is consistent with standard industry practice (e.g. recommendations of the Qld WQ Guidelines 2013). Closed	Ok - no further comment
(5)	6.3.4	The 2-year review should also include data analysis to evaluate whether the sample size was appropriate during operation phase.	Please address.	The requirement to assess sample sizes is provided for in Appendix A1, in Review and Auditing (under Program Review), amended as in the next item (6)	Noted and closed	-

Comment	Section no.	Comment	Recommendation	PSD Response (28/11/2019) and Changes in Rev 1	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses and bold)
(6)	6.3.4	In addition to remaining cost effective etc., the program review should consider whether the monitoring program is sufficiently robust to detect changes at the stated level of precision (i.e. a 10% change – see comment (41)) and to implement management measures to mitigate unexpected impacts, where required.	Please add note.	The wording has been extended as follows: .....reviewed and refined to ensure it remains cost-effective, practical and focused, 'and that it is both sufficiently robust to detect changes at the stated level of precision, and suitable to provide for triggers and management measures to mitigate unexpected impacts.' Appendix A1, in Review and Auditing, under Program Review, has been amended to read: 'This [the 2-year review] will include an assessment of whether the program is sufficiently robust to detect changes at the stated level of precision (i.e. suitable sample size, temporal and spatial replication, other relevant factors), and whether it adequately provides for triggers and actions to mitigate unexpected impacts.'	Noted and closed	-
(7)	Appendix A1	Actions / Mitigation Measures – in addition to clearing during the dry season, it is recommended that cleared areas be stabilised prior to wet season. *Corrective actions triggers* (point 3) – please provide examples of injury to biota, e.g. fish kills, visible signs of disease, fish gasping at surface etc. *Corrective actions* (point 5): • it might not be necessary to re-sample if the laboratory has sufficient material for re-analysis, and parameters are within holding times. • In terms of ceasing discharges, consider providing some bounds, such as "…until such time as the underlying issue has been rectified and the ecosystem has fully recovered.	Please address.	The following has been added to the earthworks note (undertake in the dry season) under construction (Actions): '..., and ensure disturbed areas are appropriately stabilised prior to the next wet season.' The following has been added to the examples to the Corrective actions, item 3: '... – e.g. fish kills, dead or dying marine fauna, boat strike, visible signs of disease or injury' Corrective Actions, point 5 has been amended to read as follows: '... - Re-test the sample (if sufficient sample remains with the lab), or re-sample and investigate potential sources of exceedances'. Regarding the final point (*consider providing some bounds...*), this was included to convey that measures may include anything up to and including stopping discharge (i.e. stopping production) if necessary. It does not aim to convey the triggers for such, nor the timing under which discharge should resume. This will need to be determined at the time of any such incident. Instead, the system is outcomes focused - discharges must comply, and impacts on receiving waters should be within reasonable limits (those accepted as such as part of the Project approvals). We prefer not to provide a prescriptive approach to this section of the plan, and do not believe it is necessary.	Agreed and closed	-
(8)	Appendix A2	This section refers to mangrove remote sensing methods in DES (2018) but the methodology in this manual refers to ground sampling. Cardno (2013) is not in the references.	Please clarify. Note also that ground surveys will be required to validate remotely sensed data.	This section has been revised to read: ' Mangrove assessments will utilise multi-spectral imagery / NDVI metrics to assess extent, health and intactness, with ground truthing to confirm findings, comparable to DES (2018) – refer to Cardno (2013) and others as needed'	Closed	-
(9)	Appendix A2	Baseline water quality monitoring frequency. Should read 18 not 8 samples. Baseline mangrove and sediment monitoring frequency. Please provide justification for collecting one baseline sample. This is unlikely to be adequate given natural variability, and it is recommended that at least two wet and two dry season samples are collected (historical imagery is available). Baseline seagrass monitoring: • Please justify seagrass identification to genera. All species should be readily taken to species level. • Include incidental macroalgae cover observations in the seagrass monitoring program, as under nutrient enriched condition seagrass meadows can switch state to macroalgae dominated assemblages	Please address.	The 8 samples was referring to the additional required, and this would take the existing 16 to 24 samples. To clarify, this has been changed to the following: 'Collect a total of at least 24 samples at the long term monitoring sites (BH01, MA03, WCDS1), and sample the other sites each round, prior to operational discharges commencing, on a quarterly or monthly basis, aiming for no overall bias in terms of tides or season.' This is also reflected in Section 10.3 in the supporting report. Note that Mangrove baseline monitoring has been split out from Sediment sampling to read: '2 wet and 2 dry analyses of satellite imagery, with at least one ground-truthed prior to operational discharge commencing' For Sediments, this has been changed to 2 rounds instead of one which will be added to the current baseline monitoring program. For seagrasses, seagrass identification has been extended to species level, and incidental macroinvertebrate cover observations has been added to the Sampling Parameters / Requirements for seagrass in this section (Table A2-3).	Noted and closed.	-
(10)	Appendix A3	Please clarify whether monthly in situ water quality measurements will be collected at the discharge (it is noted that no discharge criteria exist).	Please clarify.	The table identifies the frequency (in Frequency and Timing) as monthly, and all of the parameters listed in the 'Parameters to sample' are to be collected for each monthly sampling event. This will include the stated in-situ measurements.	Noted and closed.	-

