Northern Territory Environment Protection Authority

ASSESSMENT REPORT 80

PROJECT SEA DRAGON STAGE 1 LEGUNE GROW-OUT FACILITY
PROJECT SEA DRAGON PTY LTD

March 2017

Environmental Impact Assessment Process Timelines

Date	Progress stage
15/07/2015	Receipt of Notice of Intent
14/09/2015	NT EPA decision Environmental Impact Statement required
07/10/2015	Draft Terms of Reference (ToR) released for public comment
06/11/2015	Final ToR issued to Proponent
08/10/2016	Draft EIS released for public comment
09/12/2016	NT EPA direction to prepare EIS Supplement issued
08/02/2017	EIS Supplement received
15/03/2017	Assessment Report issued

Dr Paul Vogel
Chairman

15 March 2017

Northern Territory Environment Protection Authority
GPO Box 3675
Darwin
Northern Territory 0801

Important Disclaimer

This document has been prepared with all due diligence and care, based on the best available information at the time of publication. Any decisions made by other parties based on this document are solely the responsibility of those parties.

The Northern Territory Environment Protection Authority and Northern Territory of Australia do not warrant that this publication, or any part of it, is correct or complete. To the extent permitted by law, the Northern Territory Environment Protection Authority and Northern Territory of Australia (including their employees and agents) exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and other compensation, arising directly or indirectly from using, in part or in whole, any information or material contained in this publication.

Contents

Abbreviations and Glossary

AAPA	Aboriginal Areas Protection Authority
Advisory bodies	Agencies having administrative responsibilities in respect of the proposed action
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ASX	Australian Stock Exchange
AWQG	Australian Water Quality Guidelines (ANZECC & ARMCANZ 2000)
Draft EIS	Draft Environmental Impact Statement
DPIR	Department of Primary Industry and Resources
EA Act	*Environmental Assessment Act*
EAAP	Environmental Assessment Administrative Procedures
EIA	Environmental impact assessment
EIS	Environmental Impact Statement
EMP	Environmental management plan
Environment	All aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects (Section 3 of the *Environmental Assessment Act*)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cmth)
EPZ	Environmental Protection Zone
EPA	Environment Protection Approval under the *Waste Management and Pollution Control Act*
EPL	Environment Protection Licence under the *Waste Management and Pollution Control Act*
FDC	Farm discharge channel
FFC	Farm feeder channel
FTE	Fulltime equivalent
FWC	Freshwater channel
IFRP	Internal farm recycling pond
K_{SAT}	Saturated hydraulic conductivity
MDC	Main discharge channel
MNES	Matters of National Environmental Significance
NLC	Northern Land Council

NOI	Notice of Intent
NT EPA	Northern Territory Environment Protection Authority
PDC	Pond discharge channel
PFC	Pond feeder channel
Responsible Minister	Northern Territory Minister for Primary Industry and Resources
The Minister	Minister for the Environment and Natural Resources
The Project	Project Sea Dragon Stage 1 Legune Grow-out Facility
The Proponent	Project Sea Dragon Pty Ltd
The Supplement	The Supplement to the draft EIS
the/this Report	This Assessment Report 80, for the Project Sea Dragon Stage 1 Legune Grow-out Facility
VRD	Victoria River District
WMPC Act	*Waste Management and Pollution Control Act*

Units and Symbols

%	percent
>/<	greater than/less than
GL	Gigalitre (1 x 10^9 litres)
ha	hectare
km	kilometre
L	litres
m	metre
m/s	metres per second
m^3/s	cubic metres per second
µg/L	micrograms per litre
mg/L	milligrams per litre
ML	Megalitre
mm	millimetre
N	Nitrogen
P	Phosphorus
TSS	Total suspended solids

Summary and Recommendations

Environmental impact assessment (EIA) is a process for identifying the potential environmental impacts and risks of a proposed action, evaluating the significance of those impacts and risks and determining appropriate avoidance, minimisation/mitigation and offset measures to reduce those impacts and risks to acceptable levels. This Assessment Report (the Report) examines the EIA for the Stage 1 Legune Grow-out Facility, proposed by Project Sea Dragon Pty Ltd (the Proponent).

The Proponent proposes to develop and operate stage 1 of a prawn aquaculture grow-out facility at Legune Station, approximately 106 km north-east of Kununurra near the Northern Territory / Western Australia border (the Project). The Project consists of three farms with 1120 ha total area of land-based ponds, 324 ha of internal recycling ponds, approximately 500 ha of settlement/treatment area, producing nominally 14 000 tonnes of prawns per annum. The total footprint of the Project is approximately 3861 ha.

The Northern Territory Environment Protection Authority (NT EPA) has produced this Report as advice to the Northern Territory Ministers for Environment and Natural Resources (the Minister) and Primary Industry and Resources (the responsible Minister) to be taken into account in decisions made by the Northern Territory Government. The responsible Minister, taking into consideration this Report, will decide whether to grant an aquaculture licence for the construction and operation of the Project under the *Fisheries Act* and if so, the conditions that may be applied. This Report provides advice and recommendations; it does not provide an environmental approval.

The NT EPA decided that the Project required assessment at the level of an Environmental Impact Statement (EIS) under the Environmental Assessment Act (EA Act). The NT EPA initially identified the following potential impacts and risks that contributed to the decision to assess the Project at the level of an EIS:

- potential to impact on threatened, marine and migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Territory Parks and Wildlife Conservation Act*
- potential to impact on the Legune coastal floodplain site of conservation significance, which is host to migratory birdlife aggregations of international significance, and includes Turtle Point, a highly significant nesting beach for the flatback turtle
- potential impacts from the discharge of waste from the prawn farming activities into receiving waters considered to be of high environmental value
- the significant management requirements for solid and liquid waste and the potential detrimental effects of inappropriate management practices
- potential impacts on the local amenity and the environment from unauthorised third-party access to the area for recreational fishing, camping and hunting
- the potential impacts of predation by birds on prawn stock held in ponds, both on the project feasibility and on bird aggregations
- potential economic, social and cultural impacts on the region and the Northern Territory, both positive and negative, including the risks of the project not realising its projected economic and social benefit.

The Project was determined to be a controlled action under the EPBC Act on 31 August 2015 as it was considered likely to have significant impacts on the following matters of national environmental significance protected under Part 3 of the EPBC Act:

- Listed threatened species (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A).

The assessment was conducted under the bilateral agreement between the Commonwealth and Northern Territory Governments for EIA under the EPBC Act.

Information requirements based on potential environmental impacts and risks were described in the final Terms of Reference for the Project and the Proponent submitted its draft EIS to address these requirements. The Proponent prepared a Supplement to the draft EIS to address respondents' issues and concerns following public review of the draft EIS.

In making this Report, the NT EPA had regard to the information provided by the Proponent, submissions on the draft EIS and Supplement, advice from specialists in government agencies and the NT EPA's appointed independent experts, and relevant guidelines and standards. The NT EPA assessed the Project against the NT EPA's objectives for the key environmental values of: water quality in marine, estuarine and freshwater systems; freshwater aquatic, floodplain and estuarine ecosystems; waterbird aggregations; matters of National Environmental Significance under the EPBC Act; and cultural and spiritual values of marine and estuarine waters, fresh waters and floodplains, including ecosystems and biota.

While the NT EPA considers the potential impacts and risks have been adequately identified and are relatively well-understood, there is inherent uncertainty in predicting with any great precision the magnitude of impacts in impact assessment due to limitations of numerical models and the complexity and variability of natural systems. In such situations, it is important to acknowledge that uncertainty remains and manage this with suitably robust monitoring and management frameworks that can respond with appropriate mitigation and contingency measures and can accommodate new knowledge and understanding as it becomes available.

The NT EPA acknowledges some uncertainty with respect to the nature and extent of a number of potential impacts, including:

- the area of influence and potential impacts of prawn pond effluent discharge on water quality in Alligator Creek
- the potential impacts to significant waterbird aggregations from alterations to the hydrology of the Legune floodplain, particularly through the proposed cessation of Dry season flows from Forsyth Dam.

These uncertainties are largely due to the high variability in aspects of the receiving environment including the macro-tidal waters of the estuary and the transient nature of avifauna populations in freshwater habitats at Legune, and a lack of understanding of this variability and the likely response of the environment to threats and change. Such variability presents challenges for baseline data collection, impact prediction, monitoring and management.

The Proponent has committed to continuing data collection prior to Project commencement and operation, to develop a significant baseline dataset and build its understanding of background conditions in the receiving environment of the Project area. The baseline dataset will form the basis of comprehensive monitoring and mitigation programs that will underpin environmental management of the site.

The NT EPA has made recommendations in this Report for review of water quality information and monitoring programs, and the establishment of a scientific advisory group for development of a waterbird monitoring and mitigation program. The recommendations, if incorporated into relevant conditions and actioned by the Proponent, should see acceptable environmental outcomes for the environmental values at Legune.

Notwithstanding the above, the NT EPA considers that the Project can be managed in a manner that is highly likely to meet the NT EPA's objectives and avoids significant or unacceptable environmental impacts. The NT EPA makes 13 recommendations as an outcome of the EIA of the Project. These recommendations are for the Proponent to address and decision-makers to consider when entering into the next stage of the Northern Territory and Commonwealth approval processes and for the implementation of the proposed action. The NT EPA considers it essential that the commitments, safeguards and recommendations detailed in the final EIS, this Report, and in the final environmental management plan and underlying strategies, approved by the NT EPA and the Agency responsible for administering the *Fisheries Act*, are implemented and subject to regular reporting and compliance auditing.

List of Recommendations

Recommendation 1

The Proponent shall ensure that the Stage 1 Legune Grow-out Facility is implemented in accordance with all environmental commitments and safeguards:

- **identified in the Environmental Impact Statement for the Stage 1 Legune 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.

Recommendation 2

The Proponent shall provide written notice to the Northern Territory Environment Protection Authority and the responsible Minister if it alters the Stage 1 Legune Grow-out Facility in such a manner that the environmental significance of the action may have changed, in accordance with clause 14A of the Environmental Assessment Administrative Procedures.

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.

Recommendation 4

The EPZ shall be designed, constructed and operated to:

- **ensure that infiltration is minimised, with reference to specific design standards/criteria for aquaculture containment structures**
- **maximise the utility of the structures for achieving consistent removal of nutrients and suspended solids**
- **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**
- **increase mixing and dispersion in the receiving environment and otherwise avoid the likelihood of visual discharge plumes from the discharge point.**

Recommendation 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.

Recommendation 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.

Recommendation 7

To the extent practicable and achievable within the requirements of the *Pastoral Land Act*, the Proponent shall reduce the herd size at Legune Station to reduce cumulative impacts of water quality on the Keep River estuary.

Recommendation 8

The Proponent shall undertake additional geotechnical testing and a pre-construction soil monitoring program to differentiate suitable construction materials from problematic soils prior to commencement of farm and channel works.

Ponds and channels shall be designed by a registered professional engineer and construction works shall be undertaken under the supervision of an appropriately qualified geotechnical engineer.

Recommendation 9

A monitoring and mitigation program addressing potential impacts from bird predation management measures to non-target waterbird species shall be developed to the satisfaction of the DENR, and with advice from a scientific advisory group established in accordance with Recommendation 10 of this Report. The program should include consideration of impacts from operational use of helicopters as well as their use as a control option.

Recommendation 10

A scientific advisory group (SAG) shall be established to advise on matters relating to waterbirds potentially impacted by the Project, in particular the development and implementation of a waterbird monitoring and mitigation program. The SAG shall be formed on the advice and agreement of the Department of Environment and Natural Resources, the Commonwealth Department of the Environment and Energy, and the Proponent.

A Terms of Reference for the SAG shall be developed to the satisfaction of the NT EPA and agreed by the aforementioned parties. Details regarding the establishment of the SAG, including roles and responsibilities, membership (including an independent chair), timeframe for commencement and scope, reporting obligations and accountability should be decided within three months of the environmental impact assessment completion date.

Recommendation 11

The Proponent shall prepare and implement a waterbird monitoring and mitigation program to the satisfaction of the Department of Environment and Natural Resources, the Commonwealth Department of the Environment and Energy, based on advice of the scientific advisory group (SAG). The program will be designed with sufficient statistical power to monitor potential impacts to waterbirds from:

- **cessation of flows to wetlands from Forsyth Dam**
- **other sources as the SAG sees fit.**

The program shall include management measures and appropriate contingencies in the event that monitoring detects impacts attributable to the Project.

The Proponent shall make the program publicly available and include annual reporting on the implementation of the program to key stakeholders and the public.

Recommendation 12

The Proponent shall develop a decommissioning and rehabilitation plan for the Project site within one year of commencement of Project works. In developing the plan, an appropriate post-closure land use should be agreed with key stakeholders.

The decommissioning and rehabilitation plan will be adapted during Project operations to take account of results from rehabilitation trials to be established by the Proponent on the Project site within the one year period.

Recommendation 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.

In preparing the Environmental Management Plan, for construction and operation, the Proponent should include any additional measures for environmental protection and monitoring contained in this Assessment Report 80.

The Environmental Management Plan should include management strategies for:

- **acid sulfate soils**
- **air and noise pollution**
- **bushfires**
- **cultural heritage**
- **effluent**
- **erosion and sediment control**
- **fauna**
- **groundwater**
- **hazardous materials**
- **land and soils**
- **social impact**
- **surface water**
- **traffic**
- **vegetation**
- **waste**
- **weeds and pests.**

The Proponent shall provide public access to the Environmental Management Plan and a reporting mechanism to inform compliance with the plans. An independent audit of compliance against the Environmental Management Plan shall be conducted at the end of five years after commencement of the Project and reported to the NT EPA and DPIR.

1 Introduction

Project Sea Dragon Pty Ltd (the Proponent), proposes to develop and operate the Stage 1 Legune Grow-out Facility at Legune Station, a prawn aquaculture production system approximately 106 km north-east of Kununurra near the Northern Territory / Western Australia border (the Project). The Project has been assessed by the Northern Territory Environment Protection Authority (NT EPA) at the level of Environmental Impact Statement (EIS) under the *Environmental Assessment Act* (EA Act).

The NT EPA has prepared this Assessment Report (this Report) in accordance with section 7(2)(g) of the EA Act and clause 14(3) of the Environmental Assessment Administrative Procedures (EAAP). The purpose of this Report is to ensure that matters affecting the environment to a significant extent are fully examined and reported. This Report is provided to the Northern Territory Minister for the Environment and Natural Resources (the Minister) and the Minister for Primary Industry and Resources (the responsible Minister) to be taken into account in decisions made by the Territory Government, and the Commonwealth Minister for the Environment and Energy to inform an approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is not intended to provide an environmental approval.

1.1 Environmental impact assessment process

Environmental Impact Assessment (EIA) is the process for identifying the potential environmental impacts and risks of a proposed action, evaluating the significance of those impacts and risks and determining appropriate avoidance, minimisation/mitigation and offset measures to reduce those impacts and risks to acceptable levels. The main purpose of the EIA is to inform decision-makers of the potential impacts and risks of a proposed action before any decisions are made and to engage and inform the public in the EIA process.

Through the assessment of the potential environmental impacts and risks of the Project, the Proponent must demonstrate:

- the potential impacts and risks can be satisfactorily managed within acceptable levels, e.g. impacts would not result in significant long-term or irreversible environmental detriment
- the effectiveness/feasibility of management measures in a precautionary/risk management framework
- that the assessment gives weighted consideration to:
    - values, potential impacts and risks
    - the likelihood of success of preventative actions and remedial measures
    - the validity and comprehensiveness of programs established to provide ongoing measures of the environmental effects of the Project.

The assessment of potential impacts and risks can be more reliably evaluated where there is a substantial baseline of relevant information. Where this information is limited or not available, assessment is inevitably constrained and less precise. In the absence of sufficient baseline information, and in keeping with the objectives of the *Northern*

Territory Environment Protection Authority Act to promote ecologically sustainable development, the NT EPA adopts the precautionary principle.[1] If potential impacts are understood with a reasonable level of certainty and are acceptable, monitoring programs can be better informed to detect impacts, and adaptive management measures can be more effectively targeted to limit impacts to predicted levels.

The legislation establishing the framework to undertake the EIA process in the Northern Territory are the EA Act and the EPBC Act, when a proposed action is considered likely to have a significant impact on matters of national environmental significance (MNES). These Acts are administered by the NT EPA and the Commonwealth Minister for the Environment and Energy (the Commonwealth Minister), respectively.

1.2 Environmental impact assessment chronology

The Northern Territory Environment Protection Authority (NT EPA) received notification under the EA Act of the Project on 15 July 2015 and decided that the Project required assessment at the level of an EIS on 14 September 2015.

The Project was determined to be a controlled action under the EPBC Act on 31 August 2015 as it was considered likely to have significant impacts on the following MNES protected under Part 3 of the EPBC Act:

- Listed threatened species (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A).

The assessment was conducted under the bilateral agreement between the Commonwealth and Northern Territory Governments for EIA under the EPBC Act.

The NT EPA issued the final Terms of Reference and directed the Proponent to prepare its draft EIS on 6 November 2015.

The draft EIS for the Project underwent an eight week public exhibition period commencing 8 October 2016. The EIS documentation is available on the NT EPA website.

Ten submissions on the draft EIS were received from Government agencies and five from interested persons and organisations. All submissions were individually forwarded to the Proponent as they were received.

On 9 December 2016, the delegate of the NT EPA directed the Proponent to produce a Supplement to the draft EIS to take account of the written public comments. The Supplement becomes part of the draft EIS it supplements and is collectively referred to as the EIS. The NT EPA received the Supplement on 8 February 2017.

The making of this Report and providing it to the Minister marks the completion of the examination of the EIS by the NT EPA. The EIA chronology and EIS, and supporting

[1] Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:
(a) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment
(b) an assessment of the risk-weighted consequences of various options.

documents, can be viewed on the Stage 1 Legune Grow-out project page on the NT EPA website at:

https://ntepa.nt.gov.au/environmental-assessments/register/sea-dragon-legune-growout.

