



PROJECT SEA DRAGON STAGE 1 LEGUNE GROW-OUT FACILITY

EN01-MN4201

WATER QUALITY MONITORING AND MANAGEMENT PLAN

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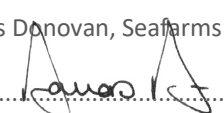
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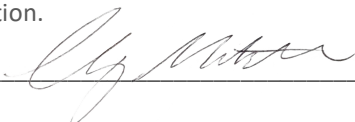
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Declaration of accuracy

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed



Full name (please print)

Organisation (please print)

Date

____/____/____

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 (ANZECC & ARMCANZ, 2000a; updated version 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 Legume Grow-out Facility
EMP	Environmental Management Plan
EMS	Environmental Management System
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth)
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
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
NO _x	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	<i>Waste Management and Pollution Control Act</i> (NT)
WQMMP	This report, the Water Quality Monitoring and Management Plan

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EXECUTIVE SUMMARY

This Water Quality Monitoring and Management Plan (WQMMP) has been developed for the Project Sea Dragon, Stage 1 Legume Grow-out Facility (the Project), located on Legume Station approximately 106 km north-east of Kununurra on the western border of the Northern Territory. It has been prepared in response to the water quality related recommendations and conditions of the Northern Territory Environment Protection Authority Assessment Report 80, the Commonwealth Department of Environment and Energy approval (EPBC 2015/7527) and the NT Waste Discharge Licence (WDL239) for the Project, 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 trigger 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 trigger values) in the supporting report included in Appendix C.

This report has been reviewed by an independent third-party reviewer, with comments provided in the supporting report in Appendix C.

1 INTRODUCTION

1.1 BACKGROUND

This Water Quality Monitoring and Management Plan (WQMMP) has been developed for the Project Sea Dragon, Stage 1 Legume Grow-out Facility (the Project), located on Legume Station approximately 106 km north-east of Kununurra on the western border of the Northern Territory.

The Project involves the development of 3 farms and 1,120ha of ponds, plus supply and discharge channels, settlement and treatment ponds, an Environmental Protection Zone and discharge to Alligator Creek to produce year-round reliable volumes of Black Tiger prawns (*Penaeus monodon*) for export markets.

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 Northern Territory Environment Protection Authority (NT EPA) recommendations, the NT Department of Environment and Natural Resources (DENR) Waste Discharge Licence (WDL) conditions of approval, and the Commonwealth Department of Environment and Energy (DoEE or Commonwealth) conditions of approval for the Project to manage water quality, particularly associated with operational discharges to receiving waters, specifically:

NT EPA Assessment Report 80 (15 March 2017) Recommendation 3:

In consultation with the NT EPA, the Proponent shall conduct a review of the water quality monitoring program to inform suitable monitoring methodologies for developing interim site-specific trigger values and water quality objectives for management. The review should include an analysis of relevant water quality data with respect to variation:

- *in response to rainfall events and rainfall patterns*
- *due to individual tidal cycles (single ebb-flood sequences)*
- *between spring and neap tidal cycles.*

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

WDL239 (29 September 2017) Condition 35:

The licensee must submit a Water Quality Monitoring and Management Program to the administering agency in accordance with requirements under EPBC 2015/7527 [see below].

Commonwealth EPBC Act approval conditions (ref: 2015/7527, 10 May 2017) Condition 2:

2. To protect habitat for listed threatened and migratory species, the person taking the action must develop a Water Quality Monitoring and Management Program (WQMMP). The WQMMP must be prepared in consultation with an appropriately-qualified independent scientific expert whose appointment has been approved in writing by the Minister. The WQMMP must be approved by the Minister and implemented a minimum of 12 months prior to the discharge of any wastewater.

The WQMMP must:

- a) explain how the WQMMP will protect the receiving environment from wastewater discharges, including the functional relationship between monitoring objectives, activities and operational decisions*



FIGURE 1-1 SITE LOCATION

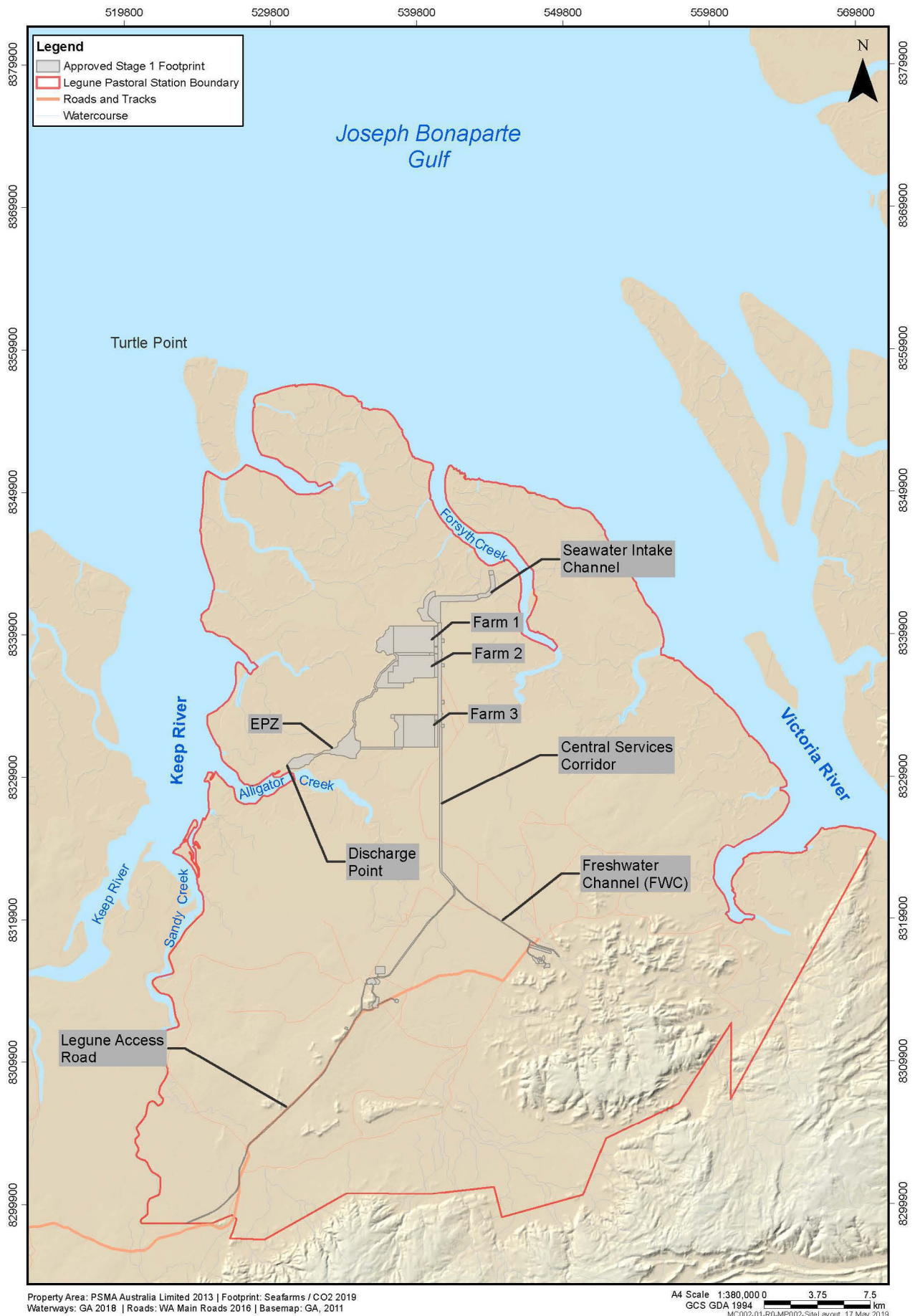


FIGURE 1-2 SITE LAYOUT

- b) *define the chemical, physical and biological parameters to be monitored in the receiving environment, including during the minimum 12-month period of baseline water quality monitoring, and justify the parameters to be monitored*
- c) *modify and/or confirm the wastewater quality parameter limits in condition 1 (a) [wastewater discharge limits] and the wastewater release regime in condition 1(c) [releases on ebb tide]*
- d) *include a methodology to:*
 - i. *monitor water quality parameters in condition 1 (a) during both baseline data collection and operations and measure discharge volumes in condition 1(b)*
 - ii. *develop site-specific water quality objectives and seasonal trigger values for water quality parameters identified in condition 1 (a) and 2(b)*
 - iii. *modify and/or confirm the wastewater quality parameter limits specified in condition 1 (a) are appropriate relative to the trigger values developed under condition 2(d)(ii)*
 - iv. *modify and/or confirm the wastewater release regime specified in condition 1 (c) in accordance with the Guidelines for Fresh and Marine Water Quality*
- e) *include a data handling program and' commitments to technical review and evaluation of the WQMMP*
- f) *identify and manage the risks of the WQMMP failing to achieve its objectives*
- g) *describe contingency responses where management triggers are exceeded, and effective corrective actions which may be implemented.*

When the person taking the action submits the WQMMP to the Minister for approval, they must also provide a copy of the advice of the independent scientific expert on the WQMMP. The approved WQMMP must be implemented.

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, 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. This is intended to be largely contained within the site EMP following approval.

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.	General - No complaints. Construction - Relevant Management Strategies fully implemented. Operation <i>Discharge</i> - Discharges comply with the discharge criteria in Appendix A3. <i>Receiving waters</i> - Outside the initial mixing zone, receiving waters comply with the water quality trigger values in Appendix A3. - Where exceedances of trigger 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. <i>Intake waters (Forsyth Creek)</i> - Intake complies with intake criteria in Appendix A3. - No changes to creek hydraulics sufficient to affect water quality.	- Number of incidents or breaches. - Number of complaints. - Number of exceedances of discharge criteria or receiving water trigger values. - Number of events showing impacts when compared to control sites. - Spatial extent and timing of erosion and scour.
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.		
Compliance with Surface Water Extraction Licence		

Objectives	Targets	Key Performance Indicator
	Intake water quality suitable to support aquaculture activities.	
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.
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

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) is the key piece of Commonwealth legislation relevant to this WQMMP, with the EPBC approval (ref: EPBC 2015/7527) stating the conditions of approval relevant to this Act. The EPBC Act is relevant to the protection of Matters of National Environmental Significance (MNES), which were identified for the Project as Listed threatened species and communities, and Listed migratory species.

Relevant Northern Territory Legislation is as follows:

- *Environmental Assessment Act 1982* (EA Act), under which the Project Environmental Impact Statement (EIS) was assessed and approved, providing the NT EPA Assessment Report 80 recommendations
- *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, including issuing of Environment Protection Approvals and Licences
- *Water Act 1992*, under which a Waste Discharge Licence has been issued (WDL 239) for the Alligator Creek discharge
- *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 key conditions from each of the above approvals relevant to this WQMMP, 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, or AWQG) (ANZECC & ARMCANZ, 2000a), particularly Chapter 7 – Monitoring and Assessment, and the updated guidelines – ANZG (2018)
- Australian guidelines for water quality monitoring and reporting (ANZECC & ARMCANZ, 2000b)
- Queensland Monitoring and Sampling Manual 2009 (DES, 2018), and
- Commonwealth 'Requirements for the Water Quality Monitoring and Management Program – 9 June 2017' guideline list (provided in the supporting report in Appendix C, along with cross-references where each element has been addressed).

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.

4.2 OPERATIONS

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

The key potential stressors relevant to the effect of discharge waters on receiving waters have been identified as follows:

- Addition of feed to ponds, representing primarily nitrogen and phosphorous addition
- Addition of fertilisers to ponds, containing micronutrients
- Growth and production of prawns including generation of prawn faeces, moults and mortalities
- Growth and control of algal biomass in ponds
- Loss of sediment from walls and floor of ponds (though likely to be comparatively small), 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.

Additional potential impacts were identified relating to the intake of seawater (altered tidal characteristics, flow and erosion/scour rates) and impingement of aquatic fauna in intake structures.

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. As required under the Commonwealth approval and NT EPA recommendations, the plan has been reviewed by an independent third-party expert. The independent expert comments are provided in the supporting report in Appendix C.

A copy will be provided to the NT EPA, NT DENR and the Commonwealth government for review prior to implementation. The Northern Land Council will be consulted in relation to activities that occur on or that traverse the bed or banks of any waterway.

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-MN-EM4001) 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), define a process to be followed for the long-term management of receiving water quality. This process has been addressed as follows (from pp 2-1 to 2-2 of the AWQG):

1. *Identify the environmental values that are to be protected in a particular water body and the spatial designation of the environmental values:*
 - The relevant waters are defined as the estuarine waters of Alligator Creek
 - EVs have been determined for these receiving waters as outlined in the supporting report in Appendix C

2. *Identify management goals and then select the relevant water quality guidelines for measuring performance. Based on these guidelines, set water quality objectives that must be met to maintain the environmental values:*
 - Overarching management goals are defined in Section 2, with the specific aims identified at the start of each program in Appendix A
 - No existing local, state or national guidelines exist or are relevant to the site, with the guideline values in the AWQGs being unsuitable to natural conditions (refer FRC, 2016)
 - Revised interim trigger values were identified in the EIS, with further revision and adoption of water quality trigger values outlined in the supporting report in Appendix C
 - Discharge criteria were identified that could be met, and that would meet the interim water quality triggers for receiving waters. The revised background levels and trigger values have been used to re-assess the discharge criteria finding they are still suitable, as outlined in Appendix C
3. *Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not):*
 - The monitoring program in Appendix A outlines a set of triggers for further investigation, with further statistical requirements outlined in Appendix C
4. *Develop tactical monitoring programs focusing on the water quality objectives:*
 - These are provided in Appendix A
5. *Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives:*
 - Appendix A provides the monitoring, escalation and management/mitigation measures to be utilised.

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 trigger 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:

- Farm operations and monitoring, including pond and channel maintenance and water quality amelioration, water exchanges and fresh/saline supply
- The Environmental Protection Zone (EPZ) and controlled releases to Alligator Creek, and
- Prawn growth, harvest and stocking rates.

6.3.3 Baseline Data Collection

Water quality sampling has been undertaken over an extended period from June 2015. The supporting report in Appendix C provides 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 support the Project, but that additional baseline data collection prior to the commencement of construction and operation should continue, albeit at a reduced frequency, to improve the reliability of post-development comparisons.

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 Alligator 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 triggers 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 then being reviewed to refine the program, to ensure it remains cost-effective, practical and focused.

7 REFERENCES

ANZECC & ARMCANZ (2000a). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy Paper No 4, Volume 1 The Guidelines (Chapters 1–7). Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), October 2000

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APPENDIX A MANAGEMENT AND MONITORING PROGRAMS

A1 WATER QUALITY MANAGEMENT

Program: Water Quality Management	
Phase	All phases
Timing	At all times and as noted in the frequencies described herein
Timeline	Aug-2019 Apr-2020 Jan-2021 Stocking Sep-2021 Mar-2022 onwards  The timeline diagram shows three overlapping phases: 'Baseline Monitoring Program' (from Aug-2019 to Jan-2021), 'Construction Phase' (from Apr-2020 to Sep-2021), and 'Operational Phase' (from Jan-2021 onwards).
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	Prior to Operations Commencing 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). 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 (WDL239) and 24-hour emergency contact details. The signage is to be clear, legible and in English. 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.

Program: Water Quality Management	
	Minimise construction equipment traversing soft marine and floodplain sediments. Utilise appropriately placed and designed culverts and channel works on infrastructure to reduce upstream ponding and to maintain waterway connectivity. Operations Implement the operational monitoring and monitoring program summarised in Figure A1-1. Implement the following controls: ■ Intake: where practicable, reduce the amount of seawater extracted from Forsyth Creek during neap tide periods. ■ Discharge: ■ Comply with the discharge criteria outlined in Appendix A3. ■ Minimise discharge of wastes (i.e. improve water quality) by efficient farm 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 ponds to be selected based on suitability for release – no antibiotic, anti-parasitic or anti-fouling agents will be used.
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. 3-month result summaries of more frequent monitoring must be reviewed quarterly when the results from the EIMP monitoring are available. The above review will include incidents, rectification works and whether these have been successful. Program Review Within the first year, prior to and 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) must 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. 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 this management plan. 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 this plan. Audits and review Conduct an internal review of 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 is delivering suitable to achieve its aims.

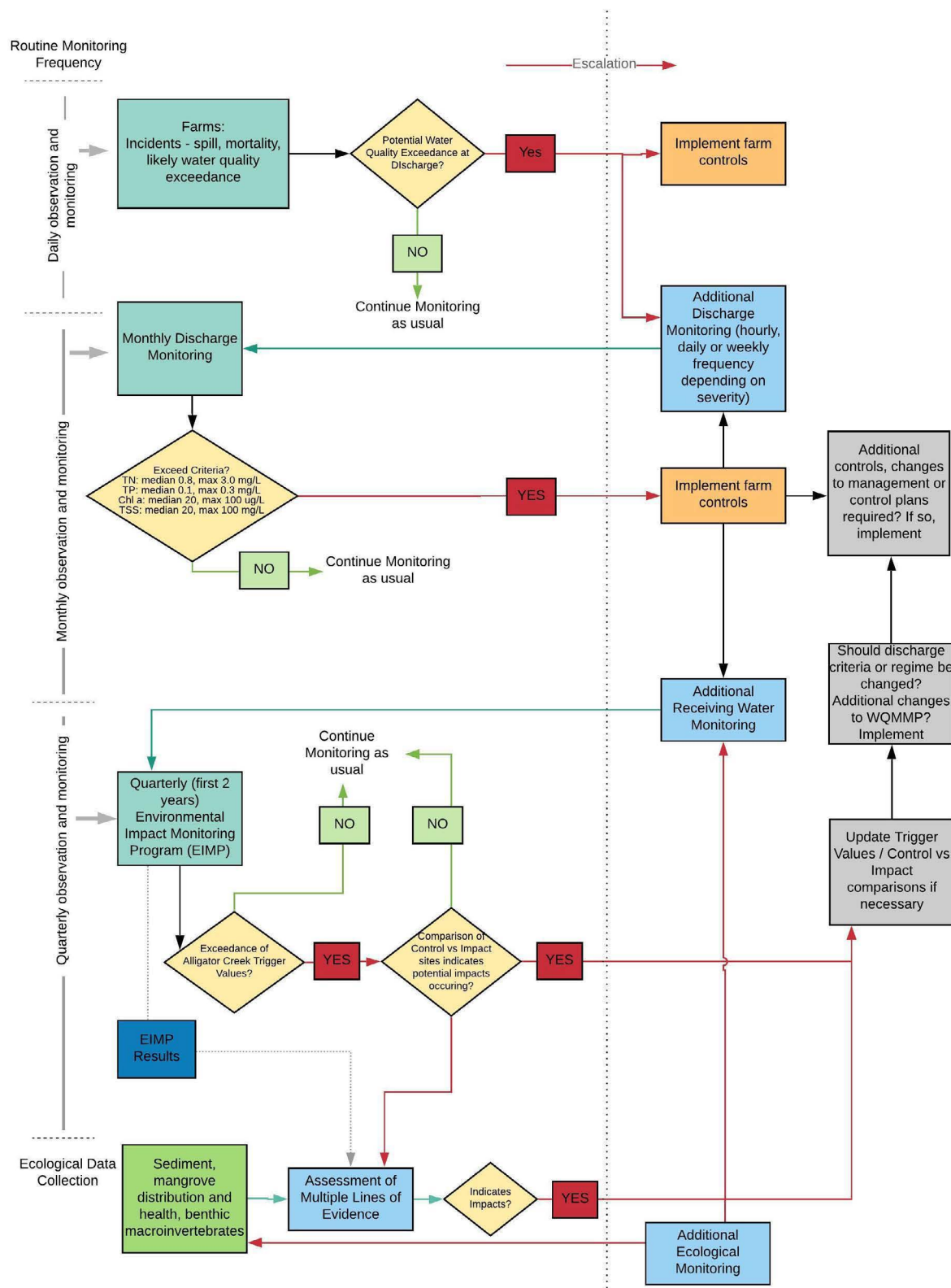
Program: Water Quality Management	
	EMS/EMP audits will include audits on the monitoring program and results. Changes to this WQMMP may be undertaken from time to time. Changes relating to water quality (trigger levels, etc.) will only be undertaken based on a suitable length of data and made in consultation with an independent third-party reviewer. Any revisions to this plan must be communicated to the Commonwealth prior to implementation; however, should the changes result in any new or increased impact, the revisions must be approved by the Commonwealth prior to implementation.
Reporting	WQMMP This report must be published on the Project website within 1 month of being approved by the Commonwealth, with the report updated within 1 month of any approval by or notification to the Commonwealth. A copy of the Waste Discharge Licence must be similarly published on the Project website. A copy of any report revisions must be provided to the Commonwealth and the NT DENR at least 4 weeks prior to its implementation. Monitoring Prepare quarterly internal monitoring summary reports, summarising: ■ 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 Notification The NT DENR must be notified when discharges commence into Alligator Creek, and again when discharges cease for any appreciable time. The Controller of Water Resources (DENR) must be notified where extraction is not $\geq 90\%$ of the water extraction limit (the Minimum Extraction Limit, MEL) for three consecutive years. Notification must be in the form of a report to the Controller outlining why the MEL was not reached and a projection of water requirements for the remaining term of the licence. Any non-conformance, 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-conformance with discharge limits or other conditions of the WDL, or discharges resulting in potential or actual environmental harm or pollution must 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 must include: ■ when the non-conformance was detected and by whom ■ the date and time of the non-conformance ■ the actual and potential causes and contributing factors to the non-conformance ■ the risk of environmental harm arising from the non-conformance ■ the action(s) that have or will be undertaken to address the non-conformance ■ 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.

Program: Water Quality Management	
	Maintain records and documentation A copy of relevant reports, management plans, procedures, approvals and licences (including EPBC approval and WDL) must be maintained at the site, along with all relevant records showing compliance and non-compliance events and provided to authorised officers on request. Requests for authorised documentation from the NT DENR must be satisfied within 10 business days from the request. Statutory Reporting Prepare an annual summary report in accordance with WDL Condition #32 and provide to DENR within 10 business days after each anniversary date of the WDL, in accordance with Condition #31 of the WDL. This requirement must be transferred into corresponding conditions in a WDL or EPL that is issued to replace or renew WDL239. The annual summary report must include a summary of the preceding 12 months' monitoring results and other implementation details of the WQMMP, including (but not limited to) general review of the monitoring program, observations and results of quality control samples, and sampling safety and efficacy. The report must be prepared in accordance with the NT EPA 'Guideline for Reporting on Environmental Monitoring'. Publish a copy of the annual summary report on the Project website and provide a copy of the report to the Commonwealth. The annual summary report must also be submitted with the annual return for the WDL (required to be submitted within 20 days of the anniversary date of the WDL). Provide the monthly seawater extraction volume to the Controller of Water Resources (DENR) within 2 weeks of the end of each month.
Corrective Actions	Correction Action Triggers: 1. Triggers shown in Figure A1-1 are exceeded. 2. Water quality impacts from construction activities – excessive erosion and sedimentation, acidic runoff, etc. 3. Excessive erosion at intake or discharge locations 4. Exceedance of discharge water quality triggers 5. Exceedance of receiving water quality triggers or control-impact comparison assessments 6. Receipt of complaint 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. Instigate bank stabilisation works to protect against erosion, implement additional control methods as needed 4. Follow the procedures in Figure A1-1. Also initiate immediate follow up investigation of: ▣ The results - are they representative, errors at the laboratory or sampling? ▣ Re-sample and investigate potential sources of exceedances ▣ In the event of genuine exceedances, undertake mitigation works, inside the farm (or other source), or alter discharges. This may include cessation of discharges if necessary. 5. As for 4 above.

Program: Water Quality Management

6. 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, must be recorded on an incident form, in the incident register, and actions assigned. Monitoring of actions must 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.



A2 BASELINE WATER QUALITY MONITORING PROGRAM

Program: Water Quality Management	
Phase	Pre-development 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, at which time the same monitoring will continue as the operational Environmental Impact Monitoring Program (EIMP).
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	Grab sampling from ~30cm depth in the water column, according to the methods outlined in <i>AS/NZS 5667.1 - Water quality - Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples and methods</i> , summarised in Appendix B.
Triggers and Escalation Procedures	Ongoing monitoring results will be incorporated into the baseline data set, with trigger values recalculated each round. If this indicates a departure from the current trigger values by >10%, the program will be assessed and frequency increased if deemed appropriate based on whether the change: ■ Is likely to reflect natural variability not captured in the existing dataset, or ■ Might reflect longer term cycles not captured in the baseline dataset, and ■ There is a need for additional data to refine trigger values prior to operations commencing.
Management and Contingency Measures	Baseline monitoring must follow the above elements and protocols, with sample collection, storage, transport, analysis, QA/QC, data management and analysis summarised in Appendix B.

Program: Baseline Water Quality Monitoring Program								
System	Alligator Creek			Forsyth Creek	Keep River Estuary			Turtle Point
Classification	Impact	Impact	Impact	Intake - potentially impacted	Control	Control	Control	Control
Site Code	AC3 (I28)	AC2 (I29)	AC1 (new)	FC1 (WT07)	KR2 (I30)	KR1 (I33)	KR3 (I34)	TP1 (I21)
Description	Downstream of discharge	Upstream of discharge	Further upstream of discharge	Near intake location	Junction with Sandy Creek	Keep River / Ord scheme influences	Mid-Estuary, adjacent to Alligator Creek	Control Site adjacent to Turtle Point
Latitude, Longitude (GDA 94) (refer Figure A2-1)	-15.1179 129.269	-15.1019 129.2921	-15.1117 129.3092	-14.9738 129.4118	-15.1682 129.2244	-15.1566 129.1929	-15.0745 129.2199	-14.8862 129.2602
Frequency and Timing	Water quality Mangroves benthic macroinvertebrates 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. <i>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.</i>							
Duration	Commence additional sampling after approval of this WQMMP. Baseline dataset finishes on first discharge into Alligator Creek from Project operations (monitoring continues under the operational Environmental Impact Monitoring Program)							
Parameter			Assessment					
In-situ / phys-chem	pH, EC, DO, Temp		Update baseline dataset, recompute trigger values. A change in trigger values > 10% will require further assessment – do trigger values require updating?					
	Turbidity							
	TSS							
Nutrients	N – NH3, NOx, TKN, TN							
	P – FRP, TP							
	TOC							
Biological	Chlorophyll a							
	Mangrove distribution / health remote sensing assessment							
	Benthic macro-invertebrates							

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

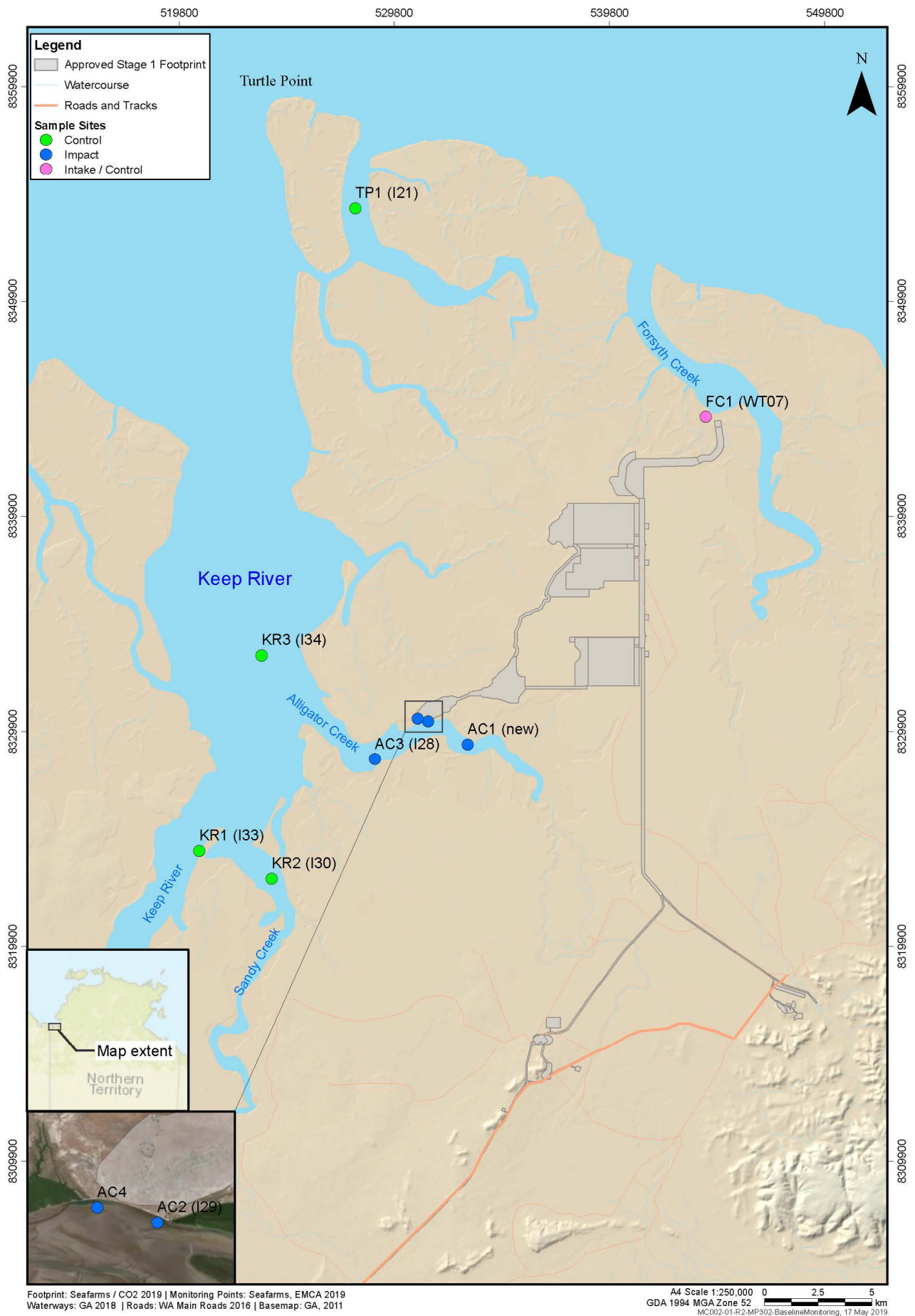


FIGURE A2-1 BASELINE SAMPLING LOCATIONS

A3 OPERATIONAL WATER QUALITY MONITORING PROGRAM

Program: Operational Water Quality Monitoring Program – General	
Phase	Operations – commences once operational discharges into Alligator Creek Commence
Synopsis	An operational water quality monitoring program, involving two tiers of monitoring – 1) regular intake and discharge monitoring, and 2) less frequent Environment Impact Monitoring Program (EIMP). The EIMP includes impact sites in Alligator Creek and control sites in the Keep River and a more remote control site near Turtle Point.
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 <i>AS/NZS 5667.1 - Water quality - Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples</i> and as summarised in Appendix B. - Continuous flow recording must be installed at a point representative of intake water volumes, and at the outlet weir for recording the timing and volume of discharges. Intake waters to be monitored in accordance with the Northern Territory Non-Urban Water Metering Code of Practice for Water Extraction Licences. - Flow and tidal prism monitoring to be based on guidance from appropriately qualified and experienced persons. - Sediment sampling to be undertaken in accordance with <i>AS/NZS 5667.12 – Water quality—Sampling, Part 12: Guidance on sampling of bottom sediments</i>, 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 methods comparable with those described in FRC (2016) – mangrove assessments will utilise multi-spectral imagery / NDVI metrics to assess extent, health and intactness, with ground truthing conducted generally as per FRC (2016).
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.