Comment	Section no.	Comment	Recommendation	PSD Response (28/11/2019) and Changes in Rev 1	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses and bold)
(11)	Appendix B, B2.4	It is recommended that sondes be checked and calibrated pre and post sampling.	Please add note.	Added the following after the requirement to calibrate prior to each run: '... and again [i.e. calibrate] after each sampling round. Errors and corrections are to be noted on the results sheets where they result in significant changes to the results (as a first estimate, >10% change). If practicable, retest samples (on an additional collected bottle) or recollect samples.'	Closed	-
(12)	Appendix B4.1	In terms of replicate samples, it is not clear who is responsible for requesting this. QA/QC field samples should be collected in accordance with relevant standards referred to in the WQMMP.	Please clarify.	Section B4.5 QA/QC Samples refers to replicate samples and sampling. In B4.5, the sentence 'QA/QC sampling will be undertaken as per AS5667.1.1998 by a NATA accredited laboratory.' has been changed to 'QA/QC testing will be undertaken as per AS5667.1.1998 by a NATA accredited laboratory.' Replicate sampling is the responsibility of the operator (i.e. PSD). To ensure clarity, the following has been added to the first sentence of the second paragraph: 'Replicate sampling will be conducted as part of the sampling program to ...'	Noted. Suggest changing "if requested" to "where appropriate". It is subtle, but "requested" is ambiguous as it gives the impression that the analysis will be done if requested by another party, such as an agency.	Completed - in Section B4.1, paragraph 3 (after bullets) **(Reviewer note – Closed)**

(-) no further comment

Table 2 Stage 1 and 2 review findings and proponent responses on EN-01-EM002

Comment	Section no. Rev 0 (Rev 1 if different)	Comment	Recommendation	PSD Response (28/11/2019)	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses)
(13)	General	The links between key controlling processes, Project related pressures and associated stressors, and ecosystem receptors is not clear. While these features are discussed in different parts of the document (especially Section 6), the document length and structure make it difficult to follow the narrative on how these interact, and how they have been considered in the development of the WQMMP. The linkages between Processes-Pressures-Stressors-Receptors is important to understand as it underpins the rationale and assumptions regarding indicator selection (e.g. do the indicators cover all elements?), the sampling design (e.g. are the sites in the right places?), and guideline value derivation (should you be stratifying by season, for example). A conceptual model can describe these relationships and the underlying assumptions. The development of conceptual models is among the first steps of the water quality frameworks on which this WQMMP is based (i.e. ANZECC (2000), ANZG (2018) and Queensland Water Quality Monitoring and Sampling Manual (2018). The conceptual model should be used as the basis for the entire monitoring program and should show the steps between discharge and changes to receiving water quality, habitat and ecosystem health, and ultimately cultural values. This will ensure that appropriate consideration is given to coral reefs.	Develop a conceptual model (supported by a brief written summary) of key Processes-Pressures-Stresses-Receptors. This could perhaps be included in Section 6. Cross reference to conceptual model in subsequent sections.	A conceptual model has been developed, similar to that developed for the Legune WQMMP, and is presented in Section 8 of the supporting report. This is supported by Section 6.3 which summarises the key pressures, stressors and indicators related to the Project, particularly Table 6-1.	Please clarify with regard to S8: • Dot point 6 - presumably this refers to fine sediment (not the gravel). • Dot point 8 - wet season inflows would deliver higher catchment nutrient loads c.f. the dry. If natural algae blooms occur here suggest including in model	Changed dot point 8 to read: ' Nutrient inputs are expected to be relatively low from the terrestrial catchments and tend toward higher concentrations due to less flushing, dilution, and greater tidal resuspension and recycling during dry periods.' Natural algal blooms are not known to occur here. **(Reviewer note – Closed)**