1.3 Approval and regulatory framework

The Project will require approval and regulation by the Northern Territory and Commonwealth Governments. The framework for approval and regulation of the Project is provided at Volume 1, Chapter 6 of the draft EIS and is summarised below, with an emphasis on the obligations and requirements of the Northern Territory Government.

The NT EPA provides this Report to the Minister. The Minister is required to give a copy of this Report to the responsible Minister, together with any written comments made by the Minister in relation to this Report. The Minister has reporting obligations to the NT EPA under section 8B of the EA Act, if the Minister makes a written comment in relation to this Report.

The responsible Minister, taking into consideration this Report, will then decide whether to grant an aquaculture licence for the Project under the *Fisheries Act* and if so, the conditions that may be applied. The *Fisheries Act* is the primary legislation for the construction and operation of an aquaculture facility in the Northern Territory. Section 8A(2) of the EA Act requires the responsible Minister to give the NT EPA notice of the decision as soon as practicable, but within seven days, after making the decision. Alternatively, if the decision by the responsible Minister is contrary to this Report, the responsible Minister must comply with reporting obligations to the NT EPA and the Legislative Assembly in accordance with section 8A(3) of the EA Act.

1.3.1 Scope of the assessment

The NT EPA assessed the potentially significant environmental impacts and risks associated with the construction, operation and decommissioning of the grow-out facility at Legune Station, in accordance with requirements under the EA Act.

The matters relating to the environment the NT EPA considered necessary to be dealt with in the EIS for the Project were identified in the Terms of Reference (NT EPA, 2015) in accordance with clause 8(3) to (6) of the Environmental Assessment Administrative Procedures.

The Project referred to the NT EPA included reference to future stages in an expansion that is proposed but undefined. This Project assessment does not include an assessment of any future expansion; it applies only to stage 1 of the Project proposed for the Northern Territory. Furthermore, the assessment does not include consideration of those issues that are relevant solely to Western Australia, nor does it include the core breeding centre and broodstock maturation centre proposed for Point Ceylon, Bynoe Harbour, a hatchery, processing facility or export facilities. These components are being or will be assessed by the NT EPA or other government jurisdictions in accordance with legislated requirements.

1.3.2 Key regulatory instruments

NT Fisheries Act

The NT *Fisheries Act* provides for the regulation, conservation and management of fisheries and fishery resources so as to maintain their sustainable utilisation. The Proponent requires an aquaculture licence to operate the grow-out facility on Legune Station. An Environmental Management Plan (EMP) is required as part of the application process and the operation of the farm must be in accordance with the approved EMP. While a broad range of aspects can be addressed in the EMP, the *Fisheries Act* regulates only those aspects of the environment directly associated with the activities

related to aquaculture. The Department of Primary Industry and Resources (DPIR) administers the *Fisheries Act*.

Waste Management and Pollution Control Act

The activity proposed is regulated under the *Waste Management and Pollution Control Act* (WMPC Act), which is administered by the NT EPA. Activities that require environment protection approval include "Constructing, installing or carrying out works in relation to premises, other than sewage treatment plants, for the storage, re-cycling, treatment or disposal of listed wastes on a commercial or fee for service basis." Listed wastes as defined under Schedule 2 of the *Waste Management and Pollution Control (Administration) Regulations* generated by the Project may include:

- Prawn pond sediment and detritus, and filtration waste
- Prawn effluent and residues including water and soil contaminated with the animal "residue" – prawn faeces, prawn moult etc.

The Proponent may require an approval/licence under the WMPC Act for the following activities on the site:

- the construction and operation of a landfill
- the construction of a dedicated area to store and treat pond sludge, which contains prawn effluent, prawn detritus and dead prawns
- the operation of an area for the collection of waste oils, tyres and used lead acid batteries
- the discharge (or flow through) of aquaculture pond water through an environment protection zone into the Keep River system.

The Proponent will be required to apply for:

a) an environment protection approval (EPA) for the construction of the project potentially including pond waste storage facilities, land fill and waste transfer stations

b) an environment protection licence (EPL) for the ongoing operation of the facility with respect to the management of listed wastes.

Should an EPL be required for the Project, regulation of the waste water discharge will be included. Therefore, a waste discharge licence under the *Water Act* is unlikely to be required for the Project.

Where an EPL is required, the WMPC Act includes provision for a financial assurance where it can be justified by the degree of risk of waste discharge causing environmental harm.

Pastoral Land Act

NT Portions 798 and 3222 are currently subject to Perpetual Pastoral Lease 1062 with the lease holder being Legune Land Pty Ltd. The lease is subject to the conditions and reservations set out in sections 38 and 39 of the *Pastoral Land Act*.

The Pastoral Land Act provides for the administration, management and conservation of pastoral land with the Pastoral Land Board the statutory authority charged with the administration of pastoral leases in accordance with the Act. Under the *Pastoral Land Act*, formal approval is required from the Pastoral Land Board before undertaking vegetation clearing on a pastoral lease and under Section 85A, the Board may permit non-pastoral use on the lease in consideration of other relevant legislative requirements. The Proponent requires a non-pastoral use permit which would allow the use of part of the Legune Station pastoral lease for a non-pastoral purpose (i.e. aquaculture).

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth of Australia)

The Project requires approval under the EPBC Act from the Commonwealth Minister before it can proceed. The EIA process includes an assessment of whether the potential impacts of the controlled action on MNES are likely to be acceptable, and an assessment of any significant residual impacts of the Project, including any offsets if required. This Report is provided to the Commonwealth Minister or delegate for consideration in any approval conditions under the EPBC Act.

2 Project

2.1 Proponent

The project proponent is Project Sea Dragon Pty Ltd (the Proponent), a wholly owned subsidiary of Seafarms Group Limited (Seafarms). Seafarms is an Australian Stock Exchange (ASX) listed company holding separate subsidiary companies each operating in emerging, non-conventional commodities areas - aquaculture, carbon and environmental offsets. The companies are Seafarms Operations Limited, Seafarms Queensland Pty Ltd and CO2 Australia Limited.

Seafarms is an Australian agri-food company which operates, builds and invests in aquaculture production platforms. Seafarms has existing aquaculture operations in Innisfail, Cardwell and Ingham, Queensland, and is a major supplier of prawns to Coles and Woolworths on the East Coast. The company is Australia's largest prawn aquaculture enterprise.

2.2 Project description

The Proponent intends to establish stage 1 of a prawn aquaculture farm consisting of three farms with 1120 ha total area of land-based ponds and 324 ha of internal recycling ponds, approximately 500 ha of treatment area, producing nominally 14 000 tonnes of prawns per annum.

The Project is proposed at Legune Station in the Northern Territory (NT). Legune Station comprises NT Portion 798 and Portion 3222 in the Victoria River District (VRD) and is located near the western border of the Northern Territory, approximately 106 km by road from the nearest town, Kununurra, in Western Australia (WA). The project is located wholly within the NT Victoria Daly Local Government Area. The location of the site is shown in Figure 1.

Legune Station is currently used for cattle grazing under a perpetual pastoral lease with an area of approximately 178 800 ha. Existing pastoral infrastructure includes dwellings and farm sheds, cattle yards, stock watering points, paddocks and fencing, and a 35 000 million litre (ML) freshwater dam constructed on Forsyth Creek that is used for irrigation of pasture during the Dry season.

While financial modelling of the project assumed a nominal 25 year operating life, the Proponent expects that the Project would continue for a significantly longer period if feasibility is proven, with site establishment and construction proposed to begin in 2017.

The Stage 1 Legune Grow-out Facility is one component of a larger production system that also includes:

- breeding program and hatchery sites – proposed to be located in the Darwin (NT) environs (the core breeding centre and broodstock maturation centre proposed for Point Ceylon is the subject of a separate EIA process)
- quarantine, founder stock facility and back-up breeding centre – proposed to be located at Exmouth (WA)
- a processing plant – proposed to be located near Kununurra in WA, and
- export facilities – proposed to be located at either or both Wyndham and Darwin.

The Proponent intends to further develop the Legune Grow-out Facility. While future stages are beyond the scope of this assessment, the proponent has identified that a full scale development is likely to include:

- 27 farms with a total productive area of 9720 ha

- internal farm recycling ponds of 2916 ha
- 10 seawater intake pumps, distributed in two seawater intake structures (Forsyth Creek and Sandy Creek)
- multiple intake settlement basins
- additional main feeder canals for the delivery of seawater
- an expanded environmental protection zone
- an additional dam for freshwater storage and added delivery channel
- additional main discharge canals
- power generation plant (hybrid) and switchyard to meet peak demand of 90 MW
- gas storage infrastructure for full scale power generation requirements, or alternatively a local gas well-field
- an expanded central village at Legune and distributed on-farm accommodation.

Any expansion beyond stage 1 would require further consideration under the EA Act.

The Stage 1 Project is limited to the following components:

- three grow-out farms
- seawater intake and intake channel
- settlement and maintenance pond
- main seawater feeder channel
- freshwater channel from Forsyth Dam
- internal farm recycling ponds
- main discharge channel
- biosecurity zones
- environmental protection zone and outfall.

Additional infrastructure supporting the farms will be required including two farm services areas, access and service roads, power transmission line, accommodation village, sewage treatment, landfill, airstrip, and areas for solar power generation. The location of components of the Project is shown in Figure 2.

2.2.1 Grow-out farms

Typically each of the three proposed grow-out farms would consist of the following elements:

- a farm feeder channel (FFC) and pond feeder channels (PFC)
- between 36 (farms 2 and 3) and 40 ponds (farm 1)
- pond discharge channels (PDC)
- a farm discharge channel (FDC)
- an internal farm recycling pond (IFRP).

The total footprint of the three farms is approximately 1500 ha.

Farms would operate independently of each other but coordinate in respect of water balance. The interconnection of farms and channels is shown in Figure 3. The total farm

system has been designed as an “all-in; all-out” water management model for termination harvests, i.e. all ponds will be successively harvested, drained, and left fallow for a period.

Prawns will be grown in 10 ha grow-out ponds. Initial assumed maximum prawn biomass densities are of the order of 5 tonnes per hectare per crop. Each pond will have one inlet and one outlet structure, which will be fitted with penstock gates, water retention and release controls, screens to prevent prawn escape, and infrastructure to enable installation of harvesting and pumping equipment.

Grow-out ponds will discharge to the PDC, either by gravity or pumping, then outfall to the FDC and into the IFRP for storage, settlement and return of water to the FFC for re-use. The size of the IFRP is proposed to be nominally equivalent to a minimum of 30 per cent of the grow-out pond volume but varies between farms.

The seawater intake volume will be minimised by continual recycling of the grow-out pond water through the IFRP, where recycled water would be filtered prior to returning to the FFC for re-use in the grow-out ponds.

Water from the IFRP would be released to the main discharge channel (MDC) in times of harvesting, high water levels due to intense rainfall events or high salinity.

2.2.2 Water supply

Seawater is required to support prawn production in grow-out ponds and freshwater is required to balance the salinity levels in periods of high evaporation.

A seawater intake pump structure comprising four intake pumps (fitted with a 100 mm aperture mesh grille) and delivery pipes is proposed for Forsyth Creek at the north of the site. Pumps are designed to operate generally from mid-tide to high tide daily with a projected peak extraction rate of 12.5 m^3/s for 12 hours per day for 18 days to enable the filling of the farm ponds after a harvest.

Seawater would be delivered to farms via an intake channel and a single settlement pond. Sediments would be periodically removed to a maintenance pond using suction dredging plant. Clean seawater from the settlement pond will report by gravity to farms via the main feeder channel, with the rate of delivery dictated by water quality variations in the farms and farm filling rate.

Freshwater is proposed to be drawn from the existing Forsyth Creek Dam, which has a capacity of 35 GL. The Project is predicted to require nominally 7 to 10 GL freshwater per annum from the dam depending on climatic variability, in particular evaporation and precipitation. Water would be delivered to the farms via a freshwater channel and then lifted from the channel by a pump adjacent to each grow-out farm.

2.2.3 Discharge water

Water that is not recycled from the IFRP back to the FFC would be released to the main discharge channel (MDC) and delivered to the Environmental Protection Zone (EPZ). A weir will be constructed at the interface of the MDC and the EPZ, to control water levels and flows, with capacity for water to be recycled back to the farm from the MDC to conserve freshwater supplies and reduce seawater intake.

The EPZ would primarily function to regulate the flow of the discharge water by reducing the velocity and holding water for controlled discharge. Discharge is proposed at a constant rate of less than 420 ML/day during ebb tides. The majority of the discharge would flow through a 100 m wide channel in the centre of the EPZ, with 'overflow' areas built in to support peak discharge and water from storm events. The Proponent expects that this 'overflow' and the margins of the channel itself would eventually be colonised by local samphire and/or mangrove species, which could assist with nutrient uptake.

A weir at the outfall to Alligator Creek would provide telemetered, automated control of outflows from the EPZ in accordance with daily tidal fluctuations in Alligator Creek. Electronic commands for adjustable gate operation would be via a central control room, where operations planning inputs can be integrated with tidal data, farm harvest and daily discharge data, rainfall forecasts, and data from field monitoring instruments.

2.2.4 Prawn farming process

The Project will grow black tiger prawns (*Penaeus monodon*). Ponds will be conditioned to balance pH and to develop a healthy and stable bloom of algae and other phytoplankton to supplement prawn dietary requirements and maintain water quality. Ponds will be stocked with 15 day old post-larval prawns, which weigh less than 0.01 grams each, transported to the site in self-contained tanks. Each 5000 L tank holds approximately 2.7 million post-larval prawns. Pond water will be continuously aerated and circulated. Prawns will be fed regularly with a formulated feed diet to optimise growth and animal health for the different stages of prawn development. Ponds are harvested when prawns are grown to marketable weight (typically 20+ grams) by draining the pond through the outlet structure equipped with a capture cage. Prawns are deposited in ice slurry to euthanase and preserve them during transport to a processing plant.

2.2.5 Farm waste management

Farm pond and channel waste is proposed to be removed from the pond or channel floor by excavator and hauled by truck to a designated area in the separation zone between farms where it would be leached of salt, solar dried and aerated. Once treated, it would be rolled out and compacted as landfill between the farms and contained to prevent scour and loss during the Wet season. It is proposed to be used to assist vegetative cover of the embankments on channels and ponds or used in selected areas outside the farm to assist with scour erosion and in the construction of new berms.

2.2.6 Ancillary infrastructure

Central Facilities are proposed approximately 15 km to the south-west of the grow-out farms and with functions that include harvest equipment storage and maintenance; harvest handling area; vehicle washing; slurry ice-making; equipment maintenance and warehousing; power generation and switchyard; energy storage and fuel dispensing; management, administration, fire, security, safety and paramedic; airstrip; communication and systems controls; security and biosecurity control; laboratory; and wastewater (sewage and equipment wash-down, etc.) treatment (Figure 2).

A permanent Accommodation Village will be located approximately 1 km south of the Central Facilities; sized to meet the projected peak of construction and operation personnel (Figure 2).

A sealed, two-lane Central Service Road would link Central Facilities to the grow-out farms and the Legune Access Road designed for triple road trains will generally follow the existing gazetted road corridor from the southern property boundary to the Central Facilities (Figure 2).

An on-site landfill is proposed to be established on the site in a depleted gravel pit (Figure 2).