Program: Operational Water Quality Monitoring Program - Discharge Monitoring				
System		Discharge to Alligator Creek		Monitoring of EPZ
Classification		Discharge		EPZ
Site Code		D1		EPZ01
Latitude, Longitude (GDA 94) (refer Figure A3-1)		-15.100136, 129.289151		TBA
Frequency and Timing		Flow Continuous monitoring of flow volumes and events Water quality Monthly Tidal level Install system for providing real-time tidal level to the control room, to enable timing of discharges with tides <i>Note: sample frequency may be altered or change 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 tide, etc.</i>		
Duration		On first discharge to receiving waters. To continue for the life of the Project.		
Parameters to sample		Discharge Criteria		
		Mean	Maximum	EPZ Monitoring
Flow	Volume (ML/day)	<420	-	Monitoring of EPZ to be conducted monthly for the following parameters:  pH, EC, DO, temp Testing at representative locations within the EPZ, at the surface, near the bottom and (where depth >1.5m) at least one depth between the two. Where stratification and poor water quality is evident, employ amelioration (e.g. aeration, mixing, farm changes) to ensure discharge waters remain compliant. Compare actual results with modelled results, particularly for dissolved oxygen modelling.
	Timing	From 1h prior to ebb tide commencing to 5.5h prior to ebb tide ending (i.e. low tide) in Alligator Creek.		
In-situ	pH, EC, DO, Temp	-	-	
	Turbidity	-	-	
Phys-Chem	TSS (mg/L)	≤20	≤100	
Nutrients	TN (mg/L)	≤0.8	≤3.0	
	TP (mg/L)	≤0.1	≤0.3	
Biological	Chlorophyll a (µg/L)	≤20	≤100	
Other	Visual	No floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter.		
	Odour	Discharge must 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

Program: Operational Water Quality Monitoring Program - Intake Monitoring			
System		Intake from Forsyth Creek	Forsyth Creek
Classification		Intake	Intake
Site Code		IN1	-
Latitude, Longitude (GDA 94) (refer Figure A3-1)		Location of flow metering installed in intake system	Forsyth Creek Tidal Prism
Frequency and Timing		Flow Continuous monitoring of flow volumes and events Forsyth Creek tidal monitoring Sample representative spring and neap tide events – aim for 2 sampling events with 3 replicates on each event for each tidal cycle. <i>Note: sample frequency may be altered or change 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 tide, etc.</i>	
Duration		On first intake and discharge to receiving waters, to continue for duration of the Project.	
Parameters to sample		Intake Criteria	Forsyth Creek Monitoring
		Maximum	
Flow	Volume (ML/day)	≤100,000ML/y AND ≤15,000ML/month BUT: ≤70,000ML between 1 May 2027 – 6 March 2028	Conduct representative monitoring to measure and calculate the flow rates and tidal prism volume within Forsyth Creek, and inundation depths and periods for the mangrove systems upstream of the extraction point over a range of spring and neap cycles during extraction. Compare with the predictions made by the modelling in the EIS and determine whether mangroves are adversely affected by changes to inundation depth and periods. Provide a report to the controller within 12 months of when seawater extraction commences outlining the results of this monitoring and assessment.
	Timing	Extraction to occur only when water level is ≥0.1mAHD in Forsyth Creek.	

Program: Operational Water Quality Monitoring Program - EIMP – Water Quality									
System	Alligator Creek				Forsyth Creek	Keep River Estuary			Turtle Point
Classification	Impact	Impact	Impact	Impact	Intake / Control	Control	Control	Control	Control
Site Code	AC3 (I28)	AC2 (I29)	AC4 (new)	AC1 (new)	FC1 (WT07)	KR2 (I30)	KR1 (I33)	KR3 (I34)	TP1 (I21)
Latitude, Longitude (GDA 94) (refer Figure A3-1)	-15.1179 129.269	-15.1019 129.2921	-15.1008 129.2874	-15.1117 129.3092	-14.9738 129.4118	-15.1682 129.2244	-15.1566 129.1929	-15.0745 129.2199	-14.8862 129.2602
Frequency and Timing	Quarterly for first 2 years: two (2) during the wet season, and two (2) 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. <i>Note: sample frequency may be altered or change 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.</i>								
Duration	On initiation of operational discharge. To continue for the life of the Project.								
Parameters to sample		Trigger Values							
		Overall	Wet season	Dry season					
In-situ	pH, EC, DO, Temp	-	-	-	Intake monitoring - collect data for use in determining intake quality. All sites: compare nutrient results with triggers. If these are exceeded, undertake additional assessment, including testing for nutrient speciation* to determine potential bioavailability (note: collect bottles for speciated analysis each round, to be available for testing if required).				
	Turbidity (NTU)	630	690	470					
Phys-Chem	TSS (mg/L)	700	830	500	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: ■ Total Nitrogen ■ Total Phosphorous ■ 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 / SEIS modelling, including for dissolved oxygen modelling. This will be used as another line of evidence in the assessment above, as part of the MLE approach adopted.				
Nutrients	TN (mg/L)	TN: 0.35	TN: 0.30	TN: 0.38					
	TP (mg/L)	TP: 0.22	TP: 0.17	TP: 0.22					
Biological	Chlorophyll a (µg/L)	8.2	4.2	9.4					
Other	Visual	No floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter. Discharge must not cause algal blooms, cause mortality of fish or other aquatic organisms in the receiving waters.							
	Odour								

EC = Electrical Conductivity; DO = Dissolved Oxygen; Temp = Temperature; TSS = Total Suspended Solids; NH3 = Ammonia; NOx = Oxides of Nitrogen; TKN = Total Kjeldahl Nitrogen; TN = Total Nitrogen; FRP = Filterable Reactive Phosphorous; TP = Total Phosphorous * Speciated nutrients = NH3, NOx, TKN, FRP; and NO2 and NO3 if required (needs rapid delivery/turn around to meet holding times)

Program: Operational Water Quality Monitoring Program - EIMP – Sediment and Ecological Monitoring									
System	Alligator Creek				Forsyth Creek	Keep River Estuary			Turtle Point
Classification	Impact	Impact	Impact	Impact	Intake / Control	Control	Control	Control	Control
Site Code	AC3 (I28)	AC2 (I29)	AC4 (new)	AC1 (new)	FC1 (WT07)	KR2 (I30)	KR1 (I33)	KR3 (I34)	TP1 (I21)
Latitude, Longitude (GDA 94) (refer Figure A3-1)	-15.1179 129.269	-15.1019 129.2921	-15.1008 129.2874	-15.1117 129.3092	-14.9738 129.4118	-15.1682 129.2244	-15.1566 129.1929	-15.0745 129.2199	-14.8862 129.2602
Mangrove assessment location	Nearest shoreline / mangrove area adjacent to each of the above sites.								
Frequency and Timing	Mangroves Sediment Benthic macroinvertebrates Remote sensing data assessment: Every 2 years Every 2 years 3 samples collected in the first 2 years of operational discharges, then every 5 years <i>Note: sample frequency may be altered or change 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.</i>								
Duration	On initiation of operational discharge. To continue for the life of the Project (frequency may change over time).								
Sampling Parameters / Requirements			Assessment Approach						
Sediment	Sediment Sizing		Make comparisons to data from past years - baseline is data from the EIS. 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.						
	Total Nitrogen								
	Total Phosphorous								
	pH, Redox Potential, TOC, Total Aluminium								
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								

TOC = Total Organic Carbon

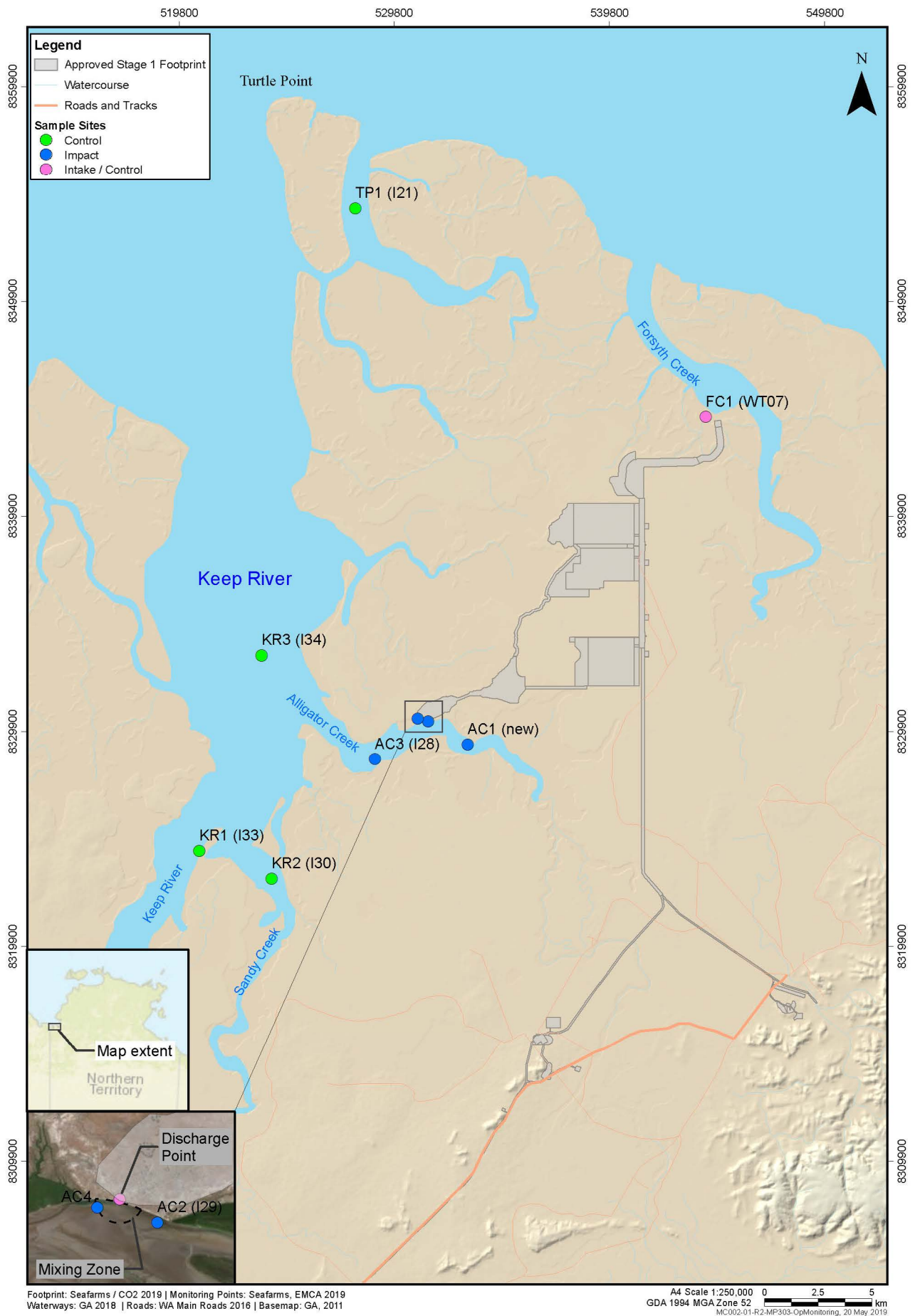


FIGURE A3-1 OPERATIONAL SAMPLING LOCATIONS

APPENDIX B SAMPLING METHODOLOGY

B1 – INTRODUCTION

B1.1 MONITORING REQUIREMENTS

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

At all times and for all events, suitably qualified and experienced personnel must undertake the works, including planning, sampling, sample preparation and analysis, data review and analysis, and subsequent actions. All personnel involved in the program must 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 must be followed during the monitoring program, 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 documents 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 must 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 must 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) must also be undertaken, particularly in regard to determining the start or end of wet seasons. In addition, tide details must be checked prior to each sampling event to ensure the sampling will be safe and (where relevant) water will be present.

B2.2 EQUIPMENT AND MATERIALS

The following equipment must be gathered for each 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 METER CALIBRATION

All meters and probes to be used in monitoring must be calibrated prior to every sampling run. 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 must be entered, as well as details of the success or failure of calibration.

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

B2.4 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 must 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 must be prepared for the potential risks involved in sampling. Personnel must 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) must 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 must 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 must 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 generally be collected from each site 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 must 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 must 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 must be sufficient to allow for the required analysis, including replicate testing if requested.

The required method, volume and bottles must 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 (DES, 2018).

Photographs of each sampling site, including key observations, must 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 must 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 must 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 must be utilised for all analysis other than in-situ field measurements. Consultation must be undertaken with the testing laboratory prior to any sample collection and delivery, to ensure that laboratory limits of reporting for each analyte are below the water quality triggers.

B4.5 QA/QC SAMPLES

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

Replicate sampling must also be conducted 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 must be labelled DupA, DupB, etc., with the site recorded on the sampling documentation. However, the laboratory must not be advised which site this relates to.

B4.6 SAMPLE STORAGE, TRANSPORT AND TRACKING

Collected and labelled sample containers must 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 must be emailed to the testing laboratory along with the anticipated time of arrival of the samples.

Samples must 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 must 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 trigger 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 must 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 STAGE 1 LEGUNE GROW-OUT FACILITY

EN01-MN4201C

SUPPORTING REPORT TO THE WQMMP

Rev 2.0, 20-May-2019

Project and Document Details

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Approved for release by: Rod Dyer, Project Sea Dragon Pty Ltd
Dallas Donovan, Seafarms Group Ltd

Terms and Abbreviations

µg/L	Micrograms per Litre, 1 µg = 1/million of 1 Litre, equivalent to parts per billion (ppb)
AHD	Australian Height Datum
Al (diss)	Dissolved Aluminium
ANOVA	Analysis of Variance, a collection of statistical tests used to analyse the difference between group means
ARI	Average Recurrence Interval
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
BOD ₅	5-day Biochemical Oxygen Demand
BTEX	Refers to the group of chemicals benzene, toluene, ethylbenzene and xylene
CDOM	Coloured Dissolved Organic Matter
Chl a	Chlorophyll a
Cl:SO ₄	Chloride : Sulfate ratio
COD	Chemical Oxygen Demand
DO	Dissolved oxygen
DoEE or the Commonwealth	Commonwealth Department of Environment and Energy
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 Legume Grow-out Facility
EMP	Environmental Management Plan
EMS	Environmental Management System
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth)
EPIRB	Electronic position indicating radio beacon
EPZ	Environmental Protection Zone
EVs	Environmental Values
FDC	farm discharge channels
Fe (diss)	Dissolved Iron
FRP	Filterable Reactive Phosphorous
IFRP	Internal Farm Recycling Pond
LAT	Lowest Astronomical Tide
MDC	Main Discharge channel
mg/L	Milligrams per Litre, 1 mg = 1/1000 of 1 Litre, equivalent to parts per million (ppm)
MNES	Matters of National Environmental Significance
NATA	National Association of Testing Authorities

NH ₃	Ammonia
NO ₂	Nitrite
NO ₃	Nitrate
NO _x	Oxides of Nitrogen (Nitrite + Nitrate)
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTU	Nephelometric Turbidity Unit
NWQMS	National Water Quality Management Strategy
OC/OP Pesticides	Organochlorine / Organophosphate Pesticides
PDC	pond discharge channels
PERMANOVA	Permutational multivariate analysis of variance (a non-parametric multivariate statistical test)
PVC	Polyvinyl Chloride
Redox	Redox Potential
SPF	Specific Pathogen Free
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
TPH/TRH	Total Petroleum Hydrocarbons / Total Recoverable Hydrocarbons
TPWC Act	<i>Territory Parks and Wildlife Conservation Act (NT)</i>
TSS	Total Suspended Solids
WDL	Waste Discharge Licence
WMPC Act	<i>Waste Management and Pollution Control Act (NT)</i>
WQMMP	Water Quality Monitoring and Management Plan
WQO	Water Quality Objective
WWTP	Wastewater Treatment Plant

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1 INTRODUCTION

This document provides supporting information used in the development of the Stage 1 Legume Grow-out Facility 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 details of the water quality review conducted for the Project, which includes baseline data assessment, identification of environmental values, discharge criteria and trigger values, and control-impact assessment methodology.

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 10,000 ha of produce 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 – proposed to be located at Exmouth (WA)
- Breeding Program - proposed to be located at Point Ceylon at Bynoe Harbour (NT)
- Hatchery Site – proposed to be located in the Darwin (NT) environs
- a 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 Stage 1 of the Grow-out Facility involving the 3 farms and 1,120ha of ponds, plus supply and discharge channels, settlement and treatment ponds, an Environmental Protection Zone and discharge to Alligator Creek.

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

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

- Intake of seawater from Forsyth Creek, and the addition of freshwater from Forsyth Creek Dam
- Addition of prawn feed, micronutrient fertilisers and pond water conditioners
- Growth and harvest of prawns
- Water exchange resulting in discharge of pond aquaculture water to Alligator Creek
- Pond aquaculture water discharges first to an Internal Farm Recycling Pond (IFRP) for settlement and reuse, with a portion being discharged through an Environmental Protection Zone (EPZ) and then into Alligator Creek
- A controlled discharge weir to enable timing of releases with respect to the tidal condition.

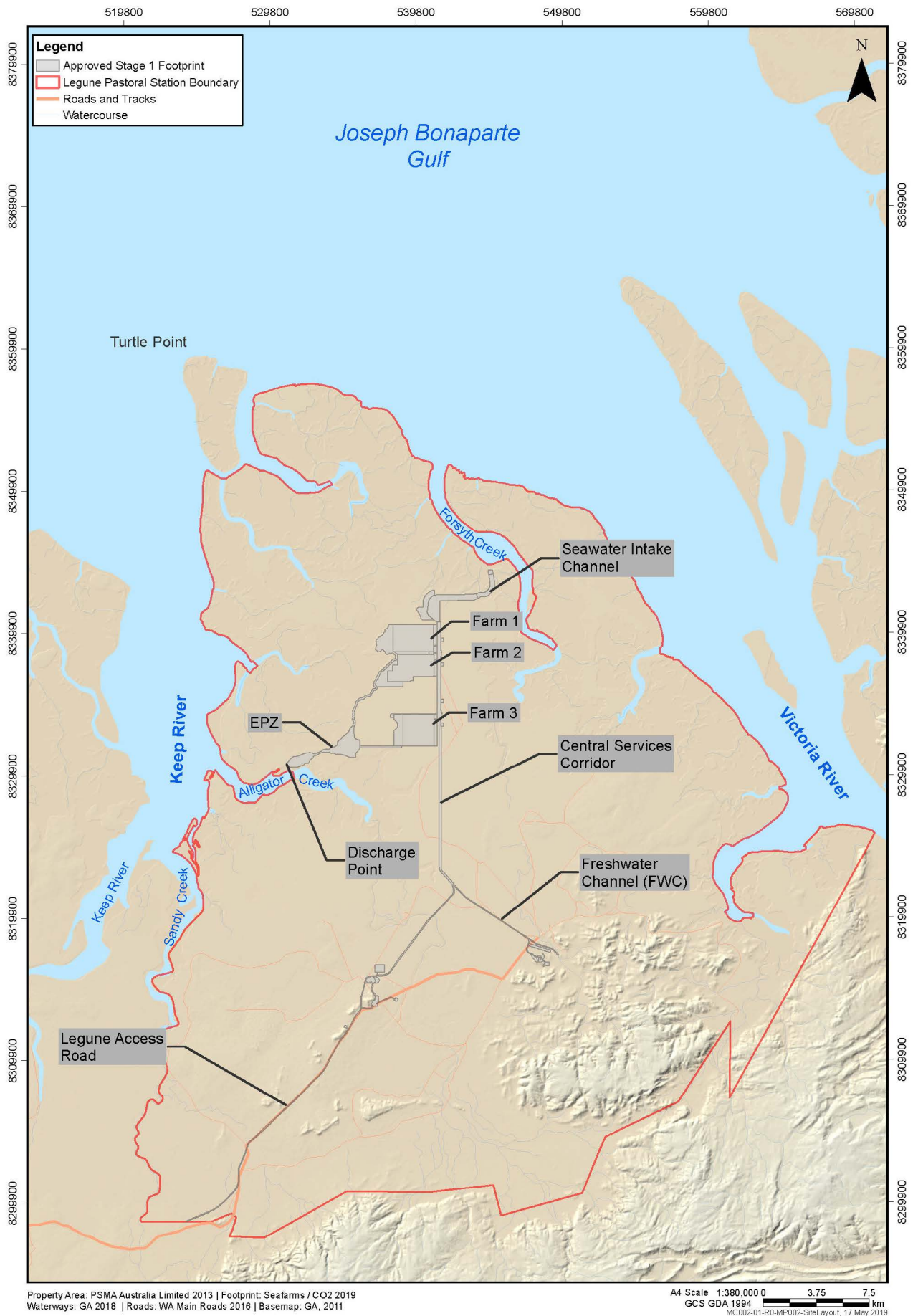


FIGURE 2-1 SITE CONTEXT

3 EXISTING ENVIRONMENT

3.1 PROTECTED MATTERS

Legume Station is bordered by the Keep River to the west, and the Victoria River to the east, with Alligator Creek being the receiving waters for the approved operational discharges to the environment. Alligator Creek flows into the Keep River. The Project Environmental Impact Statement (EIS) undertook a review of potential protected matters and impacts, with the Commonwealth identifying two controlled actions relevant to the Project under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act):

- Listed threatened species and communities, and
- Listed migratory species.

Volume 2, Chapter 7 of the EIS found that 15 aquatic species listed as threatened under the EPBC Act and/or the Territory Parks and Wildlife Conservation Act (NT) (TPWC Act) had the potential to occur in the region. Of these, nine - northern river shark, spear-tooth shark, dwarf sawfish, green sawfish, freshwater sawfish, green turtle, hawksbill turtle, olive ridley turtle and flatback turtle - were considered to have high or moderate likelihood of occurring in the estuarine environment surrounding the Project.

The EIS also identified that 18 aquatic species listed as migratory under the EPBC Act had the potential to occur within the region. Of these, eight - green turtle, hawksbill turtle, olive ridley turtle, flatback turtle, estuarine crocodile, dugong, Australian snubfin dolphin and Australian humpback dolphin were considered to have high or moderate likelihood of occurring in the estuarine environment surrounding the Project.

The key risk to these species relevant to this WQMMP is a change in water quality due to the site discharge into Alligator Creek. The results of the EIS impact assessment found that these risks are unlikely to cause a significant impact to any threatened or migratory species. Additional though less important risks relate to changes to hydraulics, boat impact and impingement in intake structures.

3.2 HYDROLOGY

The Project site is in the lower part of Joseph Bonaparte Gulf, a relatively shallow marine area with a coastline dominated by sand banks, extensive mudflats, mangrove systems, tidal creeks and the estuaries of the Victoria River and Keep River systems (refer to Figure 2-1). In this region, estuaries are well-mixed, macro-tidal (tides > 4m), with little or no vertical water column stratification. They are characterised by extensive shifting unvegetated intertidal flats dominated by relatively fine sediments, and the waterways typically experience high levels of bed and bank erosion and high natural levels of turbidity due to strong tidal and wind generated currents.

In general, Forsyth Creek has a meandering channel form, comprising a single main channel with smaller tidal creeks joining along its length. At the proposed intake location this changes to a series of channels forming a more braided morphology along this 3km section (refer Figure 3-1). Upstream of the divided channels, the creek reverts to a single flow path, however the channel centreline follows a more meandering form than the downstream channel, indicating that lower current speeds are present.

The intake is to be located on the outside bend of the southern channel (refer Figure 3-1), which is significantly deeper than the central or northern channels and conveys the majority of flood and ebb tide flows. Bank scour in this region has been estimated at around 15 m laterally per year.

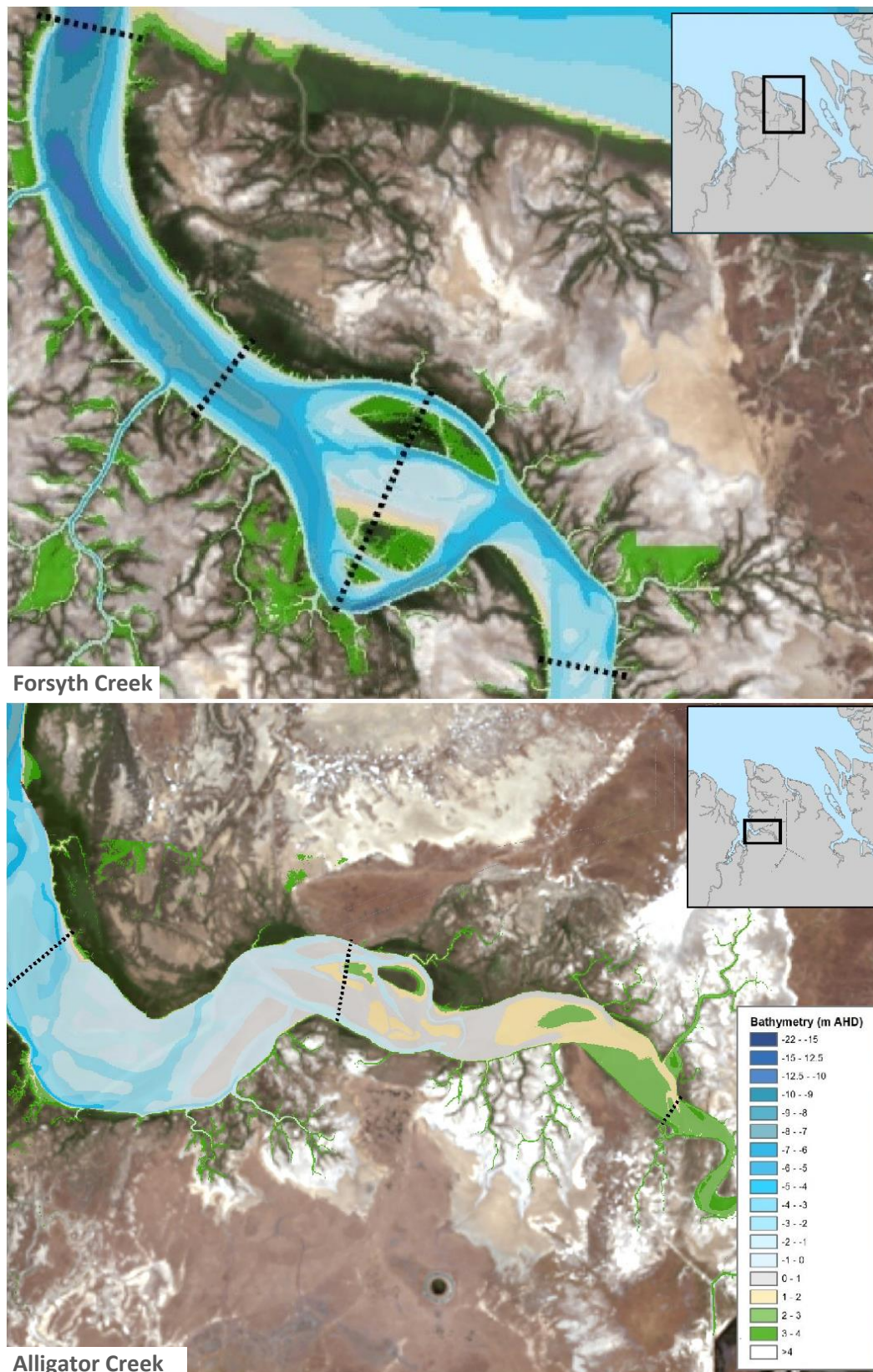


FIGURE 3-1 FORSYTH AND ALLIGATOR CREEK BATHYMETRY AND CHANNELS

Alligator Creek is comprised of a series of sub-channels separated by braid bars, essentially low tide flats, which are flooded at high tide (refer to Figure 3-1). Channels are highly dynamic with significant changes occurring over relatively short timeframes. The banks are typically sloping over much of the tidal range, transitioning abruptly to a near vertical bank at the channel margins.

In terms of hydrology, the volume of water extracted from Forsyth Creek and subsequently discharged to Alligator Creek represents a very small percentage of the tidal prism. The extraction or discharge of water will be unlikely to affect water levels or current speed within the waterways.

3.3 EXISTING WATER QUALITY

A baseline water quality monitoring program was conducted in the estuarine and marine environments around the Project over a 22-month period. The program found waters were generally extremely turbid, with high concentrations of total phosphorus. Forsyth Creek and Alligator Creek in particular had high levels of turbidity and suspended solids at all times, with higher levels during the dry season. Nitrate was also elevated compared to the Darwin Harbour Water Quality Objectives (refer DLRM, 2014) though total nitrogen was moderate to low.

Compared to AWQG trigger values and the Darwin Harbour WQOs, the 80th percentile results for total nitrogen are comparable (0.31mg/L compared to 0.25 – 0.44mg/L trigger value/WQO), while phosphorous is an order of magnitude higher (0.20mg/L compared to 0.02mg/L trigger value/WQO). This is consistent with a system which has considerable particulate phosphorus sources, likely to be bound to the sediment and as such, related to the high rates of sediment re-mobilisation occurring in the system due to the high tidal energy which dominates mixing and transport processes. Given the relative levels compared to guideline objectives, the system might be nitrogen limited, assuming that phosphorous is suitably available to marine organisms.

The median Chlorophyll a levels are <1µg/L, with an 80th percentile of 3.2 µg/L with the vast bulk of results below 20 µg/L. There were four results above 20 µg/L:

- 21 µg/L in Alligator Creek (I28) in January 2016
- 25 µg/L at Turtle Point (I25) in August 2015
- 29 in the Victoria River (I11) in July 2016, and
- 140 in Sandy Creek (I30) in September 2016.

High turbidity levels typically limit the ability for nutrients to drive primary productivity, even where nutrients are elevated. Visual inspection of time series data around the above data points show levels to have dropped to low levels by the next sampling round, although other sites appear to be slightly elevated on these occasions. This shows that primary productivity, as measured by Chlorophyll a, can respond to conditions, although no particular drivers can be identified other than turbidity being at the lower end of the measured range, at around 200 – 600 NTU (but not 'clear'). Nutrients were not particularly high, and were in fact generally lower, and salinity indicates generally saline conditions rather than fresh runoff).