Comment	Section no. Rev 0 (Rev 1 if different)	Comment	Recommendation	PSD Response (28/11/2019)	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses)
(14)	General	The WQMMP contains “recommendations” regarding additional data collection to address gaps. It is unclear who the audience is for these recommendations. Section 7.3.1 also states that “Pre-construction baseline benthic habitat mapping for these locations would be desirable…”, but it is not clear whether this is a commitment. The WQMMP should state commitments rather recommendations.	Reconsider terminology.	The Supporting Report provides a review of the existing data, with recommendations provided for the development of the WQMMP (i.e. for Project Sea Dragon), which have been adopted. However, to provide better clarity, these recommendations have been strengthened in the supporting report. These remain as commitments in the main report. The statement referring to benthic habitat mapping, referring to the intake and outlet pipes, has been changed to the following: 'Baseline benthic habitat mapping for these locations, along with suitable control-impact benthic macroinvertebrate monitoring locations, needs to be conducted prior to construction in these areas commencing.' In addition, in Appendix A2, Table A2-3, benthic habitat mapping has been added (intake and discharge locations, incorporating benthic observations in the water quality monitoring program, and updating the benthic mapping based on this information). Similar post-discharge benthic mapping is proposed at 1 year and 2 years after discharge commences (Table A3-5).	Closed	-
(15)	2	Regarding site components affecting water quality, there are three drivers of water quality impacts: • Intake (dot point 1) • Licensed discharge of farm wastewater (dot points 2-4) • Construction-related impacts (not mentioned here, but taken to include all construction footprint areas shown in Fig 1.2)	Include construction related disturbance.	This section discusses the Project itself, and the section referred to references key operational site elements in terms of their impacts to water quality, rather than defining key impacts themselves. Construction related impacts (along with operational impacts) are addressed in Section 6 (refer Section 6.2) - importantly, as this section states, since 'activities associated with construction (acid sulfate soils, clearing and ground disturbance) and spills or leaks are specifically addressed elsewhere in the Environmental Management Plan for the site, only the effect of prawn farm discharges is further addressed in this report'	Noted and closed	-
(16)	3.1	It is stated here that significant features, including ‘the coastal environment’, will not be impacted. However, elsewhere it is stated that localised water quality impacts will occur near the outfall. Are estuarine creeks included in the definition coastal environments?	Please re-word to contextualise.	This section has been reworded by separating out the coastal environment and discussing in a separate paragraph, as follows: 'The coastal environment is (by design) in close proximity to the Project. However, direct disturbance to these areas will be minimal, limited to the immediate vicinity of the intake and outlet pipelines, with intake and outfall pipelines and inlet/outlet works sited and buried/fixed to avoid impacts to coastal processes'	Closed	-
(17)	3.4	Reef-associated benthic communities (hard and soft corals, sponges etc.) likely represent the most sensitive ecological receptor in the harbour. There are several issues to consider: • The baseline data does not accurately define their extent, location and condition. Related to this, the habitat description for the discharge location (rock, sand, mud etc.) does not match the mapping in Figure 3-1 (sand). • The sensitivity of these communities to Project stressors is not described. • The lack of reliable habitat mapping data is a limitation with regard to site selection for benthos and water quality monitoring components (i.e. ideally sites would be placed at the boundary of sensitive receptors).	Include reefs and linkages to project pressures in the conceptual model. Undertake benthic habitat mapping in potentially affected areas to inform the design and indicators for the benthos monitoring program. If reefs occur nearby to the discharge point, consider the need or otherwise for additional water quality monitoring sites at these locations.	The work conducted for the EIS and summarised in the WQMMP Supporting Report indicates that benthic organisms and communities are present in the general Bynoe Harbour area, although reported as 'sparse and patchy in nature'. Within proximity to the Project, and more so within Wheatley Creek and Mackenzie Arm (in proximity to the discharge outlet), seagrass has not been identified, either through observations of intertidal areas at low tide by Water Technology through the EIS, from previous works in the area (Enesar, 2006; Smit et al, 2000) or by the Paspaley oyster leases. Smit et al (2000) notes that sponges and soft corals dominate the reef benthos of Bynoe Harbour, together with hard corals of the genus Turbinaria. However, sampling within the area indicates again very sparse presence of some of these species. Wheatley Creek and Mackenzie Arm upstream of its confluence with Wheatley Creek is identified as intertidal by NT DENR, and the reach downstream is subject to higher velocities, with substrate more sandy in nature (refer further below). More recent video and camera grab sampling by ECOz Environmental (unpublished data) was examined against the existing data summarised in Figure 3-1. The results support the finer textured material in intertidal areas	Google Earth imagery (14/08/2016) shows what appears to be intertidal seagrass meadows on sand shoals in Mackenzie Arm, approx 3km from the discharge and near site BH3. This is possibly ephemeral, which may be why it has been undetected. It is recommended that site placement is reviewed on the basis of the proposed additional baseline sampling of habitats.	The monitoring team (PSD personnel) have inspected the identified site location via helicopter on 11 February 2020 in an attempt to identify whether this area supports seagrass. The water was very turbid and they were unable to positively confirm the presence of seagrass. Based on our assessments to date we consider that this area is unlikely to support seagrass due to: - The turbidity of the water, and the light limiting factor. - The aerial patterns in this location look identical to the darker sand patterns in the imagery to the north, and these appear to be sand patterns created by the