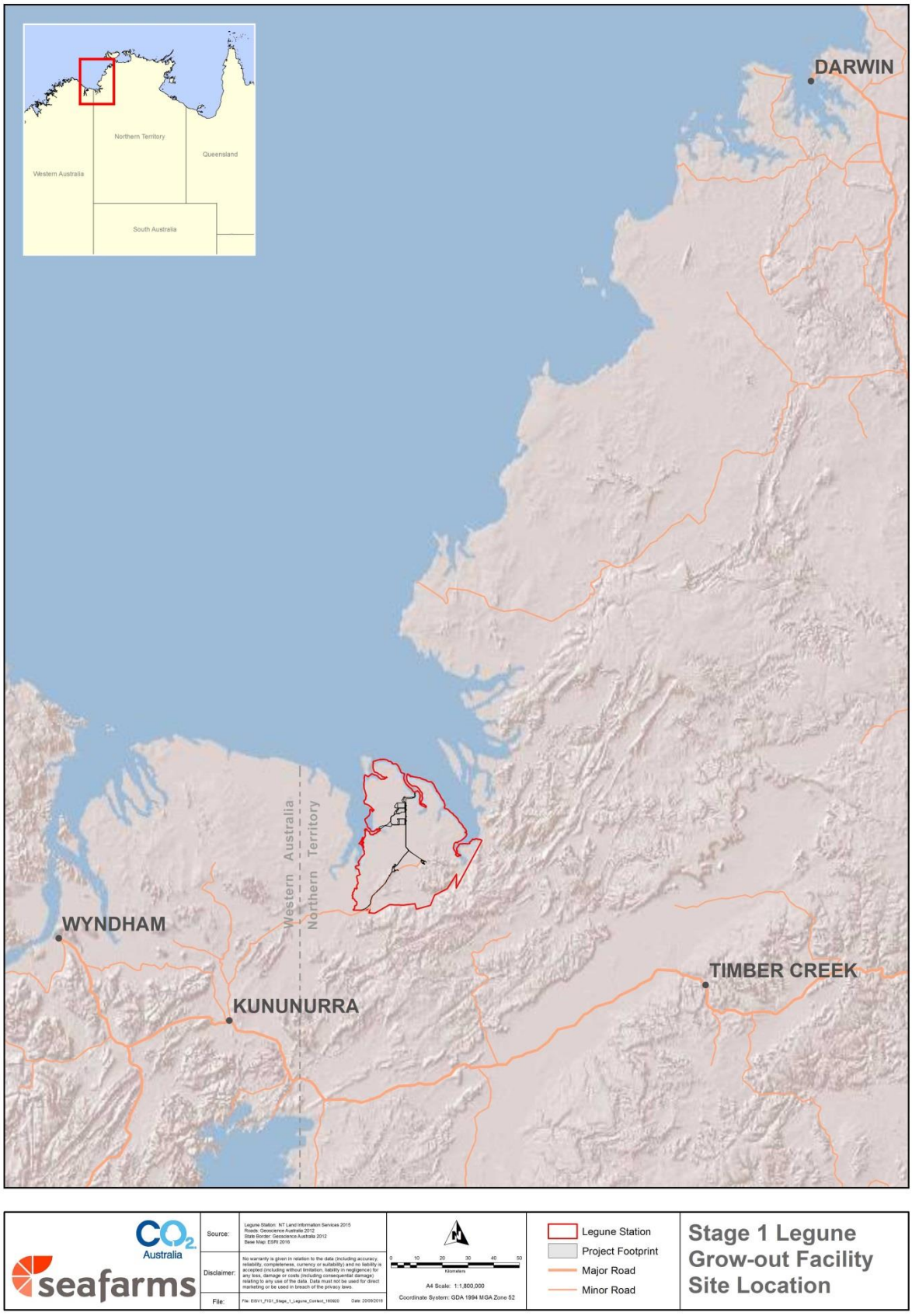

Figure 1: Location of the Project site (from draft EIS, Vol 1, Ch 3)

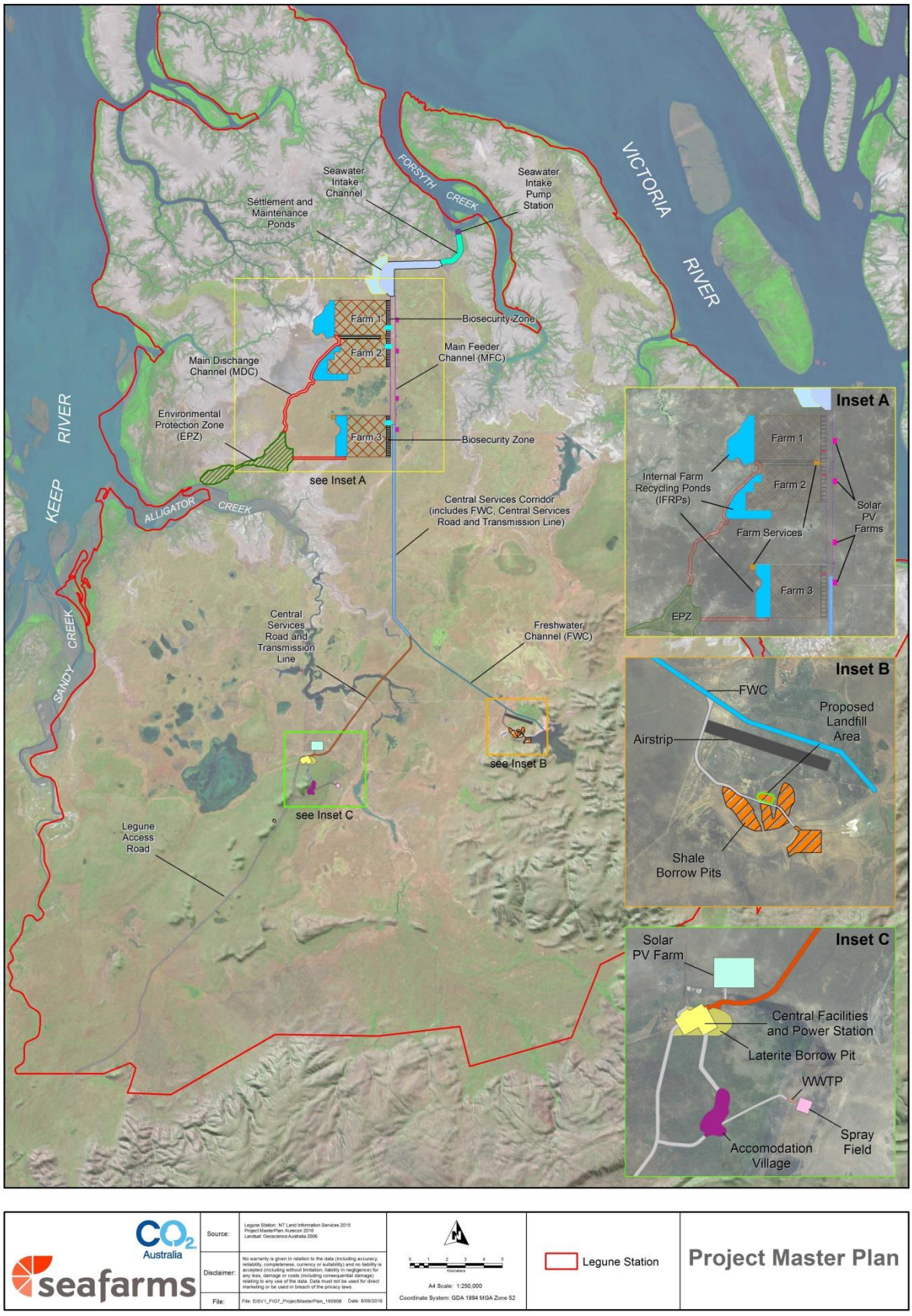

Figure 2: Location of Project components at Legune Station (from draft EIS, Vol 1, Ch 3)

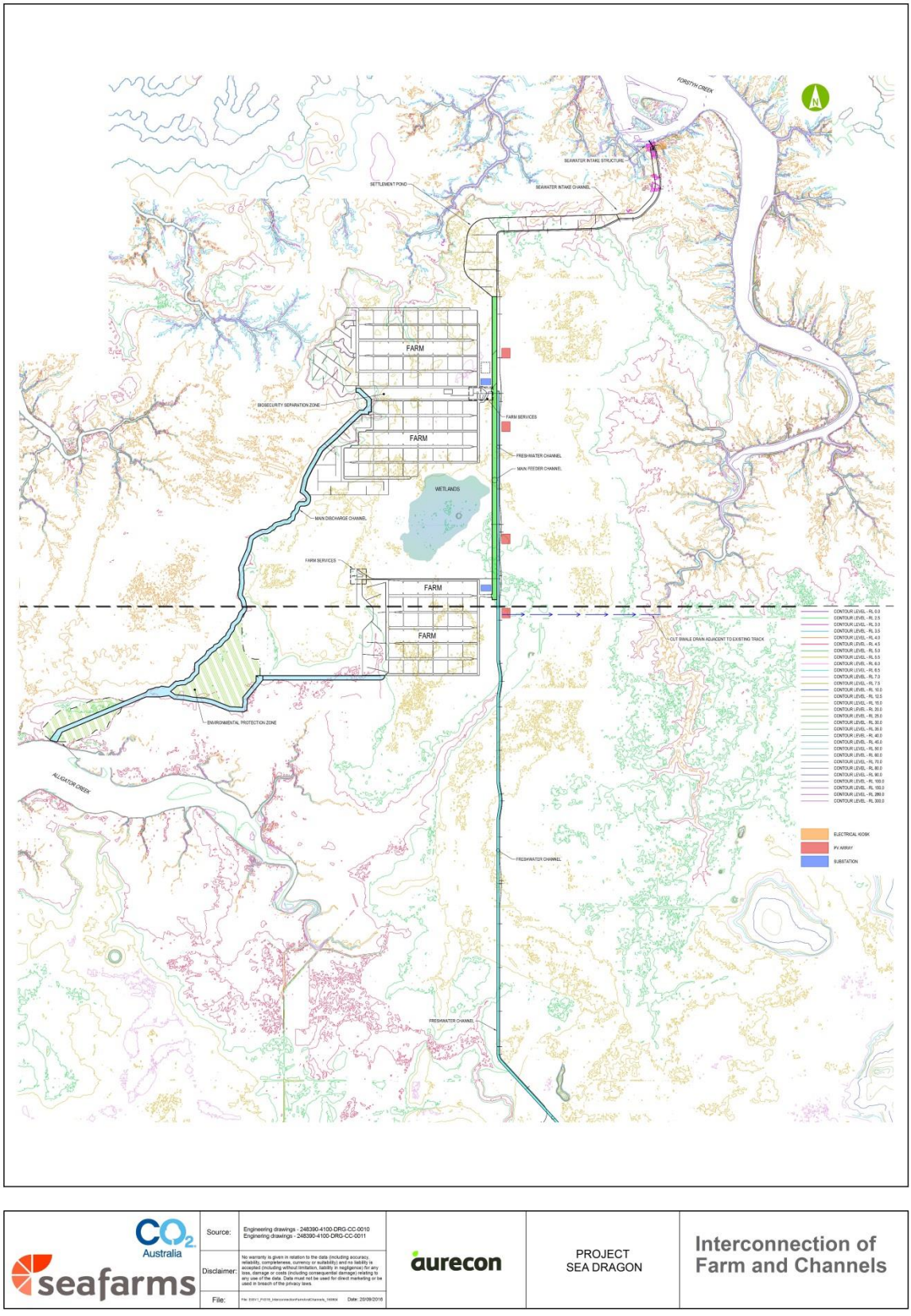

Figure 3: Interconnection of farm ponds and channels (from draft EIS, Vol 1, Ch 3)

3 Regional setting

Detailed descriptions of the physical and ecological aspects of the Project region are presented in the draft EIS. The following section provides a broad overview of the regional setting of the Project.

The climate of Legune Station is tropical monsoonal, consisting of two predominant seasons; the Dry season, which is characterised by low rainfall and relative humidity, and the Wet season, which is typically humid with significant rainfall events, most rain falling between November and April. The tropical cyclone season generally corresponds with the Wet season.

The landscapes, soils and vegetation of Legune traversed by the Project are dictated by their position on the plains and can be considered as four tiers from north to south across Legune Station. The plains extend from the delta between the mouths of the Keep and Victoria Rivers to the foot of the Legune ranges and Spirit Hills. The land systems can be characterised as:

- the Coastal plain (an area of tidal flats and low closed mangrove forest / samphire forbland vegetation, between sea level and 4.5-5 m Australian Height Datum (AHD), with poorly drained hydrosols - silty clays and muds)
- the Estuarine Deltaic Plain (located between 4.5-5 m and 10 m AHD, with scattered residuals up to 30 m, comprised of poorly drained vertosols - self mulching cracking clays) with sandstone residuals, and grassland, open woodland and wetland/swamp areas. This area contains freshwater and tidal estuarine systems, typically saline shallow groundwater (~2-3m depth) and some deeper productive bores)
- the Coastal Erosional Plain (characterised as lateritic plains and rises, situated between 10 and 50 m AHD, with residuals rising to 100 m, Tenosols - Deep red and yellow sands and sandstone residuals, with Sclerophyll woodland, and minor wetland areas around shallow depressions)
- the Flood-out Plain (located below the Ranges and inland from the Coastal Erosional Plain, with sclerophyll woodland and soils comprising hydrosols).

The Project site is located in a macro-tidal environment with a large tidal range; up to 9 m during spring tides. The coastline is dominated by sand banks, extensive and mobile intertidal mudflats, mangrove systems, tidal creeks and the Victoria River and Keep River estuaries. The waterways are typically highly turbid due to bed and bank erosion as a result of strong tidal and wind generated currents, and periodic flow of sediment-laden water during Wet seasons.

Freshwater bodies in the area are characteristically ephemeral, with extensive floodplains forming in the Wet season and drying out in the Dry season. Surface water in the Dry season is confined to the bunded areas of Alligator Creek, with small channels, billabongs and swamps gradually evaporating. Forsyth Creek Dam is a significant permanent freshwater feature on Legune Station.

The Project footprint sits within the Legune Coastal Floodplain Site of Conservation Significance with the Legune Wetlands recognised as a Nationally Important Wetland (Harrison *et al.* 2009). These wetlands host significant aggregations of waterbirds, particularly within the Osmans Lake complex, and meet criteria for Ramsar listing. The Legune Coastal Floodplain, particularly the Turtle Point area, provides nationally significant habitat for migratory shorebirds and important nesting sites for Flatback turtles.

Legune Station is remote with the nearest population centre being the town of Kununurra in Western Australia, and Timber Creek the closest population centre in the Northern

Territory. Kununurra is part of the Shire of Wyndham – East Kimberly, which has an estimated permanent population of approximately 8,500 people. The majority of the population is based in the towns of Kununurra and Wyndham with the remaining people scattered through several Aboriginal communities, pastoral stations and mining camps. Aboriginal people comprise of about 35% of the total population of the area. The Marralum family outstation, 10 km south of the Project area, is the closest settlement and is occupied in the Dry season.

Dominant industries in the region are agriculture including pastoral industries and irrigated agricultural operations, mining, tourism and fishing. The labour force participation rate in the region is 67%, which is similar to Australia as a whole (65%) but unemployment is higher within the Aboriginal population (8%) than non-Aboriginal (4%).

4 Key environmental values

Having regard to the Notice of Intent, the draft EIS and Supplement, and comments from the public and advisory bodies during the EIS review, the NT EPA identified the following key environmental values during the assessment process:

- water quality in marine, estuarine and freshwater systems
- freshwater aquatic, floodplain and estuarine ecosystems
- waterbird aggregations
- matters of National Environmental Significance under the EPBC Act
- cultural and spiritual values of marine and estuarine waters, fresh waters and floodplains, including ecosystems and biota

The NT EPA identified the following potential environmental impacts and risks that contributed to the decision to assess the Project at the level of an EIS:

- potential to impact on threatened, marine and migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Territory Parks and Wildlife Conservation Act*. Risks to biodiversity values could arise from habitat clearing, poor weed hygiene, downstream impacts from discharge of nutrient-rich water and extraction of large volumes of freshwater
- potential to impact on the Legune coastal floodplain site of conservation significance, which is host to migratory birdlife aggregations of international significance, and includes Turtle Point, a highly significant nesting beach for the flatback turtle (*Natator depressus*; listed as vulnerable under the EPBC Act)
- potential impacts from the discharge of waste from the prawn farming activities into receiving waters considered to be of high environmental value
- the significant management requirements for solid and liquid waste and the potential detrimental effects of inappropriate management practices
- potential impacts on the local amenity and the environment from unauthorised third-party access to the area for recreational fishing, camping and hunting. The proposed action would establish all-weather access, which could unintentionally provide entry to previously inaccessible areas
- the potential impacts of predation by birds on prawn stock held in ponds, both on the project feasibility and on bird aggregations
- potential economic, social and cultural impacts on the region and the Northern Territory, both positive and negative, including the risks of the project not realising its projected economic and social benefits.

Information requirements based upon identified potential impacts and risks were described in the Terms of Reference for the Project (NT EPA 2015). The Proponent submitted the EIS to address these requirements.

5 Environmental impact assessment

5.1 Introduction

The purpose of this section is to evaluate the Project and to present the view of the NT EPA on the environmental acceptability of the Project. The environmental acceptability of this Project is based on an analysis of:

- the proposed action (particularly which components or activities are likely to impact the environment)
- the existing environment (particularly environmental values and sensitivities)
- the potential environmental impacts and risks of the Project and the evaluation of the significance of those impacts and risks
- proposed avoidance or minimisation / mitigation measures to reduce potential impacts and risks to acceptable levels and to meet NT EPA objectives.

Conclusions drawn and recommendations made in this Report are derived from consultation on the final EIS with advisory bodies, the NT EPA's examination of the EIS and responses from the Proponent to comments/consultation. Recommendations are made in this Report to add to or emphasise/clarify any commitments made by the Proponent, where the proposed avoidance or minimisation/mitigation measures are considered insufficient or where a safeguard is deemed particularly important.

In this Report, the recommendations (in **bold**) are preceded by text that identifies issues and undertakings associated with the Project. For this reason, the recommendations should not be considered or read in isolation.

Minor and insubstantial changes are expected in the design and specifications of the Project following the conclusion of the EIA process. It will be necessary for approval mechanisms to accommodate subsequent changes to the environmental safeguards described in the final EIS and recommendations in this Report. If the Proponent can demonstrate that changes are unlikely to significantly increase potential impacts on the environment, an adequate level of environmental protection may still be achieved by modifying the conditions attached to relevant statutory approvals governing the Project. Otherwise, further environmental assessment may be required.

Therefore, subject to decisions that permit the Project to proceed, the overarching recommendations of this Report are:

Recommendation 1

The Proponent shall ensure that the Stage 1 Legune Grow-out Facility is implemented in accordance with all environmental commitments and safeguards:

- **identified in the Environmental Impact Statement for the Stage 1 Legune 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.

Recommendation 2

The Proponent shall provide written notice to the Northern Territory Environment Protection Authority and the responsible Minister if it alters the Stage 1 Legune Grow-out Facility in such a manner that the environmental significance of the action may have changed, in accordance with clause 14A of the Environmental Assessment Administrative Procedures.

In making this Report, the NT EPA considered the information presented in the draft EIS; submissions from Government advisory bodies, interested persons and organisations; the Supplement to the draft EIS in response to submissions; and final advice from Government advisory bodies on the Supplement. The NT EPA also considered the advice of independent experts in nutrient cycling and water quality modelling, commissioned by the NT EPA to review the prawn pond effluent discharge aspects of the EIS.

A range of potential impacts and risks identified through the EIA process were addressed by the Proponent to the satisfaction of commenters, including the NT EPA and advisory bodies. Where potential impacts were considered to have been satisfactorily addressed and can be managed through other legislated processes and recognised standards, they are not discussed in detail in this Report. Some of these include:

- biting insect impacts (addressed through biting insect surveys to the satisfaction of the Department of Health)
- historic or aboriginal archaeological heritage (addressed to the satisfaction of Department of Infrastructure, Planning and Logistics (DIPL), Heritage Branch with amendments to Cultural Heritage Strategy)
- roads and transport (addressed to the satisfaction of the DIPL Transport)
- recreational access (addressed to the satisfaction of Department of Culture and Tourism).