Sampling at different depths indicated that water quality was well mixed throughout the water column, with little variation between surface and deep water at any of the sites. Salinity was relatively stable at most sites, with lower levels in the wet and higher in the dry seasons, as could be expected.

Sampling was conducted for the concentration of potential toxicants including metals, hydrocarbons and pesticides. Dissolved metals occasionally exceeded the AWQG trigger values for a range of metals, with aluminium and zinc consistently exceeding the trigger values. Results from Forsyth Creek indicated that Forsyth Creek can supply source waters to the operation without concern for metals or metalloids in the waters adversely affecting farming processes.

Given that none of these substances will be added to pond or process waters, it is also considered that Alligator Creek can receive wastewater flows with no associated environmental impact concerning metals and metalloids. Levels of hydrocarbons and pesticides were low and non-detectable, respectively, with hydrocarbons likely to be naturally derived.

Sediments were dominated by silt / clay with sand, with nutrient levels consistent with other sites in the Keep River estuary, and metals, metalloids and pesticides being generally low or below the laboratory limits of reporting. Hydrocarbons in the C15-C36 fraction were detected at most sites in June 2015; however, concentrations were mostly below laboratory limits of reporting in March 2016. While the C15 to C36 fractions include diesel, fuel oils and lubricating oils, they are also found in vegetation. Given the highly dynamic nature of these environments, and that none were not detected in March 2016, the source of hydrocarbons in this survey was most likely natural.

A detailed review of the baseline program is provided in Section 5, including a determination of the suitability of this data to support setting trigger values for impact assessment.

3.4 CONCEPTUAL MODEL

A conceptual model was developed for the estuary surrounding Legume Station by FRC (2016) – refer to Figure 3-2. Key characteristics comprise:

- a well-mixed, macro-tidal estuary, with little or no vertical stratification
- estuary lined with mangroves and extensive areas of hypersaline saltmarsh and saltflats
- these flats tend to trap terrigenous sediment
- extensive shifting unvegetated intertidal flats dominated by relatively fine material
- high bank erosion, contributing to high turbidity
- strong tidal and wind generated currents readily re-suspend the fine sediments
- high turbidity and suspended solids, and consequently low light availability
- no seagrass and little macroalgae due to low light availability, high currents, and long exposure periods
- primary productivity of phytoplankton limited by light availability
- concentrations of dissolved inorganic nitrogen and phosphorus relatively high due to low uptake by phytoplankton
- benthic invertebrate communities dominated by polychaetes and crustaceans, relatively low abundance and diversity
- benthic invertebrate communities are limited by high turbidity, high sediment mobility, and long exposure periods
- few filter feeders in the benthic community due to high turbidity
- migrant and resident shorebirds, fish and reptiles feed on macroinvertebrates – capturing carbon and nitrogen
- shorebirds in low numbers – thought to be due to the low abundance and diversity of benthic invertebrates, and
- denitrification through the water column and sediment.

In the wet season, water from the catchment is flushed into the estuarine receiving environment from high flows created by 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. Despite nutrient availability, high turbidity limits primary production.

In the dry season, currents driven by stronger offshore winds suspend the sediment, increasing turbidity and limiting primary production even further.

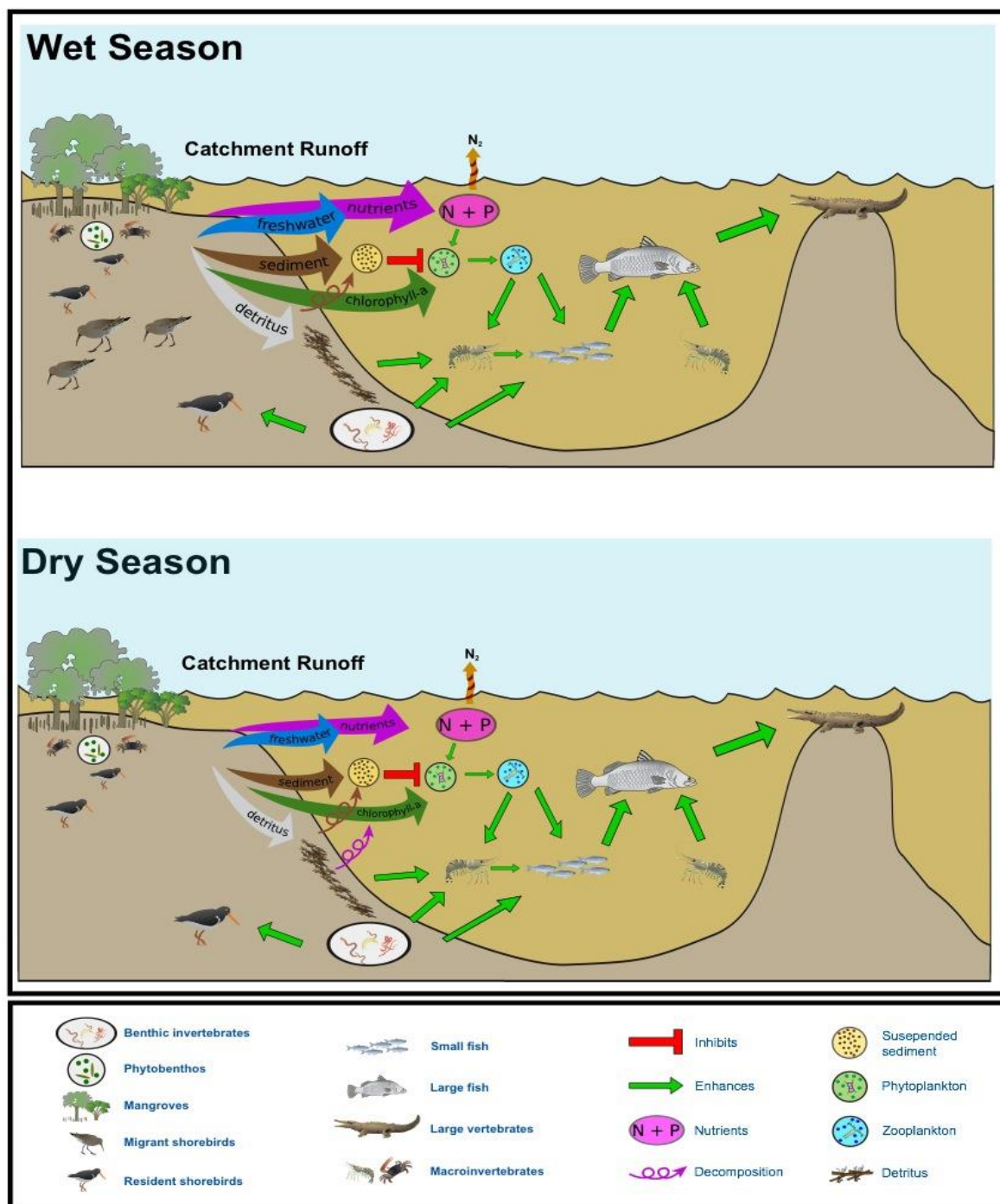


FIGURE 3-2 CONCEPTUAL MODEL OF ESTUARINE RECEIVING ENVIRONMENTS

4 RISK ASSESSMENT

4.1 RISK ASSESSMENT FRAMEWORK

A Project wide risk assessment was conducted for the Project, as outlined in Volume 1, Chapter 8 of the Project 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, Volume 1, Chapter 8. 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.

4.2 OPERATIONAL DISCHARGES

4.2.1 Water quality

The Stage 1 Legume Grow-Out Facility Supplementary EIS (Seafarms, 2017) provided an assessment of the inputs to the ponds and the resultant components of the discharge waters. These farm additions are identified as follows:

- filtered seawater, freshwater – discharged to Alligator Creek, less evaporation
- formulated feed (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. Probiotics (bacterial colonies) may be present, but would be transformed into proteins (used as food by zooplankton and fish). Feed additives 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 (Seafarms, 2017), antibiotics will not form a part of the animal feed or routine pond addition regimen.

- hydrated and agricultural lime for renovation of the pond beds during farm dry-out
- commonly used agricultural fertilisers (silicate, sodium bicarbonate and sodium nitrate), which are transformed into animal protein, microbial colonies, microalgae, mineralisation of nutrients
- molasses used to add soluble carbon to the ponds, containing calcium, magnesium, potassium, copper, iron, phosphorous, chromium, cobalt, sodium, niacin, vitamin B-6, thiamin and riboflavin. This is transformed through biological processes into animal protein, microbial colonies, microalgae, mineralisation of nutrients and trace minerals not taken up by prawn biomass.
- Hydrogen peroxide for emergency oxygenation and pond sediment disinfection, breaking down to water and oxygen

- chlorine for disinfection, rapidly breaking down to sodium chloride and oxygen
- pond dye may be used, but breaks down so as to result in no release.
- Loss of sediment from pond and channel walls and floors.
- Organic matter, including prawn faeces, uneaten food and dead algae and primary producers (ponds are screened to prevent the escape of live prawns and prawn carcasses).

Available literature data, monitoring at existing Seafarms' Queensland sites and the data above indicates the following characteristics of discharge waters:

- Total nitrogen in 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).
- 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).
- Chlorophyll a, an indicator of algae and primary producers, varied between ~1.2 – 36 µg/L, averaging 11.3 µg/L in Seafarms' Queensland sites.
- The bulk of the total suspended load (60 – 90%) is inorganic material eroded from the pond floor and banks (Preston et al, 2000), with the remainder 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 much less than 1.3mg/L¹ total vitamins and minerals based on the average use and licenced discharge rate. This threshold does not account for uptake in the pond system and since it also includes the total vitamin and mineral components in a typical premix minerals mix, the actual level of each of the key metals that might be problematic in aquatic environments (including selenium, cobalt, copper, zinc, iron, magnesium and manganese, silicate, chromium, sodium and chloride) is anticipated to be quite low.

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, channels and environmental protection zones to treat effluent
- use of outfall controls and 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).

¹ Based on 19,400 tonnes per year or from the Project EIS (Volume 1, Chapter 3, Table 12, page 3-94) (Seafarms, 2016).

4.2.2 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 faecal 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.

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.

The receiving environment for this Project has a much higher turbidity and greater tidal range than of the studies discussed above from northeast Queensland. The primary consequence of the high turbidity levels and greater tidal range is that the waters of Alligator Creek will generally be light limited with respect to algal growth and primary productivity processes, and that the discharge will be dispersed relatively quickly.

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.' 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.

4.3 KEY INDICATORS

Table 4-1 details the key indicators relevant to the various potential impacts and stressors during both construction and operational phases, as identified in the Project risk assessment and summarised in Section 4.2 for operational discharges. Based on Table 4-1, the key indicators to be measured are as follows (abbreviations are shown in Table 4-1):

Fuel spills and incidents

- Relevant to the type of spill: hydrocarbons (fuel, oil spills), metals (fuels, other chemicals), chemical and biochemical oxygen demand (various elements that could deplete oxygen), pesticides (OC/OP pesticides), visual indicators.

Construction phase monitoring:

- ASS impacts - pH, DO, redox, dissolved aluminium and iron, Cl : SO₄ ratio, visual indicators
- Sedimentation and vegetation clearing – pH, turbidity, TSS, DO, visual indicators.

Note: these are incorporated into the relevant construction phase management strategies under the EMP.

Operational phase monitoring

In terms of measuring impacts on receiving environments, this will comprise indicators including:

- Nitrogen and phosphorous as the primary stimulators of eutrophication and nutrient impacts in coastal estuaries
- Chlorophyll a, useful in measuring primary productivity and algal load discharged.
- Trace metals, given the exceedances recorded in the receiving waters additional baseline monitoring of a set of metals is recommended. Monitoring of changes in sediment composition over time is also recommended to determine whether total loads are increasing significantly, and whether sediment characteristics (pH, redox potential) might be changing resulting in more release (or uptake) of dissolved metals into the environment.
- Phys-chem parameters, including pH, dissolved oxygen, electrical conductivity and turbidity. Note that electrical conductivity will be used to estimate total dissolved solids (TDS) (i.e. salinity) levels but unlike TDS can be measured on-site. Both TDS and TSS are not impactors, since salinity is not variable enough to cause impacts (refer to the EIS), and TSS (and turbidity) are anticipated to be lower than receiving waters.
- Biological and ecological monitoring, involving mangrove health and extent and benthic macroinvertebrates.

Discharge monitoring would involve:

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

Baseline/Operational phase EIMP monitoring would involve:

Initial 2-year assessment program:

- 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 (NH₃, NO_x, TKN, TN), phosphorous species (FRP, TP).
- Biological - Chlorophyll a
- Other – visual indicators and odour
- Sediment sampling:
- Sediment sizing, TN, TP
- pH, redox potential, TOC
- Metals are not proposed to be sampled given that no significant sources of metals are anticipated in the discharge – baseline data is however available for metals in sediments if required.
- Ecological - mangrove ecological health and extent, benthic macroinvertebrates.

Following initial 2-year assessment program:

- As above as refined or altered by the 2 year review.

TABLE 4-1 KEY INDICATORS

Effect / Impact	Indicator	Abbreviation	Notes	Holding Time Issue?*
Construction				
Disturbance of Acid Sulfate Soils (ASS)	pH		A measure of the acidity (pH < 7) or alkalinity (pH > 7) nature of waters. pH can affect the availability and toxicity of certain elements. Oxidised ASS runoff may be acidic with a pH < 7	✓
	Dissolved Oxygen	DO	Chemical reactions related to acid generation can affect and be affected by dissolved oxygen levels and redox potential. Low DO can affect aquatic organisms	✓
	Redox Potential	Redox		✓
	Dissolved Aluminium	Al (diss)	A potential indicator of oxidised ASS runoff (often released from acidic soils)	-
	Dissolved Iron	Fe (diss)		-
	Chloride : Sulfate ratio	Cl:SO ₄	A potential indicator of oxidised ASS runoff, to determine the source of sulfate (ASS or seawater)	-
	Visual Indicators (small water bodies or drains): - clear, yellow-brown, blue-green, milky white waters - iron floc in waters - salt crusts, scalds, iron monosulfides (black oily sludge)		Visual indicators that waters or soils may be affected by acidic soils, particularly derived from ASS	-

Effect / Impact	Indicator	Abbreviation	Notes	Holding Time Issue?*
Loss of sediment from disturbed areas	Total Suspended Solids	TSS	Suspended solids shows the quantity of solids in the water lost from exposed surfaces. Turbidity shows the cloudiness of waters, directly affecting organisms in waters, and used as a rapid field indicator of TSS	-
	Turbidity	Turbidity		✓
	pH	pH	Erosion of soils may result in changed pH due to acidic or alkaline soils (natural or otherwise)	✓
Loss of vegetation and sediment from disturbed areas	Dissolved Oxygen	DO	A measure of the oxygen dissolved in the water column available for aquatic organisms, reduced through addition of oxygen demanding substances possibly available in soils and large quantities of rotting vegetation	✓
Operation				
Discharge nutrient load, available nutrients in receiving waters	Ammonia	NH ₃	Nitrogen species associated with biological activity and therefore wastewater, relatively rapidly degrades in natural waters. Potentially directly toxic and available for biochemical degradation, influencing oxygen demand	-
	Oxides of Nitrogen (Nitrite + Nitrate)	NO _x (NO ₂ + NO ₃)	Inorganic nitrogen available for biological uptake.	✓
	Total Kjeldahl Nitrogen	TKN	A measure of organic nitrogen plus ammonia/ammonium	-
	Total Nitrogen	TN	Total nitrogen concentration, including available, organic and inorganic fractions	-
	Total Phosphorous	TP	Total phosphorous concentration, including available and bound (to solids) forms (bound forms can present a significant fraction of the total load)	-
	Filterable Reactive Phosphorous	FRP	Biologically available phosphorous	✓
Solids load in discharge waters, and indicators of receiving waters water clarity	Total Suspended Solids	TSS	The total solids present suspended in the water column	-
	Turbidity		A measure of water clarity, may be used as a rapid field indicator of TSS after suitable comparison	✓
Algal biomass in discharges and receiving waters, biological activity and effects on oxygen levels in receiving waters	Dissolved oxygen	DO	A measure of the oxygen dissolved in the water column available for aquatic organisms, affected by primary productivity	✓
	Chlorophyll a	Chl a	An indicator of biomass – the amount of algal presence in the water	✓
	5-day Biochemical Oxygen Demand	BOD ₅	A measure of the potential oxygen used by the decay of chemical constituents in the water (tested over 5 days). High BOD indicates potential for low DO levels. More suitable for discharge water testing than receiving waters.	✓

Effect / Impact	Indicator	Abbreviation	Notes	Holding Time Issue?*
	Total Dissolved Solids	TDS	A measure of salinity, determined from the mass of dissolved salts. Can be estimated from EC where a suitable relationship can be derived.	-
	Electrical Conductivity	EC	Rapid field indicator of TDS / indicator of fresh/salt conditions and therefore dry/wet season conditions	-
Seasonal influences in discharge and receiving waters	Total Dissolved Solids	TDS	A measure of salinity, determined from the mass of dissolved salts. Can be estimated from EC where a suitable relationship can be derived.	-
	Electrical Conductivity	EC	Rapid field indicator of TDS / indicator of fresh/salt conditions and therefore dry/wet season conditions	-
Spills or leaks (construction or operation)				
Fuel/oil spills	Dissolved Metals		Toxic effects of metals in waters are available through the dissolved fractions of metals. Requires field filtration.	-
	Total Metals		A measure of the total metal concentration in waters, including that bound with solids. Indicates a worst case concentration in the case of release in the environment (e.g. due to changes in pH, redox potential), does not require field filtration	-
	Visible oils slicks, surface sheens		Indicates fuel or oil spill into waters. Care needs to be taken to differentiate hydrocarbons from iron bacteria which can cause similar sheens and may be natural	-
	Total Petroleum Hydrocarbons / Total Recoverable Hydrocarbons	TPH / TRH	Measures of fuel or oil concentration, relevant to a spill but also includes biological sources such as peat, oils and gums. This measures the total petroleum concentration by group, which can indicate which tests may be required for further investigation (if TPH is found). A silica gel cleanup may assist with differentiating petrochemical sources.	-
Oxygen Demanding Substances (e.g. cement, organics/sewage)	Dissolved Oxygen	DO	Spills of oxygen demanding substances, such as cement or high organic loads, indicating whether oxygen is being deprived from waters (relevant to small waters or very large releases). COD is relevant to chemical contaminants, and BOD5 to organic loads. Both should be tested in case of a spill, since COD results are available sooner allowing action to be taken quicker.	✓
	Chemical Oxygen Demand	COD		-
	5-day Biochemical Oxygen Demand	BOD ₅		✓
Pesticide/herbicide spill (minor quantities may be used for weed control on-site)	OC/OP Pesticides		Direct measure of key components of these chemicals, in the case of a spill	-

Effect / Impact	Indicator	Abbreviation	Notes	Holding Time Issue?*
Indicators of long term uptake, change or effects in the receiving waters (operation)				
Sediments	Sediment Sizing		The size and how well graded the sediments are. This is useful in determining change in dynamic conditions (sedimentation and transport), and in characterising benthos.	-
	Total Nitrogen	TN	Indicates change in receiving environments, related to baseline levels. More indicative of long term trends than short term fluctuations.	-
	Total Phosphorous	TP		-
	Metals	Various		-
	pH	pH	Indicative of chemical status of sediments, whether constituents might be being released or absorbed.	✓
	Redox Potential	Redox		
	Total Organic Carbon	TOC	A measure of the organic carbon in a sample, indicative of organic matter content.	-
Ecological Health	Mangrove intactness/extent review of satellite imagery		Track changes in mangrove coverage and health over time and allow for comparisons with water quality results to detect negative changes - aerial extent, and an assessment of health from the satellite imagery (using the Normalised Difference Vegetation Index (NDVI) derived from satellite imagery spectral bands). Where changes are found, on the ground mangrove community health assessments can be conducted to confirm (as per FRC, 2016) or otherwise a less frequent groundtruthing exercise to be undertaken (~5yearly).	-
	Benthic Macroinvertebrates		Additional baseline sampling to provide at least 3 baseline samples for the nominated sites to compare to at least 3 post-operational discharge sampling rounds.	-

Table notes:

* Refer to Section 4.4

4.4 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 the lab within the required time limits from this remote site. The analytes with potential issues due to short holding times, along with the recommended solution, are as follows:

- pH, dissolved oxygen, turbidity, 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 may also change quickly)
- Nitrate (NO₃), Nitrite (NO₂): the baseline data indicates that very little if any nitrogen is present as NO₂ (most results are < limit of reporting) and given that the holding time for NO_x (NO₂ + NO₃) is relatively long, only NO_x should be sampled with the assumption that it is all NO₃. Should an issue arise and these need to be speciated, then a rapid turn-around delivery can be arranged, or alternative preservation and storage methods employed (e.g. freezing)

- 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.
- 5-day Biochemical Oxygen Demand: the holding time limit is ~2 days. It is considered that BOD₅ has limited value at this location, given the inclusion of dissolved oxygen and Chlorophyll a monitoring which can detect changing oxygen levels and indicate higher algal loads. As such, BOD₅ is not proposed as a useful measure of potential impact or change. Should this type of measure be required, COD may be used in its place (in certain circumstances), express delivery utilised, or the test conducted within the water laboratories on the site.

5 WATER QUALITY DATA REVIEW

5.1 SAMPLING EFFORT

5.1.1 General Water Quality

Sampling was conducted at a number of sites between June 2015 and April 2017, a period of 22 months, generally on a monthly basis. Sample sites, total number of samples taken, the number by season (wet and dry), the sample period and resultant interval, and the months where a depth profile, or a series of samples for analysis of tidal variation were taken are summarised in Table 5-1. The sample locations are shown in Figure 5-1.

Good coverage of the key sites has been provided, although marginally short of the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000a, or the AWQG) 24 month recommended sample collection period. Sampling for depth profiles was included at a relatively large number of sites, with a number of key and important sites included in diurnal tidal variation studies. The variation in season and by tide is discussed further in Section 5.2.1.

TABLE 5-1 SUMMARY OF SAMPLING EFFORT BY SITE

System	Site	N			Sample Period	Sample Interval	Depth Profile	Tidal Variation
		Total	Dry	Wet				
Bob's Ck	I01	2	2	0	Jun, Sep 2015	3 months	-	-
	I02	19	11	8	Jun 15 - Apr 17	22 months	Jun, Oct 15; Jan, Mar 16	-
	I03	2	2	0	Jun, Sep 15	3 months	Jun 15	-
	I04	3	3	0	Jun, Aug, Sep 2015	3 months	Jun 15	Jun 15
Creek E of Turtle Pt	I21	19	11	8	Jun 15 - Sep 15	22 months	Jun, Oct 15; Jan, Mar 16	-
Turtle Pt	I25	16	8	8	Aug 15 - Apr 17	20 months	Oct 15; Jan, Mar 16	-
Victoria R	I11	12	7	5	Jun 15 - Apr 17	22 months ¹	Jun 15	-
	I35	11	6	5	Apr 16 - Apr 17	12 months	-	-
Nth Reference Sites	I22	20	12	8	Jun 15 - Aug 15	22 months	Jun, Oct 15; Jan, Mar 16	-
	I23	2	2	0	Jun, Aug 2015	2 months	Jun 15	-
	I24	1	1	0	Jun 15	1 month	Jun 15	Jun 15
Alligator Ck	I28	17	10	7	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	-
	I29	20	12	8	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	-
	I29A	8	5	3	Jun 16 - Apr 17	8 months	-	-
	I09	2	2	0	Jun, Aug 2015	2 months	Jun 15	-
	WT04	1	1	0	Mar 16	1 month	Mar 16	-
Offshore Keep R	I12	28	14	14	Jun 15 - Apr 17	22 months	Jun, Oct 15; Jan, Mar 16	Oct 15; Jan, Mar 16
Sandy Creek / Keep R	I30	18	10	8	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	-
Keep R	I10	20	12	8	Aug 15 - Apr 17	22 months	Jun, Oct 15; Jan, Mar 16	-
	I27	18	10	8	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	-
	I33	18	10	8	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	-
	I34	25	12	13	Sep 15 - Apr 17	19 months	Oct 15; Jan, Mar 16	Oct 15; Jan, Mar 16

System	Site	N			Sample Period	Sample Interval	Depth Profile	Tidal Variation
		Total	Dry	Wet				
Forsyth Ck Offshore	I08	32	18	14	Jun 15 - Apr 17	22 months	Jun, Oct 15; Jan, Mar 16	Jun, Oct 15; Jan, Mar 16
Forsyth Ck	WT07	16	8	8	Nov 15 - Apr 17	17 months	Oct 15; Jan, Mar 16	-
	I05	2	2	0	Jun, Sep 2015	3 months	Jun 15	-
	I06	3	3	0	Jun, Aug, Sep 2015	3 months	Jun 15	-
	I07	3	3	0	Jun, Aug, Sep 2015	3 months	Jun 15	-
Offshore Marine	I13	1	1	0	Jun 15	1 month	Jun 15	-
Total		339	198	141	Jun 15 - Apr 17	22 months	25 sites, 1-4x	5 sites, 1-4 x

Table notes:

1 However missing 8 months

5.1.2 Toxicants

Toxicants were sampled in June 2015 (dry season) and in January 2016 (wet season), comprising:

- Total and dissolved metals
- OC/OP Pesticides
- Hydrocarbons – TPH/TRH, BTEX.

5.1.3 Other Sampling

Sampling and testing of sediment quality, benthic macroinvertebrates, mangrove distribution and health, and the presence or absence of coastal seagrass communities was also undertaken during the EIS phase, as summarised in Table 5-2.

TABLE 5-2 SUMMARY OF ADDITIONAL SAMPLING EFFORT

System	Site	Habitat type	Sediment Sampling	Benthic Macro-invertebrates	Mangroves & Isotopes
Bob's Ck	I01	Shallow subtidal	Jun-15	Jun-15	Jun-15
	I02	Shallow subtidal	Jun-15, Oct-15, Mar-16	Jun-15, Oct-15, Mar-16	Jun-15, Oct-15, Jan-16
	I03	Shallow subtidal	Jun-15	Jun-15	Jun-15
	I04	Shallow subtidal	Jun-15	Jun-15	Jun-15
Creek E of Turtle Pt	I21	Shallow subtidal	Jun-15, Oct-15	Jun-15, Oct-15	Jun-15, Oct-15
Turtle Pt	I25	Shallow subtidal	Oct-15, Mar-16	Oct-15, Mar-16	Jan-16
Victoria R	I11	Low intertidal	Jun-15	Jun-15	Jun-15
Nth Reference Sites	I22	Low intertidal	Jun-15, Oct-15	Jun-15, Oct-15	Jun-15, Oct-15
	I23	Low intertidal	Jun-15, Mar-16	Jun-15, Mar-16	Jun-15, Jan-16
	I24	Low intertidal	Jun-15	Jun-15	Jun-15
Alligator Ck	I28	Low intertidal	Oct-15, Mar-16	Oct-15, Mar-16	Oct-15, Jan-16
	I29	Low intertidal	Oct-15, Mar-16	Oct-15, Mar-16	Oct-15, Jan-16
	I09	Shallow subtidal	Jun-15	Jun-15	Jun-15
	WB2	Low intertidal	-	Mar-16	-
	WB3	Low intertidal	-	Mar-16	-
Offshore Keep R	I12	Shallow subtidal	Jun-15, Oct-15, Mar-16	Jun-15, Mar-16	-
Sandy Creek / Keep R	I30	Shallow subtidal	Oct-15	Oct-15	Oct-15
Keep R	I10	Low intertidal	Jun-15, Oct-15	Oct-15	Jun-15, Oct-15
	I27	Low intertidal	Oct-15	Oct-15	Oct-15
	I33	Low intertidal	Oct-15	Oct-15	Oct-15
	I34		Oct-15, Mar-16	Mar-16	-
	WB1	Low intertidal	-	Mar-16	-

System	Site	Habitat type	Sediment Sampling	Benthic Macro-invertebrates	Mangroves & Isotopes
Forsyth Ck	WT07	Shallow subtidal	Oct-15	Oct-15	Oct-15
	I05	Shallow subtidal	Jun-15	Jun-15	Jun-15
	I06	Shallow subtidal	Jun-15	Jun-15	Jun-15
	I07	Shallow subtidal	Jun-15, Mar-16	Jun-15, Mar-16	Jun-15, Jan-16
	WB4	Low intertidal	-	Mar-16	-
<i>Total</i>			<i>23 sites, 1 – 3 times</i>	<i>25 sites, 1 – 3 times</i>	<i>21 sites, 1 – 3 times</i>

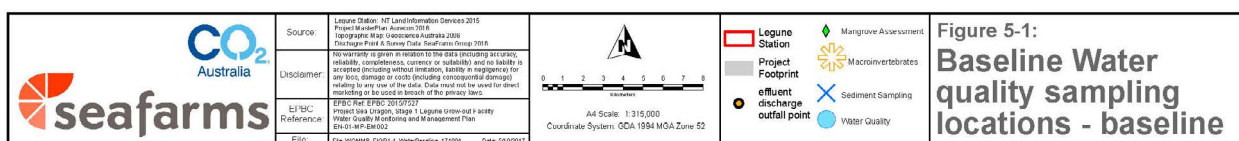


FIGURE 5-1 BASELINE WATER QUALITY SAMPLING LOCATIONS

5.2 BASELINE DATA ASSESSMENT

This section provides an assessment of the importance of the key functions determining water quality in local receiving waters, how representative the data are, and whether there are any particular biases apparent. Based on the available data, a determination is made as to whether further baseline monitoring is likely to be required. The assessment addresses water quality (variation by season, depth and tide), toxicants (hydrocarbons, metals and metalloids) and biological monitoring (sediments, benthic macroinvertebrates and mangroves).

5.2.1 Water Quality

An assessment of the data with respect to seasonal and tidal variation, and variation with depth, is provided in this section, along with an assessment of sample size requirements and 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 trigger 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.

5.2.1.1 Seasonal Variation

Wet seasons are dominated by waters with lower salinity / electrical conductivity, with clear distinctions noted between dry and wet season waters, as shown in Figure 5-2. This shows seasons (based on rainfall and electrical conductivity) to typically be:

- Dry Seasons: June to December, and
- Wet Seasons: January to May.