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				along shores (i.e. in mangrove and mud flat areas), and the general substrate categories mapped. Within Mackenzie arm and Wheatley Creek (not mapped in the WQMMP), data supports sandy and muddy substrates, depending on position across the creek and along the centreline (results variable as noted in the WQMMP). Further sediment sampling is planned and all data will be used to refine the mapping. As for benthic communities, most sites in the vicinity of the Project did not record any hard or soft corals, sponges or seagrasses, with individuals recorded along the centre of Bynoe Harbour in two locations (Smit et al, 2000) and seaward by several authors. The only rocky area (described in the EIS as a 'rocky reef') is located 450 m offshore from Point Ceylon. Due to the relocation of the intake pipe within Geranium Channel this rocky area will no longer be disturbed or directly impacted by the Project. In addition, modelling conducted as part of the EIS determined that within Geranium Channel, at the location of the new intake point, discharge constituents 'would be undetectable and/or undistinguishable from background variable levels' (SEIS, Appendix A, p11-216). Given the results of this modelling, we can conclude that discharge constituents will also be undetectable at the rocky area which is located further to the east of the intake point. It is also important to note that from an operational perspective it is critical that there is a very low risk of recirculation of discharge waters. Based on the assessments undertaken PSD is confident that no discharge will be present at the intake point. Opportunistic monitoring has been conducted during the water quality, macroinvertebrate and sediment sampling events, including camera and video sampling, to identify benthic communities. So far in 2019, only some scattered individual seagrasses have been found in grab samples (see above), but no communities identified. This monitoring will be undertaken again during the final sediment sampling event. Discussions with rangers undertaking the sampling also indicate no substantial seagrass beds closer than the north side of Indian Island. Note that there are extensive reef communities and seagrass beds located at the mouth of Bynoe Harbour, approximately 16 km from the Project site. Given the above, and that reefs do not occur nearby to the discharge point, reef communities have not been explicitly included in the conceptual model as such, although benthic communities are represented in general. Baseline benthic habitat mapping will be undertaken for the intake and discharge locations, which may be subject to direct impacts. The results of benthic observations will be incorporated into baseline water monitoring and will be used to update the existing habitat mapping where appropriate. This has been included in Table A2-3 of the main report.		current rather than seagrass. - Discussions with local rangers regarding the presence of seagrass in the area. The rangers have advised that they are only aware of seagrass located north of Indian Island. We would expect the rangers to be aware of seagrass meadows in this area if they were present. Given the low likelihood of seagrass presence in this area, and that modelling shows that guideline values are not expected to be exceeded at this location, we consider that the existing requirements of the WQMMP are sufficient to address the risk of impact on seagrass. These include the following: - Undertake visual assessment of intertidal areas for presence of seagrasses. - Where possible locate sites in proximity to the water quality monitoring locations. - Provide baseline presence / density, and identification of representative samples to species. - Include macroalgae cover observations where seagrass are identified. As such we will continue to observe this area for seagrass presence as part the WQMMP. Should any seagrass be identified baseline presence/density and identified of samples will be recorded as per the requirements of the WQMMP. **(Reviewer note – Closed)**