The remainder of this section of this Report discusses the key environmental values and potential impacts and risks to those values based on likely significance and concerns from commenters, and the Proponent's investigations and studies and/or commitments to identify, avoid, mitigate, monitor and manage the potential impacts and risks. For each key environmental value, the NT EPA assesses whether or not the proposal meets the environmental objective set for each value. The key areas of concern relate to potential impacts and risks to water quality values from waste water discharges, earthworks and solid waste management; to ecosystem values from disturbance of estuarine and freshwater habitats; and to cultural values.

5.2 Water quality (marine, estuarine and freshwater)

5.2.1 NT EPA objective

To ensure surface water and groundwater resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained.

5.2.2 Waste water (prawn pond effluent)

5.2.2.1 Marine and estuarine values

Waste water from prawn farms is proposed to be discharged into Alligator Creek, a tributary of the Keep River.

Alligator Creek experiences high current speeds on the flood tide and low current speeds on the ebb tide. The low velocity tidal currents during the ebb tide are a result of the elevated bed in Alligator Creek where water levels are restricted from dropping below approximately -2 m AHD. The bed level of Alligator Creek is relatively high and the majority of the creek dries during low tide, exposing wide flat banks and bars. A number of channels cut through the bars. However, the channels are not continuous and ponding occurs throughout the length of Alligator Creek. As a result, the ebb tide in Alligator Creek continues for 9-10 hours. The EIS indicates that phase lags are highest during the spring ebb tides within Alligator Creek with the ebb tide still draining up to 4.5 hours after the offshore low tide. Conversely, high water may be reached on the flood tide in less than 4 hours.

Flow rates across the total width of Alligator Creek are much greater than the local channel adjacent to the discharge location. Peak flows in the narrow local channel during neap tides are < 50 m^3/s, whilst during the spring tide the flow rates increase to a range of 100 – 400 m^3/s. The peak flood tide flow rate is 2-3 times those on the ebb tide during spring tides due to the rapid filling and slow draining of Alligator Creek. Across the wider Alligator Creek channel, the peak flow rates during a neap tide range between 1200 m^3/s on the flood tide and 800 m^3/s on the ebb tide, whilst spring tides result in a flood tide flow rate of up to 5400 m^3/s and an ebb tide flow rate of 2000 m^3/s.

The water quality attributes of the Keep River include high turbidity due to the highly dynamic nature of the tidal regime and transportable soft sediments in beds and banks of waterways; this is exacerbated by sediment inputs to the system from intense rainfall events in the Wet season. The Keep River generally contains low existing inputs of nitrogen but ready sources of particulate phosphorus, likely related to adsorbed phosphorus in sediments and the high rates of sediment remobilisation due to the dynamics of the system. Chlorophyll *a* levels are generally low with higher levels measured in the upstream section of Alligator Creek.

Habitats supported in the estuary and tidal creeks include extensive mangroves in the intertidal zone and benthos in bottom sediments. The estuary is also likely to support a number of threatened and marine species including sawfish and turtles. Shoreline habitats support rich and abundant migratory shorebirds both in terms of roosting habitat and feeding resources. Turtle Point at the mouth of the Keep River as it enters Joseph Bonaparte Gulf (draft EIS Vol 2, Ch 6, Figure 12), is particularly significant for nesting marine turtles and roosting shorebirds. A number of respondents to the draft EIS were concerned about the potential for nutrients and suspended solids from waste water to impact these values. Potential impacts to estuarine ecosystem values are discussed further in Section 5.3.3.

5.2.2.2 NT EPA assessment

Level of protection for the Keep River estuary

Defining the appropriate level of protection for the receiving environment is of primary importance in determining appropriate water quality objectives and guidelines for use in assessing the potential impacts of the discharge, and for ongoing monitoring and management of water quality.

The National Land and Water Resource Audit (2002) classified the condition of the Keep River estuary as “near-pristine”. However, since then, developments for the pastoral industry on Legune Station have altered hydrological systems and inputs to the estuary. The Proponent proposed in the EIS that the estuary be considered a condition 2 ecosystem, or slightly to moderately disturbed, in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000), referred to hereafter as the Australian Water Quality Guidelines (AWQG). This position was supported by the findings of an assessment of the Keep River conducted by Bennett & George (2014) who proposed that *"[T]he physicochemical baseline data*

indicate that the lower Keep River is best classified as a 'Category 2' system, being a 'slightly to moderately disturbed system', rather than 'Category 1', which is defined as a 'high conservation/ecological value system'. The lower classification is a result of the influence of natural (tidal influence, climate variability, groundwater discharge, heavy metal mineralisation, terrestrial vegetation growth dynamics and run-off dynamics) and anthropogenic (rangeland cattle grazing) factors. It was not possible to quantify the relative influence of each of the natural and anthropogenic factors on the condition of the lower Keep River. It does appear, however, that the anthropogenic influences mainly affect the nutrient aquatic stressors N and P."

Advice from the Department of Environment and Natural Resources suggested that the condition 2 classification "*could be justified based on catchment grazing and its impact on wet season sediment loads, which are assumed to have an impact during the dry season when river inflows cease".*

The NT EPA acknowledges that anthropogenic influences resulting from changes in land use in the catchments adjacent to the lower Keep River estuary have affected water quality to the extent that the estuary is likely to meet the criteria for a condition 2 classification, albeit at the 'slightly disturbed' end of the scale.

The process to determine the appropriate level of protection is described in the Management Framework for Applying the Guidelines (ANZECC & ARMCANZ 2000) and involves the consideration of environmental values, water quality guidelines, management goals and finally the development of water quality objectives based on an analysis of the relevant social, environmental and economic issues. The appropriate level of protection will be finalised through the EPL application process under the WMPC Act.

Baseline water quality assessment

The Proponent undertook a baseline water and sediment quality sampling program. A range of biological indicators were also sampled at 17 locations in Forsyth, Alligator and Bob's Creeks, Turtle Point, and the Keep and Victoria Rivers, as well as some reference sites.

The data indicate that these rivers and creeks have high levels of turbidity, total phosphorus, nitrate/nitrite and phosphate, relative to AWQG trigger values. This is consistent with previous studies in this region of northern Australia that have shown that the combination of soil types, hydrological conditions and tidal regime results in substantial erosion, with associated high total suspended solids, total phosphorus and dissolved nutrients (e.g. Burford *et al*. 2011, Robson *et al*. 2013). These erosive processes are likely to be exacerbated by cattle grazing.

Due to the naturally high concentrations of a number of water quality parameters, the AWQG have limitations in this environment, and hence the importance of baseline values for comparison with discharge values once operations are underway. Additionally, there is likely to be high seasonal variation in water quality, or more accurately, high variability centred around high rainfall events. As such, water quality in northern Australia is event driven. It is very difficult using standard methods to accurately capture the natural range of water quality parameters due to the high rainfall and runoff and these events are likely to have flow-on effects to water quality for some time after the event.

The NT EPA considers that the Proponent's water quality monitoring strategy does not adequately account for natural variability in the receiving environment; specifically, sampling was not standardised in consideration of the potentially significant variation in water quality that is likely to occur through single ebb and flood tidal movements, and over longer-term lunar cycles.

This will limit the utility of the monitoring program and, while the NT EPA considers the Proponent's commitment to obtain a total of two years of baseline data to be sufficient and in line with the AWQG, continuing the collection and treatment of data as currently proposed is unlikely to provide meaningful baseline data. The quality of the data is essential to inform robust interim site-specific trigger values and ultimately the development of appropriate water quality objectives for the receiving waters of the Keep River estuary.

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.

Effluent treatment

Prawn pond water recycling and passive treatment prior to discharge is proposed for the Project. The EIS indicates that water from the recycling ponds (IFRPs), would likely be released to the MDC during prawn harvesting when pond water is drained, when salinity levels are too high or to prevent overtopping of ponds due to intense rainfall. The water discharged into the MDC and subsequently the EPZ will contain waste product from the farms. This 'effluent' is likely to have elevated nutrient and algal levels. Water recycling in the pond system and waste water treatment are described in Volume 1, Chapter 3 and Appendix 8 of the draft EIS and summarised in Section 2.2 of this Report.

The Proponent expects Stage 1 effluent quality to be similar to the existing Seafarms' prawn farming operations at Ingham in North Queensland (Table 1).

Table 1 Ingham (Farm 3) operation discharge water quality – licence conditions (from draft EIS Vol2, Ch2, Table 7)

Parameter	Mean	Maximum
Total nitrogen (mg/L)	0.8	3.0
Total phosphorus (mg/L)	0.1	0.3
Chlorophyll *a* (ug/L)	20	100
Total suspended solids (mg/L)	20	100

In proposing the Ingham licence conditions as discharge limits at the outfall into Alligator Creek, the Proponent reasoned that these were the most recent conditions issued by the Queensland Government for an operating farm and amongst the most stringent conditions imposed in Australia for similar operations. Optimising the operation of the

farms and adequate treatment of the effluent prior to release is therefore paramount to ensure such conditions can be met in this Project.

The predominant source of nutrient liberated with pond effluent is associated with unutilised or unconverted feed. The Proponent's breeding program aims to breed species that achieve fast growth rates and with improved feed conversion ratios (FCR) to limit food wastage. Nutritional formulations have improved feed conversion ratios in prawns by improving feed digestibility. Improved feeding regimes (e.g. feed requirements calibrated to prawn body weight; daily feed uptake monitoring with consequent adjustments to feed volumes) can reduce feed wastage, which is a commercial priority as feed represents the greatest cost during operations. Current FCRs in prawn aquaculture are consistently 1.7 (that is, 1 tonne of prawns produced from the addition of 1.7 tonnes of food). Seafarms has been consistently achieving FCRs of 1.4 to 1.5 in Queensland (Dallas Donovan *pers. comm.* 2017).

The relevant features of the Project in terms of water treatment are the IFRPs and the EPZ. The IFRPs facilitate internal exchange (recirculation) of farm water to manage pond water nutrient levels and microalgae growth. In doing so, they retain water in the system thereby reducing the potential effluent volumes and total contaminant loads that would otherwise be discharged to the receiving environment.

The primary function of the EPZ is to regulate the flow of the discharge water by reducing the velocity and holding the water so that discharge can be timed. The EPZ would act as a pre-discharge settlement pond with the potential for incidental or intentional colonisation of salt-tolerant vegetation. The draft EIS stated that colonisation could not be relied upon and therefore the Project had been '*designed to achieve the required water quality objectives without relying upon the nutrient uptake benefits conferred by an EPZ'*. In reality, there would be some level of sedimentation and nutrient assimilation within the EPZ.

No other pre-discharge treatment was described in the draft EIS and no information was presented that enabled an assessment of the likelihood that the discharge limits for water quality proposed by the Proponent could be met during operations. The NT EPA requested information on improvements in effluent treatment that may have been incorporated into the design of the Ingham operation to meet the water quality criteria.

Information on the likely efficacy of the treatment/recycling system could not be provided in the draft EIS due to insufficient data, and production data for existing operations could not be provided for comparison due to reasons of commercial confidentiality. However, the Supplement expanded its discussion on the treatment system stating that the proposed prawn production system included:

- *a modern 'green water' prawn production system that uses in-situ primary production as part of the production process*
- *a system of IFRPs that facilitates both nutrient treatment and recirculation and therefore nutrient recycling and re-use*
- *the design of the MDC to be engineered with design velocities that assist sediment fall-out*
- *an EPZ that has been designed to enable hydraulic control and settlement as well as biological assimilation of nutrients through the colonisation and/or planting of samphire and other species.*

Discussion with the Seafarms' Chief Operating Officer in Queensland, Mr Dallas Donovan, clarified that the MDC and EPZ would be designed to behave like an estuary with biological processes stripping nutrients from the water column and sediments dropping out of suspension to the bottom. The water would be shallow (the EPZ channel

is 1.5 m deep) and moving continuously so that stratification and turn-over would not occur.

Information provided by the Proponent on the Seafarms Ingham Farm 3, which has a settlement pond system representing approximately 15% of productive area (the MDC and EPZ together represent approximately 45% of the total pond area of the farms at Legune), indicates that mean discharge concentrations and loads of nutrients, total suspended solids and chlorophyll *a* are generally well below the licensed limits. The data show total nitrogen loads and suspended solids approximately 16% and 8% respectively of the allowable loads. These data appear to demonstrate that settlement ponds can be very effective at removing suspended solids and nutrients, and with proportionately larger areas proposed for passive treatment at Legune, the NT EPA considers that the Project should be able to achieve the discharge limits proposed in Table 1.

The NT EPA supports the application of the Ingham Farm 3 discharge limits proposed by the Proponent for this Project and considers that skilled and experienced operation of the farms in accordance with the Environmental Code of Practice for Australian Prawn Farmers (Donovan, 2001), and passive treatment of pond effluent as proposed, can sufficiently improve water quality to meet the proposed discharge limits. Should this level of performance be difficult to achieve consistently, corrective measures may need to be implemented to avoid the potential for environmental harm, through the development and implementation of an adaptive management plan. Any such requirements can be addressed through the EPL.

Recommendation 4

The EPZ shall be designed, constructed and operated to:

- **ensure that infiltration is minimised, with reference to specific design standards/criteria for aquaculture containment structures**
- **maximise the utility of the structures for achieving consistent removal of nutrients and suspended solids**
- **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**
- **increase mixing and dispersion in the receiving environment and otherwise avoid the likelihood of visual discharge plumes from the discharge point.**

Effluent discharge

The proposed effluent discharges will result in a significant mass load of nutrients and oxygen demanding substances to an estuarine water body. There is therefore the potential for eutrophication and associated fish kills and other ecological impacts in Alligator Creek.

The proponent has undertaken modelling to assess the likely dispersion of nutrients and chlorophyll *a* in prawn farm effluent on the waters around Legune Station and within Alligator Creek. The approach adopted was to apply a 2-Dimensional model (MIKE21) to the region that simulates currents, water level, salinity, temperature and tracer mixing as these respond to the driving forces of tides, wind, precipitation, evaporation and riverine inputs.

The NT EPA's independent expert advised that the MIKE21 model could generally be considered appropriate for such applications but cautioned that the quantitative predictions of effluent dilution should be treated as indicative only. This is due to inherent limitations of the model in simulating effluent mixing and dilution, particularly

within the context of the complex and dynamic nature of Alligator Creek and the receiving waters around Legune. Issues were also identified with the Proponent's validation of the model, chiefly the limited measured data available and large differences between measurements and simulations in the model outputs.

The modelling was useful in confirming that Alligator Creek tended to accumulate the effluent discharged into it when discharge was continuous through the tidal cycle. Based on a simulated continuous release, up to 50% of average concentrations of nutrients and suspended solids along Alligator Creek were derived from the discharged effluent, despite the effluent volume released over a tidal cycle being a small fraction of the intertidal volume of the creek (Table 2).

Table 2 Alligator Creek tidal prism compared with proposed outlet discharge rate (from draft EIS Vol2, Ch 2, Table 6)

Tidal Prism (m^3)	Spring Tide	Neap Tide
Alligator Creek	90.0×10^6	22.0×10^6
Alligator Creek (upstream of discharge)	15.0×10^6	0.7×10^6
Alligator Creek Outlet - Proposed volume (m^3)	0.42×10^6	
Proportion of spring / neap tidal prism	0.5% / 1.9%	

The predicted dilution rates improved, and the accumulation effect decreased, when an equivalent effluent volume was released during the ebb tide only with concentrations reduced in Alligator Creek by a factor of approximately two. Concentrations of effluent in the Keep River from a discharge into Alligator Creek were predicted to be low. The NT EPA considers that ebb tide only discharges for Stage 1 discharge volumes (<420 ML/day) are not likely to be problematic beyond the mouth of Alligator Creek given the significant dilution in the Keep River.

It can be expected that due to the inability of the model to represent the true detail of the braided channel and the mixing processes along it, that mixing with Keep River waters and mixing along the Alligator Creek would be more effective in reality than represented in the model and that effluent concentrations would be lower than simulated. Therefore the model is likely to over- rather than under-estimate effluent concentration. Further, in calculating distributions, the model assumed that all effluent constituents were conservative; that is they did not decay with time.

In reality the uptake of nutrients by organisms, gaseous exchange and settling of suspended sediments and degradation of chlorophyll *a* would tend to reduce water column nutrient concentrations in the receiving environment. In other macro-tidal channels that have residence times of months or more, such as the Fitzroy and Norman Estuaries in Queensland, water can be flushed out in days or less during times of river flow (Webster *et al* 2005; Burford *et al* 2012) and the same would be expected of Alligator Creek.

The NT EPA expects that high turbidity in these river systems will lower primary productivity due to a combination of low light availability and physical effects of suspended sediment on phytoplankton. This is consistent with studies of Burford *et al*. (2011) and Robson *et al.* (2013). Within the Keep River there will be substantial dilution of nutrients due to the very large tidal prism and flow rates and this is likely to ensure that primary productivity remains relatively low in the lower estuary.

While there is insufficient data to examine in detail the effect of the processes highlighted above, the NT EPA considers that discharging on the ebb tide only, as proposed by the Proponent, is the more appropriate method of releasing the effluent to avoid accumulation in Alligator Creek. The NT EPA agrees with the Proponent that ceasing discharges well before the bottom of the tide, preferably before braid bars are exposed, would maximise the movement of discharged effluent from the creek prior to a return of the flood tide. This would accommodate the phase lags between the ebb tides within Alligator Creek and the lower Keep River estuary, as discussed in Section 5.2.2.1. Certainly, the NT EPA recommends against discharging on the lower end of the ebb tide when the local channel adjacent to the discharge outfall is significantly reduced and neap tide flow rates can drop below 50 m^3/s.

Recommendation 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.

Proposed interim site-specific trigger values

The Proponent proposed interim site-specific trigger values (proposed trigger values) derived from the 80th percentiles of water quality data collected at Legune. To assess impacts to the receiving environment, the Proponent compared the simulated dilution of effluent discharged into Alligator Creek with the proposed trigger values.

The EIS showed that the modelled water quality within Alligator Creek complied with the proposed interim site-specific trigger values (proposed trigger values) within a distance of 200 m of the discharge outfall.