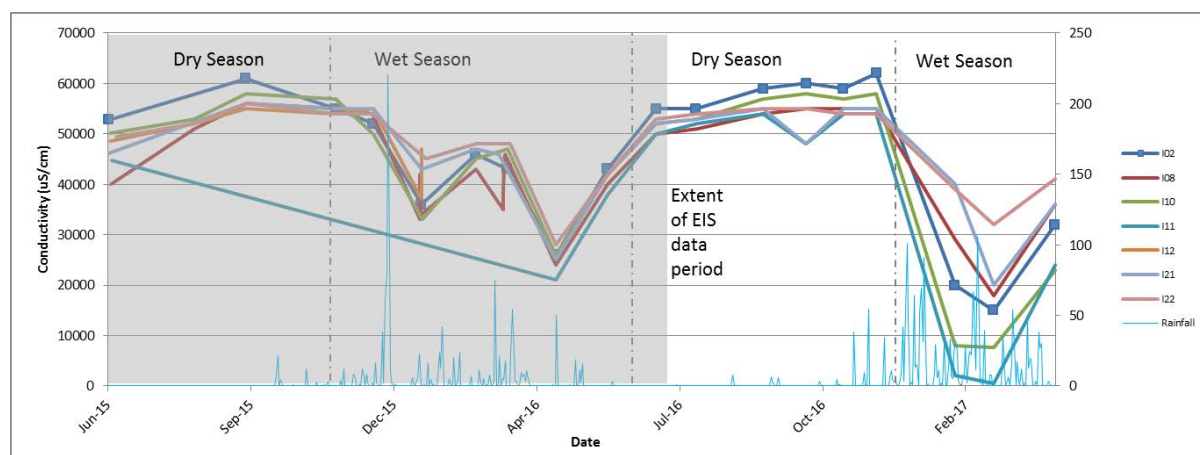


FIGURE 5-2 ELECTRICAL CONDUCTIVITY OVER TIME

The baseline sampling effort has so far covered 2 dry seasons and 2 wet seasons. Compared to the longer term climatic averages in Figure 5-3, one of these wet seasons was relatively dry (1,197mm, Dec 2015 to May 2016), and one particularly wet (1,906mm, Dec 2016 to May 2017)², although December rainfall totals were similar for both years. Monthly rainfall totals during the wet season were below average after December 2015, and generally between the average and 90th percentile totals after December 2016.

Note that the EIS (Volume 2, Chapter 2) describes wet seasons as extending from November to April, and dry seasons from May/June to October/November. This can be seen in the rainfall data in Figure 5-3. However, water salinity (refer Figure 5-2) does not appreciably change until December or January in response to wet

² Based on rainfall data from Port Keats Airport, Bureau of Meteorology station no. 014948

season rainfall. Wet and dry seasons in this assessment have therefore been based on the influence of these patterns in water quality, rather than first rainfall as may suit terrestrial and climatic considerations.

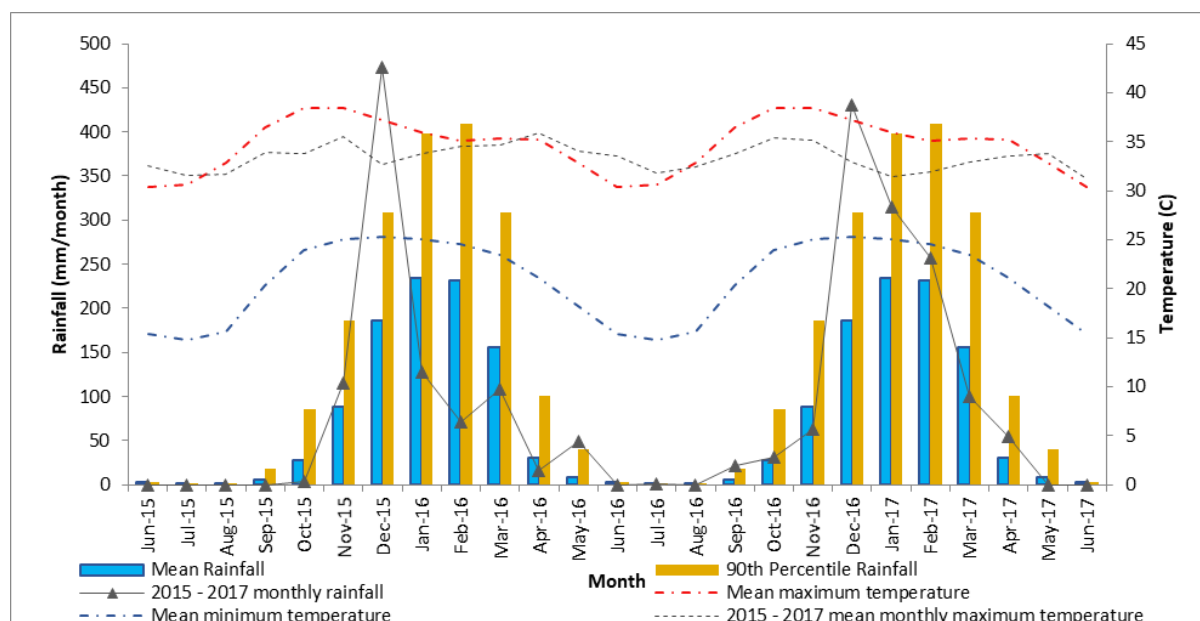


FIGURE 5-3 CLIMATE DATA COMPARED TO LONG TERM RECORDS

For the samples taken, Table 5-1 summarised the sampling effort by season, showing approximately half of all samples for the key sites (those with longer term sampling effort) were taken in the dry, and half in the wet. An analysis of water quality by season was conducted by FRC (2016) on data from June 2015 to April 2016. This found distinct differences between seasons (significance level: ANOSIM Global $R = 0.155$, $p = 0.001$), due to total dissolved solids (less saline in the wet season), total suspended solids (higher in the wet season), total nitrogen (higher in the dry season), oxides of nitrogen ($\text{NO}_2 + \text{NO}_3$, higher in the dry season), and ammonia (higher in the dry season).

No significant difference was found between seasons for total phosphorous, chlorophyll a or turbidity, although for chlorophyll a matrix interference and raised LORs may have contributed to this lack of difference. Visual inspection of the data indicates total phosphorous is highly variable, with peaks recorded on approximately every second sample occasion. Chlorophyll a appears to generally peak during the late dry and through the early wet season (November to January), with occasional peaks during the dry season (June-July 2016). Some of the Keep River sites show elevated levels throughout the wet season (to March), and the Victoria River sites were consistently low, with small peaks in June-July 2016. Forsyth Creek and the offshore and more distant references sites were consistently low.

An analysis of the full dataset (to April 2017) confirmed the above differences. As found by FRC (2016), turbidity was not significantly different. However, when evaluated at individual sites, there did appear to be some differences, notably in Forsyth Creek and some sites in the Keep River - site I33 in the main channel, offshore of the Keep River (I12) and in Sandy Creek (I30) at the lower end of the Keep River.

Seasonal influences are considered important in capturing an unbiased baseline data set and in determining pre- and post-development impacts.

5.2.1.2 Variation with depth

A number of depth profiles were conducted across a number of tidal cycles by FRC (2016), as follows:

- June 2015: Dry season, 7 days covering neap through to spring tides, all key sites, flood, ebb and low tides
- October 2015: Dry season, 7 days covering spring to intervening tides, all key sites, flood, ebb and high tides
- January 2016: Wet season, 5 days covering intervening to neap tides, all key sites, flood, ebb, low and high tides
- March 2016: Wet season, 9 days covering spring through to neap tides, all key sites, flood, ebb, low and high tides.

The data have been analysed in Volume 5, Appendix 8 (Coastal Assessment and Hydrodynamic Modelling, p79), and Volume 5, Appendix 9 (Estuarine and Marine Quality and Ecology, p57) of the Project EIS. This analysis showed relatively uniform temperature, salinity and dissolved oxygen with depth, indicating well mixed conditions. Slightly more variation was seen for pH, and more again for turbidity. However, generally depth is not considered an important element in terms of determining water quality at the sites for the purposes of determining Trigger Values or detecting change.

As such, depth will not be further considered here as an important variable.

5.2.1.3 Diurnal tidal variation

In the EIS submitted for the Project (FRC, 2016), analysis of a number of sampling events which covered the daily tidal patterns was conducted at a number of sites. It was found that while some variation was noted, no distinct pattern could be found across sites or locations in the data between the different tides. Further qualitative analysis of the entire dataset (to April 2017) confirms that there are differences between ebb and flood tides, however again no distinct pattern emerged, with some sites showing higher results and others lower for the same parameter in the flood vs ebb tide comparison.

There is little high or low slack tide data available, although water quality would be expected to be similar to the water quality preceding slack water (high similar to flood, low similar to ebb). The percentage of samples collected during slack tide compared to flood and ebb tides approximately mirrors the amount of time the system is in slack conditions (10 – 20%), indicating no particular bias towards or against slack tides.

Table 5-3 shows the number of sampling events for each site by tidal cycle. As can be seen, approximately equal numbers of ebb and flood tide samples were taken. Sufficient coverage has been included to allow for tidal influences to be incorporated into the overall dataset, with no identified significant bias towards one particular tidal regime.

TABLE 5-3 SAMPLING BY DIURNAL TIDAL CYCLE

System	Site	Flood	High	Ebb	Low
Bob's Ck	I02	9	2	7	1
Creek E of Turtle Pt	I21	6	1	12	0
Turtle Pt	I25	6	0	9	0
Victoria R	I11	6	1	4	1
	I35	5	1	4	1
Nth Reference Site	I22	7	0	12	1
Alligator Ck	I28	8	1	8	0
	I29	5	2	13	0
	I29A	4	0	4	0
Offshore Keep R	I12	11	1	14	2
Sandy Ck / Keep R	I30	11	2	5	0
Keep R	I10	11	1	8	0
	I27	9	2	6	1

System	Site	Flood	High	Ebb	Low
	I33	12	1	4	0
	I34	11	3	9	2
Forsyth Ck Offshore	I08	14	0	16	1
Forsyth Ck	WT07	8	1	7	0
	<i>All</i>	<i>143</i>	<i>19</i>	<i>142</i>	<i>10</i>

5.2.1.4 Lunar cycle variation

Table 5-4 shows the sampling effort by lunar cycle. As can be seen, the effort varied from site to site. Neap tides were sampled at each site between 7 and 11 times (average 8.7 times), with spring tides sampled 1 to 8 times (average 4.4 times), with intervening cycles (between neap and springs) sampled between 2 and 17 times (average 5.9 times) at all sites other than the I29A site (upstream Alligator Creek) which did not include intervening periods.

TABLE 5-4 SAMPLING BY LUNAR CYCLE

System	Site	Neap	Spring	Inter	All
Bob's Ck	I02	9	4	6	19
Creek E of Turtle Pt	I21	8	6	5	19
Turtle Pt	I25	8	3	5	16
Victoria R	I11	8	1	3	12
	I35	8	1	2	11
Nth Reference Site	I22	11	5	4	20
Alligator Ck	I28	7	5	5	17
	I29	8	6	6	20
	I29A	7	1	0	8
Offshore Keep R	I12	11	7	10	28
Sandy Ck / Keep R	I30	8	5	5	18
Keep R	I10	11	4	5	20
	I27	8	5	5	18
	I33	8	5	5	18
	I34	11	8	6	25
Forsyth Ck Offshore	I08	9	6	17	32
Forsyth Ck	WT07	8	3	5	16
	<i>All</i>	<i>148</i>	<i>75</i>	<i>94</i>	<i>317</i>

A reasonable coverage of lunar cycles has been included in the baseline sampling, although the available data varies markedly at some sites with very little available in some cases for some tidal cycles. Determining whether there are statistical differences between lunar cycles is compounded by differences between daily tidal cycles and seasons.

A qualitative assessment of the data showed that for many of the parameters, the lunar cycle did not represent as much variation as the daily tidal cycle. In some cases, and for some parameters, this was not the case, though with the available data it is difficult to determine this with high confidence. At many sites and for many of the parameters, the neap/spring/inter results are similar, or with similar spread of data, but it does seem evident that some higher results are generally found in the neap compared to the spring periods, with intervening tides being generally consistent with spring, neap or both.

As such, lunar cycle influences are important to capture.

Given the tide data so far collected, with a general spread across lunar and daily tidal cycles, sufficient coverage has been included to allow for tidal influences to be incorporated into the overall dataset, with no identified significant bias towards one particular tidal regime.

5.2.1.5 Sample size and statistical power

Proposed analysis approach

The post-development impact assessment methodology is described in Section 5.5.3, involving the assessment of data against trigger values, and assessment based on a Before-After-Control-Impact (BACI) type design and assessment.

Section 5.1.1 provides that the data does not quite meet the AWQG recommendation of 24 months of monthly samples, although the data is representative of seasons and tide and without other obvious biases. The value of an additional several sample points is likely to provide limited improvement on the current data set for the purposes of setting trigger values, given the marked wet / dry season differences in water quality. Some additional baseline sampling is recommended to cover / account for longer term seasonal variation to include in setting trigger values, although a lower frequency would be suitable (e.g. quarterly).

In terms of the BACI type design, the approach taken in Section 5.5.3 is based on measuring deviation against the trigger values over time (before-after), and comparing the deviation itself between control and impact sites (control-impact) using control charting as outlined in the AWQG. The AWQG approach compares the median of collected samples against the 80th percentile from the reference population, providing for an effect size between the median and 80th percentile. This equates to (on average):

- Chlorophyll a: an effect size of 0.8 standard deviations
- Total nitrogen: an effect size of 0.5 standard deviations
- Total phosphorous: an effect size of 1 standard deviation
- Total suspended solids: an effect size of 0.8 standard deviations
- Turbidity: an effect size of 1.2 standard deviations.

Given the recommended default target for the detectable effect size for ecologically conservative decisions outlined in the AWQG of 1 standard deviation, the above provides for a suitable detection level for the program.

Examination of more complicated statistical design requirements

To ensure the baseline data is of sufficient size, the sample size was examined for a more complicated analysis based on an ANOVA type multifactorial design.

This was for the purpose of sample size analysis only and does not represent the preferred analysis approach, which is detailed in Section 5.5.3.

A power analysis was conducted using the following two approaches:

1. Power analysis:

- General Full Factorial Design in Minitab 18.1
- 2 levels for 4 factors – period (before-after), season (wet-dry), location (control-impact),
- Effect Size = Standard Deviation = 1
- Power = 0.8
- Include terms in the model up to order 2
- Significance level 0.05

2. Mock data:

- Assessed Chlorophyll a, total nitrogen and total phosphorous (separate ANOVA runs)
- Constructed using the mean and standard deviations from the existing (natural log transformed) dataset and generating a new random 'After' set from the log-normal distribution
- Adding 1 standard deviation to each log transformed mean in the impact sites and back transforming to the original (untransformed) units
- allowing for only 4 replicates at each site in each season (two years of quarterly sampling)
- undertaking a 4 factor ANOVA assessment
- repeating the above with 8 replicates at each site in each season to match the existing baseline data.

The resulting power curve for approach 1 is shown in Figure 5-4, which identifies 3 replicates required to achieve an effect size of 1 standard deviation, and power of 0.80 (actually the effect size is closer to 0.8 standard deviations). This is supported by the existing baseline data.

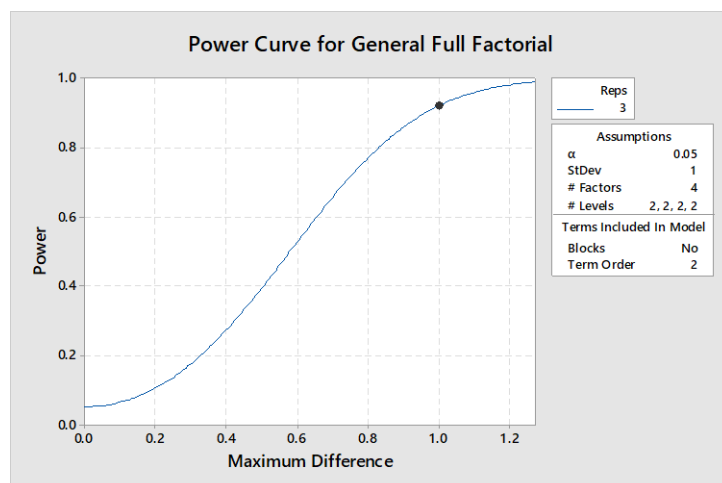


FIGURE 5-4 POWER CURVE ESTIMATE FOR FACTORIAL DESIGN

For approach 2 and adopting 4 replicates (instead of 3) per season, per site, a significant location * period interaction was detected for all parameters, identifying that water quality 'After' the impact in Control sites had changed significantly compared to Control sites ($p = 0.012, 0.001, 0.036$ for Chlorophyll a, total nitrogen and total phosphorous respectively). Looking at effects for one season only, and one impact site only, the effect size was higher, at between 1 – 2 standard deviations (the larger end was for one season and one site only for consistent detection).

Increasing the 'After' samples to 8 replicates at each site in each season improved the results, with one season one site impact detected across all parameters at an effect size of 1.7 standard deviations, with a 0.9 standard deviation departure detected when the effect was across both seasons.

This analysis shows that four replicates (quarterly sampling across two years) would be sufficient to provide an overall 1 standard deviation detection for overall impacts across seasons, able to detect a larger departure during one season only at an effect size of 1.5 standard deviations, and for one site in one season at 2 standard deviations.

With 8 replicates (after four years of quarterly data collection, or should other lines of evidence indicate an impact may be occurring, and so more frequent collection be conducted), this is improved so that detection for a single season at a single site reduces to close to 1.5 standard deviations.

Sample size requirements

The above analysis indicates that the current baseline dataset is sufficient to support the proposed impact assessment analysis. More detailed analysis indicates it also meets the requirements for more complicated and detailed multi-factorial analysis at a suitable power and effect size, as recommended by the AWQG.

To ensure ongoing seasonal effects are still captured (and improving power and detection levels), further baseline data collection is recommended. Given the timeframes until the first pond aquaculture water discharge will occur into Alligator Creek, a program aiming to capture longer seasonal cycles, while still adding sufficient wet season samples, and balancing program complexity and cost is recommended, adopting a less frequent monitoring timetable, nominally two samples per season (dry and wet).

5.2.1.6 Summary

As shown in the above sections, important cyclical variation was found between seasons, and for the lunar and daily (diurnal) tidal cycles, though the most important differences appear to be seasonal and daily tidal cycles. Given the spread of sampling events across seasons and tides, the current dataset is considered sufficiently randomised and unbiased, and is representative of receiving waters.

While the data does not quite meet the AWQG recommendation of 24 months of monthly samples, the value of an additional several sample points is likely to provide limited improvement on the current data set for the purposes of setting trigger values, given the marked wet / dry season differences in water quality. As such, the available data are considered appropriate for setting trigger values in receiving waters. Additional baseline sampling is recommended to extend the measure of seasonal variation beyond the two years collected so far – a quarterly program collecting two wet and two dry samples per year would likely be suitable. This data would be used to confirm or adjust the trigger values, if required.

In terms of before-after and control-impact comparisons, the data can be considered a randomised sampling effort across the various factors, without obvious bias. Further baseline monitoring is recommended, though the frequency can be reduced. Post-development sampling would need to adopt a similar randomised approach to sampling (with respect to time) rather than standardising to any one particular tidal regime, although randomising the order of sampling where practicable is recommended to reduce systematic biases in sampling.

Given the importance of tidal regimes in the area, sampling of different sites should be matched to the same tidal regime during each sampling event. Given the large area and lag effects in the system, sampling different sites at the same tidal cycle, but over a number of days is not expected to present any issues in terms of the comparisons or bias of the data, and instead provide a more powerful comparison.

5.2.2 Toxicants

As noted above, total and dissolved metals, OC/OP Pesticides and Hydrocarbons were tested in the June 2015 (dry season) and January 2016 (wet season) sampling events.

As outlined in FRC (2016), the concentrations of some total metals (aluminium, iron, chromium, cobalt, copper and nickel) were relatively high compared to the AWQG trigger values. This is likely to be due to high metal concentrations in the catchments, with the Keep River catchment noted for significant outcrops of metal mineralisation. Total cobalt, copper and zinc were commonly above the AWQG in the upper estuarine reaches of the Keep River, and in the Keep catchment. In the upper Keep River catchment, mining of silver, lead and zinc are being considered.

The concentration of dissolved metals generally remained below the laboratory limit of reporting (LOR), other than boron at all sites, and aluminium, iron and manganese at one site and one occasion (only aluminium was above the low reliability trigger value). However, LORs were generally above the AWQG trigger value. This means that dissolved metals may be present in estuarine / marine waters and may exceed the AWQG criteria without being shown in the results.

Sampling of metals was conducted in estuarine waters of the Keep River by Bennett & George (2014) from 2011 – 2013, with 2 sites comparable to the FRC (2016) sites (E4 and E5), and another 3 sites in the upper Keep River estuary (E1 – E3). In contrast to FRC (2016), their study found detectable concentrations of a range of metals, explained by the lower LORs which were also generally below or sometimes comparable to the AWQG trigger value.

Based on these results, levels of aluminium and zinc were consistently above detection limits, averaging 0.13mg/L at sites E4 and E5 for aluminium (median 0.028mg/L at sites E1 – E3) and 0.028mg/L at sites E4 and E5 for zinc (median 0.023 mg/L at sites E1 – E3)³. Both exceed the trigger values (aluminium low reliability TV 0.0005 mg/L, zinc TV 0.015mg/L).

Beryllium, bismuth, lanthanum and selenium were below detectable levels on all occasions, with antimony, cadmium, chromium, copper, gallium, molybdenum, nickel, thallium and tin recording >80% non-detects (the limit of detection was above the TV only for cadmium and cobalt, though marginally). Exceedances of TVs were recorded for:

- Arsenic – 1 exceedance at site E1 only
- Boron – some marginal exceedances were recorded against the low reliability TV across all sites
- Cadmium – one sample round (of 3) above the TV at both E4 and E5 sites (none at sites E1 – E3)
- Chromium – no exceedance at site E4 or E5, with 1 exceedance at E1 – E3
- Copper – no exceedances at site E4 or E5 (on the one occasion sampled), with around 30% of results above the TV at sites E1 – E3 (around 2 x the TV)
- Mercury – results were above the TV in March 2012 at all sites, with an additional exceedance in May 2013 at site E3 (3 to 7 x the TV)
- Silver – 2 of the 3 results above the TV at E4 and E5 (around 4 x the TV), with 2 of 11 exceedances at sites E1 – E3 (around 2.5 x the TV)
- Uranium – no TV exists for uranium in marine waters, however all results were above the low reliability freshwater TV for all sites of 0.05µg/L.

Results for lead and vanadium were below the TV, and for manganese below the low reliability TV.

These results indicate detectable levels of dissolved metals in estuarine receiving waters for the Project, with exceedances of default trigger values for aluminium and zinc, with some exceedances recorded for arsenic, boron, cadmium, chromium, copper, mercury and silver. These metals should form part of any baseline or operational monitoring conducted for metals.

Beryllium, bismuth, lanthanum, selenium, lead, vanadium and manganese were either not detected or were below the TV or low reliability TV.

³ Sites E4 and E5 contained only 3 results, and so the average was used instead of the median

Most of the total metal concentrations recorded found levels 1 to 2 orders of magnitude higher, with aluminium and iron showing the highest total to dissolved ratio (~400 x and 270 x respectively). As would be expected in such a turbid environment, the bulk of the total metal concentration in the water is bound to particulate matter (i.e. sediment) and not bioavailable.

The concentrations of recoverable hydrocarbons and pesticides were low and predominantly undetectable.

Additional baseline monitoring of at least a subset of metals is important to ensure that elevated metals in the environment are not attributed to the Project, given the expectation that discharge levels will be low. Data should be collected during the remaining baseline program, and as part of the operational program, at least for the initial impact assessment period. While dissolved metals represent the important bioactive fraction, both total and dissolved should be tested to provide a reasonable baseline dataset. Importantly, laboratory reporting limits should be at or below the AWQG criteria where possible – those adopted by Bennett & George (2014) should be achievable for most sampling events.

5.2.3 Other Sampling

5.2.3.1 Other water quality analyses

Some additional sampling was conducted for coloured dissolved organic matter (CDOM) in October 2015 (dry season) and in January and March 2016 (wet season); for chemical and biochemical oxygen demand (COD, BOD) in March 2016; and phytoplankton in March 2016.

Phytoplankton communities were dominated by diatoms, with no flagellates or green algae. Cyanobacteria were only recorded in the Keep River at site I34 and comprised Phormidium sp. This species of cyanobacteria is not considered to be toxic. Densities were low compared to estuarine phytoplankton communities in Darwin Harbour (FRC, 2016).

All oxygen demand results were below the limit of reporting, showing low BOD within the catchment at that time of year. The COD limit of reporting was 250mg/L, elevated from the standard 20mg/L LOR due to matrix interference, which is not useful for catchment analysis.

CDOM measurements were made as part of assessing the turbidity levels in receiving waters and were all below 7/m.

All the above will be retained in the dataset but are not considered important or relevant to continue in future monitoring at this stage.

5.2.3.2 Sediment Sampling

Sediment was collected from up to 23 sites, using a 2L PVC corer (June and October 2015) and a 2L stainless steel corer (January and March 2016), from accreting banks in the intertidal and shallow subtidal zone (between approximately 0.5m below Lowest Astronomical Tide (LAT) to 3.75m above LAT). All sediment samples were analysed by a NATA-accredited laboratory for:

- particle size distribution
- total metals and metalloids
- nutrients
- total petroleum hydrocarbons
- total recoverable hydrocarbons, and
- pesticides.

Sediments from each of the sites were dominated by silt / clay with sand. The concentrations of total nitrogen, total kjeldahl nitrogen and total phosphorus were typically greater than 100 mg/kg at each site, which, based on the limited available data, is typical of the region. All other nutrients were typically below laboratory limits of reporting. The concentration of all metals and metalloids were low, and below sediment quality guideline trigger values.

Hydrocarbons were detected at most sites in June 2015, however were not detected in March 2016. Given the widespread (though low) detection across sites combined with the large tidal range and the limited sources for these constituents in the region, the findings most likely indicate widespread low level persistent addition in the environment from natural sources. The Bonaparte Basin is noted as being a hydrocarbon bearing sedimentary basin which may explain these low levels found, or possibly decomposing plant matter, particularly in the dry season where estuarine flushing is reduced.

The key control and impact sites relevant to the Project were generally sampled twice. Given the lag inherent in sediment quality changes over time, this is considered sufficient to provide a baseline for ongoing sediment quality comparisons. Further monitoring during operations may be justified, to assist in providing early warning, long term trends and in interpreting water quality results.

5.2.3.3 Benthic Macroinvertebrate Communities

Benthic macroinvertebrate communities were sampled in June and October 2015, and March 2016 in accordance with the AWQG (Method 8 Capitellid Worms), in each seasonal survey in the same location as the sediment samples. In addition, in January 2016 and March 2016, benthic macroinvertebrates were sampled in areas likely to be used by shorebirds.

At each site, five cores were collected using a 2 L stainless steel corer from soft sediment on accreting banks in the intertidal and shallow subtidal zone (between approximately 0.5m below to 3.75m above LAT). Cores were sieved in the field using a 1 mm sieve and later identified to family, with the abundance of each family recorded.

The abundance and taxonomic richness of the benthic macroinvertebrate communities were low throughout the area, compared to similar estuaries, almost certainly due to a combination of factors including highly turbid water, fine highly mobile sediment, and for the intertidal sites, the long periods of exposure, and extreme range of conditions due to the macrotidal nature of the estuary. Taxonomic richness was highest where suspended solids in the water were lowest, and the highly mobile sediment, evidenced by rapidly changing channels and banks was expected to constrain colonisation by benthic invertebrates, and result in the smothering of others, limiting both abundance and diversity.

Therefore, physical processes are likely to be the primary influence on macroinvertebrate diversity and abundance. Furthermore, the uptake of nutrients by benthic macroinvertebrate communities is likely to be low (due to low abundance of benthic invertebrates, resuspension of sediment and long exposure periods for intertidal species). As such, the benthic macroinvertebrate communities in the intertidal sandbanks in Alligator Creek and the Keep River are unlikely to be significantly impacted by the proposed discharge (see FRC, 2016).

Macroinvertebrates have been successfully used in numerous locations to test for changes between impact and control sites. While it is not anticipated that benthic macroinvertebrate communities will be significantly impacted by the proposed discharge, some additional baseline and post-operational discharge monitoring is warranted to confirm that any changes in macroinvertebrates as a result of the project would be within the range of the natural variation, and to provide an additional line of evidence to assist in the post-operational discharge assessment.

However, the actual sampling of macroinvertebrate communities can be difficult, expensive and have safety implications in this type of remote area in northern Australia. Given that Project Sea Dragon is undertaking helicopter water quality surveys of its sites for cost, safety and sampling holding time reasons, collection of sediment grab samples for macroinvertebrate abundance and taxonomy could be collected in a similar manner (e.g. by benthic Ekman grab sampler, as was undertaken by Dittmann et al (2013) at some less accessible (underwater, wadable) sites, for example. This could be trialed in the early part of the baseline assessment for practicality and safety.

5.2.3.4 Mangroves

The community composition and ecological health of mangroves were assessed at ten sites in June and October 2015, and March 2016. This involved an assessment of the community composition and health of mangroves in three 10 x 10 m quadrats recording canopy cover (%), canopy height (m) and percent cover of each species. Data collection was in accordance with the protocol for mapping and monitoring mangrove communities in Queensland, with mangrove health visually assessed by scoring against 16 categories and rating from 0 (no stress) to 3 (stressed) (refer FRC, 2016).

At each site, crab hole density was also recorded in three 0.5 x 0.5 m quadrats, and observations recorded of fauna living on the trunk, branches and leaves (e.g. marine molluscs or bivalves).

In total, eight species of mangrove were recorded along the foreshore, with *Avicennia marina* var. *eucalyptifolia* dominating. The number of mangrove species and the composition of the mangrove communities observed in the study area are typical for the Joseph Bonaparte Gulf region. The mangroves along the creeks and rivers in the study area were in good condition; however, there was some insect damage to the leaves and the density of seedlings was relatively low. Notable, but not surprising, features included the colonisation of mangroves on accreting banks, and the loss of mangroves on eroding banks.

Two samples, each composed of approximately 20g of recently matured leaves were collected from the outside canopy of the grey mangrove (*Avicennia marina* var. *eucalyptifolia*) for $\delta^{15}\text{N}$ testing. This analysis provides a snapshot of the ratio of different isotopes of nitrogen (^{15}N and ^{14}N), which can be compared to nitrogen sources, or compared over time to detect changes in the source of nitrogen. While this has been successfully used in many locations, there are potential issues where nitrogen is not the limiting nutrient in an environment, in which case significant fractionation can occur affecting the isotopic ratios between sources and sinks for nitrogen. As noted in Section 3.2, nitrates were somewhat elevated compared to the Darwin Harbour Water Quality Objectives (refer DLRM, 2014), while total nitrogen was found to be at moderate to low levels.