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(18)	3.5	It is stated that “urban and rural runoff is estimated to increase nutrient loads by 1.7 and 5.9 times for nitrogen and phosphorous loads…”. It is not clear whether this is a general statement or a specific to Bynoe Harbour. If it is Bynoe, it needs to be articulated how these interact with discharge from the prawn farm and how they will account for this in analysis and response.	Please clarify.	This statement has been changed to clarify that the results were for Darwin Harbour, as follows: 'In Darwin Harbour, Smith (2009) notes that urban and rural runoff is estimated to have increased nutrient loads by 1.7 and 5.9 times...' In terms of identifying this in the sampling program, monitoring sites located along Mackenzie Arm would be expected to pick up existing urbanisation impacts. Further work can be undertaken if required during operations (should impacts be identified), and the opportunity exists to differentiate based on isotopic (or similar) analysis, given the different sources of nutrient inputs, however the primary inflow will be to Wheatley Creek, which has minimal urban runoff. Milne inlet (with 2 reference sites, to the east) also has an area of rural residential development in its catchment, though of a smaller size, offering the opportunity to compare similar types of catchments with and without the Project discharge.	Closed	-
(19)	4.2	It would be useful to briefly explain why it is important to define water types, i.e. justification for site placement, different guideline values for different water types	Please clarify.	The following has been added after the first sentence: 'Within estuaries and coastal streams, water quality and the optimum water quality level can vary. As such, differentiating between these different systems is important in determining levels of protection and water quality guideline values, with the aim to define water types within which natural water quality is reasonably consistent.'	Closed	-
(20)	4.3.1	While there are human activities in Bynoe Harbour, the main differentiator between Level 1 and 2 ecosystems is level of intactness of the ecosystem, specifically whether there has been a ‘measurable change’ to ecosystems. Different locations within the harbour could likely be classified as Level 1 ecosystems. There is however insufficient information to make such a determination.	Add a note that clarifies this.	This may be the case [different levels of protection within Bynoe Harbour], however in proximity to the Project, and particularly in the receiving waters of Mackenzie Arm - a significant part of the catchment is rural residential. Some of Wheatley Creek is also rural residential, and is also filled on the flood tide from Mackenzie Arm. Given the nature of the catchment, a slightly-moderately disturbed catchment has been identified as the most appropriate, noting that the WQMMP is still based on a reference site condition assessment. To clarify this, the residential area was measured against the catchment areas draining to Wheatley Creek and Mackenzie Arm in proximity to the site, and Section 3.3 updated to include (bottom of page 6) the following: 'Wheatley Creek and Mackenzie Arm catchments include areas of rural residential development, with approximately 7% of the Wheatley Creek and 12% of the western Mackenzie Arm catchment (i.e. west of the waterline) described as residential in the DENR 2008 Land Use Mapping Project of the Northern Territory. Cumulatively, this represents ~10% of the land area draining into these two waterways in proximity to the Project.' This is referenced in this Section (4.3.1).	Closed	-
(21)	5.1	Environmental values now referred to as community values under ANZG (2018) = Beneficial Use under NT Water Act	Add a note that clarifies this.	A footnote to Section 5.1 title has been added as follows: ' These are now termed Community Values in ANZG (2018). The term Environmental Value has been retained herein to maintain consistency with the EMS and EMP for the Project, and previous correspondence and liaison with the NT Government and others.'	Closed	-
(22)	5.2	The derivation of local guideline values for physio-chemical stressors in preference to default regional guideline values is consistent with the approach of ANZG (2018) and supported by the reviewer. Local guidelines have only been calculated for parameters where there is a departure from other Darwin Harbour WQOs. It is not clear why local reference site data has not been to derive local guideline values for all physio-chemical stressors.	Please provide rationale.	The approach taken has been to adopt the DHWQOs as the initial interim guideline values, and to amend these where sufficient evidence exists to show that reference conditions depart from these guideline values (the DHWQOs are based on more data than available for Bynoe Harbour, and from reference sites described as not impacted by point source discharges or impaired by nearby land uses (DNREAS, 2010)). Local guideline values have been computed and are presented for all parameters in Table 7-3 (Section 7.2.3).	Closed	-

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(23)	5.2	The WQMMP notes that several parameters (e.g. FRP, TP) have laboratory detection limits (LDL) greater than default Darwin Harbour WQOs. A high proportion of samples were recorded as non-detects for these parameters. It is not explained how non-detects were treated in the derivation of median and "trigger values" shown in Table 7-3. If non-detects were rejected from the calculations, then the percentile values are biased (artificially raised) and are therefore not conservative. If this approach was taken then it could partly explain why some of the derived guideline values differ from the Darwin WQOs. If replacement methods were used for non-detects (e.g. zero values, half detection limit, detection limit etc.) then the approach should be explained and justified.	Please clarify. Please state laboratory detection limits for each parameter in Table 7-3. Note - Table 7-3 does not have colour codes described in the footnote.	Non-detects were replaced by half the LOR, with the method followed outlined in Note 2 to Table 7-3. This is described as a valid approach where the number of non-detects <15% and was used to simplify the analysis at the time. Ammonia, FRP, TP, TN and Chlorophyll a were above 15%, however: - for Ammonia, TN and Chlorophyll a, the LOR was less than the DHWQOs (Chlorophyll a had some LORs higher, but this did not affect the 80th percentile) - for TP and FRP, while some of the LORs were suitable, too many were above the DHWQOs. Given the number of non-detects, the 80th percentile can best be described as a <LOR result, as shown in the table. Further monitoring is required as outlined in the main report (Table A2-2), as follows '*analyse data for TP, FRP and DO and determine whether the existing dataset will be sufficient, given issues with historically collected data. Where required, implement additional water quality monitoring to obtain data sufficient to set local guideline values.*' The colour codes have been reinstated. Further to the above, a preliminary re-assessment of the data has been conducted, including more recent data collected in 2019, for those parameters with high % non-detect - FRP (76%), Ammonia (70%), TP (48%), TN (35%), Chlorophyll a (59%). Upper and lower 80th percentiles (calculated subsituting 0 for the <LOR in one set, and again with LOR for the <LOR values in another set as recommended in the AWQGs) converged for Ammonia and TN, making more advanced statistical methods unneeded. Chlorophyll a recorded a possible range between 1.7 - 2.0 (1.5 - 2.0 for BH01), which matches well with the Darwin Harbour WQO for Mid-estuary sites of 2µg/L (although one of the sites was upper estuary, with a DHWQO of 4µg/L - the mid-estuary WQO may be more appropriate here). Results for TP are relatively close (BH01 = 0.036 - 0.05; 0.048 - 0.056 for the other two sites). Alternative methods exist for censored data that are improvements over simple substitution. Using Robust ROS (after Helsel, 2012), results were similar to the lower limit in the above ranges, and coupled with meeting the assumptions of the method (lognormal distribution, <80% non-detects) indicates that for these analytes, the censoring issue can be adequately addressed on the existing data. However, FRP was weighted heavily by earlier limits of reporting that were too high. When only the later, lower LOR results were included, a relatively stable dry season 80%ile of 0.003-0.004 was computed between sites (i.e. the 2019 dataset). Using the above requirement from Table A2-2 of the WQMMP, additional data needs to be collected (particuarly wet season data) - this is currently being planned for.	Noted and agreed. Closed.	-
(24)	5.2	Table 5-1 notes that further investigation of low dissolved oxygen concentrations is required. Given the estuary is well mixed and in near-reference condition, it is highly unlikely that it would have such low dissolved oxygen concentrations. Unless further investigations prove otherwise, these data should be considered erroneous and therefore rejected.	Please add note.	Have removed the data to avoid confusion, and added a note as follows: 'the available data provides for low dissolved oxygen results for the bulk of the dataset. However, given the high value and well mixed nature of Bynoe Harbour, these are considered more likely to be erroneous (data from 2019 does not show such low results). As such, the data has not been used in this assessment (to be calculated following baseline assessment collection).' The note in the text following the table and figures has been changed to: ' Dissolved Oxygen was generally below the DHWQOs, other than a marginal reading at BH03 in May 2016, and compliant results in December 2017. Given the nature of Bynoe Harbour (well mixed, good condition), it is considered that these results are more likely to be errors, such as from the delay between sample collection and testing, improper calibration, or other similar issues.' Further to the above, a reassessment of the data with the pre-December 2017 data excluded (the suspiciously low values) provides for 8 results over 1 wet and 1 dry season (mostly dry season) with results stable for 20th and 80th percentiles. Further sampling will be required, as stipulated in Table	Closed	-