As discussed previously in this section, the NT EPA is concerned that there are limitations with the baseline dataset due to lack of standardisation during sampling and therefore there is uncertainty in terms of the appropriateness of the proposed trigger values.

The modelling indicates that with ebb tide only discharges, expected concentrations ‘upstream’ of the discharge point are always likely to be well below the proposed trigger values for nitrogen and phosphorus. This would suggest that the proposed trigger values do not reflect background conditions in Alligator Creek during the Dry season and therefore may not be useful for assessing the acceptability of likely water quality impacts.

In the absence of suitable site-specific trigger values, it is difficult if not impossible, to reliably predict the available assimilative capacity (how much load the environment can absorb without compromising environmental values) and sustainable load of the receiving environment (how much load can be added without exceeding the environment’s assimilative capacity). Such deficiencies will affect the determination of an appropriate ‘mixing zone’ within which the interim trigger values, and ultimately, the

accepted water quality objectives for the receiving environment, can be exceeded without further investigation.

The simulations of the dilution of effluent within Alligator Creek indicate that the discharge could have a large area of influence in terms of the average concentrations of nitrogen, phosphorus and chlorophyll *a* above background. This influence extends downstream from the discharge point for distances of at least a kilometre, which is considered to be excessive, i.e. the distances exceed the general guidance level for an appropriately sized 'initial mixing zone' in accordance with the Technical Guideline: Licensing Wastewater release to Queensland waters (DEHP 2016). This could potentially alter the water column and sediment biogeochemistry with flow-on effects to aquatic life within this section of Alligator Creek.

While the assimilative capacity of the Keep River is expected to mitigate any significant impacts outside of Alligator Creek, the NT EPA considers that a review of the interim site-specific trigger values for Alligator Creek is necessary using the baseline data collected from the revised water quality monitoring program, as provided for in Recommendation 3 in this Report.

Consideration should also be given to developing distinct seasonal water quality trigger values for periods of catchment inflow (Wet season) and negligible inflows (Dry season).

Recommendation 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.

Further modelling by the Proponent may be required as part of the EPL, utilising the revised interim site-specific trigger values to determine an appropriate 'mixing zone'.

Cumulative impacts

The grazing of cattle at Legune has had, and will continue to have, an impact on water quality in the Keep River estuary. The key influences as discussed previously appear to be nitrogen and phosphorus (Bennett and George 2014) and Wet season sediment loads. The discharge of effluent from the prawn farm will contribute additional nutrients to this system, delivering a cumulative nutrient load.

The Proponent has committed to making reductions to the herd as grazing land is replaced by prawn farm infrastructure for the Project. There are limitations on the extent to which the herd can be reduced under the *Pastoral Land Act*. As discussed later in this report, there is some advantage to maintaining a well-managed cattle grazing regime at Legune, including grazing of grassy weed species that have the potential to impact wetlands.

With these considerations in mind, the NT EPA is of the opinion that there is further scope for reducing the herd on Legune, leading to a commensurate reduction in the contribution of nutrients and sediments to the Keep River estuary during Wet season flows.

Recommendation 7

To the extent practicable and achievable within the requirements of the *Pastoral Land Act*, the Proponent shall reduce the herd size at Legune Station to reduce cumulative impacts of water quality on the Keep River estuary.

5.2.2.3 NT EPA conclusion

Having regard to the AWQG, the information presented in the EIS, advice from the NT EPA's independent experts and the Technical Guideline: Licensing Wastewater release to Queensland waters, the NT EPA considers that the residual uncertainty in relation to:

1. the standardisation of baseline data and its suitability for developing appropriate interim trigger values for the local receiving environment
2. limitations in the reliability of the water quality modelling studies
3. the extent of influence of the modelled discharge in Alligator Creek

can be adequately managed through the imposition of the following recommendations.

The NT EPA makes Recommendation 3 to review the water quality monitoring program, Recommendation 4 regarding treatment of the effluent, Recommendation 5 to emphasise the need for ebb tide effluent discharge, Recommendation 6 to review the proposed interim trigger values, and Recommendation 7 to reduce cumulative nutrient loads.

The NT EPA considers that with the implementation of these recommendations, the inherent conservatism of the modelling, large dilution in the Keep River and an appropriate water quality monitoring and adaptive management program with contingency measures built in to mitigate impacts, the Project is highly likely to meet the NT EPA's environmental objective for estuarine water quality (Section 5.2.1).

The NT EPA should be notified of any requirement for larger mass load discharges in accordance with Recommendation 2 of this Report. Any such requirement would need further modelling to predict potential impacts.

5.2.3 Pond and channel construction

5.2.3.1 Values

The area of the channels and grow-out ponds containing saline and nutrient-rich water is sited largely within the coastal plain and estuarine-deltaic plain. As discussed in Sections 0 and 5.3 of this Report, the estuarine deltaic plain is an ephemeral floodplain containing wetland areas that are considered ecologically significant and intersected by tidal inlets. Much of the floodplain within the footprint of grow-out ponds is influenced by naturally derived soil salinisation. Soil salinity can wax and wane depending on natural conditions, particularly when a run of above average Wet seasons causes saline groundwater expression.

The grasslands on the estuarine-deltaic plain are thought to be seasonally reliant on Wet season rains saturating the clay soils and ponding on the surface for long periods of time rather than on the groundwater table, which is generally 2.5 - 3m below the surface in the Dry season. These grasses' root zones extend to 0.5 - 1m below the surface and cannot generally access groundwater. While there are some vegetative systems on the site that may make facultative use of groundwater, these are associated with the low hills and rises on the plains and are not present within the farm sites.

5.2.3.2 NT EPA Assessment

The NT EPA considered that potential impacts to shallow water tables could arise from seepage of nutrient-rich, saline water from ponds and channels. There were concerns raised regarding the likely integrity of ponds and channels to withstand erosive forces such as intense rainfall with unmanageable erosion of structures leading to potential sedimentation and surface water quality issues. The exposure of potential acid sulfate soils (PASS) by excavation was also a concern.

Construction of ponds and channels is proposed to be via a cut-to-fill operation. Generally, the ponds would be constructed by scraping 300 mm of the top layer of soils to form the walls over a 10 ha area while channels would be excavated to greater depth, with PASS material underlying some areas. Ponds and channels would be lined by compacting in-situ surface soils (the black clay soils on the estuarine-deltaic plain).

The draft EIS included a report on geotechnical investigations (draft EIS Volume 5 Appendix 7), which characterised soils at various locations on Legune Station, including observations of turkey's nest dams. An on-site earthworks trial and test work was conducted in June 2016 representing a scaled-down part of a farm consisting of two ponds and part of an adjacent drainage channel, to simulate the shallow pond construction, and the recycling ponds and other deeper channels respectively.

The soils within the footprint of farms 1 and 2 were classified in the EIS as Unit 1 and 2A soils or black cracking clays, based on test pits. Spatial distribution of soil tests for the Project was limited, particularly within the proposed farm 3 footprint where no survey effort was apparent. However, studies commissioned by the Proponent and a previous study conducted at the site by Tickell and Hill (2001) suggest that while there is some variability, the soils of the estuarine-deltaic plain are generally consistent across the site.

The characteristics of these soils include swelling and shrinking with wetting and drying that typifies black cracking clays, highly to potentially dispersive and generally highly sodic. The Australian Prawn Farming Manual (DPIF 2006) advises against using or disturbing problematic soils that have the potential to interfere with the construction and operations of pond systems. Dispersive and expansive clays are listed amongst the problematic soils.

While the draft EIS indicated that the soils when compacted would meet the low permeability requirements for clay liners (K_{SAT} values between $2 – 9 \times 10^{-10}$ under optimum moisture conditions) and structural integrity needs, given the problematic soil properties and the absence of relevant data from the trial earthworks, commenters requested further evidence to support the claims.

Appendix F of the Supplement provided a more comprehensive description of the soil properties and the effects of compaction on permeability parameters. Preliminary results of the trial earthworks were also presented. These suggested that under particular compaction regimes at the optimum moisture content, Units 1 and 2A soils could be regarded as appropriate for pond and channel construction. However, any variability in soil properties would need to be investigated further in the field to ensure quality assurance and quality control during construction.

The Proponent plans to conduct additional geotechnical testing, as well as a pre-construction soil monitoring program to differentiate suitable materials for construction from problematic soils. The NT EPA supports further work and considers that soil testing should be a requirement of pond and channel construction.

Recommendation 8

The Proponent shall undertake additional geotechnical testing and a pre-construction soil monitoring program to differentiate suitable construction materials from problematic soils prior to commencement of farm and channel works.

Ponds and channels shall be designed by a registered professional engineer and construction works shall be undertaken under the supervision of an appropriately qualified geotechnical engineer.

As well as informing geotechnical and permeability characteristics, information from further geotechnical testing and soil monitoring could inform the practicality of utilising

the topsoil as an embankment stabilisation option given the encouraging revegetation results on the trial embankments evident in Appendix F of the Supplement. Although not specified in the results of the trial, there are two possibilities for the varying degree of ground cover establishment and extent of rill erosion observed on the embankments. Apart from the effect of slope, this difference could be related to which of the soil layers was placed on the surface during the construction of the embankments. It is likely that areas where topsoil was placed on the surface would regenerate more readily due to the presence of seed stock and favourable soil properties for germination and growth. Where the sodic and dispersible soil horizons provide the surface layer, it would be more prone to rill erosion, particularly on slopes. This should be further investigated.

The Proponent has committed to compaction of berms during construction to Australian Standards for in-situ density and moisture content, for acceptance or rejection. The investigation works and design in relation to pond impermeability provide for the primary mitigation against leaks to groundwater from the ponds, along with early warning and rapid response procedures for leaks to be included in the EMP.

While there is potential for PASS to be excavated in constructing some elements of the Project, construction techniques are expected to largely avoid the deeper soils. The Proponent has committed to the NT Government's requirements for an acid sulfate soil management plan.

The plan will need to be developed by a suitably qualified and experienced professional, in accordance with the *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guideline* (Dear et al. 2014) or the Western Australian *The Acid Sulfate Soils Guideline Series* (DER 2015).

5.2.3.3 NT EPA conclusion

The NT EPA is satisfied that the soils on site can be engineered for purpose to the appropriate standards to minimise seepage to shallow water tables and to withstand erosion, provided the works are supervised by appropriately qualified personnel with engineering expertise and commitments made in the EIS are adhered to. The NT EPA makes Recommendation 8 to emphasise the importance of well-informed design. While there is some uncertainty regarding the seasonal variability and values of the water table underlying the estuarine-deltaic plain, the NT EPA considers that impacts to these values can be minimised by actioning Recommendation 8 and implementing the relevant management plans developed in accordance with appropriate standards and approved under the relevant licences. The NT EPA considers that in regards to the construction of ponds and channels on the Estuarine-deltaic plain, it is highly likely that the NT EPA's environmental objective for water quality can be met (Section 5.2.1).

5.2.4 Waste

5.2.4.1 Values

As for Section 5.2.3 above.

5.2.4.2 NT EPA assessment

Pond sludge

Between crops, the Proponent proposes to remove pond spoil (sludge) containing silt, algal matter, uneaten prawn feed and prawn faeces to a remediation stockpile between farms 1 and 2. Periodically but less frequently, accumulated silt and organic matter from recycling ponds, settlement ponds and channels would also be removed as required and mixed with the pond spoil. Based on the information provided in the EIS, the annual volume of farm pond waste for three farms was estimated to be up to 24 000 m^3.

The pond spoil material is proposed to be solar dried and aerated and then rolled out and compacted as landfill between the farms and contained to prevent scour and loss during the Wet season. The material, with its high levels of organic material, would then potentially be used to help revegetate pond banks, or to assist with scour erosion or construction of new berms.

The NT EPA raised concerns about the risks associated with high concentrations of nutrients and salts potentially being mobilised from farm pond waste into surface and/or groundwater systems.

The EIS included a description of the proposed remediation of the material, which included solar drying and aeration, rolling out and compaction as landfill between the farms, and containment to prevent scour and loss during the Wet season. Salts would be leached by spreading the material in thin layers of <1 m depth in any season, suitable for flushing of salts over a small number of Wet seasons.

The Proponent proposes to manage the material in accordance with relevant guidelines and standards, with the intent to comply with the Environmental Code of Practice for Australian Prawn Farmers. The Code requires that any designated storage area be sufficiently compacted to minimise leaching (suitability of soils for this purpose is discussed in Section 5.2.3 of this Report) and be designed to minimise entry of overland flows (e.g. perimeter bunding). The Code also requires that methods be used to minimise erosion of material from storage areas (or areas where material is disposed/deposited) into adjacent waterways. The Proponent has committed to complying with the Code.

The material would primarily be used inside farm areas within the farm water system and therefore any surface runoff would be captured. While some of it may be used external to the farms, the Proponent considers that the material would be remediated appropriately to avoid significant effects on surface water quality. Where not able to be used on the site, the material is proposed to be stockpiled and compacted into a low stable landform. Such a stockpile would need to comply with the Code and may also require approval and a licence under the WMPC Act.

Biological waste and pond sludge containing prawn effluent, prawn detritus and dead prawns fit the description of “animal effluent and residues (abattoir effluent, poultry and fish processing waste)” under the WMPC Act and are regulated as “listed wastes”. The activity of constructing, installing or carrying out works in relation to a premise for storing, recycling, treatment or disposal of listed waste will require an environment protection approval. Proposed operational activities relating to listed waste handling activities may require an environment protection licence depending on the level of environmental risk. The proponent will be required to submit an application for an environment protection licence for assessment.

Prawn bodies (mass mortality)

A number of commenters were concerned about potential impacts from disposal of prawn bodies in the event of a mass mortality such as a disease outbreak.

The Proponent indicated that a realistic scenario for contingency planning would be less than 1500 tonnes of prawn stock, taking into account the likely standing stock in operating farms that could be affected at one time. The proponent identified four plausible potential sites and pathways for appropriate disposal as requested by the NT EPA. These are:

- As a result of holding the pond water and disinfection, the in-pond mortalities have rotted out and 'mass disposal' is not needed.

- Disinfected water is released, mortalities are retained in the pond and decompose in-situ or are ploughed in, with subsequent treatment to sterilise the pond floor through extended dry-out or treatment with lime.
- Mortalities are 'harvested' and are buried within a trench or pit on site and treated with hydrated lime, as required.
- Incineration - this may be an option but does not fall within the criterion of common operational practices.

If such a mass mortality was to occur, the NT EPA considers that disposal of prawn bodies would be manageable at Legune and, depending on circumstance, would be at the direction of the relevant authorities in accord with the Intergovernmental Agreement on Biosecurity, and the *Commonwealth Biosecurity Act 2016*.

5.2.4.3 NT EPA conclusion

The Proponent has committed to apply for the appropriate approvals and licences under the *Waste Management and Pollution Control Act* for relevant activities during the construction and operational stages of the Project, and has committed to consult with the NT EPA in making the applications.

The NT EPA considers that Project wastes can be managed by the Proponent to minimise potential environmental impacts and risks to water quality at Legune, and thus is highly likely to meet the NT EPA's environmental objective (Section 5.2.1).

5.3 Freshwater aquatic, floodplain and estuarine ecosystems

5.3.1 NT EPA objective

To maintain the conservation status, abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts (on the Project area and on adjacent areas that may be impacted).

5.3.2 Vegetation

5.3.2.1 Values

Wet season surveys were conducted in 2015 and 2016 to map vegetation communities present and determine the presence, or likelihood of presence, of threatened species and declared weeds on the Legune site. Threatened species and communities are discussed with other MNES in Section 5.4 of this Report.

Twenty vegetation communities were defined and mapped, across the Legune area. The majority of these communities are wetland or significant vegetation communities as defined in the Land Clearing Guidelines (a referenced document under the Northern Territory Planning Scheme).

Section 0 of this Report refers to distinct tiers in the landscape that dictate vegetation types. Of these landscape tiers, the estuarine-deltaic plain is the landscape that would be predominantly affected in extent by construction of Project components.

Almost 75% of the estuarine-deltaic plain is comprised of grassland, of which there are two major communities present, northern rice grass in areas of higher salinity, and canegrass (*Ophiuros exaltatus*) and/or Australian wild rice (*Oryza australiensis*) in areas with a lower soil salinity and subject to extended periods of inundation.

Large areas of wetland are a conspicuous element of the estuarine-deltaic plain. This vegetation community is generally a mixed species closed to open sedgeland, and includes areas of open water with aquatic plant beds dominated by Nymphaea spp. (waterlilies). Ephemeral wetland communities that become inundated during the Wet

season are present within the grassland mosaic with mixed species of open sedgeland/tall open forbland occurring on shallow depressions and gilgais. This community generally dries out rapidly in the Dry season.

The estuarine-deltaic plain also includes approximately 5000 ha of woodland comprising three communities, adjacent to grassland areas.

The coastal plain includes vegetation types that are most subjected to tidal influences. Approximately 17 000 ha of mangrove low closed forest has been mapped on the coastal plain in Legune Station. This community is situated in the inter-tidal zone and is invariably dominated by grey mangrove (*Avicennia marina*) and/or freshwater mangrove (*Excoecaria agallocha var. ovalis*).

The most abundant vegetation community on the coastal plain is samphire forbland, which includes areas of bare salt pan and areas dominated by forbs and grasses such as beadweed (*Suaeda arbusculoides*), samphires (*Tecticornia spp*.), marine couch (*Sporobolus virginicus*) and northern rice grass (*Xerochloa imberbis*). Samphire forbland is located in the supra-tidal zone (i.e. the zone above the usual extent of the tide), and occupies over two thirds of the coastal plain (approximately 43 500 ha).

The remaining vegetation types likely to be affected to a lesser extent by the Project are comprised of sclerophyll woodland dominated by *Eucalyptus / Corymbia spp.* and *Melaleuca spp.*

5.3.2.2 NT EPA assessment

Overall 3820 ha of native vegetation is to be cleared for the Project equating to two percent over the 178 800 ha Legune station. The most extensive clearing is of the Estuarine-deltaic Plain Grassland Mosaic communities for the ponds and the associated infrastructure and environmental protection zone. Linear clearance of vegetation for access and supply corridors crosses many vegetation communities. The remaining clearing is localised clearing for project support infrastructure such as the camp, wastewater treatments and power station.