While the $\delta^{15}\text{N}$ signature of mangrove leaves varied between surveys and between sites, it was typically >2 and <6 , indicating the mangroves were unlikely to be using nitrogen derived from anthropogenic pollution.

The data collected to date involved 21 sites, with two rounds undertaken in the important control and impact sites. This is considered a suitable baseline for the Project should the results be needed. However, given the nature of the Project and the naturally elevated available nitrogen in the environment, it is possible that the $\delta^{15}\text{N}$ signatures may in fact change, but that this change will still not indicate whether an ecologically significant impact has in fact occurred, or that fractionation will make results biased.

However, ongoing ground-based assessment is limited in terms of the area it can cover, and the risks and costs of sampling. As outlined in FRC (2016), it is proposed to utilise remote sensing technology which uses changes in satellite imagery over time and can provide an assessment both of the extent and health of mangrove (and other vegetation) communities.

This uses different spectral bands within the imagery – particularly the red and near-infrared bands, with one of the more popular methods being the Normalised Difference Vegetation Index (NDVI). These provide specific, highly accurate and both safer and more cost-effective methods than traditional field-based measurements and over much larger areas.

A baseline mangrove health and extent satellite imagery assessment will need to be compiled for comparison with post operational health and extent, with the imagery data obtained as close to the time period as the ground-based assessments where practicable. During operations, similar analysis of satellite imagery can then be conducted at the same time as the ecological and sediment assessment program for cross comparability.

Should potential impacts be identified, ground truthing may be required, using the same methods as FRC (2016) and as outlined in the latest Queensland draft Monitoring and Sampling Manual mangrove health monitoring guidelines (DEHP & DSITI, 2017). A less regular ground truthing assessment should be continued (e.g. on a 5-year cycle) to support the satellite imagery assessment.

5.2.3.5 Other marine and estuarine aspects

Seagrass, Algae and Corals

No seagrass beds, macroalgal beds or coral / rocky reefs were recorded in the area during field investigations and from literature searches. Distribution of these communities is likely to be severely limited by extreme light limitation due to the highly turbid water. While there is some phytoplankton, its primary production is also likely to be limited by light availability.

As such, further assessment for these elements are not proposed.

Fisheries and Fish

A number of species of fish, marine mammals and reptiles occupy or are likely to be present in the waters around the Project site, as identified under the desktop and literature searches conducted for the EIS. A number of species typical of northern Australia were observed during field work for the baseline assessment, including seven-spot archerfish, barramundi, dwarf sawfish, pop-eye mullet, crocodiles and marine turtle tracks.

However, there are difficulties in identifying the relative abundance and distribution of species in this region, due largely to the logistically difficult and potentially dangerous conditions that are present. As such, the goal to ensure protection of these species will involve monitoring water quality in the receiving waters, as a more practical and achievable goal.

5.3 ENVIRONMENTAL VALUES

The overarching objective is to essentially ensure that Project operations do not negatively affect the Environmental Values (EVs) of the receiving environment, which is classified as a slightly to moderately disturbed ecosystem as per the AWQG. The waters surrounding the Project area are not subject to a Beneficial Use Declaration under the NT Water Act 1992. As such, all Northern Territory Beneficial Uses relevant to marine waters have been conservatively applied here, namely:

- Aquaculture
- Environment, and
- Cultural.

The equivalent AWQG EVs are the protection of:

- Marine and estuarine aquatic ecosystems
- Human consumers (primarily for fish species)
- Cultural and spiritual values of marine and estuarine waters, including ecosystems and biota
- Suitable salt water supply to support the Project (primary industries, aquaculture) related to the intake waters.

5.4 DISCHARGE CRITERIA AND TRIGGER VALUES

5.4.1 Trigger Values for Alligator Creek

The immediate receiving environment for off-site discharges during operations is Alligator Creek, with four key sites with a suitable duration of data along a gradient from upstream (I29A) to the mouth and confluence with the Keep River (I27). A similar set of longitudinal sites can be found in the Keep River from I30/I33 seaward to I12.

An analysis of the key sites relevant to Alligator Creek is shown in Figure 5-5, which identifies that:

- The I28 and I29 sites appear quite alike, and the I27 site is also similar for many parameters, the exception being Chlorophyll a and Nitrate/Nitrite
- Site I29A is different for a number of parameters, with obvious differences for salinity (TDS & EC) (fresher inflows observed), suspended solids and turbidity (lower generally), Chlorophyll a (higher), FRP (lower), and Nitrogen (higher).

The I29A site is not representative of the broader Alligator Creek water quality but rather the upstream estuary which is heavily affected by the tidal barrage located upstream.

Looking at the less frequently sampled sites, additional data are available for the I09 site (~3km towards the Keep River) prior to sampling at I28 and I29 which appears to be of a similar magnitude to these sites. Some of the key data is shown in Figure 5-6 to Figure 5-10, which shows the data appears to be from the same general statistical population. Given the proximity of I09, this was included in the overall assessment of Trigger Values in Alligator Creek to allow for the data to be extended, providing an overall 22-month coverage (with 21 data points) between June 2016 and April 2017.

To derive trigger values, the 80th percentile from each site was determined, with the I09 site added to the I28 dataset, and the overall trigger value determined based on an average of the I28/I09 and I29 trigger values⁴.

The results are shown in Table 5-5 as an overall trigger value, seasonal trigger values and comparisons to the interim trigger values proposed in the EIS, along with the standard error for each estimate (as per the Queensland Water Quality Guidelines, DEHP, 2013).

⁴ An alternative approach involving an aggregated dataset (for each distinct tide cycle sampled during each monitoring round) found that the trigger values did not adequately represent what was occurring at each site, due to levelling of values and so was not further incorporated

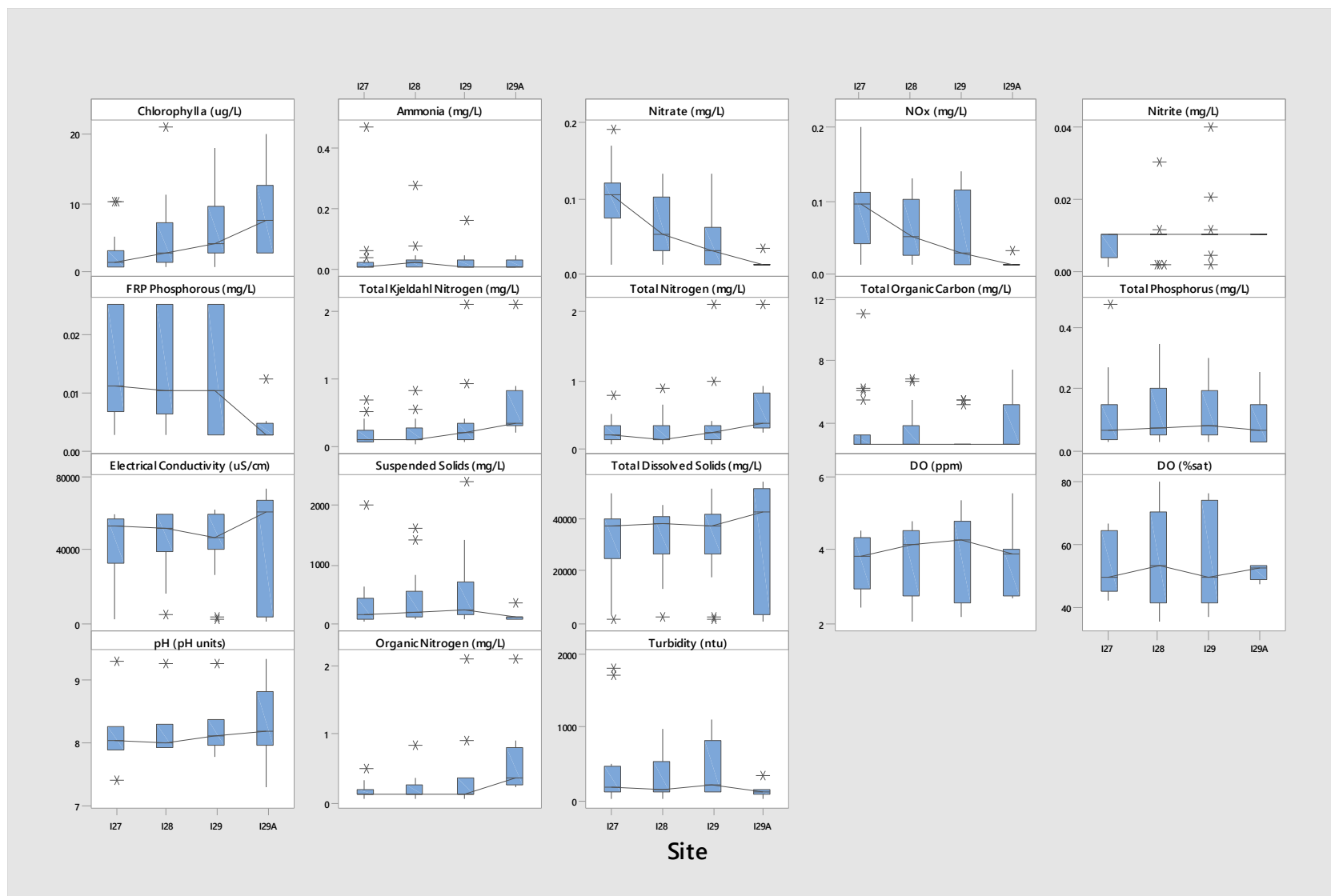


FIGURE 5-5 BOXPLOTS OF KEY WATER QUALITY PARAMETERS, ALLIGATOR CREEK SITES

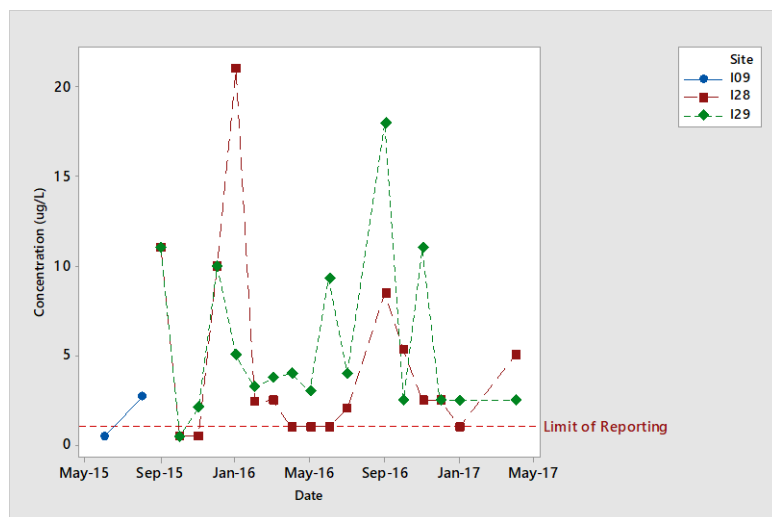


FIGURE 5-6 CHLOROPHYL A IN ALLIGATOR CREEK SITES

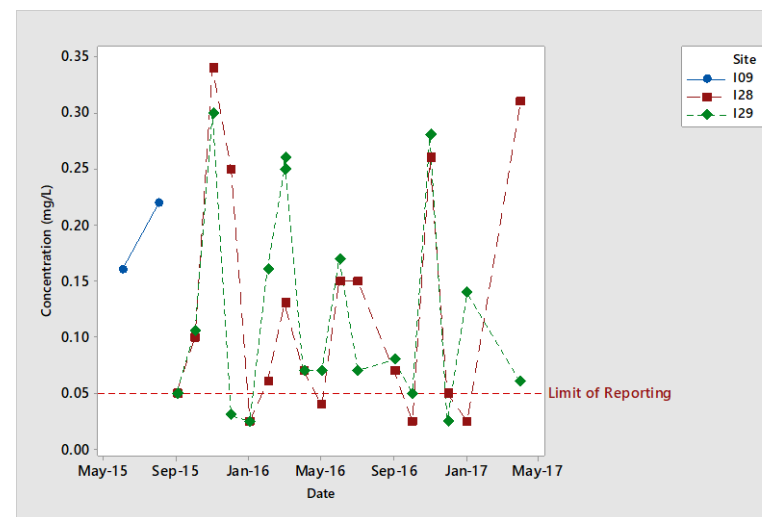


FIGURE 5-8 TOTAL PHOSPHOROUS IN ALLIGATOR CREEK SITES

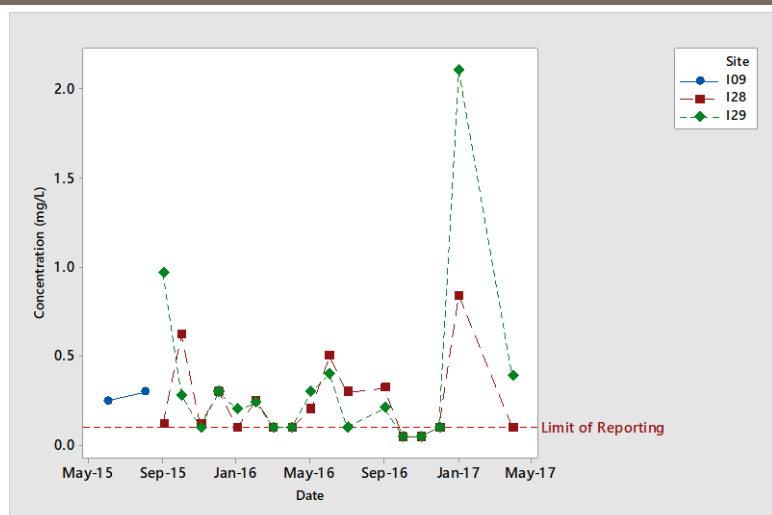


FIGURE 5-7 TOTAL NITROGEN IN ALLIGATOR CREEK SITES

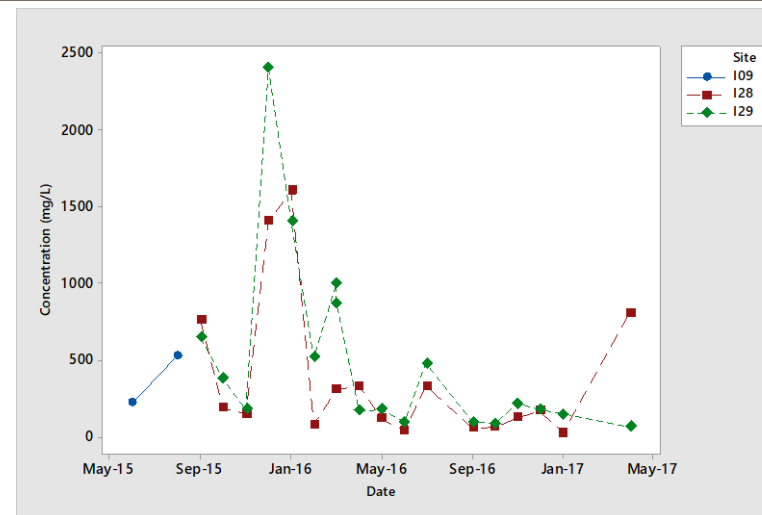


FIGURE 5-9 TOTAL SUSPENDED SOLIDS IN ALLIGATOR CREEK

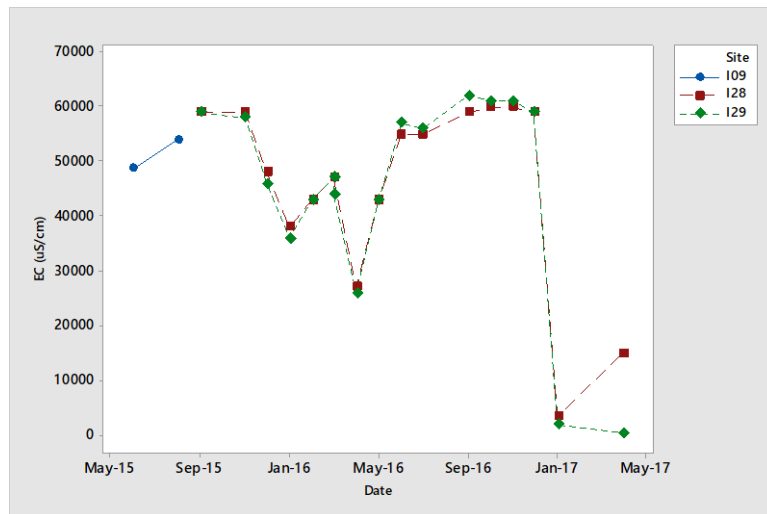


FIGURE 5-10 ELECTRICAL CONDUCTIVITY IN ALLIGATOR CREEK SITES

TABLE 5-5 ALLIGATOR CREEK TRIGGER VALUES

Parameter	Interim Trigger Values ¹	N	ND ²	Calculated Trigger Value ± Standard Error ³	Adopted Trigger Value
Overall Triggers: Dry and Wet Seasons					
Chlorophyll a (µg/L)	3.2	17	47%	8.2 ± 1.6	8.2
Total Nitrogen (as N) (mg/L)	0.31	17	33%	0.353 ± 0.044	0.35
Total Phosphorus as P (mg/L)	0.20	17	14%	0.225 ± 0.007	0.22
Suspended Solids (mg/L)	490	17	0%	702 ± 80	700
Turbidity (ntu)	450	17	0%	636 ± 92	630
Seasonal Triggers: Wet Season					
Chlorophyll a (µg/L)	-	10	50%	4.2 ± 0.3	4.2
Total Nitrogen (as N) (mg/L)	-	10	43%	0.297 ± 0.057	0.30
Total Phosphorus as P (mg/L)	-	10	21%	0.166 ± 0.048	0.17
Suspended Solids (mg/L)	-	10	0%	831 ± 117	830
Turbidity (ntu)	-	10	0%	691 ± 137	690
Seasonal Triggers: Dry Season					
Chlorophyll a (µg/L)	-	14	45%	9.4 ± 1.6	9.4
Total Nitrogen (as N) (mg/L)	-	14	28%	0.382 ± 0.026	0.38
Total Phosphorus as P (mg/L)	-	14	9%	0.218 ± 0.026	0.22
Suspended Solids (mg/L)	-	14	0%	502 ± 12	500
Turbidity (ntu)	-	14	0%	471 ± 11	470

Table notes:

1 from the Project EIS, Volume 2 Chapter 2

2 Non-detects

3 Based on the average of the 80th percentile for each site (I28/I09 and I29) following the method outlined in the Queensland Water Quality Guidelines (DEHP, 2009)

5.4.2 Discharge Criteria

The discharge criteria were defined using data collected at existing prawn farms operated by Seafarms, and the EIS impact assessment was based on this data and background levels based on the baseline data available at the time.

The modelling conducted in Appendix 8 of the EIS (Coastal Assessment and Hydrodynamic Modelling) relied on the following background and added concentrations for total nitrogen, total phosphorous and chlorophyll a:

- Total Nitrogen: background of 0.2mg/L based on median in receiving waters; increase due to discharges typically less than 0.1mg/L

- Total Phosphorous: background of 0.1mg/L based on median in receiving waters; increase of 0.1mg/L due to discharges
- Chlorophyll a: background of 1µg/L based on median in receiving waters, with an increase of ~2µg/L outside of the mixing zone.

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

- Total Nitrogen: the median background level is 0.20mg/L. With the additional 0.1mg/L this elevates the potential concentration to 0.30mg/L, below the revised trigger value of 0.35mg/L
- Total Phosphorous: the median background level is 0.09mg/L. With the additional 0.1mg/L this elevates the potential concentration to 0.19mg/L, below the revised trigger value of 0.22mg/L
- Chlorophyll a: the median background level is 3.1µg/L. With the additional 2µg/L this elevates the potential concentration to 5.1µg/L outside of the 200m exclusion zone, below the revised trigger value of 8.2µg/L.

Note that the elevated values for total phosphorous and chlorophyll a are above the wet season trigger values in Table 5-5. This apparent non-conformance of the nominated Water Quality Objective (WQO) is not considered relevant as:

- The increase in concentration in the wet season is over stated as the modelling focused on the worst case dry season conditions. With the additional flow and dilution in the wet season, 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 WQO 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.

5.5 MONITORING PROGRAM DESIGN

5.5.1 Overview

The EIS (FRC, 2016) proposed a BACI experimental design for the operational monitoring program. BACI designs aim to compare the condition of a location before and after development at the same sites, to detect possible changes due to the development, while including Control sites to determine whether changes may be due to larger influences beyond the scope of the Project.

The EIS program provided for water quality analysis as well as indicator monitoring of benthic macroinvertebrate communities, distribution and ecological health of mangrove and saltmarsh communities, $\delta^{15}\text{N}$ signature of mangroves and sediment quality as extended indicators of estuarine and marine water quality.

Based on the review provided in Section 5.2, an initial 2-year post-operational discharge validation study is proposed to compare the EIS impact assessment with the monitoring data, 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.

5.5.2 Selection of Sites

5.5.2.1 Control Sites

FRC (2016) found that the I30, I33 and I34 sites in the Keep River were suitably similar to Alligator Creek to be used as reference sites. To determine whether these sites could be considered unimpacted, given the potential for flows from Alligator Creek to affect these sites, the results from the modelling undertaken for the EIS (Watertech, 2016) were reviewed. The modelling adopted a conservative tracer approach (no breakdown, uptake or settlement), and found that median residual tracer concentrations were less than 2% within the Keep River. Adopting the median discharge limits of 0.8mg/L for total nitrogen, 0.1mg/L for total phosphorous and 20µg/L for Chlorophyll a, this would result in a residual concentration increase of less than:

- Total nitrogen: 0.016mg/L
- Total Phosphorous: 0.002mg/L
- Chlorophyll a: 0.4 µg/L

These levels are below the limit of reporting used by ALS Laboratories (a NATA accredited laboratory) of 0.01mg/L for nitrogen and 0.005mg/L for phosphorous (ultra-trace limits), and 1 µg/L for Chlorophyll a. For bioavailable forms of nutrients and ammonia, the ultra-trace limits are 0.001mg/L for both oxides of nitrogen (NO_x) and filterable reactive phosphorous (FRP), and 0.002mg/L for ammonia. In comparison, the ratio of nutrient species to totals is as follows:

- NO_x was typically below detection limits in the background data (87% non-detects), with a median ratio of 80 : 1 for TN : NO_x.

This amounts to a NO_x increase of 0.0002mg/L, which is below the detectable limit.

- For FRP with 52% non-detects the median ratio was 19 : 1 for TP : FRP.

This amounts to 0.0001mg/L, less than the detectable limit.

- For ammonia with 59% non-detects, the median ratio was 9.8 : 1 for TN : ammonia.

This provides an increase of 0.0016mg/L, which is less than the detectable limit.

In each case, the median would be expected to be less than the detectable limit of reporting, even using ultra-trace methods, and assuming that matrix interference would allow these lower levels to be reached.

From a statistical perspective, this would be unlikely to be resolved to a significant level even if the difference could be detected by the laboratory. The median differences calculated above are between 2% (total phosphorous) and 12% (chlorophyll a) of the standard deviation (calculated for each parameter and for each site). Given that the effect size in this type of experimental design is typically equal to or greater than one standard deviation (default target for ecologically conservative decisions outlined in the AWQG), this would not be expected to be detectable in the statistical analysis⁵.

For the purposes of this report, and in terms of detecting noticeable change within Alligator Creek, the selected Keep River sites are reasonably adopted as control sites. These sites will also allow for non-Project

⁵ For NO_x and ammonia, a worst case ratio was calculated by assuming non-detects were at the limit of reporting (LOR). For filterable reactive phosphorous, the LOR was too high to make useful comparisons, with many recording a ratio of 1:1 or even less due to the high LOR. Only available data was used (around 48% of sampling events).

related changes in the Keep River and Sandy Creek systems to be captured. An additional control site, I21, in a creek immediately east of Turtle Point, has been selected as being both sufficiently removed and unimpacted, yet close enough to be able to be practically included in the sampling program.

The WT07 Forsyth Creek site is another potential control site, although this location will be proximate to the Project intake. The peak extraction rate is equivalent to ~0.5% of the tidal prism during a spring tide and 1.5% during a neap tide, with typical extraction representing 0.1% and 0.2-0.4% of the spring and neap tidal prism respectively (EIS, Volume 2, Chapter 2, page 2-59). As further noted in the EIS, this is unlikely to have any impact on tidal water levels or currents. As such water quality would not be expected to be impacted outside of the immediate area of the intake structures. Given that this site should be monitored for intake water quality anyway, and the relative ease of monitoring close to on-site infrastructure, this additional control will be included for sampling and analysis.

Other, more distant, reference sites identified by FRC (2016) are considered logistically difficult, given the lack of roads and tracks, the muddy and potentially hazardous terrain (particularly for crocodiles) and tidal regimes, particularly noting that tides should preferably be matched for each event. They are also less comparable, being distant from the site and representative of generally different catchment conditions. As such they have not been included, and regardless are not considered as useful as the identified control sites in closer proximity to the site.

5.5.2.2 Impact Sites

Sampling of the Alligator Creek I28 and I29 sites as impact locations remains suitable, however an additional upstream site should be added to provide a better longitudinal comparison within Alligator Creek to assist in the analysis of potential impacts. As noted in Section 5.4, the I29A site does not reflect the Alligator Creek estuary as well as the I28 and I29 sites do, and another new site has been proposed, located ~2.5km upstream of the discharge (as I28 is 2.5km downstream of the discharge).

As such, there are three sites along Alligator Creek – I28 (2.5km downstream); I29 (400m upstream, and 300m upstream of the mixing zone); and the new site (2.5km upstream). Another site needs to be added immediately downstream of the mixing zone to test for compliance within receiving waters.

5.5.2.3 Site Summary

For ongoing monitoring, the naming convention used will be changed, so as to better reflect the systems being monitored. As such, the proposed monitoring sites are as follows:

Impact Monitoring Sites – Alligator Creek (AC)

- AC1 (new): 2.5km upstream of discharge point
- AC2 (I29): 400m upstream of discharge point
- AC3 (I28): 2.5km downstream of the discharge point
- AC4 (new): downstream edge of mixing zone (i.e. 200m downstream of discharge point)

Control Monitoring Sites

- Keep River (KR):
 - KR1 (I33)
 - KR2 (I30)
 - KR3 (I34)
- Turtle Point (TP): TP1 (I21)
- Forsyth Creek (FC): FC1 (WT07)

These sites are identified in the WQMMP document, Appendices A2 and A3.

5.5.3 Monitoring parameters

Based on the review in Section 5.2, the initial 2-year post-operational discharge validation study will include the following programs and parameters:

- Water quality: sampling at each site for in-situ parameters (pH, EC, DO, Temp, Turbidity); total suspended solids; nitrogen (ammonia, oxides of nitrogen, total kjeldahl nitrogen, total nitrogen); phosphorous (filterable reactive phosphorous, total phosphorous); total organic carbon; Chlorophyll a; total and dissolved metals (Aluminium, Arsenic, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver, Uranium, Zinc)
- Mangrove health assessment: satellite imagery health assessment (NVDI or similar), ground based assessment (less frequent or as required) based on methods by FRC (2016).
- Sediment quality: sediment sizing, total nitrogen, total phosphorous, pH, redox potential, total organic carbon
- Benthic macroinvertebrates: based on methods by FRC (2016), with collection methods to be adapted for helicopter based sampling at least during the baseline period.

5.5.4 Monitoring Frequency

As noted in Section 5.2.1.6, ongoing baseline sampling for water quality is recommended at quarterly aiming for two wet and two dry sample events per year. This frequency would be adopted for the initial 2 year assessment period, and reviewed after this period.

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.

The existing mangrove and sediment baseline datasets are expected to be sufficient, with mangrove satellite data to be collected corresponding to the timing of mangrove health assessment field work conducted. This should be repeated at the end of two years after post-operational discharges commence.

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 2 years, with confirmatory ground based assessments every 6 (coincides with the below sampling) years or where satellite data indicates an impact
- Sediment sampling: every 2 years
- Benthic macroinvertebrate sampling: every 6 years (coinciding with the sediment sampling).

5.5.5 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, along with the running median of the previous 12 months' results, against trigger values, using control charting approaches as outlined in the AWQG
2. Where trigger 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.

Both the overall and seasonal trigger values will be used in the above analysis.

The control charting approaches outlined in the AWQG for both comparisons to trigger values and control-impact sites are recommended. An example of these charts for total nitrogen is shown in Figure 5-11, where the control site is I21, and the impact site I29. As can be seen, sites are comparable and compliant other than the January 2017 event, although a similar pattern can be seen at both sites (although the magnitude is different). The 4-month median remains below the trigger value.

One would expect that the departure from median would not diverge differently between the two sites over time, as seen on an event by event basis in the second chart, and over the long term in the third. Should the impact site continue to diverge in the third graph, this may indicate an impact.

Other supporting analysis that might be considered includes general descriptive and exploratory statistics and graphical techniques, including gradient charts (concentration compared to the trigger values along Alligator Creek and along the Keep River) and robust regression⁶ of impact sites against control sites.

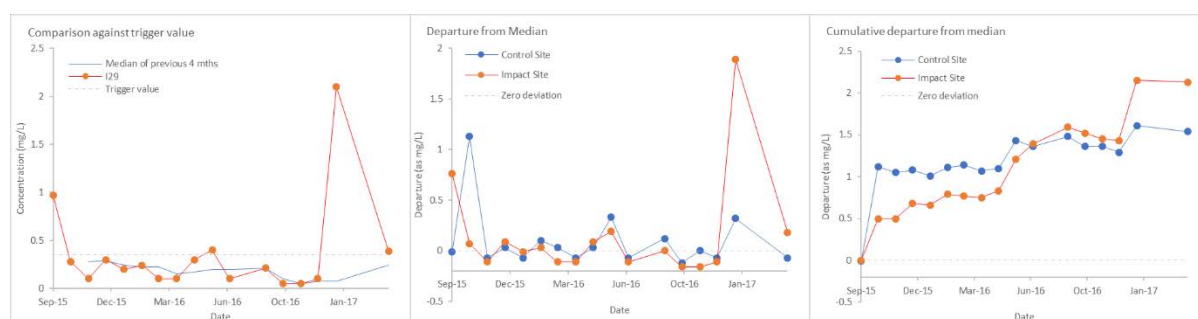


FIGURE 5-11 EXAMPLE OF CONTROL CHARTS – TOTAL NITROGEN

⁶ 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

6 REFERENCES

BMT WBM (2016). Caloundra South -Water Quality Management Plan. Rev 5, 15 June 2016.

DEHP (2009) Queensland Water Quality Guidelines, Version 3. Department of Environment and Heritage Protection, July 2013.