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				A2-2 in the main report - *'analyse data for TP, FRP and DO and determine whether the existing dataset will be sufficient, given issues with historically collected data. Where required, implement additional water quality monitoring to obtain data sufficient to set local guideline values.'*		
(25)	6.2.1	Are the reported chlorophyll levels at Seafarm sites from within farm ponds or receiving environments?	Please clarify.	These values are from discharge water only (at the licensed discharge point from the site), not from within the receiving environment. A note has been added to this effect.	Closed	-
(26)	6.2.2	This is an informative section and should underpin the conceptual model as explained above. Some additional points to consider: • Turbidity - It is agreed that in macro-tidal tropical estuaries, turbidity may reach levels where it affects phytoplankton productivity (e.g. during storms, high rainfall etc.). The baseline data outlined in the WQMMP does not however suggest that ambient turbidity is especially high and is also consistent (often lower) than values recorded in nearshore environments of the GBR region. It should not be assumed that ambient turbidity will mitigate the impact of additional nutrient loading by limiting algae productivity. • Impacts to GBR – the last paragraph of this section requires contextualisation regarding "…the very strong consensus that it is very difficult to find any impact of aquaculture on the Great Barrier Reef". The preceding paragraph explains how prawn farm discharges impact on receiving environments in the GBR region, albeit at a localised scale.	Please revise.	The information on turbidity was erroneously left in the report from the Legune WQMMP, and has been removed. For the second point, the following sentence has been modified: 'Evidence from both CSIRO and James Cook University indicated that, notwithstanding the above observations, amongst the scientific community, the CSIRO and the universities, there is a very strong consensus that it is very difficult to find any impact of aquaculture on the Great Barrier Reef, notwithstanding localised changes'	Closed	-
(27)	6.3	The selected indicators appear to cover most of the pressures, stressors and ecological receptors. The exception is reef communities, which as discussed in Section 3.4, occur in the vicinity of the operations.	As for recommendation in 3.4.	As noted above, reef communities are not present close to the discharge - refer to the response to Comment 17 above.	Closed	-