Clearing and disturbance of native vegetation for the development represents small proportions of the local (< 5% in most cases) and regional extent (<1%) of these communities and the vegetation management strategy is adequate to ensure that potential impacts to biodiversity are as low as reasonably practicable. Clearing of Wild Plum low open woodland, Northern Rice Grass (*Xerochloa imberbis*) grassland and Canegrass (*Ophiuros exaltatus*) grassland communities will exceed 5% of the local proportion, but will be less than 10% local and 5% of the bioregional extent. The significance of clearing of Wild Plum is discussed briefly in Cultural Values Section 5.6.

Estuarine and intertidal habitats directly impacted by the construction of the seawater intake and effluent discharge outfall structures include non-vegetated soft sediments, mangrove forest and samphire forblands. Approximately 9.3 ha of mangrove forests (0.05% of the mangrove forests on Legune Station) and 278.7 ha of samphire forbland (0.64% of the area of samphire forbland on Legune Station) are expected to be cleared. This represents a small proportion of existing habitat and is not considered critical with respect to regional habitat types or significant impacts to estuarine flora and fauna. Even so, the NT EPA advises that clearing of these habitats, particularly mangrove communities, should be minimised as far as is practicable.

The introduction and spread of weeds is considered to be the most significant potential impact to biodiversity values associated with clearing and disturbance of vegetation communities on the Project site. Three class A weed species, Gamba Grass (*Andropogon gayanus*), Mimosa (*Mimosa pigra*) and water hyacinth (*Eichhornia crassipes*) have been identified or are established on the site, as well as eight class B weeds. There is a high likelihood that some of these weed species may be spread

through movement of machinery and vehicles. Weed spread may be further exacerbated by the removal of grazing on grassy weed species particularly the introduced aquatic pasture species, para grass (*Urochloa mutica*). The spread of weed species across the floodplain can result in the establishment of monocultures across large areas reducing the habitat available for other native flora and fauna species.

The Proponent has committed to undertaking a comprehensive weed survey in the Project footprint in consultation with DENR prior to construction commencing with weed monitoring to track changes in weed infestation over time.

The Proponent has committed to preparing and implementing a Weed Management Plan in consultation with DENR. Management will be focused on biosecurity and surveillance measures, and on control of high priority species. Following land clearing activities the proponent has committed to undertake follow-up chemical control to manage weed germination triggered by soil disturbance.

5.3.2.3 NT EPA conclusion

The NT EPA considers that the native vegetation to be cleared for the Project generally represents a limited proportion of the extent of those vegetation types within the Legune area and more widely in the region. Clearing is unlikely to significantly impact these vegetation types at local or Bioregional scales.

To limit the potential for weed species to infest wetland areas, weed surveillance and management will be critical. Particular vigilance will be required to avoid infestation of key habitat areas for waterbirds by para grass, olive hymenachne and water hyacinth, as discussed in the following section of this Report (Section 5.3.3). Maintenance of grazing regimes in areas with grassy weeds may be required with careful management and on the advice of the DENR.

The NT EPA considers that the Project can be undertaken with minimal impact from weeds provided the Proponent conducts activities in accordance with its commitments in the EIS and its weed management plan, with advice from the DENR. The NT EPA considers therefore that its environmental objective is highly likely to be met (Section 5.3.1).

5.3.3 Fauna

Eleven terrestrial fauna species listed as threatened occur or may occur on the site. A discussion of the potential impacts to these species is present in the MNES section (Section 5.4.2). The key fauna group likely to be impacted by the Project is the avifauna using the freshwater and estuarine habitats of the Legune Coastal Floodplain, discussed below. The term ‘waterbird’ in this Report refers to those avifauna that primarily use freshwater wetlands and are typically resident or nomadic. The term ‘shorebird’, being a subset of waterbirds, refers to those that primarily use saline intertidal habitat and are typically international migrants.[2]

[2] The term waterbird refers to those species from the following families: Anseranatidae, Anatidae, Podicipedidae, Anhingidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Threskiornithidae, Ciconiidae, Gruidae, Rallidae, Scolopacidae, Rostratulidae, Jacanidae, Burhinidae, Haematopodidae, Recurvirostridae, Charadriidae, Glareolidae, Laridae and Sternidae, which are ecologically dependent upon wetlands (Legune EIS, 2016).
The term shorebird refers to a subset of both resident and migratory species from the following waterbird families: Scolopacidae; Burhinidae; Rostratulidae, Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae, which are ecologically dependent upon wetlands (Legune EIS, 2016).

5.3.3.1 Waterbird values

The key ecological value of the Legune area is the aggregation of a high species diversity and large total numbers of waterbirds. The Legune Coastal Floodplain meets the criteria for an internationally important site for waterbirds, which was recognised in the inclusion of the area as a NT Site of Conservation Significance (*Legune Coastal Floodplain*; Harrison *et al.* 2009). Internationally important sites for waterbirds are defined by the Ramsar Convention criteria 5 and 6. Criterion 5 states a wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds. Criterion 6 states that a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Survey programs conducted by the Proponent in 2015 and 2016 recorded 71 species across nine different feeding guilds. More than 20 000 waterbirds have been consistently reported across the Legune Coastal Floodplain (Criterion 5), the 2015/16 surveys by the Proponent supported previous data on the importance of the site for waterbirds.

Internationally significant numbers of individuals for six waterbird species were recorded by the Proponent (Ramsar Criterion 6; Table 3). Previous surveys (Chatto 2006) additionally recorded internationally significant numbers of Pied Heron and nationally significant numbers of Purple Swamphen and Glossy Ibis (>1% Oceania population: Wetlands International 2012).

Table 3 Waterbird species recorded at internationally significant numbers at Legune Station under the Ramsar Criterion 6 during 2015/16 surveys by the Proponent.

Name	Species
Magpie Goose	*Anseranas semipalmata*
Green Pygmy-goose	*Nettapus pulchellus*
Plumed Whistling Duck	*Dendrocygna eytoni*
Wandering Whistling-duck	*Dendrocygna arcuata*
Radjah Shelduck	*Tadorna radjah*
Pied Heron	*Ardea picata*

Five waterbird breeding colonies have been recorded at the site (from all data sources), and three were reported as active in March 2016 by the Proponent. One colony was on the floodplain of Forsyth Creek while the other two were in the vicinity of two previously recorded colonies on the Keep River intertidal area.

5.3.3.2 Shorebird values

Legune Coastal Floodplain provides at least nationally significant habitat for migratory shorebirds. The EPBC Act criteria (Policy Statement 3.21) for nationally important habitat for migratory shorebirds are: regularly supports 0.1% of the flyway population of a single species of migratory shorebird; or regularly supports 2000 migratory shorebirds; or regularly supports 15 migratory shorebird species. These thresholds are all met for the Legune Coastal Floodplain, particularly the Turtle Point area.

The Proponent undertook surveys for shorebirds using the site, over a one year period in 2015/16, and these surveys were well-designed and comprehensive. During 2015/16 surveys, one shorebird species (Greater Sand Plover *Charadrius leschenaultii*) was recorded at levels of international significance (RAMSAR Criterion 6) and fifteen other

species were recorded at levels of national significance (Table 4). Previous surveys in the region identified internationally significant numbers for Terek Sandpiper *Xenus cinereus* (Chatto 2003).

Twenty-one species of migratory shorebird species were recorded at Legune Coastal Floodplain by the Proponent, including seven listed as threatened under either the EPBC Act or TPWC Act (Table 4), slightly less than reported by Chatto from surveys in the 1990s (25 species; Chatto 2003). The NT EPA generally agrees with the significant impact assessments for these species presented in the EIS (draft EIS Vol 2, Ch6, Section 4). The discussion below assessing impacts applies to all of the threatened shorebird species unless specified otherwise, as most species use the same habitat and are subject to the same potential impacts.

Table 4 Shorebird Species listed as threatened and/or recorded at national and internationally significant numbers at Legune Station.

Name	Species	Nationally Significant	Internationally significant	EPBC Status	TWPC Status
Greater Sand Plover	*Charadrius leschenaultia*		X	Vulnerable	Vulnerable
Marsh Sandpiper	*Tringa stagnatilis*	X			
Red-necked Stint	*Calidris ruficollis*	X			
Long- toed Stint	*Calidris subminuta*	X			
Sharp-tailed Sandpiper	*Calidris acuminate*	X			
Curlew Sandpiper	*Calidris ferruginea*	X		Critically Endangered	Vulnerable
Little Curlew	*Numenius minutus*	X	X		
Whimbrel	*Numenius phaeopsis*	X			
Eastern Curlew	*Numenius madagascariensis*	X		Critically Endangered	Vulnerable
Black-tailed Godwit	*Limosa limosa*	X			
Bar-tailed Godwit	*Limosa lapponica*	X		*L. l. baueri* Vulnerable *L. l. menzbieri* Critically Endangered*	Vulnerable
Common Greenshank	*Tringa nebularia*	X			
Lesser Sand Plover	*Charadrius mongolus*	X		Endangered	Vulnerable
Oriental Plover	*Charadrius veredus*	X			
Terek Sandpiper	*Xenus cinereus*	X			
Grey-tailed Tattler	*Tringa brevipes*	X			
Wood Sandpiper	*Tringa glareola*	X			
Ruddy Turnstone	*Arenaria interpres*	X			
Great Knot	*Calidris tenuirostris*			Critically Endangered	Vulnerable
Red Knot	*Calidris canutus*				Vulnerable

**Legune includes the known distribution of both subspecies of Bar-tailed Godwit (subspp. bauera and mensbieri)*

5.3.3.3 NT EPA assessment

The Proponent correctly noted that Legune is not listed under the Ramsar Convention, and this reduced some assessment requirements under the EPBC Act. Nevertheless, the site clearly meets criteria as internationally significant under the Ramsar Convention and the NT EPA is of the opinion that these values should be maintained.

The major sources of potential impact on waterbird habitat are modification of surface flows by project infrastructure, cessation of water release from Forsyth Dam, clearance or modification of soil and vegetation, and changes to water quality from farm discharge.

The current wetland dynamics on parts of the Legune Coastal Floodplain are highly modified and controlled by the land manager, through bunding infrastructure to control water movement between paddocks, damming of Forsyth Creek and flood irrigating paddocks in the Dry season. The bunds separate the upstream freshwater part of the system from the estuarine downstream area, effectively increasing the amount of freshwater habitat compared to pre-bund configuration. Modelling described in the EIS

suggests that the current management of surface water flow, compared with pre-modification regimes, results in an increase in flood depth and extent in Alligator Creek and a decrease in flood extent in the Forsyth Creek floodplain in the Wet season. The release of water from Forsyth Dam during the Dry season considerably increases habitat available for waterbirds in both the Alligator and Forsyth Creek areas, and this was reflected during the 2015 and 2016 surveys by a large increase in numbers of waterbirds, particularly magpie goose and plumed whistling duck, following water release. The freshwater wetlands of the Alligator Creek system consistently supported the highest waterbird density and species richness across the site.

Surface flow changes due to infrastructure

Upgrading the site access road for all weather conditions is the major infrastructure development with potential to impact on Wet season waterbird habitat. The road could cause blockages on the upper floodplains, generally increasing upstream flood extent and depth. The Proponent has proposed a series of under road culverts to improve water flow under the road. Water modelling appears to show that the culvert system will greatly reduce the impact of road blockages, leaving only highly localised changes to water depth, even under 100 year flood events. On the basis of this modelling, the NT EPA accepts the conclusion in the EIS that the culverts would minimise changes to Wet season surface flows, to the extent that potential impacts to waterbird habitat values from upgrading the access road are not likely to be significant.

Cessation of Forsyth Dam releases

During the Dry season, discontinuing the annual release of Forsyth Dam will result in a decrease in the extent of surface water, generally reducing available habitat for waterbirds, particularly in the freshwater section of the Alligator Creek floodplain. The impact of this change on the ecological value of the Legune site as a whole is difficult to assess with any confidence. Available data that pre-dates the introduction of bund infrastructure, Forsyth Dam and Dry season water release information showed that the site supported significant aggregations of waterbirds with 'natural' Dry season water regimes. Some important parts of the wetland complex (notably Osmans Lake and vicinity) are not affected by Dry season water release, and there is no direct pathway for impact from the proposed development on these areas. The large increase in total waterbird numbers observed in August 2015 following water release (draft EIS Vol 2, Ch 6, Table 4) was heavily influenced by two highly mobile species – Magpie Goose and Plumed Whistling-Duck. Nevertheless, maintenance of larger areas of suitable waterbird habitat in the mid to late Dry season may be important in maintaining local and regional populations of a larger number of waterbird species, and may be particularly important in increasing resilience of waterbird populations to highly variable rainfall and inundation conditions across years.

Natural environmental flows to the floodplain will remain restricted by Forsyth Dam without any compensatory water release, when all of the water is withheld for use on the prawn farm.

Uncertainty about the potential impact of the proposed development on waterbird habitat, particularly arising from changes in floodplain hydrology and inundation regimes, led the NT EPA to focus on avifauna monitoring as a critical component of the Proponent's impact management. A framework waterbird monitoring plan was provided to the NT EPA for consideration in consultation with the DENR and the Commonwealth Department of the Environment and Energy (DEE). A key outcome of discussion was the requirement for expert advice to inform the program and the formation of a scientific advisory group (SAG) to facilitate this. The framework monitoring plan is considered further at the end of this section of the Report (Section 5.3.3.3).

Habitat clearance/modification

The 2015/16 surveys by the Proponent demonstrated that the area in the vicinity of the proposed prawn ponds is of relatively low importance for all waterbirds (including migratory shorebirds), so that vegetation clearing and excavation of the ponds is not likely to have a significant impact on waterbirds.

Water quality from farm discharge

Changes to water quality from the farm discharge at Alligator Creek is the main potential impact pathway for the most important habitat areas for the majority of the migratory shorebirds within the Legune Coastal Floodplain. Important habitats for migratory waders are Turtle Point and the Keep River intertidal flats, with additional feeding habitat available on the intertidal banks of Forsyth and Alligator Creeks. Turtle Point is located approximately 24 km from the prawn farm site. Modelling of the prawn farm discharge presented in the EIS, despite its limitations (as discussed in Section 5.2.2), generally indicates that with distance from Alligator Creek, water quality changes as a result of farm effluent discharge will be minimal or barely detectable in the broader marine environment, including the Keep River mouth, Turtle Point and upstream in the Keep River. Hence, the potential for significant ecological impact downstream at Turtle Point and within the broader Keep intertidal flats is likely to be very low.

Bird predation

Predation of prawns by birds is considered a potential impact for the Project, both from a commercial perspective but also in terms of potential impacts to bird aggregations on Legune. The Proponent acknowledged that bird predation could be an issue that will require management.

Complete enclosure of waterbodies with fencing/netting is the only proven, effective way of eliminating waterbirds from ponds, according to the EIS. Unless predation is having a significant impact on production, though, such a measure is highly unlikely to be implemented due to the prohibitive costs involved. Evidence is presented that management techniques are more effective when implemented prior to birds becoming established in the area using the ponds as a food source. The proponent has proposed human disturbance (patrols on foot or in a vehicle), helicopters and drones as methods to deter prawn predators at the Project site. Helicopters are also proposed for operational use.

The potential for predation impact by the majority of waterbirds on site was assessed as negligible to low, due to the known species specific feeding behaviours and the design features of the ponds. Two groups with a higher potential for predation impact are the cormorants and the Australasian Darter. Cormorants and darters are plunge divers, an important feeding behaviour for targeting *Penaeus monodon*, which prefer epibenthic habitats (bottom dwellers). The four species of cormorant and the Australasian darter are considered to be common in areas of inland waters across the Top End and have all been recorded at Legune station.

Balancing the deterrence of predator species (if required) and reduction of impacts on non-target species is important. Evidence presented in the Supplement indicated that helicopters may be ineffective at scaring diving birds (the species posing the most significant predation threat) from ponds as their response is to dive under the water in ponds rather than fly off. However, helicopters are known to cause significant disturbance to other waterbird species. While the impact is likely to be short lived, with birds returning soon after a helicopter has passed, even short term disturbances on migratory wader species when feeding can impact on their ability to gain sufficient fat for moulting and migration. The NT EPA does not support the use of helicopters for deterring predator bird species, particularly in areas where disturbance to migratory waders is likely. Although the requirement of bird deterrents to reduce predation is not

yet established, the impact of helicopter use for operations on waterbirds is considered by the NT EPA to be the primary concern.

The Proponent intends to manage the impacts of operational helicopter use to non-target species by:

- restricting low altitude movements (< 450m above ground level) to the airspace above the farm footprint
- constraining all movements between farms or other parts of the site to the airspace above the Project footprint (e.g. the infrastructure corridor)
- operating flight procedures which minimise the incidence and duration of rotor blade slap noise.

Management may reduce helicopter impacts across some areas of the site. However, uncertainty remains as large numbers of waterbirds have been recorded within relatively short distances of the areas of the restricted helicopter movements (e.g. site AC6 is within 250 m of the transport corridor between the central facilities and the farms).

The Proponent has committed to undertaking a series of experimental trials during the 2018/2019 Wet season to assess responses of waterbirds to helicopters and drones within the wetland habitats adjacent to the farms. Key objectives of this work are to investigate flight protocols for future operations and the potential impacts to avifauna. The NT EPA is of the opinion that the objectives and the methods used to assess them should be developed in consultation with the SAG. The objectives must include consideration of migratory shorebird species. A monitoring and mitigation program should be developed and implemented, informed by results of the trials, to manage potential impacts to waterbirds as a result of predatory waterbird control measures and helicopter use.

Recommendation 9

A monitoring and mitigation program addressing potential impacts from bird predation management measures to non-target waterbird species shall be developed to the satisfaction of the DENR, and with advice from a scientific advisory group established in accordance with Recommendation 10 of this Report. The program should include consideration of impacts from operational use of helicopters as well as their use as a control option.