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GAA (2006). Operating Procedures for Shrimp Farming: Global Shrimp OP Survey Results and Recommendations. Global Aquaculture Alliance

Jackson, CJ, Preston, NP, Burford, MA and Thompson, P 2003, 'Managing the development of sustainable shrimp farming in Australia: the role of sedimentation ponds in treatment of farm discharge water', Aquaculture, 226, 23-34.

Seafarms (2016). Project Sea Dragon Stage 1 Legume Grow-Out Facility: Environmental Impact Statement. CO2 / Seafarms, October 2016.

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Ziemann, DA, Walsh, WA, Sapphire, EG and Fulton-Bennett, L 1992, 'A survey of water quality characteristics of effluent from Hawaiian aquaculture facilities', Journal of the World Aquaculture Society, 23, 180-190.

APPENDIX A WQMMP REQUIREMENTS CHECKLIST

TABLE A1-1 KEY NT AND COMMONWEALTH APPROVAL CONDITIONS / RECOMMENDATIONS

# ¹	Condition Text	Cross Reference												
Commonwealth Approval EPBC 2015/7527, granted 10 May 2017														
1	To protect habitat for listed threatened and migratory species, wastewater discharges to Alligator Creek as a result of the action: a. must not exceed the mean and maximum limits for the following wastewater quality parameters: <table border="1"> <thead> <tr> <th></th><th>Mean</th><th>Maximum</th></tr> </thead> <tbody> <tr> <td>Total nitrogen (mg/L)</td><td>0.8</td><td>3.0</td></tr> <tr> <td>Total phosphorus (mg/L)</td><td>0.1</td><td>0.3</td></tr> <tr> <td>Total suspended solids (mg/L)</td><td>20</td><td>100</td></tr> </tbody> </table> b. must be restricted to an annual average daily discharge rate of less than 420 ML/day c. must only occur from one hour prior to the Alligator Creek ebb tide and cease 5.5 hours before the Alligator Creek ebb tide ends.		Mean	Maximum	Total nitrogen (mg/L)	0.8	3.0	Total phosphorus (mg/L)	0.1	0.3	Total suspended solids (mg/L)	20	100	Incorporated into the operational program, Appendix A3 of the WQMMP.
	Mean	Maximum												
Total nitrogen (mg/L)	0.8	3.0												
Total phosphorus (mg/L)	0.1	0.3												
Total suspended solids (mg/L)	20	100												
2	To protect habitat for listed threatened and migratory species, the person taking the action must develop a Water Quality Monitoring and Management Program (WQMMP). The WQMMP must be prepared in consultation with an appropriately-qualified independent scientific expert whose appointment has been approved in writing by the Minister. The WQMMP must be approved by the Minister and implemented a minimum of 12 months prior to the discharge of any wastewater. The WQMMP must: a. explain how the WQMMP will protect the receiving environment from wastewater discharges, including the functional relationship between monitoring objectives, activities and operational decisions b. define the chemical, physical and biological parameters to be monitored in the receiving environment, including during the minimum 12 month period of baseline water quality monitoring, and justify the parameters to be monitored c. modify and/or confirm the wastewater quality parameter limits in condition 1 (a) and the wastewater release regime in condition 1(c) d. include a methodology to: - monitor water quality parameters in condition 1 (a) during both baseline data collection and operations and measure discharge volumes in condition 1(b) - develop site-specific water quality objectives and seasonal trigger values for water quality parameters identified in condition 1 (a) and 2(b) - modify and/or confirm the wastewater quality parameter limits specified in condition 1 (a) are appropriate relative to the trigger values developed under condition 2(d)(ii) - modify and/or confirm the wastewater release regime specified in condition 1 (c) in accordance with the Guidelines for Fresh and Marine Water Quality e. include a data handling program and commitments to technical review and evaluation of the WQMMP f. identify and manage the risks of the WQMMP failing to achieve its objectives	The WQMMP. Approval of, and comments from, the independent reviewer are provided in Appendix D to this report. This is summarised in Figure A1-1 in Appendix A1 in the WQMMP. Listed in Appendix A3 in the WQMMP and described in Section 4.3 in this report. Derived from the risk assessment in Section 4 of this report. Section 5.4.2 in this report. Appendices A2 and A3, Appendix B in the WQMMP. Section 5.4.1 in this report, Appendix A2 in the WQMMP. Section 5.4.2 in this report. Section 5.4.2 in this report. WQMMP Appendix A1 (review and auditing) and WQMMP Appendix B4. Section 4 of this report. WQMMP												

# ¹	Condition Text	Cross Reference
	g. describe contingency responses where management triggers are exceeded, and effective corrective actions which may be implemented. When the person taking the action submits the WQMMP to the Minister for approval, they must also provide a copy of the advice of the independent scientific expert on the WQMMP. The approved WQMMP must be implemented.	Appendix A incorporates contingency and control measures to mitigate against failure. WQMMP Appendix A, particularly Appendix A1, A3 and Figure A1-1. Appendix D to this report.
11	The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the monitoring programs required by this approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	WQMMP Appendix A1 (Reporting) WQMMP Appendix B4.
14	The person taking the action may choose to revise a plan approved by the Minister under conditions 2 and 4 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the person taking the action makes this choice they must: - notify the Department in writing that the approved plan has been revised and provide the Department, at least four weeks before implementing the revised plan, with: - an electronic copy of the revised plan; - an explanation of the differences between the revised plan and the approved plan; and - the reasons the person taking the action considers that the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. 14A. The person taking the action may revoke its choice under condition 14 at any time by giving written notice to the Department. If the person taking the action revokes the choice to implement the revised plan, without approval under section 143A of the EPBC Act, the plan approved by the Minister must be implemented. 14B. If the Minister gives a notice to the person taking the action that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then: - condition 14 does not apply, or ceases to apply, in relation to the revised plan; and - the person taking the action must implement the plan approved by the Minister. To avoid any doubt, this condition does not affect any operation of conditions 14 and 14A in the period before the day the notice is given. At the time of giving the notice, the Minister may also notify that for a specified period of time condition 14 does not apply for the plan required under the approval. Conditions 14, 14A and 14B are not intended to limit the operation of section 143A of the EPBC Act which allows the person taking the action to submit a revised plan to the Minister for approval.	WQMMP Appendix A1 (Reporting).
17	Unless otherwise agreed to in writing by the Minister, the person taking the action must publish all monitoring programs and reports referred to in these conditions of approval on their website. Each monitoring program and report must be published on their website within 1 month of being approved by the Minister or being submitted under condition 14.	WQMMP Appendix A1 (reporting).

# ¹	Condition Text	Cross Reference															
Key Definitions	Receiving environment is the area downstream of the mixing zone determined by the Water Quality Monitoring and Management Program (condition 2) that begins at point 15° 6' 0.4477" S 129° 17' 54.4283" E (Geocentric Datum of Australia 1994), as shown at Attachment A, where it is depicted as 'discharge release point'.	Noted. This is shown in Figure 1-2 in the WQMMP, and Figure 2-1 in this report.															
Northern Territory Assessment Report 80, issued 15 March 2017																	
1	The Proponent shall ensure that the Stage 1 Legume Grow-out Facility is implemented in accordance with all environmental commitments and safeguards: - identified in the Environmental Impact Statement for the Stage 1 Legume Grow-out Facility (draft Environmental Impact Statement and Supplement) - recommended in this Assessment Report 80. The Northern Territory Environment Protection Authority considers that all safeguards and mitigation measures outlined in the Environmental Impact Statement are commitments made by the Proponent.	This WQMMP has been prepared to be consistent with these documents.															
3	In consultation with the NT EPA, the Proponent shall conduct a review of the water quality monitoring program to inform suitable monitoring methodologies for developing interim site-specific trigger values and water quality objectives for management. The review should include an analysis of relevant water quality data with respect to variation: - in response to rainfall events and rainfall patterns - due to individual tidal cycles (single ebb-flood sequences) - between spring and neap tidal cycles. Based on the review, a revised monitoring program should be peer reviewed by an appropriately-qualified independent professional, and implemented, to the satisfaction of the NT EPA.	Section 5 in this report provides a review of existing data and variation due to seasons, lunar and daily tidal cycles. The WQMMP provides the revised program. Independent review advice is provided in Appendix D to this report.															
5	The Environment Protection Licence under the Waste Management and Pollution Control Act shall include conditions that: - require discharge to meet the proposed concentrations as listed in Table 1 (Assessment Report 80) - limit discharges of effluent into Alligator Creek to the ebb tide only - ensure discharges cease in sufficient time prior to the bottom of the ebb tide to maximise the flushing of effluent from Alligator Creek - restrict annual average discharge rates to less than 420 ML/day. The licence shall apply for five years at which time it will be reviewed. [Table 1] <table border="1"> <thead> <tr> <th>Parameter</th><th>Mean</th><th>Maximum</th></tr> </thead> <tbody> <tr> <td>Total nitrogen (mg/L)</td><td>0.8</td><td>3.0</td></tr> <tr> <td>Total phosphorus (mg/L)</td><td>0.1</td><td>0.3</td></tr> <tr> <td>Chlorophyll a (µg/L)</td><td>20</td><td>100</td></tr> <tr> <td>Total suspended solids (mg/L)</td><td>20</td><td>100</td></tr> </tbody> </table>	Parameter	Mean	Maximum	Total nitrogen (mg/L)	0.8	3.0	Total phosphorus (mg/L)	0.1	0.3	Chlorophyll a (µg/L)	20	100	Total suspended solids (mg/L)	20	100	These criteria are included in the WQMMP Appendix A3, and in the Waste Discharge Licence (WDL) (see next section below). Note that the discharge regime is specified according to the Commonwealth condition 1c.
Parameter	Mean	Maximum															
Total nitrogen (mg/L)	0.8	3.0															
Total phosphorus (mg/L)	0.1	0.3															
Chlorophyll a (µg/L)	20	100															
Total suspended solids (mg/L)	20	100															
6	In consultation with the NT EPA, the Proponent shall review, and revise if necessary, the proposed interim site-specific water quality trigger values for Alligator Creek. The review shall be based on the outcomes of the water quality monitoring program review provided for in Recommendation 3 of this Report, and be undertaken when a sufficient revised dataset is available. The review should consider the development of seasonal interim trigger values.	A review and revision of the trigger values for Alligator Creek is provided in Section 5.4 of this report, based on the review in Sections 5.1 - 5.2 of this report.															

# ¹	Condition Text	Cross Reference
13	The Proponent taking the proposed action is wholly responsible for implementation of all conditions of approval and mitigation measures contained in the Environmental Management Plan and must ensure all staff and contractors comply with all requirements of conditions of approval and mitigation measures contained in the Environmental Management Plan and individual management strategies.	Noted.
NT Waste Discharge Licence (WDL239, 29 September 2017)		
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.	Waste Strategy, part of the site EMP.
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.	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.	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.	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	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	Noted.
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.	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.	Noted. 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 licence, 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 Keep River.	The target is to protect Alligator Creek, which in turn will protect the Keep River. This is reflected in Objectives and Targets (WQMMP Section 2), and in the monitoring sites selected (Section 5.5 of this report, 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 14.3. is operated by a person trained to use the plant and equipment.	Personnel 'fit for work requirements' are outlined in the EMS.
Discharges		

# ¹	Condition Text	Cross Reference															
15	This licence authorises discharge to Alligator Creek from the Authorised Discharge Point as identified in Table 1. Table 1 - Authorised Discharge <table> <tr> <th>Authorised Discharge Point</th><th>Description</th><th>Location</th></tr> <tr> <td>Discharge Point 1 (DP1)</td><td>Discharge Point 1 (DP1) receives wastewater from three prawn aquaculture grow-out farms that feed into pond discharge channels (PDC) and flow into farm discharge channels (FDC). FDC run into three internal farm recycling ponds (IFRP). Wastewater from IFRP is released into two main drainage channels (MDC) connected to farms 1 & 2 and farm 3. The MDC flows into the environmental protection zone (EPZ) which discharges via weir at the outfall to Alligator Creek. DP1 is located to the south east boundary of the EPZ approximately 18-20 metres back from receiving waters.</td><td>Latitude: -15.100136° Longitude: 129.289151 °</td></tr> </table>	Authorised Discharge Point	Description	Location	Discharge Point 1 (DP1)	Discharge Point 1 (DP1) receives wastewater from three prawn aquaculture grow-out farms that feed into pond discharge channels (PDC) and flow into farm discharge channels (FDC). FDC run into three internal farm recycling ponds (IFRP). Wastewater from IFRP is released into two main drainage channels (MDC) connected to farms 1 & 2 and farm 3. The MDC flows into the environmental protection zone (EPZ) which discharges via weir at the outfall to Alligator Creek. DP1 is located to the south east boundary of the EPZ approximately 18-20 metres back from receiving waters.	Latitude: -15.100136° Longitude: 129.289151 °	Shown in Figure 1-2 in the WQMMP and Figure 2-1 in this report. Location identified in the WQMMP Appendix A3.									
Authorised Discharge Point	Description	Location															
Discharge Point 1 (DP1)	Discharge Point 1 (DP1) receives wastewater from three prawn aquaculture grow-out farms that feed into pond discharge channels (PDC) and flow into farm discharge channels (FDC). FDC run into three internal farm recycling ponds (IFRP). Wastewater from IFRP is released into two main drainage channels (MDC) connected to farms 1 & 2 and farm 3. The MDC flows into the environmental protection zone (EPZ) which discharges via weir at the outfall to Alligator Creek. DP1 is located to the south east boundary of the EPZ approximately 18-20 metres back from receiving waters.	Latitude: -15.100136° Longitude: 129.289151 °															
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, 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: 17.1. the time the discharge commenced and duration of discharge; and 17.2. the total estimated discharge volume per discharge event.																
18	The licensee must ensure that the discharge from all discharge events at DP1 listed in Table 1 does not: 18.1. contain any floating debris, oil, grease, petroleum hydrocarbon sheen, scum, litter or other objectionable matter; 18.2. cause or generate odours which would adversely affect the use of surrounding waters; 18.3. cause algal blooms in the receiving water; 18.4. cause mortality of fish or other aquatic organisms; or 18.5. cause adverse effects on plants.	WQMMP Appendix A3 (Discharge Criteria, Trigger Values and Assessment Approach). The EIMP provides for monitoring of chlorophyll a and ecological health.															
19	The licensee must ensure that the authorised discharge: 19.1. does not exceed the mean and maximum limits in Table 2; 19.2. is restricted to an annual average daily discharge rate of less than 420 ML/day; and 19.3. only occurs from one hour prior to the Alligator Creek ebb tide and cease 5.5 hours before the bottom of the Alligator Creek ebb tide. Table 2 - Discharge Limits <table> <tr> <th></th><th>Mean</th><th>Maximum</th></tr> <tr> <td>Total nitrogen (mg/L)</td><td>0.8</td><td>3.0</td></tr> <tr> <td>Total phosphorous (mg/L)</td><td>0.1</td><td>0.3</td></tr> <tr> <td>Chlorophyll a (µg/L)</td><td>20</td><td>100</td></tr> <tr> <td>Total suspended solids (mg/L)</td><td>20</td><td>100</td></tr> </table>		Mean	Maximum	Total nitrogen (mg/L)	0.8	3.0	Total phosphorous (mg/L)	0.1	0.3	Chlorophyll a (µg/L)	20	100	Total suspended solids (mg/L)	20	100	WQMMP Appendix A3 (Discharge Criteria).
	Mean	Maximum															
Total nitrogen (mg/L)	0.8	3.0															
Total phosphorous (mg/L)	0.1	0.3															
Chlorophyll a (µg/L)	20	100															
Total suspended solids (mg/L)	20	100															
20	The licensee must as soon as practicable notify the administering agency when discharges commence at the Authorised Discharge identified in Table 1.	WQMMP Appendix A1 (Reporting).															
21	The licensee must as soon as practicable notify the administering agency when discharges cease at the Authorised Discharge identified in Table 1.	WQMMP Appendix A1 (Reporting).															
Recording and Reporting																	

# ¹	Condition Text	Cross Reference
22	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 19:	WQMMP Appendix A1 (Reporting).
22.1	the licensee must conduct monitoring in accordance with conditions 18 and 19.	WQMMP Appendix A3.
23	The licensee must ensure that the notification includes the following information: 23.1. when the exceedance was detected and by who; 23.2. the date and time of the exceedance; 23.3. the actual and potential causes and contributing factors to the exceedance; 23.4. the risk of environmental harm arising from the exceedance; 23.5. the action(s) that have or will be undertaken to address the exceedance and/or environmental harm; and 23.6. if no action was taken, why no action was taken.	WQMMP Appendix A1 (Reporting).
24	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.	WQMMP Appendix A1 (Reporting).
25	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.	WQMMP Appendix A1 (Reporting).
26	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.	WQMMP Appendix A1 (Reporting).
27	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.	WQMMP Appendix A1 (Reporting).
28	The licensee must immediately and in any case within 24 hours notify the administering agency of any potential or actual environmental harm or pollution.	WQMMP Appendix A1 (Reporting).
29	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).
30	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.	WQMMP Appendix A1 (Reporting).
31	The licensee must complete and provide to the administering agency a Monitoring report within 10 business days after each anniversary date of this licence.	WQMMP Appendix A1 (Reporting).
32	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;	WQMMP Appendix A1 (Reporting).

# ¹	Condition Text	Cross Reference
	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.	
Performance Improvement		
33	The licensee shall conduct a review of the water quality monitoring program to inform suitable monitoring methodologies to develop site-specific trigger values and water quality objectives for management. The review should include an analysis of relevant water quality data with respect to variation: 33.1. in response to rainfall events and rainfall patterns 33.2. due to individual tidal cycles (single ebb-flood sequences) 33.3. between spring and neap tidal cycles. Based on the review, a revised monitoring program should be peer reviewed by an appropriately qualified independent professional, and implemented, to the satisfaction of the NT EPA.	Section 5 provides a review of existing data and variation due to seasons, lunar and daily tidal cycles. The WQMMP provides the revised program. Independent review advice is provided in Appendix D to this report.
34	The licensee shall review, and revise if necessary, the proposed interim site-specific water quality trigger values for Alligator Creek. The review shall be based on the outcomes of the water quality monitoring program review provided for in condition 33, 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 trigger values for Alligator Creek is provided in Section 5.4 in this report, based on the review in Sections 5.1 - 5.2 to this report.
35	The licensee must submit a Water Quality Monitoring and Management Program to the administering agency in accordance with requirements under EPBC 2015/7527.	Refer to the start of this table (Table A1).
36	The Environment Protection Zone shall be designed, constructed and operated to: 36.1. ensure that infiltration is minimised, with reference to specific design standards/criteria for aquaculture containment structures; 36.2. maximise the utility of the structures for achieving consistent removal of nutrients and suspended solids; 36.3. avoid the potential for stratification and turnover events and other processes that may lead to episodic water quality fluxes and discharge of poor quality effluent to the receiving environment; and 36.4. increase mixing and dispersion in the receiving environment and otherwise minimise the likelihood of visual discharge plumes from the discharge point.	Noted – adopted for design stage of the Project. Monitoring and management is included in the WQMMP in relation to these issues.
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.
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;	The WQMMP has been prepared in relation to the water quality aspects of the Project.

# ¹	Condition Text	Cross Reference
	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.
39	The licensee must submit documents referred to in conditions 33, 35, 36, and 38 with the 2020 Annual Return.	Noted. Annual return requirements relevant to this WQMMP are included in the WQMMP Appendix A1 (Reporting).

Table notes:

1 Conditions in the Commonwealth approval, Recommendations in the NT Assessment Report

TABLE A2. KEY GUIDELINE DOCUMENTS

# ¹	Condition Text	Cross Reference
Commonwealth 'Requirements for the Water Quality Monitoring and Management Program – 9 June 2017' guideline list		
1	The plan includes a Declaration of Accuracy signed by the approval holder.	Included behind document cover in WQMMP.
2	The plan includes an executive summary which states the relevant EPBC Act approval conditions, and outlines the purpose of the plan and the primary strategies to manage key risks and achieve the plan's objectives.	Included.
3	The plan includes a table containing: a. EPBC Act approval conditions that specify the requirements for and content of the plan; b. plan section and page numbers that address those requirements; and c. key commitments addressing those requirements.	Table A1 in Appendix A to this report. Table A1 in Appendix A to this report. In the references provided in Table A1, Appendix A to this report against each item.
4	The plan describes the project sufficiently to give context to the purpose of the program, and includes: a. the location and nature of project activities; b. a schedule of commencement and completion dates, distinguishing between project stages and construction and operation phases;	Section 2 in this report provides a summary of the project and Section 3 the existing environment. Figure 1-1 in the WQMMP shows the site location, and Figure 1-2 the site layout. Project activities are described in Section 2 of this report. Timing for the Project is incorporated into the start of the monitoring and

# ¹	Condition Text	Cross Reference
	c. the location of listed threatened species habitat to be protected; and d. environmental information and significance of these locations, including relationship to the approved project.	management plans in the WQMMP Appendix A. Summarised in Section 3 of this report (habitat is the receiving waters in Alligator Creek). Summarised in Section 3 of this report.
5	The plan states the environmental outcomes to be achieved by implementing the program. The plan defines environmental outcomes as measurable extent and condition targets, or circumstances of, the protected matters (EPBC Act listed threatened/migratory species and their habitat) and water quality environmental values.	Section 2 of the WQMMP details the environmental objectives and targets relevant to the WQMMP (i.e. the environmental outcomes).
6	The plan includes completion criteria and interim performance targets that evidence protection of EPBC Act listed/migratory species and their habitat. For the purpose of the plan: a. completion criteria are longer term time-bound values, specified for measurable parameters, that if attained and maintained ensure the plan's environmental outcome/s have been achieved; and b. interim performance targets are time-bound short and medium term targets, for management interventions and environmental condition, that are used to monitor, evaluate, review and improve the effectiveness of the plan to avoid, mitigate or offset impacts.	Section 2 of the WQMMP details the environmental objectives and targets relevant to the WQMMP, with discharge criteria, trigger levels and control-impact assessments detailed in Section 5 of this report and summarised in the WQMMP Appendix A3. The WQMMP contains the following interim and completion (or success) criteria which can be described by timeframes: ■ Short term or interim targets – discharge criteria (Section 5.4 of this report, Appendix A3 of the WQMMP) ■ Medium term targets - Alligator Creek trigger values (Section 5.4 of this report, Appendix A3 of the WQMMP) ■ Long term completion (or success) criteria - the objectives, targets and KPIs in Section 2 of the WQMMP, most notably the operational target <i>'impact monitoring shows that changes at impact sites are not significantly different from changes at control sites.'</i> These targets provide for maintenance of receiving water quality such that no significant impact can be detected (refer to Section 5.5 in this report).
7	The plan assesses the risk of failure to achieve the programs performance targets and completion criteria. To this end the plan: a. states the plan's performance targets and completion criteria; b. identifies events or circumstances that prejudice attainment/maintenance of performance targets and completion criteria. The events or circumstances must address scientific/ecological uncertainty, stochastic events and legal/land use planning factors that may represent risks; c. includes a qualitative assessment of the likelihood and consequence of those events or circumstances, and the	Section 4 in this report describes the risk assessment, with the findings provided in Appendix B in this report. Section 2 of the WQMMP and refer to response to item 6 above. Risk assessment in Section 4 and Appendix B of this report. Management and mitigation measures in the WQMMP Appendix A, particularly Appendices A1 and A3 and Figure A1-1. Risk assessment in Section 4 and Appendix B of this report.

# ¹	Condition Text	Cross Reference
	residual risk of failure to achieve those criteria due to identified events or circumstances (assuming management measures will be implemented); d. characterises risk as low, medium, high or severe, and derived from likelihood (highly likely, likely, possible, unlikely, rare) and consequence (minor, moderate, high, major and critical); and e. explains how consequence, likelihood and risk level for each risk have been determined.	Risk assessment in Section 4 and Appendix B of this report. EN-PR-EM0201 Risk Management Procedure in Appendix C of this report.
8	The plan manages the risk of failure by: a. defining the chemical, physical and biological parameters to be monitored in the receiving environment; during the 12 month baseline water quality monitoring and during the project; b. detailing management measures that will be implemented to achieve the performance indicators; c. enhancing monitoring and management measures for high risk events or circumstances, thereby providing a 'margin of safety' to detect, avoid or mitigate the likelihood and/or impacts of the event or circumstance; d. specifying management triggers (measurable events or circumstances) that detect actual or potential issues in a timely manner to avoid, minimise or mitigate adverse impacts; e. ensuring the water quality monitoring program includes activities to detect management triggers, and explaining how monitoring activities may inform the selection and implementation of corrective actions f. detailing effective contingency responses and corrective actions that may be implemented if a management trigger is realised; and g. monitoring the effectiveness of corrective actions and implementing a 'stop work' response in the event corrective actions are not effective.	WQMMP Appendices A1 and A3 specifically assess performance against the triggers and provide links to, and detail of, management actions to mitigate potential impacts. A series of escalation procedures are included for various triggers in the WQMMP Appendix A1, summarised into the decision tree in that plan. Listed in the WQMMP Appendix A3 and described in Section 4.3 of this report. WQMMP Appendix A, particularly Appendix A1, A3 and Figure A1-1. The monitoring program described in the WQMMP Appendix A3 (in particular) incorporates a multi-level monitoring approach. Monitoring frequency is selected based on the degree of control or early warning provided, and further monitoring is triggered where thresholds are exceeded or early warnings are noted. The monitoring and management measures have been targeted at the higher risk events identified in the risk assessment (Appendix B to this report). Appendix A3 to the WQMMP. Appendix A1 to the WQMMP (review, management and contingency measures). WQMMP Appendix A1, particularly Figure A1-1. WQMMP Appendix A1 (review, management and contingency measures). WQMMP Appendix A1, particularly Figure A1-1. WQMMP Appendix A1 (review, management and contingency measures). WQMMP Appendix A1 (contingency measures) and Figure A1-1. Also the monitoring procedures in the WQMMP Appendix A3.
9	The plan ensures there will be no significant impact on Matters of National Environmental Significance (MNES) arising from impaired water quality or flow, and includes planning, monitoring and management activities informed by the NWQMS. The plan: a. describes and maps surface water and discharge sources relevant to the action;	The plan has been developed following the National Water Quality Management Strategy (NWQMS) process (refer to Section 6.2 in the WQMMP). Figure 1-2 in the WQMMP (and Figure 2-1 in this report) shows the major waterways in proximity to the Project and the discharge point. Also incorporated in the monitoring and management plans in the WQMMP, with

# ¹	Condition Text	Cross Reference
	b. includes hydrological assessments, including of hydrological interactions between connected water sources; c. delineates NWQMS environmental values of those waters; d. provides baseline data and information on current chemical, physical and biological parameters, water quality and flow of those waters; e. identifies and describes potential water quality and flow hazards, risks and cumulative effects are evaluated and quantified; f. includes threshold triggers and/or guideline values to protect MNES; and g. includes chemical, physical, biological and flow monitoring and assessment procedures.	a summary provided in Section 3 in this report. Detailed hydrological assessments have been conducted for the Project EIS. A summary has been included in Section 3 in this report. Environmental Values are detailed in Section 5.3 in this report and incorporated into the objectives and targets in Section 2 of the WQMMP. Baseline water quality is summarised in Section 3.3 in this report and assessed in more detail in Section 5 in this report. Information on flow is provided in Section 3.2 in this report. A risk assessment, including hazard assessment, is discussed in Section 4 and provided in Appendix B in this report. Provided in the WQMMP Appendix A3. The program includes chemical, physical, biological and flow monitoring (refer to the WQMMP Appendix A). Sampling procedures are provided in Appendix B to the WQMMP.
10	The plan includes management measures that will protect EPBC Act listed threatened species and their habitat. Each management measure: a. has timeframes for implementation; b. is described sufficiently to avoid ambiguity and to inform plan implementation; c. is related to completion criteria and interim performance targets; and d. is derived from recognised principles, practice, or guidelines, and is justified - technically, scientifically and/or legally – as an effective and appropriate measure to attain and/or maintain the plan's completion criteria and interim performance targets.	Refer to the WQMMP Appendices A1 (management and contingency measures) and A3 (monitoring and triggers). Timeframes are included at the beginning of each of the above plans. Each of the above is set out to be clear and unambiguous. Each plan in the WQMMP Appendix A includes Objectives and Targets referenced to the overarching WQMMP Objectives and Targets. Appendix A1 in the WQMMP contains 'Triggers and Escalation Procedures'. Confirmed – the plan has also been reviewed and accepted by the approved third-party reviewer.
11	The plan identifies and manages uncertainty. To this end the plan specifies: a. key data/information used to formulate the plan; b. the limitations and/or uncertainty associated with the use of that data/information; c. the risks the limitation and/or uncertainty represents for plan failure/to achieve targets; and	This is detailed in this supporting report. This is detailed in Section 5 in this report, particularly Section 5.2. This is detailed in Section 5 in this report, particularly Section 5.2, and incorporated into monitoring and management measures, and the escalation procedures detailed in the WQMMP Appendix A1 and Figure A1-1. Refinement of trigger values is incorporated into the baseline monitoring program (WQMMP Appendix A2) and the operational program (Appendix A3 of the WQMMP).

# ¹	Condition Text	Cross Reference
	d. how limitations and/or uncertainty, and associated risks, are mitigated during plan implementation. For example, where a margin of safety is applied to management measures until uncertainty is reduced to an acceptable level or performance/completion criteria are attained/maintained.	The monitoring and management measures have been designed as a multi-level monitoring and response program, allowing for early warning, and adopting conservative triggers for more detailed assessment where uncertainty is larger. The escalation procedures are detailed in the WQMMP Appendix A1 and Figure A1-1.
12	The plan includes an adaptive implementation program to ensure uncertainty is reduced over time, and that performance targets and completion criteria are achieved. The plan therefore includes arrangements for: a. ensuring new data/information is collected and incorporated into the plan, as a result of implementing the plan and from new information derived from external sources (e.g. academic literature, EPBC policy statements); b. effectively coordinating, scheduling and/or triggering monitoring, risk management, auditing and reporting activities; c. periodically reviewing risks, including in response to the risk level, changing circumstances or the results from implementing contingency responses; d. frequent review of the effectiveness of management measures with significant levels of uncertainty, relatively long implementation timeframes, and upon which the strategy/plan is highly dependent; e. addressing the consequences of significant environmental incidents (pre-determined and unanticipated); and f. reviewing the plan under the following circumstances: • performance reports indicate performance targets/completion criteria may not be achieved; • according to approved timeframes; and • the impacts of significant environmental incidents.	The WQMMP Appendix A3 and Figure A1-1 outline an adaptive program with triggers from the farms through to the impact monitoring program providing escalation to further monitoring plus management actions. Refinement of trigger values is incorporated into the baseline monitoring program (WQMMP Appendix A2) and the operational program (Appendix A3 of the WQMMP). A review and auditing program is included, as described in the WQMMP Appendix A1 (Review and Auditing). Also see above. This is described in the 'Frequency and Timing' section of each plan in the WQMMP Appendix A and in the 'Reporting' section of Appendix A1 in the WQMMP. Additional monitoring triggers based on monitoring results are summarised in the WQMMP Appendix A, Figure A1-1. The project risk assessment is reviewed as required, and as stipulated in the WQMMP Appendix A1 (Review and Auditing). Ongoing and frequent review is stipulated in the WQMMP Appendix A1 (Review and Auditing). This includes higher risk reviews triggering additional program review. Monitoring and mitigation measures are provided in the WQMMP Appendix A. Provided in the WQMMP Appendix A1 (Review and Auditing) and Figure A1-1.
13	The plan describes the purpose of monitoring and its functional relationship to operational decisions.	The overall aim of the WQMMP is provided in the WQMMP Section 2, with monitoring and management aims discussed in Section 6 of the WQMMP. Each plan in the WQMMP Appendix A contains its own specific Aim. Functional relationships to operational decisions are described by way of the monitoring and escalation procedures described in the WQMMP Appendix A, summarised in Figure A1-1.