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(28)	6.3	It is agreed that nutrient loading is the key Project pressure, with potential stressors including direct toxicity, algae blooms, increased microbial production and dissolved oxygen sags. Related indicators (dissolved oxygen, nutrients, chlorophyll) have great variability over a range of temporal and spatial scales. It is unlikely that the spatial and temporal replication proposed in the WQMMP will adequately capture this variability.	It is strongly recommended that remotely sensed water quality data are collected to support the field sampling data. Chlorophyll and suspended solids can be derived from freely available satellite data, enabling the capture of broad-scale data at regular intervals (e.g. twice weekly, subject to cloud cover).	The following dotpoint has been added to Section 11 (Additional baseline data requirements): ' To extend the amount of data collected, investigate and where practicable utilise remotely sensed water quality data for Chlorophyll a, turbidity and suspended solids' This has also been added to Table A2-2 in Appendix A2 of the main report.	Closed	-
(29)	6.3	The WQMMP notes “Operational monitoring – TN and TP – undertake additional monitoring of N and P speciation if required”.	It is strongly recommended that speciation is undertaken to determine any changes in bioavailable forms. The need or otherwise for ongoing monitoring of these (and other) parameters can be assessed in the WMMP 2 year review, in accordance with the framework in ANZG (2018).	Speciated nitrogen and phosphorous monitoring has been added to the baseline/operational phase monitoring section under Table 6-1. Table A3-4 in the main report has also been updated to include testing for speciated nitrogen and phosphorous.	Closed	-
(30)	6.4	Any procedures to mitigate issues around short holding times should be in accordance with industry methods.	Please add note.	The text has been modified as follows: Paragraph 1: added '…The analytes with potential issues due to short holding times, along with the recommended solution (after discussions with ALS Environmental, Australia), are as follows:...' At end, added: 'Alternative methods are suitable, as long as they meet the method requirements of the NATA accredited testing laboratory.'	Closed	-
(31)	7.2	Sample collection biases towards wet season and particular tidal stages are noted, and reviewer agrees with the proposed strategy for additional data collection. Additional sampling will also be required to address data gaps resulting from any removal of baseline data due to quality issues (see Section 5.2 Comment 23 and 24).	Please clarify.	Based on the LOR issues for the Project, additional data is required for FRP (refer response to Comment 23 for a discussion of the other analytes) and dissolved oxygen (refer to response to Comment 24). Two additional dot points have been added to Section 11 as follows: ' - Once some of the additional baseline data has been collected for those parameters with high non-detects in the existing dataset, a re-analysis of the data is to be conducted using statistical techniques if required to better treat non-detects, and determine whether further data is required for these parameters – of particular interest are total phosphorous and filterable reactive phosphorous. - Dissolved oxygen also needs further monitoring to determine how meaningful the existing baseline dataset is and confirm whether they are likely to be in error. Following this assessment, further baseline data collection requirements are to be determined and added to the program.' Table A2-2 in the main report has been amended to add: 'Analyse data for TP, FRP and DO and determine whether the existing dataset will be sufficient, given issues with historically collected data. Where required, implement additional water quality monitoring to obtain data sufficient to set local guideline values.' See response to commets 23 and 24 for preliminary additional monitoring requirements.	Closed	-

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(32)	7.2.3	Revise this section to take into account comments made in Section 5.2 (Comment 23 and 24).	Please address.	Refer to response to comment 31	Closed	-
(33)	7.2.4	Were the laboratory detection limits for hydrocarbon and pesticide less than guideline values? Additional baseline monitoring of metals/metalloids should be undertaken given the stated issues on detection limits falling above guideline values.	Please address.	Additional monitoring for metals/metalloids has been required in this section, and has been added to Section 11: ' Undertake at least 3 rounds of analysis for total and dissolved metals prior to operations commencing.' Table A2-2 in the main report has been updated to include at least 3 rounds of monitoring for total and dissolved metals. The results for pesticides were above the DGVs from the AWQGs (though these are almost all low reliability GVs) - this was undertaken as a screening level assessment rather than to determine guideline levels, and are not expected to be present given the lack of high impact agriculture and high tidal ranges. Hydrocarbon detection levels were below the AWQG DGVs (where available) and as stated in the report below detection levels.	Closed	-
(34)	7.2.5	An assessment to determine the need or otherwise for seasonal guideline values is supported.	Please clarify when the assessment of seasonal guideline values will be undertaken – at the two year review? Revise section in light of any re-calculations of local guideline values taking into account comments in Section 5.2.	Section 11 has been updated to add: 'Determine seasonal guideline values at the 2 year review (or before if sufficient data is collected). Determine whether these are significantly different from the overall guideline values, and whether there is merit in meeting the aims of this WQMMP in using seasonal triggers instead of (or as well as) overall guideline values. If so, these must be utilised in the assessment following the 2-year review period.' Table A1-1 in the main report has also been updated to reflect this approach.	Closed	-
(35)	7.3.1	See comments in Section 3.4. As for Section 3.4.	As for Section 3.4. Please clarify whether benthic habitat mapping is a commitment. If reefs are in the receiving waters then reef benthos should be monitored along with soft sediment benthos.	As noted above (Comment 14), recommendations have been changed to requirements (as needed). This includes further benthic mapping and delineation, as described above in response to Comment 17. As per our response to Comment 17, benthic habitat mapping is a commitment, and has been included in the plan. However, reefs do not occur nearby to the discharge point, and so are not explicitly included in the benthic monitoring program. Refer to our response to Comment 17 for more information.	Closed	-
(36)	8 (9)	See comments in Section 3.4 regarding any biases resulting from statistical treatment of non-detects.	Revisit this section should re-calculations be required.	No changes are required (the limit of reporting issue only applies to total phosphorous, and this was explicitly addressed in the assessment). Note - Section 8 is now Section 9	Closed	-
(37)	8 (9)	Chlorophyll a. Using a passive tracer to predict chlorophyll in receiving environments is not appropriate as it is not a conservative substance. The modelling is also not conservative with regard to chlorophyll.	Recommend removing reference to using passive tracer to predict chlorophyll.	An additional memorandum was provided by Watertech in 2017 relating to chlorophyll a modelled levels. This has been incorporated into the supporting report. Note - Section 8 is now Section 9.	It is still unclear whether predictions of chlorophyll a in modelling was based on a passive tracer. The last dot point on pg 45 suggests that it was.	Chlorophyll has been used as an indicator of algal / primary production levels in the prawn farm discharge, and has been modelled as a discharged analyte, rather than modelling uptake, conversion, etc. in the environment. To clarify this point, paragraph 3 (after the bullet points) in Section