It should be noted that any future proposed “mitigation” of native predatory birds would require a permit under the TPWC Act, and mitigation measures for the Project should avoid this requirement wherever possible.

Noise and visual disturbance

Noise and visual disturbance associated with construction may have localised impacts on waterbirds. Limiting the work to the Dry season when migratory waders are less likely to be present will lessen the potential impact to ecological values at the site. The proposed restrictions on access to the site and strictly enforced speed limits are also likely to be effective mitigation measures. When developing construction schedules that minimise the period taken to do the work, consideration of the time of day (and where practicable, limiting to times when birds are roosting rather than feeding) should be included to further reduce the impact.

The EIS states that the use of temporary noise barriers to provide acoustical shielding will be dependent on monitoring avifauna responses to noise. No measures were provided on how disturbance responses would be measured and at what thresholds of disturbance (such as degree of vigilance) mitigation measures would be enacted. Any avifauna monitoring would need to be adequately designed to enable adaptation of

mitigation measures in response to any observed significant disturbance. As with previous discussion on monitoring in this section (Bird predation; Cessation of Forsyth Dam releases), monitoring and mitigation should be considered in consultation with the SAG to ensure the methods are most appropriate to minimise detrimental effects.

Introduced species

The introduction and spread of introduced plant and animal species can impact aquatic ecosystems by altering habitat and reducing habitat availability, and reducing the abundance and diversity of native species. Weeds in particular have the potential to significantly impact waterbirds at the Project site if not managed.

A number of weed species have been recorded at Legune Station as identified in Volume 2 Chapter 5 of the draft EIS. A key concern for waterbird habitat is the proliferation of aquatic and semi-aquatic weeds, particularly in the permanent freshwater habitats. The DENR Weed Management Branch identified that water hyacinth (*Eichhornia crassipes*), a Declared Class A aquatic weed, was present on the site. Olive hymenachne (*Hymenachne amplexicaulis*), a Class B semi-aquatic grass was identified by the Proponent in shallow water along the bank of the Forsyth Creek channel, approximately seven kilometres downstream of the Forsyth Creek Dam. The introduced aquatic grass species, para grass (*Urochloa mutica*) is also established and has the potential to be invasive. The EIS indicates that although this species is not a major problem at present, it may have the potential to become problematic in the future if grazing regimes are not maintained.

As discussed in Section 5.3.2, the Proponent has committed to undertaking a comprehensive weed survey in the Project footprint and to preparing and implementing a Weed Management Plan, in consultation with DENR. Management will be focused on biosecurity and surveillance measures, and on control of high priority species. Following land clearing activities the proponent has committed to undertake follow-up chemical control to manage weed germination triggered by soil disturbance.

A number of introduced animal species are also present at Legune Station. These species are generally well established in the Project site and the region more broadly, and the Project is unlikely to significantly increase their numbers. The Proponent has committed to implementing control measures for species such as feral dogs, pigs and the cane toad. While this is commendable, there is one introduced species where a management program would be of greater benefit, the black rat (*Rattus rattus*). This species is the most likely to become established as a result of the Project and can predate on ground-nesting birds and other fauna. The Proponent has committed to preparing a Fauna Management Plan, which will include strategies to manage pest animals. As with weed management, the focus of management should be on surveillance and biosecurity measures, and management strategies for high priority species such as the black rat.

Waterbird monitoring and mitigation program

A key consideration of the potential impacts to waterbirds at Legune is the implementation of an appropriate avifauna monitoring and mitigation program. Limited detail was provided in the draft EIS of any monitoring of biodiversity values that may be potentially impacted by the Project, and proposed fauna and flora monitoring was generally limited to the construction period (draft EIS Vol 2, Ch 6, section 5; Vol 4, Ch 3 & Ch 6). As described above, the key ecological value of the site is the internationally significant aggregation of waterbirds, and there remains some uncertainty about the impacts of the development on this value, particularly in relation to any changes in the hydrology and inundation regimes of the freshwater wetlands. An essential tool for reducing this uncertainty is the development of a monitoring and mitigation program that can robustly track changes in waterbird composition, abundance and habitat usage over

medium timeframes having regard for the context of wetlands regionally and nationally, that includes indicators of waterbird habitat quality, and allows for an adaptive management response in the event that negative impacts are observed.

The framework avifauna monitoring and mitigation plan submitted as part of the Supplement was deemed appropriate as a preliminary management document.

The framework prepared by the Proponent for a Waterbird Monitoring Plan for the Freshwater Wetlands of the Legune Coastal Floodplain was provided to the NT EPA following discussion with the Proponent, the DENR and the DEE. The NT EPA considers the framework generally adequate as an indicator that the monitoring program will be robust. Further development of this framework into a useable management tool will be undertaken in consultation with a scientific advisory group (SAG), the membership of which will be formed on the advice and agreement of the DENR, the DEE and the Proponent. As previously discussed, the SAG would also be called upon to provide advice on matters relating to bird predator deterrence, and noise and visual disturbance.

Recommendation 10

A scientific advisory group (SAG) shall be established to advise on matters relating to waterbirds potentially impacted by the Project, in particular the development and implementation of a waterbird monitoring and mitigation program. The SAG shall be formed on the advice and agreement of the Department of Environment and Natural Resources, the Commonwealth Department of the Environment and Energy, and the Proponent.

A Terms of Reference for the SAG shall be developed to the satisfaction of the NT EPA and agreed by the aforementioned parties. Details regarding the establishment of the SAG, including roles and responsibilities, membership (including an independent chair), timeframe for commencement and scope, reporting obligations and accountability should be decided within three months of the environmental impact assessment completion date.

Recommendation 11

The Proponent shall prepare and implement a waterbird monitoring and mitigation program to the satisfaction of the Department of Environment and Natural Resources, the Commonwealth Department of the Environment and Energy, based on advice of the scientific advisory group (SAG). The program will be designed with sufficient statistical power to monitor potential impacts to waterbirds from:

- **cessation of flows to wetlands from Forsyth Dam**
- **other sources as the SAG sees fit.**

The program shall include management measures and appropriate contingencies in the event that monitoring detects impacts attributable to the Project.

The Proponent shall make the program publicly available and include annual reporting on the implementation of the program to key stakeholders and the public.

5.3.3.4 NT EPA conclusion

Having regard to information presented by the Proponent in the EIS, and advice provided by the DENR, the NT EPA is satisfied that the key potential impacts and risks to freshwater aquatic, floodplain and estuarine ecosystems as a result of the Project have been adequately identified. The majority of potential impacts to avifauna, which are considered the key environmental value within the Legune Coastal Floodplain, have

been determined either not significant or manageable in accordance with standard methods.

Some uncertainty remains with respect to potential impacts from elements of the Project such as the management of predatory birds, particularly using helicopters, and the cessation of flows from Forsyth Dam to the floodplain during the Dry season. The NT EPA makes Recommendations 10 and 11 in regards to the establishment of a scientific advisory group to provide advice on the detail of a monitoring program for waterbirds to be implemented by the Proponent. The NT EPA considers that implementation of a monitoring program with practicable contingency measures will minimise potential impacts to waterbirds and enable decision-making that ensures the values of the Legune Coastal Floodplain as a significant site for waterbird aggregations are retained. Provided potential impacts from helicopter use and hydrological changes are minimised, the Project is not considered inconsistent with relevant recovery plans, conservation advice or threat abatement plans for migratory shorebirds. The NT EPA considers that by actioning the recommendations, the environmental objective for freshwater aquatic, floodplain and estuarine ecosystems, including the protection of avifauna, is highly likely to be met.

5.4 Matters of National Environmental Significance/listed species

5.4.1 NT EPA objective

To minimise the risk of Significant Impacts to threatened species and communities, and migratory species listed under the EPBC Act, and species listed under the TPWC Act.

5.4.2 Threatened Species and Communities

5.4.2.1 Values

No threatened ecological communities occur on the project site. 24 species (or subspecies) listed as threatened under the EPBC Act occur or are likely to occur on the project site. Of these, six are terrestrial fauna species, one terrestrial flora species, one non-migratory waterbird, nine marine species and seven migratory shorebirds. The likelihood of occurrence and potential impact for each species is discussed under the relevant subheadings below.

5.4.2.2 NT EPA assessment

Terrestrial Species - Fauna

In general, the NT EPA agrees with the assessment undertaken by the Proponent of likelihood of occurrence (draft EIS Vol 2, Ch 6, Table 10) and significant impact assessment (draft EIS Vol 2, Ch 6, Tables 14, 20, 21, 23-28) for terrestrial fauna species, with some additional details below.

<u>Threatened Species recorded on site</u>

Bare-rumped Sheath-tailed Bat *Saccolaimus saccolaimus* (Critically Endangered EPBC Act), was detected by consultants by aural sampling. There remains some doubt around the ability to differentiate the calls of this species from *Saccolaimus flaviventris*, although the consultants have devoted significant effort to validate this. However, assuming that the species is present, the NT EPA agrees with the Proponent that the Project will not result in a significant impact to the Bare-rumped Sheath-tailed Bat, due to very limited pathways for impact. Roosting sites were not found in the area to be cleared despite reasonable search efforts. This species forages over large areas, therefore the loss from clearing of a small proportion of potential foraging habitat lost is not likely to result in a significant impact.

Ghost Bat *Macroderma gigas* (Vulnerable EPBC Act), was detected on site by the Proponent, in an area outside the project footprint. The species has only recently been listed and a significant impact assessment was not presented in the EIS, although it was discussed in the Terrestrial Fauna Appendix (draft EIS Vol 5, Appendix 15). Suitable habitat for roost sites was not present within the project footprint. The detection of a Ghost Bat suggests that there may be a roost site in the rocky ranges to the south of Forsyth Dam and/or Lindens Range. However, this area is likely to be outside of the project impact area.

Gouldian Finch *Erythrura gouldiae* (Endangered EPBC Act; Vulnerable TPWC Act) was detected on site by the Proponent. The NT EPA agrees with the assessment that the Project will not result in a significant impact on this species, as no potential breeding habitat exists within the project footprint. There is a small area of potential Wet season foraging habitat that will be impacted by widening of the access road but this is a very small proportion of available habitat in the local area.

Grey Falcon *Falco hypoleucos* (Vulnerable TWPC Act): One sub-adult Grey Falcon was recorded during 2015/16 surveys. The NT EPA agrees with the assessment that the Project will not result in a significant impact on this species due to its highly mobile nature and the area to be cleared being a very small proportion of the widely available habitat.

Threatened Species which may occur on site

Northern Quoll *Dasyurus hallucatus* (Endangered EPBC Act; Critically Endangered TPWC Act): The survey effort for Northern Quoll described in the draft EIS was not sufficient to reliably detect the species at the low densities at which it now occurs on the NT mainland. However, the NT EPA agrees that the likelihood of occurrence of the Northern Quoll in the project area is low to moderate and that the Project is not likely to result in a significant impact on this species. The majority of the project footprint occurs in marginal habitat for quoll and the extent of higher quality habitat to be cleared is small (<1% of woodland). Cane toads are already well established across the site and the likelihood of fire regimes being modified by this project to the further detriment of this species is low.

Red Goshawk *Erythriorchis radiatus* (Vulnerable EPBC Act and TPWC Act): the NT EPA agrees that the likelihood of occurrence of the Red Goshawk is low to moderate and that the Project is not likely to result in a significant impact on this species. The majority of the potential habitat for this species is outside the project footprint.

VRD Blacksoil Ctenotus *Ctenotus rimicola camptris* (Vulnerable TWPC Act): While this species occurs on black soil floodplains to the south and east of Legune, adequate targeted surveys by the Proponent demonstrated that it is unlikely to occur within the project footprint. The EIS also describes some analysis of soil mapping in relation to the known distribution of the species, which supports its absence from the site.

Water Mouse *Xeromys myoides* (Vulnerable EPBC Act) is not likely to occur on site (Legune is well outside the species known distribution, the nearest record being approximately 220km to the northeast). Potentially suitable habitat for the species (mangrove and intertidal grass, sedge and forb-lands) on Legune is not likely to be significantly impacted by the proposed development.

None of the three Varanus species, Merten's Water Monitor *Varanus mertensi*, Mitchell's Water Monitor *Varanus mitchelli* and Yellow Spotted Monitor *Varanus panoptes* (all Vulnerable TWPC Act), were detected on site, despite adequate survey effort. While these species would be expected to occur on the site based on their distribution and habitat preference, the observed absence may reflect major local decline attributable to cane toad invasion. Riparian habitats in the upper Alligator Creek wetland system and Alligator Springs should provide habitat for Mitchell's Water Monitor and Merten's Water

Monitor, and the Project is not likely to have a significant impact on these habitats. Habitat for the Yellow-spotted Monitor is widespread on the site and up to 7% of this habitat will be cleared for the Project. Clearing 7% of habitat is not likely to cause a significant impact.

Species not detected or with low likelihood of occurrence

The following seven species were assessed by the Proponent as having unlikely or highly unlikely potential occurrence:

- Masked Owl (Northern) *Tyto novaehollandiae kimberli* (Vulnerable EPBC Act and TWPC Act)
- Pale Field-rat *Rattus tunneyi* (Vulnerable TPWC Act)
- Partridge Pigeon *Geophaps smithii* (Vulnerable EPBC Act and TWPC Act)
- Purple-crowned Fairy-wren (western) *Malurus coronatus coronatus* (Vulnerable EPBC Act and TWPC Act)
- Brush-tailed Rabbit-rat *Conilurus penicillatus* (Vulnerable EPBC Act; Endangered TWPC Act)
- Plains Death Adder *Acanthophis hawkei* (Vulnerable EPBC Act and TWPC Act)
- Northern Crested Shrike-tit *Falcunculus frontalus whitei* (Vulnerable EPBC Act and TPWC Act)
- Night Parrot *Pezoporus occidentalis* (Endangered EPBC Act; Critically Endangered TPWC Act).

The NT EPA agrees with this assessment, and in some cases adequate survey was undertaken to confirm that the species was absent (Masked Owl, Purple-crowned Fairy-wren and Partridge Pigeon).

Terrestrial Species – Flora

One plant species of Commonwealth conservation significance was predicted to potentially occur in the Legune area, Craven's native hibiscus *Hibiscus cravenii* (Vulnerable EPBC Act and TPWC Act). This species was considered unlikely to be present and it was not found in targeted surveys.

A further two flora species of conservation significance under the TPWC Act were nominated in the search results, both listed as vulnerable; *Platysace saxatilis* and *Zeuxine oblonga*. Both species are considered unlikely to occur on Legune and if so their respective habitats are outside of the project footprint.

Two species listed as Near Threatened and four species listed as Data Deficient under the TWPC Act were recorded in Legune Station during the surveys including respectively; fine-leafed Kimberley fan palm *Livistona lorophylla* and *Turraea pubescens*, and *Eleocharis acutangula*, *Ptilotus capitatus*, *Spermacoce gibba* and *Triodia triticoides*.

The Proponent considered that the Near Threatened species were unlikely to be present within the footprint of project disturbance. While it was unclear from the EIS whether the data deficient species would be disturbed by the Project, the nature of a species being Data Deficient reduces the ability to assess impacts on a local or regional scale. Any data collected on data deficient species should be passed on to the NT Herbarium.

Threatened waterbird species

The only threatened waterbird species (excluding migratory shorebirds) likely to occur on the site is the Australian Painted Snipe *Rostratula australis* (Endangered EPBC Act; Vulnerable TPWC Act). This species was not detected by field surveys but the

Proponent assessed it as likely to occur on site, due to the mobility of the species and the large extent of suitable habitat. The primary area of suitable habitat for this species is associated with the Osmans Lake complex, with smaller areas within the Forsyth Creek catchment. Seven per cent of the potential habitat for this species will be cleared, but the Osmans Lake complex will not be impacted by the Project.

Further assessment and management of potential impacts to this species will be dealt with through the waterbird monitoring and mitigation program, as discussed in Section 5.3.3 of this Report.

5.4.2.3 NT EPA conclusion

Overall the Project will result in only minor disturbance and destruction of habitat for terrestrial threatened species known or likely to occur in the project area. In general, the Project is not inconsistent with recovery plans, conservation advice or threat abatement plans for threatened species. The major potential pathway for impact from the proposed development on terrestrial fauna and flora is through facilitating the introduction and spread of environmental weeds and feral animals. Species of particular concern include Gamba Grass (*Andropogon gayanus*), Mimosa (*Mimosa pigra*) and Black Rat (*Rattus rattus*).The Proponent has committed to implementing a Weed Management Plan for the construction and operational stages of the Project and a Fauna Management Plan. The plan will focus on biosecurity and surveillance and management of high priority species.

The only threatened water bird species, Australian Painted Snipe *Rostratula australis*, is unlikely to be significantly impacted by the Project. Provided weeds are controlled and potential impacts from hydrological changes are managed, the Project is not inconsistent with conservation advice or any threat abatement plans for this species. The potential impacts of hydrological changes will be monitored as part of the Proponent's waterbird monitoring plan in accordance with Recommendation 11 of this Report.

5.4.3 Marine Species

5.4.3.1 Values

Nine threatened marine species have a moderate or high likelihood of occurrence in the Legune area (Table 5). The NT EPA agrees with the assessment in the EIS that an additional six threatened marine species have nil to low likelihood of occurrence as they are only vagrant or very occasional visitors to the Northern Territory (draft EIS Vol 2, Ch 7, Table 5). There are seven marine and migratory species with a moderate or high likelihood of occurrence, including three marine turtles that are also listed as threatened (Table 5).

Migratory shorebirds are also listed as marine. The relevant species are identified in Section 5.4.4 Listed Migratory Species. Potential impacts to migratory shorebirds are discussed with waterbirds in Section 5.3.3.

Areas of high habitat value in the marine, estuarine and littoral environment bordering Legune include a significant nesting area for Flatback Turtle at Turtle Point. The Keep River and Victoria River are likely to be important areas for sawfish and *Glyphis* species due to the current low levels of human disturbance.