# ¹	Condition Text	Cross Reference
14	The plan states monitoring objectives to meet operational decision-making. To this end: - for each objective, the monitoring plan specifies the variables to be measured, the state and/or rate of change, the precision and confidence, the spatial resolution and time scales required to inform operational decision-making; and - the monitoring objectives provide for ‘early-control’ (that management actions are effective) and ‘early warning’ (corrective actions are required) functions, so as inform timely decisions on corrective actions to ensure performance and completion criteria are achieved.	The overall Objectives and Targets of the WQMMP are provided in Section 2 of the WQMMP. Each plan in the WQMMP Appendix A links to these Objectives and Targets. Each Objective is matched to Targets and Key Performance Indicators. These are (where necessary) further elaborated in other parts of the plan, such as the discharge and receiving water monitoring targets described in the WQMMP Appendix A3. Details of existing water quality for these parameters is provided in Section 5. Early control is provided through management to achieve discharge limits, with early warning provided by farm incidents, discharge exceedances and through to exceedance of trigger values in the WQMMP (Figure A1-1 in Appendix A) and the control-impact regression assessment described in Section 5.5 in this report.
15	The plan includes a monitoring program comprised of monitoring methods, a data handling strategy, arrangements for the periodic technical review and evaluation of the monitoring program and timeframes for implementing program components.	The programs are described in the WQMMP Appendix A, with monitoring methods, data handling, etc. discussed in the WQMMP Appendix B. Review procedures are detailed in the WQMMP Appendix A1 (Review and Auditing). Timeframes are detailed at the beginning of each monitoring plan in the WQMMP Appendix A.
16	The plan describes the monitoring methods that will be implemented, and: - includes quantitative baseline data that establish the start quality/condition of the environment; - describes the sampling methodology (including monitoring sites/area, site selection and sampling intensity over space and time) and statistical analyses to be employed; - justifies the sampling strategy/monitoring methods, including through the likely statistical power delivered by the strategy/method; - justifies the monitoring methods to be used, including: - an assessment of effectiveness and constraints to use; - capacity to detect change in environmental condition due to management interventions; - capacity to demonstrate attainment of performance targets and completion criteria;	The WQMMP Appendix B details the monitoring methods to be adopted, along with the specifics for each program in the WQMMP Appendix A. Baseline data are discussed in Section 5 in this report with a baseline monitoring program in Appendix A2 in the WQMMP. Sampling methods, locations, sampling intensity and timing are discussed in Section 5.5 in this report, and in Appendices A and B in the WQMMP. Statistical analysis is described in Section 5.5 in this report for control-impact assessment. Section 5 in this report assesses the existing data and justifies the sites and trigger values/criteria used. An analysis of the statistical power of the analysis is provided in Section 5.2.1.5. The monitoring methods have been adopted based on best practice, and justification is provided in the reports (the WQMMP and this report) where relevant. Specific detail on the methods to be used is provided in the WQMMP Appendices A and B.

# ¹	Condition Text	Cross Reference
	e. commits to engage appropriately qualified experts to design and conduct monitoring and survey activities, and analyse monitoring results; and f. the location, nature and number of monitoring sites, including benchmark/reference sites to evaluate management performance (c.f. seasonal variation)	Detailed hydrological and water quality modelling was conducted showing the project can meet receiving water quality trigger values. A re-appraisal of the assessment provided in Section 5.4 in this report shows the findings remain valid following the review of background and trigger values. Appropriately qualified persons are detailed in the WQMMP Appendix B. These are provided in the WQMMP Appendix A, with the sites (including reference sites) discussed in Sections 5.4 and 5.5 in this report.
17	The plan includes a data handling program for data storage and protection, data extraction, quality control, analysis, interpretation, reporting and presentation. Data ownership, and distribution, availability and licensing to the Department for compliance and recovery planning purposes, must be specified. Timelines for the data handling, analyses and delivery should be specified.	This is incorporated in the WQMMP Appendix B.
18	The plan outlines a procedure for periodic technical review and evaluation of the plan and monitoring program.	This is incorporated in the WQMMP Appendix A1 (review and auditing).
19	The plan provides evidence that advice received by the Independent Scientific Expert has been used to prepare the plan. A copy of the advice should be provided separately.	Appendix D in this report provides advice from the independent scientific expert.
20	The plan includes a schedule and triggers for self-auditing the implementation and effectiveness of the plan, and outlines auditable systems for recording plan implementation and the environmental outcomes/performance indicators achieved.	The self-auditing procedures are included as part of the overall EMS and the site EMP. Review and auditing requirements specific to this WQMMP are provided in the WQMMP Appendix A1 (review and auditing).
21	The plan includes commitments to report on program implementation. This is achieved by: a. identifying relevant reporting obligations under the EPBC approval; b. specifying how plan implementation will be reported in accordance with those obligations; and c. including a reporting template specifying key risk management, management measure, monitoring and adaptive implementation outcomes for the reporting period.	Reporting requirements are detailed in the WQMMP Appendix A1 (Reporting). A reporting template will be prepared and agreed with the Commonwealth prior to the first report being due, in sufficient time to allow the report to be finalised by the due date.
22	The plan specifies accountabilities for implementing the plan, including management measures, risk management, monitoring, reporting, review, auditing and contingency responses.	Roles and responsibilities are defined in the site EMP, as well as being specified in the plans in the WQMMP Appendix A (Responsible Person).
23	Maps, plans, figures, images and sections used in the plan: a. show the monitoring area in a state and regional context; b. must be clearly legible, including fine print, when printed on A4; c. show areas with differing environmental condition or quality; d. show the location of static monitoring plots and/or the general location of random monitoring/survey activities that will be undertaken; e. are scaled to enable the reader to clearly identify, based on local landmarks (trees, fences, structures) the location of management activities being shown on the map;	Refer to the WQMMP Figure 1-1 (site location) and Figure 2-1 in this report (site context), and the figures accompanying the WQMMP Appendix A plans.

# ¹	Condition Text	Cross Reference
	f. include appropriate standard metric scales to represent the information (for example 1:100 000). Datum – plans and cross sections refer to AHD; g. have metric measurements, graphic bar scales, local grid lines and standards and north point or orientation of sections (include a key) are used throughout; and h. include title blocks in the lower right hand corner with the following information: EPBC number and project name, title and number of the plan, author, scale, date, source and date of data.	
24	The plan references scientific, legal or other claims or statements that support the effectiveness of the plan, e.g. references to scientific literature, published guidelines, legislation, conservation advice, recovery plans, threat abatement plans.	Confirmed – refer to Section 7 of the WQMMP and Section 6 of this report for references used.
25	The plan uses the terms ‘will’ and ‘must’ when committing to actions, instead of ‘where possible’, ‘as required’, ‘to the greatest extent possible’, ‘should’ or ‘may’.	Confirmed (where appropriate). ¹
26	The footer or header of each page of the plan states the name of the project, EPBC number, the date of the plan and sequential page numbering.	Confirmed.
27	The plan includes a glossary of terms comprised of acronyms, terms open to different interpretations, not in common use, technical or defined in the approval conditions.	Refer to ‘Terms and Abbreviations’ at the beginning of the WQMMP and this document.
28	The plan includes risk assessment/management, implementation and monitoring schedules consistent with <u>Appendix A</u> .	Confirmed.

Table notes:

- These terms are used in this document suitable to their meaning, adopting their meanings defined under ISO 9001:2015 – Quality Management Systems, namely ‘Shall’ [or must] indicates a requirement [will indicates a commitment]; ‘Should’ indicates a recommendation; ‘May’ indicates a permission; and ‘Can’ indicates a possibility or a capability. In this document, terms such as ‘if possible’ or ‘as practical / practicable’ are considered as actions that are contingent upon some specific factor and will be used where needed (where the action cannot in all circumstances be undertaken). These will be preceded by the above ‘Shall’, ‘Should’, etc. terms. Actions shall be prescriptive only where necessary for the success of the plan.

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	
Site establishment, vegetation clearing and earthworks.	Threatened and Migratory Species	Clearing of vegetation results in the change or loss of habitat/biodiversity values for threatened and migratory species.	5	2	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 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.	5	1	M	- Erosion and sediment controls will be put in place. - Limited works near waterways and wetlands. - Considering much of the Legume floodplain becomes one major water body for months at a time during the wet season, the relatively small loss of ephemeral wetlands it is not likely to have a measurable ecological impact beyond the Project footprint.
	Freshwater Streams, Rivers and Wetlands	Clearing of vegetation near waterways and wetlands leads to bank destabilisation, direct damage, or release of sediments and/or organic matter to waterways which impacts on water quality.	3	3	M		2	2	L	
		Site establishment and construction of farms	5	2	M		5	2	M	

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		results in the loss of ephemeral wetlands.				- Develop and implement vegetation clearing sub-plans 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. - Controlled burns and/or vegetation mulched for re-use where practicable, no disposal of cleared vegetation into waterways or wetlands. - No laydown areas or material storage in wetland areas. - Soil management procedures to target specific areas subject to salinity, sodicity and enhanced erosion including mitigation, soil amelioration and rehabilitation as required. - Strict controls for waterway crossing works including erosion and sediment controls, defined trafficable areas etc.				
	Marine and Estuarine Waters	Clearing of mangroves leading to bank destabilisation, increased erosion and runoff resulting in release of sediments and/or organic matter to waterways impacting water quality.	3	2	M		2	1	VL	
		Construction phase impacts to freshwaters water quality leads to runoff and impacts to marine and estuarine water quality. Erosion, spills or leaks where construction works are adjacent to tidal waters	3	3	M					
	Land	Clearing and/or working of sodic soils leads to enhanced	2	3	M		2	2	L	As detailed in the Geology, Geomorphology and Soils chapter (Volume

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		erosion and soil degradation.								2, Chapter 1), sodic soils have been identified on site. This is from active seawater influence rather than problematic dryland sodic soils. Typically, only the surface soils are sodic and no change in saline/freshwater regime anticipated outside of grow-out pond areas.
	Freshwater Streams, Rivers and Wetlands	Dust emissions result in increased levels of dust deposition which leads to changes in water quality.	2	2	L		2	1	VL	- Freshwater environments on-site habituated to already dusty environment. - Given the significant rainfall events expected on an annual basis, impacts from dust will be short term and minor at most. - The vast majority of the construction footprint is well

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										removed from freshwater environments (construction in the dry season).
Disturbance of acid sulfate soils (ASS) during earthworks.	Freshwater Streams, Rivers and Wetlands	Disturbance of ASS results in the generation of acid leachate which acidifies runoff and leads to changes in water quality in freshwater streams, rivers and wetlands.	2	2	L	- ASS management plan to be implemented. - Soil investigations for any excavations into potential ASS. - Avoid disturbance and oxidation of ASS or ensure disturbed ASS have sufficient neutralising capacity to permanently avoid oxidation (adding lime if necessary).	2	1	L	- Minimal excavation work near freshwater environments. - Minimal excavation in intertidal zone and specific management measures in place for ASS in intertidal areas. - If encountered ASS can be neutralised. - Acid sulfate soils are only found below 2-3 m. The majority of Project footprint (i.e. grow-ponds) will only excavate to 300 mm.
	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 Marine and Estuarine Waters.	3	2	M		2	1	L	
Spills or leaks of contaminants such as fuel, oils,	Land	Spills of contaminants result in contamination of soils.	3	4	M	Fuel, oil, chemical and liquid waste to be stored in bunded and appropriately contained areas.	2	2	L	With mitigation and management measures in place spills are unlikely 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	
chemicals or liquid waste.						- Fuel and chemical transfer points to be bundled. - Spill kits and spill management controls utilised at all storage and transfer points. - All waste disposed appropriately offsite or disposed of in the onsite landfill. - Training and incident/notification procedures to be adopted. - An unexpected findings protocol will be implemented including stop work, containment and remediation actions.				procedures are in place to rectify them immediately.
	Freshwater Streams, Rivers and Wetlands	Contaminants enter surrounding waterways and lead to changes in water quality in freshwater streams, rivers and wetlands.	3	3	M		2	2	L	- Minimal construction work will be undertaken near freshwater environments. - With mitigation and management measures in place spills are unlikely and procedures are in place to rectify them immediately.
	Marine and Estuarine Waters	Contaminants enter surrounding waterways and lead to changes in water quality in Marine and Estuarine Waters.	3	3	M		2	2	L	- Minimal construction work will be undertaken near marine and estuarine environments. - With mitigation and management measures in place spills are unlikely and procedures are in place

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										to rectify them immediately.
	Land	Increased traffic results in soil compaction, rutting and soil erosion outside of designated traffic areas.	3	1	L	- Vehicles to stay on defined ingress and egress points. - Vehicles to adhere to site speed limits and road rules.	2	1	VL	

TABLE B1-2 EXTRACT FROM PROJECT RISK ASSESSMENT – WATER QUALITY (OPERATIONAL PHASE)

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
Intake of seawater from Forsyth Creek.	Marine and Estuarine Waters	Intake structure alters dynamics of Forsyth Creek changing scour and erosion rates.	4	3	M	- Design of the intake minimises impacts to current speeds and direction by using pile structures to access to centre of Forsyth Creek, as opposed to more solid structures. - Monitor bank erosion and scour rates around piles and instigate rectification works if negative changes are observed.	3	2	M	- Bathymetry of the marine and estuarine environment is naturally extremely dynamic. - Design minimises risks of scour and erosion to as low as practicable.
		Intake of water results in a change in the tidal prism of Forsyth Creek which affects tidal water levels or currents.	5	2	M		5	2	M	- As detailed in the Marine and Estuarine Water chapter (Volume 2, Chapter 2), the peak rate of extraction represents a small percentage of the tidal prism in Forsyth Creek (less than 0.5% during a spring tide and less than 1.5% during a neap tide). - No follow-on consequences for marine fauna or water quality.

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
	General Ecological Values	Entrainment or impingement in intake structures results in mortality or injury of aquatic fauna.	5	2	M	- The area of potential influence in the vicinity of the four bell-mouth intakes is small and represents a very small area of potential impact relative to the considerable size of Forsyth Creek. - The intake is positioned approximately 9 m from the creek bed which will avoid bottom dwelling species.	4	1	M	- As detailed in the Marine and Estuarine Ecology chapter (Volume 2, Chapter 7), current velocities in Forsyth Creek are high and therefore resident and transient fish in this area are likely to be able to negotiate these currents. - Juveniles of threatened species considered possible to occur are relatively large (e.g. sawfish pups > 65 cm and river shark > 50 cm) and therefore they are likely to have a relatively strong swimming ability. - Flatback turtle hatchlings (approximately 6 cm at emergence) have a swimming speed of >1 m/s. - Adults of threatened species likely to occur are large and are considered likely to be able to swim away. In any event, the 100 mm aperture mesh grille
	Threatened and Migratory Species	Entrainment or impingement of threatened and migratory aquatic fauna in intake structures.	3	2	M	- The intake bell-mouth will be fitted with a 100 mm aperture mesh grille, to exclude all but small debris and aquatic fauna. - Water will only be drawn from the mid and high tides daily, which allows a 12-hour period each day of no operation. - The bell-mouth design will have a target intake velocity of <0.4 m/s within 1.0 m radius of the bell-mouth. This target velocity accords with published data that most fish can swim against a current of 0.4 m/sec. - The above results in an intake velocity of 0.1 m/sec, 1.25 m from the bell-mouth. Published data indicates that	2	2	L	

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						all fish can swim against currents of 0.1 m/s.				will exclude any adult threatened species from being entrained.
Discharge of waste water into Alligator Creek.	Marine and Estuarine Waters	High levels of nutrients in discharge water results in a change in water quality above site specific water quality trigger values.	5	3	H	- Choice of Project location: - Macrotidal receiving environment increases dilution and flushing. - Largest privately owned dam ensures adequate supply of freshwater which maximises ability to recirculate pond waters and therefore minimise discharge. - Project design: - Use of freshwater minimises the amount of seawater flow-through and therefore discharge. - Maximum water re-use through Internal Farm Recycling Ponds. - Environmental Protection Zone (EPZ) designed to slow water flow and 'polish' discharge water.	5	1	M	- As detailed in the Marine and Estuarine Water chapter (Volume 2, Chapter 2), there will be no exceedances of interim water quality guidelines outside the mixing zone. - The mixing zone at the discharge point (i.e. where the interim site-specific water quality trigger values are exceeded) is approximately 200 m either side of the discharge infrastructure.

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						- Potential for EPZ to be naturally colonised by vegetation to assist with nutrient uptake. - Weirs within the Main Discharge channel (MDC) and EPZ allow for controlled timing, rate and dispersion of discharge. - Farm ponds and IFRP will settle out the bulk of organic material before the EPZ. - A 100 m wide channel has been designed through the centre of the EPZ to keep water moving so it will be unlikely to go stagnant or develop excessive algal blooms (typically observed in still waters). - Location of discharge into Alligator Creek as opposed to a smaller tidal creek with less flushing ability.				
						Project operation:				

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						- Release of discharge on ebb tide to ensure minimum residence time in Alligator Creek. - No use of antibiotics. - Maximum feed conversion via feed formulation and pond management strategies. - Aerators create pond spoil mound in the middle which is removed at end of harvest (i.e. is not discharged). - Aerators also reduce biochemical oxygen demand. - Annual drainage of ponds and removal of pond waste from the pond floor.				
		Discharge water results in scour and/or changes to the bathymetry of Alligator Creek.	3	2	M	All the above control strategies will apply, in addition to: - Rock armouring of the discharge point to control bank erosion. - Peak ebb and flood tidal velocities in Alligator Creek are higher than the discharge current speed, hence	2	1	VL	Bathymetry of the marine and estuarine environment is naturally extremely dynamic.

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						discharge is likely to have minimal impact on bathymetric and sediment transport processes in comparison to natural tidal currents.				
		Discharge of water results in a change in the tidal prism of Alligator Creek which affects tidal water levels or currents.	5	2	M		5	2	M	As detailed in the Marine and Estuarine Water Quality chapter (Volume 2, Chapter 2), the average daily discharge rate of 420 ML represents a small percentage of the tidal prism of Alligator Creek (less than 0.5% during a spring tide and 1.9% during a neap tide). No follow on consequences for marine fauna or water quality.
	General Ecological Values	High level of nutrients in discharge water results in changes in water quality which in turn causes a change or loss of habitat/biodiversity	5	3	M	All the above control strategies for the discharge of water into Alligator Creek will apply.	5	3	M	As detailed in the Terrestrial Fauna and Avifauna chapter (Volume 2, Chapter 6), there is a low abundance and diversity of shorebirds. This is thought to be a consequence of the low abundance and

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
		values for flora and fauna.								diversity of benthic infauna in the estuarine environment. - Higher value habitats for threatened and migratory species include Turtle Point and Osmans Lake which will not be impacted by the discharge. - The Marine and Estuarine Water modelling (Volume 2, Chapter 2) shows that there will be no exceedances of interim water quality guidelines outside the mixing zone.
	Threatened and Migratory Species	High level of nutrients in waste water results in changes in water quality which in turn causes a change or loss of habitat/biodiversity values for threatened and migratory aquatic and avifauna fauna.	3	2	M	All the above control strategies for the discharge of water into Alligator Creek will apply.	1	2	VL	The receiving environment in Alligator Creek has been identified as being of low importance for threatened and migratory avifauna. This is thought to be a consequence of the low abundance and diversity of benthic infauna in the estuarine environment

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										surrounding the Project Area. - Higher value habitats for threatened and migratory avifauna include Turtle Point and Osmans Lake which will not be impacted by the discharge. - Effects of discharge are confined to Alligator Creek and in particular the mixing zone which extends approximately 200 m either side of the discharge infrastructure. - The threatened marine species likely to present are wide ranging and this area does not represent critical habitat. Furthermore, the discharge itself is unlikely to constitute a significant impact to these species. - The potential impact area represents a relatively small proportion of available habitat. There are extensive

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
										areas of similar habitat in the region. Regardless, the discharge itself is considered unlikely to have an impact on individual species if they are to pass through the mixing zone.
Uncontrolled discharges or leaks from grow-out ponds and channels.	Marine and Estuarine Waters	Uncontrolled discharges (e.g. through the overtopping of farm ponds and channels) lead to changes in estuarine and intertidal water quality.	2	1	VL	The Project has been designed so that: - In storm events less than a 50-year average reoccurrence interval (ARI), flows are captured by a system of swales adjacent to the farm bunds and transported to the MDC for controlled release to the environment. - In extreme rainfall events (> 50-year ARI), uncontrolled releases of water will enter the bio-security zones between farm 1 and farm 2. Excess water will then be channelled along the biosecurity zone and discharged to the tidal floodplain through a culvert under the MDC.	1	1	VL	The inundation extent is limited and depths are shallow. Much of the water released is ponded on the upper tidal floodplain with little interaction with the tidal creeks. This inundation extent is considered insignificant when compared to expected flooding conditions during a rainfall event that would cause this degree of overtopping.
	Freshwater Streams, Rivers and Wetlands	Uncontrolled discharges (e.g. through the overtopping of farm ponds and channels) lead to changes in water quality in freshwater streams, rivers and wetlands.	2	2	L		1	2	VL	

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
Escape of prawn stock from grow-out facility.	General Ecological Values	The escape of prawn stock from the grow-out farms leads to changes in aquatic ecology.	2	2	L	- All pond outlets will be screened with a mesh of a suitable size to prevent prawns escaping. - A cage screened with a mesh of a suitable size will be inserted inside the monk (the outlet structure) during harvesting. - A bird predation management strategy will be implemented to prevent birds predating on prawns and potentially removing prawns from the grow-out ponds. - The grow-out facility will be stocked with post-larvae that are bred from Specific Pathogen Free (SPF) prawn stock. - A biosecurity plan has been developed for the Project and will operate across the entire grow-out facility to prevent the introduction and spread of diseases through pathways such as staff and equipment movements. - In addition to the biosecurity plan, a health monitoring and surveillance program will be implemented to identify any disease outbreaks.	1	1	VL	The grow-out facility will be stocked with black tiger prawns (<i>Penaeus monodon</i>) which are native to the Joseph Bonaparte Gulf. The founder stock which will be used to establish the breeding program for the Project will be sourced from wild populations of black tiger prawns from the waters around the Northern Territory and Western Australia.

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						If a disease is identified, immediate steps will be taken to contain the disease to the pond(s) in which it has been identified.				
Spills of contaminants such as fuel and/or chemicals.	Freshwater Streams, Rivers and Wetlands	Contaminants enter surrounding freshwater waterways and lead to changes in water quality in freshwater streams, rivers and wetlands.	3	3	M	- Fuel, oil, chemical and liquid waste to be stored in bunded and appropriately contained areas. - Fuel and chemical transfer points to be bunded. - Spill kits and spill management controls utilised at all storage and transfer points.	2	2	L	With mitigation and management measures in place, spills are unlikely and procedures are in place to rectify them immediately.
	Marine and Estuarine Waters	Contaminants enter surrounding freshwater waterways and lead to changes in water quality in Marine and Estuarine Waters.	3	3	M	- All waste disposed appropriately offsite or disposed of in the onsite landfill. - Training and incident/notification procedures to be adopted.	2	2	L	
Release of waste water from waste water treatment plant (WWTP)	Freshwater Streams, Rivers and Wetlands	Inappropriate disposal of waste water results in a change in water quality of freshwater streams, rivers and wetlands.	3	2	M	- The WWTP will be sized appropriately to the load, suitable to the soil types and climate. - The WWTP will be designed with alarms and other safeguards to avoid overflow.	1	1	VL	- With mitigation and management measures in place, the potential impacts from the WWTP are considered to be very low. - There are no known threatened or migratory

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
	General Ecological Values	Inappropriate disposal of waste water results in a change in freshwater quality which in turn causes a change or loss of habitat/biodiversity values for flora and fauna.	2	2	L	 A Wastewater Works Design Approval will be obtained and the WWTP will be managed in accordance with State and National codes and guidelines, including the Guidelines for Wastewater Works Design Approval of Recycled Water Systems.	1	1	VL	aquatic species within the freshwater environments of Legume Station.
	Threatened and Migratory Species	Inappropriate disposal of waste water results in a change in freshwater quality which in turn causes a change or loss of habitat/biodiversity values for threatened and migratory flora and fauna.	1	1	VL		1	1	VL	
Contact with crocodiles	Human Health and Safety	Contact with crocodiles results in injury or death.	3	4	M	 All personnel will be made aware of the dangers of crocodiles in the Project Area.  Appropriate signage will be installed around the Project Area to remind	2	4	M	

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						personnel of the potential presence of crocodiles. - All sightings of crocodiles in and around the Project Area will be immediately reported to the farm manager. - Access will be restricted to any area that is known to be inhabited by a crocodile until the crocodile has been moved on or relocated from the area. - Personnel will be required to observe waterbodies and surrounding areas for crocodiles prior to working near the water's edge. - Vegetation surrounding waterbodies will be maintained as low in height as practical to enable easy observation of the area. - Any work required to be undertaken on water (e.g. boat activities) will always be conducted by multi-person work crews with one person acting as an observer at all times. - When a crocodile has taken up residence within the Project Area, the NT Parks and Wildlife Commission or				

Source of Impact	Risk		Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						other such authority will be notified and a request to trap and relocate the crocodile will be submitted. Only trained, competent and authorised persons will attempt to move, relocate, capture or otherwise handle a crocodile.				
		Dehydration and heat stroke from extreme temperatures.	3	4	M	- All personnel working outdoors will be required to wear long sleeved shirts and hats to help reduce sun exposure. - Sunscreen will be made available to all personnel. - All personnel will be made aware during induction training of the signs and symptoms of overexposure to heat and its effects, including dehydration. - Drinking water will be made readily available onsite.	3	2	M	
Operation of boats	General Ecological Values	Mortality or injury of aquatic fauna from boat strike.	3	1	L	- Boat crew to maintain a look out for aquatic fauna during all operations. - If a boat approaches aquatic fauna (or vice versa), the vessel will take all care to avoid collisions, including stopping, slowing down and/or steering away.	2	1	VL	Boats will only be used during the construction of the seawater intake pump and then intermittently during operations (e.g. for water quality sampling).
	Threatened and	Mortality or injury of threatened or migratory aquatic	3	1	L		2	1	VL	

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
	Migratory Species	fauna from boat strike.								
	Human Health and Safety	Injuries or fatalities of personnel resulting from the operation of boats.	3	4	M	- Personnel responsible for the operation of the boats will hold appropriate licences. - All personnel on the boat must be fit for work and not under the influence of alcohol or other drug. - Any boat activities will always be conducted by multi-person work crews with one person acting as an observer at all times. - Boat ramps will be constructed where required to assist in the launching or retrieval of boats from the water. - All boats will be adequately sized and equipped with life vests, first aid kit, emergency position indicating radio beacon (EPIRB), fire extinguisher and emergency provisions (e.g. water, food and insect repellent). - All personnel on the boat are to wear life vests at all times. - All boats are to be fitted with a working means of communication	2	3	M	

Risk			Initial Risk			Control Strategies	Residual Risk			Evaluation Rationale
Source of Impact	Consequence Aspect	Consequence	Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						(e.g. a two-way radio and/or satellite phone).  Tides and weather conditions will be consulted and a journey management plan prepared prior to operating a boat in the waterways surrounding the Project site.				

APPENDIX C EN-PR-EM0201 RISK MANAGEMENT



PROJECT SEA DRAGON

EN-PR-EM0201

RISK MANAGEMENT FRAMEWORK

Rev: A, 28-Sep-2017

Document Details

Proponent:	Project Sea Dragon Pty ACN: 604 936 192
Project Title:	Project Sea Dragon
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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.

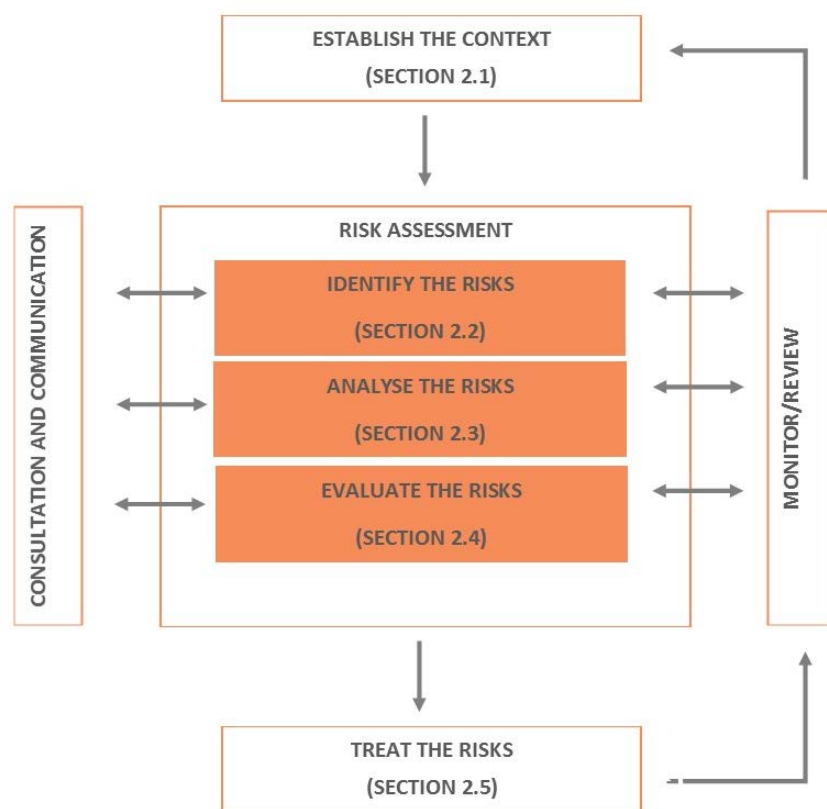


FIGURE 1 RISK ASSESSMENT PROCESS

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 INDEPENDENT REVIEWER ADVICE



Australian Government

Department of the Environment and Energy

Dr Chris Mitchell
Director
Project Sea Dragon Pty Ltd
PO Box 7312
Cloisters Square WA 6850

**EPBC 2015/7527 – Project Sea Dragon Stage 1 Prawn Aquaculture Project,
Legune Station, NT – Approval of Independent Scientific Expert**

Dear Dr Mitchell,

Thank you for your letter dated 2 June 2017 to the Department, requesting approval of Dr Darren Richardson as the Independent Scientific Expert for EPBC Act approval 2015/7527.