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						9 (page 45) was amended to add the following: *'Note that Chlorophyll a relates to the discharge as an indicator of algal / primary production load into the receiving environment. The modelling did not set out to determine dynamic uptake, conversion, or effects of nutrients in the environment directly on Chlorophyll a levels.'* **(Reviewer note – Closed)**
(38)	9.2.1 (10.2.1)	Site selection/replication was also presumably informed by the water types mapping?	Note in text.	This is correct - the following was added to the first paragraph in section 10.2.1 (formally 9.2.1): 'Given the hydrology in the vicinity of the discharge, a gradient type monitoring program has been adopted, with sites chosen either side of the discharge, upstream and downstream of the discharge, and to reflect the water types in proximity to the Project. Control or reference sites were chosen in areas nearby that are as similar as practicable, however are not impacted by the Project discharge.' The following dotpoint was also added to the last set of dot points in Section 10.2.1 [the above design provides....] '- Sites within both upper and mid-estuary waters, including control sites'	Closed	-
(39)	9.2.1 (10.2.1)	Macroinvertebrate sample site selection should ensure that control and test sites are similar in terms of water type, depth and sediment type.	Consider the need for modifying sites to account for habitat conditions. Habitat mapping would assist in this regard.	The following note has been added to the last paragraph in section 10.2.1 (which was formally 9.2.1): 'Sites should be chosen to provide similar comparison sites at control and impact locations in terms of water type, depth and sediment type.' Note - the macroinvertebrate monitoring currently being conducted includes 5 replicate samples at each site, and sites are relatively uniform in terms of depth (<4m, other than MA03 (2-5m) and BH01 (~7m) - both of which are in deeper areas but provide some baseline information) and sediment (silty clayey sands and muds). Waterway types are directly comparable in control and impact areas, with only the MA03 and BH01 having deeper areas sampled (MA03 has directly comparable sites to other shallow control sites and to the BH01 deeper sites).	Closed	-
(40)	9.3, 10 (10.4, 11)	Revisit baseline monitoring frequency to account for any additional sampling in response to issues identified in Comments 23 and 24.	Please clarify.	Refer to the response to Comment 31 above, which provides for an analysis of the data and addition of additional sampling where required. Regarding additional sampling and frequency, collection of samples are proposed to coincide with the quarterly monitoring at the Legune Project site, and an additional round is proposed for November 2019. Given the data paucity for FRP over wet seasons, some additional rounds are proposed during the 2019/2020 wet season (in addition to the above).	Closed	-

Comment	Section no. Rev 0 (Rev 1 if different)	Comment	Recommendation	PSD Response (28/11/2019)	Reviewer response	PSD Response 26 Feb 20 (Final reviewer note in parentheses)
(41)	9.3 (10.4)	Further justification is required to support the proposed sampling frequency for water sampling (4 episode per year). Is this statistically valid based on the adopted effect size (variously referred to as 1SD or 10% in Appendix A2, A3)?	Please clarify.	A quarterly frequency was adopted as a pragmatic approach to water quality monitoring - cost and time efficient while still capturing annual variability. This number of samples also provides for a suitable Type I error rate (~5%). However, on analysis of the baseline data, this has been increased to 2-monthly for the first 2 year assessment period. Section 10.4 (previously Section 9.3) was updated to include explicit consideration of the power of the proposed analysis by way of a comparison of the discharge location pre- and post-discharge. For a simple guideline value comparison a detection limit of 1.3 standard deviations was able to be detected at a power of 80%, and a comparison of group differences provides for a detection limit of 1.1 standard deviations at the same power. When coupled with the control charting method outlined in Section 10.3 (previously 9.4), and adopting a trigger for further assessment based on the number of exceedances, clustering of exceedances or departure from reference sites, this allows for suitable detection of potential departures.	Closed	-

(-) no further comment