Officers of the Department have advised me on the suitability of Dr Darren Richardson. As delegate of the Minister for the Environment and Energy, I am satisfied that Dr Richardson has suitable qualifications and experience to advise on preparation of the Water Quality Monitoring and Management Program required in accordance with condition 2 of the approval.

Should you require any further information please contact Heather Cross, Project Officer, Post Approvals Section, on (02) 6274 1432 or by email: postapproval@environment.gov.au.

Yours sincerely

James Barker
Assistant Secretary
Assessments (Qld, Tas, Vic) and Governance Branch
Environment Standards Division

5 / 7 2017



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8 June 2018

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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 STAGE 1 LEGUNE GROW-OUT FACILITY**

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 the *Sea Dragon Project, Stage 1 Legune Grow-Out Facility*. 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 EN-01-MP-EM002, Rev I, dated 14 February 2018
 - Supporting Report EN-01-EM002, Rev I, dated 14 February 2018.
- Stage 2 - A review of the updated WQMMP responding to the Stage 1 review:
 - Draft Water Quality Monitoring and Management Plan EN-01-MP-EM002, Rev K, dated 14 Feb 2018 (Reviewer note – issue date appears to be erroneous)
 - Supporting Report EN-01-EM002, Revision number not noted, dated 23 April 2018.

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

Basis for the Review

This Peer Review responds to requirements set out in the Department of the Environment and Energy (DoEE) conditions attached to the approval for *Project Sea Dragon Stage 1 Prawn Aquaculture Project, Legune Station, NT (EPBC 2015/7527)*. In particular, Condition 2 requires the proponent to develop a Water Quality Monitoring and Management Program (WQMMP) to protect habitat of threatened and migratory species, and that “*The WQMMP must be prepared in consultation with an appropriately-qualified independent scientific expert whose appointment has been approved in writing by the Minister*”. Condition 2 also provides specific guidance on the content of the WQMMP, which provides the basis of this review.

Summary

The conclusions drawn from the review process are given in detail in this report and in its Conclusions. In summary, this review has satisfied the reviewer that the WQMMP is fit for purpose and meets requirements set out in Condition 2 of the DoEE Approval document.

Stage 1 Review Findings

Table 1 presents the findings of the Stage 1 review, and the proponent's responses to the issues raised. In summary, the Stage 1 review raised the following issues requiring clarification:

- gaps regarding the characterisation of potential contaminants in grow-out pond waters
- an explanation for the non-detections of dissolved metals/metalloids in receiving environments
- further details on statistical analyses describing baseline water quality conditions, and drivers of change
- further details on the statistical analyses and experimental design for calculating sample sizes
- justification for indicator selection in the biological sampling program
- suggestions regarding adopting a formal multiple lines of evidence framework to assess discharge impacts and validate the water quality Trigger Values.

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 were reviewed in the context of:

- amendments to the WQMMP in response to the Stage 1 review
- requirements set out in Condition 2 of the DoEE Approval document.

All items raised in the Stage 1 review are now considered closed (see Table 1). In this regard:

- additional information has been provided to better characterise potential contaminants in grow-out pond waters (refer to Section 4.2 of the Supporting Report). The additional information is based on case-studies from existing prawn farms operated by the proponent in North Queensland, and therefore in the context of this Project.
- an explanation on the non-detects for dissolved metals/metalloids has been provided (i.e. inappropriate laboratory detection limits). The proponent has committed to undertaking additional baseline sampling to address deficiencies in the existing baseline data. The additional sampling will not provide a complete, high quality 12-month data-set for dissolved metals/metalloids. The reviewer does not consider this to be a major limitation given that metals are unlikely to represent a contaminant of concern in prawn pond discharges. In this regard, only trace amounts of metals are proposed to be used in feeds, as outlined in Section 4.2.1 of the Supporting Report. The proponent is committed to undertaking monitoring of trace metals/metalloids during operations (in both waters and sediments) to validate this assumption.
- the description of the statistical analyses and experimental design has been substantially simplified and revised to address queries raised in the Stage 1 review.

- indicator selection has been adequately justified in the revised document. The incorporation of multiple physio-chemical and biological indicators within an adaptive monitoring and management framework is supported.

Table 2 provides an assessment of the adequacy of the WQMMP in addressing Condition 2 of the DoEE Approval document. It is considered that all sub-components of Permit Condition 2 have been satisfactorily addressed by the WQMMP. Some suggestions are provided in Table 2 to improve the report – refer to item (b) regarding discussion on concentrations and loads, and a query regarding the use of OC/OP pesticides, and item (f) regarding typographical errors.

Yours Faithfully
BMT

A handwritten signature in black ink, appearing to read 'Darren', with a large, stylized loop at the end.

Dr Darren Richardson
Senior Principal Scientist

Table 1 Stage 1 review findings and proponent responses

Item	Section	Reviewer Comment	Reviewer Recommendation	Updated Report Section	Seafarms' Response	Item Status
1	2	Other than total nitrogen and phosphorus, no information is provided on specific constituents (here or in S4.2 of the main report) of chemicals used in ponds, e.g. NOx, NH3, other additives. It is therefore uncertain whether monitoring indicators address all water quality stressors.	Please include: - typical concentrations (range, based on other operations) of key nutrient species, dissolved oxygen, algae biomass, bacteria in pond waters - the typical composition of conditioners and other additives used in ponds - a brief description of potential effects of the above on receiving environment water quality This will form the justification for indicator selection in Section 4.2.	4.2	A new Section 4.2 - Operational Discharges - has been added including Section 4.2.1 Water Quality (inputs and outputs, additives, typical or anticipated concentrations or loads) and Section 4.2.2 Potential Impacts.	Item Closed
2	3.3	Para 2 – This gives the impression that concentrations of TP > TN; is the point more about concentrations relative to guideline values? Fig 5-5 shows that TN is not especially low (c.f. ANZECC guideline value). It is agreed that turbidity will control phytoplankton productivity. However, chlorophyll data (Fig 5-5 and 80th percentile values) shows that high levels can occur, and the system is not insensitive to additional nutrients.	Please reword	3.3	This section has been reworded to make clear that this is in comparison to the guidelines (TN comparable, TP an order of magnitude greater than). For Chlorophyll a, a more detailed interpretation is now included, which concludes that it is generally low, occasionally high, but with no readily apparent cause for these spikes.	Item Closed
3		Para 4 – it is interesting that no dissolved metals/metalloids were detected (not even aluminium?), noting that it is stated elsewhere that there are significant metal outcrops in the catchment.	Please confirm that laboratory limits of reporting are < ANZECC guideline values, and whether levels are consistent with case-studies elsewhere.		An analysis of the metals concentrations from the most relevant previous study (Bennett & George, 2014) found that dissolved metals are present in the estuarine waters, and were in some cases above the trigger values. It also found that the LORs used by FRC (2016) were too high and should have been lowered. This has been included in Section 5.2.2 in detail, with Section 3.3 updated to reflect these findings	Item Closed
4	5.2.1.1	Fig 5-2. There is great variability in the baseline data between years. Is the baseline monitoring period representative of especially wet or dry years compared to the long-term climate record?	Please provide context on representativeness of data relative to relative to long term (inter-annual) climate cycles and rainfall patterns.	5.2.1.1	A new Figure 5-3 has been inserted showing a comparison with longer term averages.	Item Closed
5		Pg17, Para 1 - Significant differences – what is the p level? No discussion provided on trends in phosphorus and chlorophyll.	Please add text		The p level from FRC (2016) has been provided (and ANOSIM Global R), and a short discussion on Phosphorous and Chlorophyll a provided.	Item Closed
6		Fig 5.3. Without supporting information this plot is not especially meaningful. If this a PCA ordination (?), what parameters were included in the analysis, and how much variation do the two PCs describe? There is a lot more scatter in the wet season, what parameters are driving this (can parameters be overlayed as vectors if this is a PCA?). The high wet season scatter is important from a design perspective – more samples would be needed to detect impacts during the wet than the dry.	Please provide additional text to clarify.		This has been taken out - an additional figure (from the one shown by FRC (2016)) is not important to determining whether there are differences between seasons (i.e. that season is important).	Item Closed
7	5.2.1.3	Para 1. The inability to detect changes in water quality in response to tidal state (and other factors) most likely reflects the sampling approach (grab samples) and small sample size for different tidal treatments. Sampling throughout the tidal cycle (on multiple occasions at representative sites) would be needed to undertake a meaningful analysis of the effects of tidal stage on water quality. Notwithstanding this, Table 5-3 shows that overall numbers of samples collected were similar between flood and ebb tides, and that there is no bias for slack tide events. On this basis, it is agreed that Trigger Values are not biased.	Were in-situ logger measurements of turbidity, EC etc. collected? This will be more meaningful for detecting changes in water quality due to tides. See comment for 5.2.1.4	5.2.1.3	Have included a new section at the start of Section 5.2.1 as suggested.	Item Closed

Item	Section	Reviewer Comment	Reviewer Recommendation	Updated Report Section	Seafarms' Response	Item Status
8	5.2.1.4	Para 2. Related to comment in B2.1.3, the report correctly points out that variation in water quality is controlled by processes operating across a range of (nested) temporal scales, which confounds assessments of key drivers. Many more samples would be required to quantify the relative influence of the different drivers considered in this report, as well as others (e.g. wind state). As for s5.2.1.3, this is not considered a major issue noting that the intent here should be describing whether the baseline data have inherent biases.	Suggest that at the start of this Section 5.2.1: • acknowledge data limitations in terms of quantifying key drivers. • state that the focus of the report section is to consider the representativeness of data covering different environmental conditions, as appropriate for deriving Trigger Values.	5.2.1.4		Item Closed
9	5.2.2	It is agreed that dissolved metals/metalloids are more bioavailable than those strongly bound to sediment. However, there will be partitioning of metals/metalloids between particulate and dissolved phases, therefore the bioavailable fraction will likely vary in response to changes in other water quality parameters (e.g. salinity, pH). The two sampling events are not sufficient to characterise baseline conditions in metals/metalloids.	Suggest continuing to sample metals/metalloids – total and dissolved, to establish baseline conditions. See comment in S3.3 re. non-detects for dissolved metals/metalloids.	5.2.2	Section 5.2.2 has been adjusted to provide for the monitoring of total and dissolved metals as part of the baseline monitoring program and extending into the operational impact monitoring program. A specific comment regarding detection limits has been included in this section (ensure they are below the criteria where possible).	Item Closed
10	5.2.3.3	The arguments for not sampling benthic macroinvertebrate assemblages are not supported. • Agree physical processes/stressors will be a key control on benthic invertebrate assemblages (BIA), and that they will experience great flux in time and space. • While physical processes are the main control on BIA (at present), this does not mean they will be insensitive to changes in nutrient concentrations. • Agreed that the sampling program would need to be carefully designed to detect any changes in BIA due to nutrient increases. • The argument that nutrient uptake by invertebrates would be low because of low abundance of BIA (low abundance c.f. which estuaries?) is speculative. It is also unclear why this statement has been included – suggest delete.	It is recommended that a study (involving sampling of assemblages at multiple times before and during operations) be conducted to validate the impact predictions in the EIS (i.e. that changes in BIA in response to additional nutrients will be small relative to natural variability). This information can also be used as an additional line of evidence for validating water quality GVs (see Appendix A comments below).	5.2.3.3	While it is anticipated that the extreme physical processes would be the key driver of change and would likely substantially obscure or at least make it difficult to ascribe changes in the environment as caused by the Project, additional monitoring has been proposed as part of the baseline program in this section, with comparison post-operational discharge monitoring provided for as a comparison.	Item Closed
11	5.2.1.5	What was the statistical procedure used to test for log-normality, and p value? Did all parameters at all sites follow a log normal distribution?	Please clarify	5.2.1.5 5.5.5	As suggested in #14 below, an alternative BACI style approach has been adopted - one that is simple to implement, relatively robust but without the potential problems identified. Refer to Section 5.5 of the report, particularly Section 5.5.5. As discussed, more complicated models in this highly variable environment may be compromised by the complexity and difficulty in both applying the model, and in ascribing the source of variation (impact or natural). Note that a power analysis has been retained in the report to confirm that the existing baseline dataset is sufficient not just for the proposed analysis, but for more detailed statistical analysis (although this is not being recommended in the report).	Item Closed
12		Assumptions for parametric tests - Along with normality, parametric tests also have assumptions around the equality of variances between groups, and independence of errors etc. Have these been met?	Please clarify			
13		Further information on the power analysis is required, specifically:				

Item	Section	Reviewer Comment	Reviewer Recommendation	Updated Report Section	Seafarms' Response	Item Status
14		<u>1. The basis for the experimental design</u> It is understood that test site data will be compared to both (i) Alligator Creek Trigger Values (both seasonal and annual), which is derived from background data, and (ii) control site data using a BACI-style approach (two methods – a 'screening assessment' using regression based analysis, and ANOVA). The calculation of an appropriate sample size for the assessment of data against Trigger Values is computationally simple, and does not appear to rely on multi-factorial comparisons (i.e. Waterway, Sites, etc.). The experimental design used to calculate the sample size for the BACI-style approaches (using regression and/or ANOVA) is not clear and requires further explanation. Please clarify why a two-way nested design (Waterway + Time, Sites nested in Waterway) was adopted, and how this relates to design to be used in the impact detection framework presented in Figure D3-1. Specifically: • what did the term 'Waterway' encompass? Is this a Control v Impact comparison? • which sites were nested in each 'Waterway'? • what does the term 'Time' encompass? Aren't 'sampling events' being used as 'replicate' samples? Or is this a seasonal comparison? If it is a seasonal comparison, how is this relevant to the proposed management framework (will the comparison consider changes within seasons or are data pooled across seasons)? • was the effect size the same for each source of variation? Was the effect size consistent across all parameters? • are sample size estimates also applicable to the regression analysis based screening assessment? • what type of BACI design is proposed?	• For the assessment of monitoring data against Trigger Values, consider using standard industry (e.g. Qld Water Quality guidelines) and computationally simple methods for deriving: ◦ confidence intervals for Trigger Values ◦ error (precision) estimates at different sample sizes for Trigger Values. • For the comparison of test site data relative to natural variability: ◦ if parametric statistical analysis is to be used in a BACI-style framework, please describe the methods/software used to derive estimates of power. Describe the rationale for the experimental design (see review queries) and the effect size for relevant factors. ◦ perhaps consider alternative experimental designs to BACI, especially noting issues about potential wastewater effects on nominated 'control' sites (5.5.2.1).		The trigger values are based on the existing dataset, and will improve with further monitoring, with an expectation that more monitoring will improve precision. As noted for item 22, error estimates are provided for TVs.	
15		<u>2. What parameters were analysed?</u>	• Please clarify		Clarified in the text in Sections 5.2.1.5.	Item Closed
16		<u>3. This section will need to be re-reviewed based on responses to the above.</u>			Revised as noted above	Item Closed
17	5.2.1.6	Para 3 – a randomised design is supported, but will 'seasons' be assessed as a separate factor?	As for comments in 5.2.1.5, please describe the experimental design for the BACI tests.	5.2.1.5 5.5	The sample size assessment includes this information, however the design for the proposed assessment has been simplified as described for #11 above.	Item Closed
18		Para 4 – sampling of a standardised tidal phase during a 'sampling event' is supported.	If practicable, it is suggested that the order of site sampling is randomised among sampling events to reduce any systematic bias.		This suggestion has been incorporated into this statement.	Item Closed
19		Community Analysis Field sampling of mangrove vegetation condition and crab hole density is consistent with standard methods. Appendix A3 indicates that mangrove coverage will be assessed using remote sensing. It is suggested that remote sensing could also be used to map vegetation health – it is specific (directly measures plant health), highly accurate (can be applied from the individual tree scale to community scale), and cheaper/safer than traditional field-based measurements.	Consider the use of rapid remote sensing techniques.	5.2.3.4	Have changed this section to promoting remote sensing technologies. In fact, given the potential risks in sampling in this environment, the preferred approach is to undertake remote sensing assessment, with ground truthing required only where potential impacts are identified and ground based assessment is warranted, or otherwise on a 5-yearly frequency to ground truth results.	Item Closed
20	5.2.3.4	Stable Isotope Analysis This indicator measures nutrient cycling processes, which is element of biodiversity as important population/community patterns (e.g. diversity, abundance, etc.). It is an additional line of evidence for assessing potential impact to the aquatic ecosystem and validating Trigger Values. This section seems to imply that N stable isotope analysis may not be appropriate for measuring discharge impacts at the site. Most coastal systems are thought to be nitrogen limited, is there evidence to suggest that this is not the case here?	Consider incorporating isotope analysis as an additional line of evidence for assessing spatial extent of discharge impacts. Note that last sentence in the second last paragraph is incomplete.	5.2.3.4	Refer to the above (#19) - this section supports the use of the FRC (2016) methods which included dN signatures during ground based assessment.	Item Closed

Item	Section	Reviewer Comment	Reviewer Recommendation	Updated Report Section	Seafarms' Response	Item Status
21	5.3	EVs are defined by the community.	If EVs have not been formally determined by the community, perhaps state that all Northern Territory Beneficial Uses relevant to marine waters have been conservatively applied here.	5.3	Have reworded as suggested.	Item Closed
22	5.4	Error estimates should be provided for TVs	Suggest applying the methodology in QWQG for deriving error estimates for TVs (mean +/- 1 S.E.).	5.4	Error estimates based on the QWQG (based on 2 sites) are now in table.	Item Closed
23		What is ND3 in Table B4-1.	Please clarify		This should have read ND with a note (3), although it should actually be note '2' (ND = Non-detects (% of)). This has been rectified.	Item Closed
24	5.5.2.1	If a site is potentially affected by the activity being monitored, it is not valid to call it a 'control'.	In addition to Turtle Point, additional control sites unaffected by discharges are required if comparisons to background conditions using a BACI design are proposed during operation.	5.5.2.1	Further analysis and assessment has been included, finding that the results of conservative modelling indicate no impact, and certainly no detectable change within the Keep River sites for water quality. These sites are retained as control sites for the experimental design.	Item Closed
25	5.5.3.1	The use of regression analysis to identify potential impacts requires elaboration and justification. Is the premise of this test that water quality at control and test sites will behave the same under natural conditions, and that a departure from this relationship indicates a potential impact? The plots in Fig 5-12 suggest there is a degree of autocorrelation between some sites for some parameters, but there are also major departures under natural conditions, resulting in false positives. What is the r2 value for these tests, and are the relationships statistically significant?	Please provide citations regarding this method and provide additional text addressing the comments.	5.5.5	The methodology has been refined and simplified, with control charting as per or similar to the AWQG approach. Note this section is now 5.5.5.	Item Closed
26	5.5.3.2	The basis for the statement that parametric tests (ANOVA) provide a more powerful test than PERMANOVA requires justification. If most of the baseline 'control' sites will not represent true control sites once operational, a BACI-style design is not appropriate.	Please clarify Either add additional controls or reconsider the use of a BACI-style design.	5.5.5	This was a general statement that parametric tests 'generally' provide more statistical power than non-parametric tests. However, based on other comments in this list, the experimental design and analysis has been clarified and simplified - this item is no longer relevant as such. Refer to the response to item 11.	Item Closed
27	Appendix A of Draft WQMMP	It is not clear how the biological indicators will be integrated into the decision-making process. The program essentially follows a multiple lines of evidence (LOE) approach to assess discharge impacts, without explicitly saying so. The LOE approach is industry best practice for water quality (and sediment) management frameworks. LOEs are considered collectively to determine whether there is evidence of changes, and on this basis, either refine water quality objectives and/or the need for alternate management strategies. The biological indicators do not consider impacts to benthic fauna or nutrient cycling processes, which are gaps (see comments in sections 5.2.3.3, 5.2.3.4). It is unclear whether the BACI design will be done quarterly or only if Trigger Values are exceeded.	It is not clear how the sediment and biological data collection links with decision making process. The decision tree could be updated by linking the "2 yearly data collection" indicators to the "Update Trigger Values..." box in Fig A-1, thereby providing a feedback loop to validate the Trigger Values. Consideration should also be given to adjusting the sampling interval for the "2 yearly data collection" indicators, subject to project staging, results from initial monitoring assessments, and likely response timeframes of indicators. Surveys of mangrove health for example may be appropriate every 2 years, but less regularly for benthic fauna (e.g. every 5-6 years) if impacts are as predicted in the WQMMP.	Appendix A of Draft WQMMP	Section 6.3.1 now includes a section explicitly stating the use of the MLOE approach. Changes to frequency - this is included in regular reviews requirements, and feedback mechanisms in Figure A1-1 (for more frequent monitoring).	Item Closed

Item	Section	Reviewer Comment	Reviewer Recommendation	Updated Report Section	Seafarms' Response	Item Status
28	Appendix A3	How were discharge criteria for chlorophyll derived?	Please describe	5.4.2 Appendix A3 of Draft WQMMP	Refer to Section 5.4.2 of the supporting report, which states: 'The discharge criteria were defined using data collected at existing prawn farms operated by Seafarms, and the EIS impact assessment was based on this data and background levels based on the baseline data available at the time' The discharge criteria are achievable based on similar operations, and shown to not cause an unacceptable impact in the EIS impact assessment modelling.	Item Closed
29		NOX and other nutrient species. Measuring TN and TP does not provide information on bioavailable nutrient species.	Suggest undertaking analysis of nutrient species as part of routine monitoring.		Nutrient species have been included in the monitoring program	Item Closed

Table 2 EPBC permit conditions relevant to the WQMMP, and review findings

Permit Condition Requirement	Relevant Section	Findings
a) explain how the WQMMP will protect the receiving environment from wastewater discharges, including the functional relationship between monitoring objectives, activities and operational decisions	Section 2, 4 and Appendix A	Satisfies requirements The aim and objectives of the WQMMP, together with unpinning targets and Key Performance Indicators, are articulated in Section 2 and specifically Table 2-1. The activities potentially affecting receiving environment water quality are summarised in Section 4 of the WQMMP. Appendix A1 describes in detail links between aims, objectives and mitigation measures, within a traditional EMP framework. This is consistent with standard practice and satisfies the permit condition requirement.
b) define the chemical, physical and biological parameters to be monitored in the receiving environment, including during the minimum 12 month period of baseline water quality monitoring, and justify the parameters to be monitored	Appendix A Section 4.3 of the Supporting Report	Satisfies requirements Parameters to be measured are summarised in Appendix A and described in Section 4.3. The Stage 1 review of the Draft WQMMP raised several queries regarding the justification for the selected parameters. In response, the proponent has added a new section (Section 4.2) to the Supporting Report to link project activities and risks issues with the selected indicators. The issues raised in the Stage 1 are now closed. The minimum 12-month monitoring period to characterise baseline water quality conditions was met or exceeded for most sites. It is noted that sampling was discontinued at several sites. A few small wording issues in Table 4-1: • TN, TP, total metals, TPH/TRH – these are concentrations not loads • chlorophyll <i>a</i> concentration – is a measure of biomass not productivity • herbicide/pesticide spill – this implies OP/OC pesticides will be used during operations, which may be erroneous? These chemicals are not listed in Section 4.2.
c) modify and/or confirm the wastewater quality parameter limits in condition 1 (a) and the wastewater release regime in condition 1 (c)	Appendix A3	Satisfies requirements Table 1A and Appendix A3 confirms that the mean and maximum limits for wastewater stipulated in Condition 1a, and discharge volumes stipulated in Condition 1b, have been adopted in the WQMMP. Additional discharge criteria have been added including chlorophyll <i>a</i>, visual and odour, which are based on NT government permit conditions and are appropriate in the context of the Project.
d) include a methodology to:		
i. monitor water quality parameters in condition 1 (a) during both baseline data collection and operations and measure discharge volumes in condition 1 (b)	Appendix A and B	Satisfies requirements The WQMMP clearly describes the sampling, analysis and reporting methodology for water quality, sediment quality, flow and biological monitoring components. Appendix B also provides standard operating procedures for sampling of water quality parameters by field operatives. Standard operating procedures for other parameters, such as sediment quality and biological indicators, are not provided in the WQMMP. This is not a specific requirement of this permit condition. Appendix A3 specifies that sediment sampling procedures must be undertaken in accordance with AS/NZS 5667.12 – Water quality—Sampling, Part 12: Guidance on sampling of bottom sediments, which is supported by the reviewer. Appendix A3 also specifies that ecological assessments should be conducted using methods comparable to those used in the EIS. This is not strictly true, noting that mangrove monitoring will be conducted using remote-sensing (Table 4-1 of the Supporting Report), which was not undertaken in the EIS. Appendix A3 also indicates mangrove health will be assessed using satellite or aerial imagery; it is suggested that Appendix A3 explicitly mentions multispectral imagery and/or generation of NDVI metrics (rather than just assessing aerial extents etc.) for consistency with Table 4-1 of the Supporting Report. Section 5.5 of the Supporting Report provides a commitment to review the results of the monitoring program as part of a ‘2 year post operational validation study’. This approach is supported and is consistent with requirements set out in Permit Condition 1(e). It is suggested however that prior to this 2-year review that the initial results of the biological sampling program be reviewed to assess the appropriateness of the sampling methods, sample unit size, and sample size. For example, the benthic macroinvertebrate sampling conducted in the EIS indicates that assemblages

Permit Condition Requirement	Relevant Section	Findings
		were highly heterogenous, suggesting the need for a larger sample unit size (e.g. larger benthic grab size) and/or larger sample size (i.e. more replicate samples) to account for this small-scale (within site) variability.
ii. develop site-specific water quality objectives and seasonal trigger values for water quality parameters identified in condition 1 (a) and 2 (b)	Appendix A3	Satisfies requirements Table 5-5 of the of the Supporting Report presents seasonal and annual trigger values derived from baseline water quality data for chlorophyll <i>a</i>, TN, TP, TSS and turbidity. The parameter set for trigger value setting is considered appropriate. The trigger values were based on the average 80th percentile value from reference sites, consistent with best practice methods for physio-chemical stressors in National (ANZECC/ARMCANZ 2000) and Queensland (DEHP 2009) water quality guidelines.
iii. modify and/or confirm the wastewater quality parameter limits specified in condition 1 (a) are appropriate relative to the trigger values developed under condition 2 (d)(ii)	Appendix A3 Section 5.4.2 Supporting Report	Satisfies requirements Table 1A and Appendix A3 confirms that the mean and maximum limits for wastewater stipulated in Condition 1 (a), and discharge volumes stipulated in Condition 1 (b), have been adopted in the WQMMP. Additional discharge criteria have been added including chlorophyll <i>a</i>, visual and odour, which are based on NT government permit conditions and are appropriate in the context of the Project. Water quality modelling was undertaken in the EIS to assess receiving environment water quality using the discharge criteria set out in Condition 1 (a). These results are presented in Section 5.4.2 of the Supporting Report, and incorporate additional baseline data collected post EIS. The modelling results predict highly localised increases to nutrients and chlorophyll concentrations within a 200 m (exclusion zone boundary) mixing zone. The modelled concentrations were typically (but not always) less than the trigger values adopted under condition 1 (a), suggesting that the discharge criteria were appropriate. Modelling provides a useful tool for exploring changes to water quality under a range of discharge scenarios and climatic conditions. However, all models have limitations - in this instance, a passive tracer was used, which does not model biogeochemical nutrient cycling processes. This can lead to conservative model results, as acknowledged in the WQMMP. Modelling results are also only representative of the environmental/climatic conditions of the modelled time periods, which are unlikely to capture the range of environmental conditions that will occur during operation. It is therefore important that field sampling is conducted over appropriate timescales to confirm the appropriateness (or otherwise) of the wastewater quality discharge limits and trigger values. In the context of the above, the WQMMP is based on an adaptive management framework that incorporates multiple lines of evidence (physio-chemical and biological indicators) to assess the need or otherwise to modify trigger values, discharge criteria (volumes, quality) and/or farm controls to protect environmental values in receiving environments (refer to Figure A1-1). Such an approach is supported by the reviewer – see comments in the Stage 1 review.
iv. modify and/or confirm the wastewater release regime specified in condition 1 (c) in accordance with the Guidelines for Fresh and Marine Water Quality	Appendix A3 Section 5.4.2 Supporting Report	Satisfies requirements Refer to comments for Condition 1 (d)(iii)
e) include a data handling program and' commitments to technical review and evaluation of the WOMMP	Section 5.5 Supporting Report	Satisfies requirements Section 5.5 of the Supporting Report provides a commitment to review the results of the monitoring program as part of a '2 year post operational validation study'.
f) identify and manage the risks of the WQMMP failing to achieve its objectives	Section 4 and Table B1-1 and B1-2 of the Supporting Report	Satisfies requirements Table B1-1 and B1-2 provide a risk assessment for water quality impacts during the construction and operational stages, respectively. The risk assessment is consistent with standard practice, and risk ratings are sound. Section 4.2.2. of the supporting report summarises the results of case-studies on the effects of prawn farm discharges in north Queensland, which suggest highly localised effects to aquatic ecosystems. The reviewer agrees that that tropical estuaries can have high assimilative and/or flushing capacity, and this also applies to the receiving environments of the Project. However, baseline results show that chlorophyll <i>a</i> at Alligator Creek frequently exceeded 5 µg/L, indicating phytoplankton biomass can be periodically elevated. This does not support the argument presented in pg10 that turbidity always 'strongly' limits phytoplankton biomass.

Permit Condition Requirement	Relevant Section	Findings
		Notwithstanding this, if properly implemented, the proposed controls provide a sound basis for detecting and managing water quality impacts before they lead to environmental impacts. The final paragraph on pg10 requires editing (typographical errors, multiple entries of “very”).
g) describe contingency responses where management triggers are exceeded, and effective corrective actions which may be implemented.	Appendix A1, Supporting Report, and Figure A1-1	Satisfies requirements The contingency responses and actions are clearly articulated.