Table 5 Marine threatened and/or migratory species likely to occur in the water around Legune Station.

Name	Species	Likelihood of occurrence	EPBC Act	TWPC Act	Migratory
Glyphis garricki	Northern River Shark	High	Endangered	Endangered	
Glyphis glyphis	Speartooth Shark	High	Critically Endangered	Vulnerable	
Pristis clavata	Dwarf Sawfish	High	Vulnerable	Vulnerable	
Pristis zijsron	Green Sawfish	High	Vulnerable	Vulnerable	
Pristis pristis	Large Sawtooth Shark	High	Vulnerable	Vulnerable	
Chelonia mydas	Green Turtle	Moderate	Vulnerable	Near Threatened	yes
Eretmochelys imbricata	Hawksbill Turtle	Moderate	Vulnerable	Vulnerable	
Lepidochelys olivacea	Olive Ridley Turtle	High	Endangered	Vulnerable	yes
Narator depressus	Flatback Turtle	High	Vulnerable		yes
Crocodylus porosus	Estuarine Crocodile	High			yes
Orcaella heinsohni	Australian Snubfin Dolphin	High			yes
Sousa sahulensis	Australian Humpback Dolphin	High			yes
Dugong dugon	Dugong	Moderate			yes

5.4.3.2 NT EPA assessment

The major pathways for potential impact on marine species are disturbance from noise and vibration during construction, entrainment or impingement by the seawater intake pump, changes in water quality due to farm discharge or overflow, increased lighting and increased site access.

Increased noise and vibration from construction activities such as pile driving may have localised impacts on marine species, particularly cetaceans. The Proponent has committed to ceasing activities during construction, if marine megafauna are observed within 500 m of the noise emitting source until the animal has passed (in accordance with previous EPBC Act approvals). The NT EPA advises that sound and vibration impacts could be minimised further if pile driving activities are conducted at low tide. With the implementation of proposed mitigation measures, potential noise-related impacts to marine species are likely to be minimal.

The seawater intake pump station in Forsyth Creek may entrain or impinge marine fauna. The proposed measures to mitigate impacts on marine species include appropriate placement of the intake pipe, maximum velocity set within the speed of tidal movements so that most marine species can swim against the current within 1.25 m of the intake point, and restricting intake to the mid to high tide period. In addition, a 100 mm mesh grille is proposed to be fitted to the intake. The NT EPA considers that the mesh size should be as small as practicable and the grille should consist of rigid rather than soft and flexible material to lessen the likelihood of sawfish entrapment. The NT EPA considers these measures sufficient to reduce potential impacts to an acceptable level. The mesh size on the intake pump is large enough to permit entrapment of hatchling flatback turtles, however, the likelihood of hatchling turtles being present near the intake is considered low.

Despite limitations in the water quality modelling in the EIS, as discussed in Section 5.2.2 of this Report, the NT EPA is satisfied that with distance from Alligator Creek,

water quality changes as a result of farm effluent discharge will be minimal or barely detectable in the broader marine environment, including the Keep River mouth, Turtle Point and upstream in the Keep River. Elevated nutrient levels are predicted to be detectable within a mixing zone upstream and downstream of the Alligator Creek discharge outlet. This area is not considered critical habitat for any marine species. Further data collection and analysis will refine the understanding of the likely mixing zone characteristics and help to define the water quality objectives for the protection of the Keep River as part of an EPL under the WMPC Act.

Increased illumination has the potential to impact nesting turtles and hatchlings. The Project site is a significant distance from known turtle nesting areas (24 km) and the vegetation present between the two locations is likely to shield light from the nesting beach at turtle eye level. The NT EPA assesses this impact as low providing the Proponent fulfils its commitment to minimising the use of light to essential purposes only, using only low intensity light and designing lighting to further reduce the impacts of light pollution.

Increased human access to the site may result in increased recreational fishing with potential negative impacts on threatened shark and sawfish species, as incidental bycatch and mortality is a common threat to these species. The Proponent is presently undecided whether recreational fishing on site will be permitted. The NT EPA is satisfied that issues associated with increased access and recreational fishing will be addressed through a Recreational Fishing Management Plan, which will include actions to reduce impacts to threatened species. The Plan will include limitations on gear use, and guidance on how to identify and safely release sawfish. In addition, boat strikes on marine megafauna or injured or stranded animals will be reported through the NT Government's Marine Wildwatch hotline or web portal.

5.4.3.3 NT EPA conclusion

Having regard to information presented in the EIS and advice from the DENR, the NT EPA is satisfied that the Project can be managed to minimise impacts to marine species and is highly likely to meet the NT EPA's environmental objective (Section 5.4.1). The NT EPA considers that the Project is not inconsistent with relevant recovery plans, conservation advice or any threat abatement plans for marine species, and does not expect significant residual impacts to these species from the Project.

5.4.4 Listed Migratory Species

The Legune Coastal Floodplain is a site of national significance for migratory shorebirds. It fulfils all three of the EPBC Act criteria for national significance (Policy Statement 3.21): regularly supports 0.1% of the flyway population of a single species of migratory shorebird, regularly supports 2000 migratory shorebirds and regularly supports 15 migratory shorebird species. All of the species in Table 4 are known to occur on the Legune Coastal Floodplain with one species being recorded at internationally significant numbers and 17 species at nationally significant numbers. In addition, the Glossy Ibis *Plegadis falcunellus,* a predominately freshwater species listed as migratory, has also been recorded in high numbers.

Potential impacts of the Project to these species are associated with those for all waterbirds and are discussed in Section 5.3.3 of this Report. Marine species listed as migratory are discussed in Section 5.4.3 above.

5.5 Socio-economic

5.5.1 NT EPA objective

To monitor and manage the intended and unintended social and economic consequences, both positive and negative, of the Project.

5.5.2 Values

The Project site is located within the VRD in the NT and adjacent to the East Kimberley. The closest population centres include the town of Kununurra in Western Australia, and Timber Creek in the Northern Territory. The Marralum family outstation, 10 km south of the Project area, is the closest settlement and is occupied only in the Dry season when accessible.

Kununurra and its surrounding lands are the traditional country of the Miriuwung and Gajirrabung peoples, with Gajirrabung families also representing the country surrounding the Project Area. Cultural heritage values are discussed further in Section 5.6 of this Report.

Local industry includes irrigated agriculture (Ord River Scheme stages 1 and 2), tourism, pastoral grazing and mining. The mining downturn has led to recent mine closures and care and maintenance of some sites in the region. Cessation of mining at the Argyle Diamond Mine is pending (expected in 2020/2021), and is likely to effect the East Kimberley economy.

Latest census population data indicates the median age of the 5524 Kununurra residents is 31 and the 234 Timber Creek residents is 30. Based on the 2011 census data alone, the proportion of the population identifying as Aboriginal or Torres Strait Islander, or both, is 26% in Kununurra and 65% in Timber Creek. However, local data for the whole Kimberley estimates 44% of the population is considered Indigenous.

In Kununurra, workforce participation for adults 20 years and over is estimate at 71% and in Timber Creek it is 58%. Unemployment rates are considerably higher in the region than the broader NT average. Real Indigenous unemployment is understood to be substantially higher than the official regional figures. Weekly rents versus income are generally relatively low though mortgage repayments are considered high.

A key consideration for NT and East Kimberley communities, is the need to secure and build Indigenous employment and business development opportunities.

5.5.3 NT EPA assessment

A number of commenters expressed support for the Project due in part to the expected economic benefits. The Proponent conducted an economic impact assessment of the Project with forecasts to 2032 using the Tasman Global computable general equilibrium (CGE) model. Advice from the Department of the Chief Minister and the Department of Trade, Business and Innovation indicated that the modelling approach and assumptions used were considered appropriate.

The economic indicators in the EIS suggest that the Project could deliver significant economic and social benefits. While the NT EPA considers that a significant proportion of the direct benefits would be felt within the East Kimberley region, the model predicted the following:

- capital investment of an estimated $411 M
- recurrent operating expenditure averaging $125 M at full production, including a significant level of local spending on support services
- prawn production valued at an average of $195 M/year at full production
- a construction workforce of 444 full time equivalent (FTE), of which 385 are likely to be sourced from the NT and 59 from Kununurra
- an operating workforce of 334 FTE, including 206 from the NT and 88 from Kununurra

- nominal tax revenues to Australian governments totalling $50 M over 15 years to 2032.

The modelling also found:

- an increase in the real gross state product of the NT by a cumulative total of $502 M over the period to 2032
- an increase in the real income of the NT by $350 M over the same period and
- an average annual increase in employment of around 161 FTE jobs per year.

The Proponent has engaged with key stakeholder groups and is negotiating an Indigenous Land Use Agreement with the Native Title holders in which potential community effects, and workforce opportunities are likely to be discussed. The EIS includes an outline of a social impact management plan (SIMP). The SIMP should be finalised before an investment decision is made and then refined as the Project progresses through its various stages.

5.5.4 NT EPA conclusion

Having regard to the information contained in the Proponent's EIS and submissions from Government agencies, and interested parties and organisations, the NT EPA is of the opinion that a successful stage 1 Project will benefit the region and the broader Territory economy with respect to employment and other social and economic opportunities. If the Project is undertaken in accordance with the management commitments made in the EIS and recommendations made in this Report to minimise impacts to the environment, the NT EPA considers that the Project is highly likely to meet the NT EPA's objective for socio-economic values.

5.6 Cultural heritage

5.6.1 NT EPA objective

To identify and protect items or places which have historic and/or cultural heritage values.

5.6.2 Values

The cultural values at the Legune Project site are predominantly associated with the continued traditional uses of the land by the Native Title holders.

The EIS indicates that the Native Title holders are members of the Gajirrabung language group whose people are known as the Gajerrong. There are three local groupings of the Gajerrong in the region with the primary Native Title Holders in the Project area being the Jarrajarrany local group.

Volume 3 Chapter 2 of the draft EIS provides some information about the cultural values held by the Gajerrong in the Legune area. The values relate to the spiritual and cultural significance of the landscape and include a number of places recognised as significant according to Aboriginal tradition as well as significant places associated with past Aboriginal occupation of the area.

The EIS states that the area between the Keep River and the Victoria River is associated with dreaming tracks and traditions that are central to the spiritual beliefs of the Native Title holders. Within the Legune area these dreaming trails follow the rivers and tributaries and other landscape features. These include traditions associated with secret ceremonies that link the Native Title holders with Indigenous groups from south and east, and connect sacred sites comprising physical landscape features.

The Aboriginal Areas Protection Authority (AAPA) has records of a large number of sacred sites significant to Native Title holders responsible for the Legune area; however, no sacred sites are currently registered or recorded by the AAPA within the Project Area.

The Proponent indicates there is a possibility there may be as yet unidentified sacred sites within the Project Area.

Seasonal inundation of the friable black cracking clays on the estuarine-deltaic plain, and the 100-year history of cattle grazing in the Legune area are considered to have irrevocably disturbed and displaced any archaeological sites or objects associated with previous Aboriginal occupation in the area.

5.6.3 NT EPA assessment

The Proponent conducted a cultural impact assessment of the Legune area. The Northern Land Council (NLC) and the AAPA were commissioned by the Proponent to jointly conduct detailed survey work in the 2016 Dry Season to address knowledge gaps regarding identification of sites, places or objects of historical or cultural significance. The Native Title holders were involved in this process.

The purpose of this work was to enable an Indigenous Land Use Agreement (ILUA) to be negotiated with the Native Title holders through the NLC. The ILUA would require, among other things, a cultural heritage management plan, which would be based on any conditions applying to the Project contained in Authority Certificates issued by the AAPA for any identified culturally significant areas that require protection.

The NLC, as an independent statutory authority established under the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth), represented the Top End (Default PBC/CLA) Aboriginal Corporation RNTBC (Top End PBC**),** the relevant agent prescribed body corporate for the Native Title holders of the Legune area. The NLC consulted with the affected Native Title holders and Aboriginal land claimants (Legune Land Claim (No 188) and Gregory National Park/ Victoria River Land Claim (No 167)) and provided comprehensive comments both on behalf of the Top End PBC and also itself.

The Native Title holders raised the following key matters:

- concern in respect of monsoon rain inundating the area
- concern in respect of the reliability of the freshwater source (Forsythe Creek Dam), particularly during the Dry season;
- concern in respect of the protection of hunting areas in and around the Project and impacts on the flora and fauna that are current food sources (such as turtle, bush turkey, kangaroo);
- a requirement for native title holder engagement in ongoing monitoring and protection of the land (for example through a ranger program)
- concern in respect of rehabilitation requirements, including that Native Title holders are consulted in respect of these requirements.

The NT EPA in making this Report has identified potentially significant impacts and risks to key environmental values. While cultural values are considered a key value, some of the matters raised by Native Title holders are inextricably linked with other key values that are included in this Report. The following sub-sections attempt to address these concerns.

Inundation of the floodplain in monsoon

The NLC submission on the draft EIS raised concerns about the uncertainties of constructing earthworks on the estuarine-deltaic plain, an ephemeral floodplain, and the stability and permeability of black soils for construction of ponds and channels. These concerns were shared by other commenters including the NT EPA and have been addressed in Section 5.2.3 of this Report. The NT EPA made Recommendation 8 to ensure that earthworks would require pre-works soil and geotechnical investigation and construction to engineered standards.

Reliability of freshwater

The reliability of Forsyth Dam as a water source for the Project was perceived as a business risk for the Proponent and was not explicitly addressed in this Report. The NLC raised a concern about water supply for future stages of the Project, which is beyond the scope of this assessment. However, the NT EPA assessed the potential impacts and risks of ceasing Dry season flows from Forsyth Dam to the pasture and wetland areas on Legune in the context of waterbird aggregations. This is a key concern for the Gajerrong and has been addressed in Section 5.3.3 of this Report with Recommendation 11 made by the NT EPA to ensure monitoring of waterbirds to detect any significant changes in the population with contingency actions required.

Protection of hunting, food resources and access

The EIS acknowledged a broader concern that the Project may erode the enjoyment of Native Title rights for the Gajerrong through the effect of the Project on access to areas used for traditional hunting and fishing and the potential for the Project to alter the environment. There is also a concern about an increase in the uncontrolled non-Aboriginal population of the area with potential for strangers to interfere with culturally significant sites and customs. The potential for damage to or interference with sacred sites on or in the vicinity of the proposed works for the Project can be mitigated through conditions imposed by Authority Certificates issued for the Project and included in the management plan. While the NT EPA considers that Native Title rights associated with cultural activities and practices are beyond the remit of the NT EPA's environmental objective for protection of cultural values, the NT EPA is of the opinion that the ILUA is the appropriate mechanism for the protection of culturally significant environmental and landscape features including ensuring that the Native Title holders can continue to discharge their traditional responsibilities to these places. The Proponent has committed to restricting access to the site to authorised personnel only and access by the Native Title holders is being negotiated as part of the ILUA.

The NT EPA has considered potential impacts to flora and fauna in Sections 5.3 and 5.4 of this Report. The NLC submission included reference to Wild Plum (*Terminalia platyphylla*) as being a regionally unique vegetation association that would be impacted by the Project. No mention is made in the EIS or the NLC submission of cultural significance of this species to the Gajerrong. The EIS indicates that it is unique due to tree size and the dominance of the single species in the 332 ha patch and that the loss of 29 ha or 9% of the extent of Wild Plum woodland found on the Legune site to be cleared for linear infrastructure (central service road, freshwater channel) will have minor impact on this vegetation community at Legune. The NLC suggested an offset for the loss, which may be achievable through the ILUA.

Land management

The NLC stated that offsets should be imposed for unmitigated (residual) impacts and provided a list of suggested projects. The Northern Territory Government supports the idea of providing training and employment opportunities to the Native Title holders while improving land management outcomes in the Project area. Programs suggested by the NLC such as improved fire management, active management of culturally important wild resources, grazing management to maintain wetland values, monitoring programs, and weed management could be achieved through the establishment of an Aboriginal ranger group. The NT EPA views this as a valuable opportunity for the Proponent and Native Title holders and considers that the ILUA is the most appropriate mechanism to negotiate such arrangements.

Rehabilitation

The Proponent committed to preparing a site decommissioning and rehabilitation plan after project approval. Given the minimum nominal operating life of 25 years and future

plans to expand from stage 1, the Proponent did not consider that decommissioning the Project would be required in the foreseeable future. Mention is made in the EIS of post-closure land use at the site including potential to re-use structures as ponded pastures or, if rehabilitation for pastoralism proves impossible, environmental purposes.

The NT EPA considers that the next land use for the site is typically a matter to be negotiated by the land holder, in this case the Native Title holders, but should be determined early in the Project as a contingency in the event of closure earlier than anticipated. This is done in the mining industry on an annual basis with a security calculated for the cost of remediating the mine site for any given year. The ILUA is considered to be the most appropriate instrument with which to negotiate a final decision on how the site should be decommissioned and rehabilitated.

The NLC stated in its submission that the capacity of Aboriginal interests to influence future protection of environmental and cultural values should be a condition set by the Minister for approval of non- pastoral use under the *Pastoral Land Act*. The Proponent has committed to preparing a decommissioning and rehabilitation plan soon after the Project commences and, as discussed in Section 5.7 of this Report, the NT EPA expects that this plan will be developed based on an agreed post-closure land use.

5.6.3.1 NT EPA conclusion

The NT EPA's environmental objective for cultural heritage is focused primarily on protecting sites and objects protected under the *Heritage Act* and the *Aboriginal Sacred Sites Act.* The NT EPA is satisfied that the Proponent has undertaken comprehensive studies and engaged with the appropriate Native Title holders through the NLC and AAPA to identify the values that could potentially be affected by the Project. The Proponent has committed to preparing a cultural heritage management plan that will incorporate requirements of Authority Certificates for the protection of any identified culturally significant areas in the Project area at risk from the Project. The NT EPA considers that the Project is highly likely to meet the NT EPA's environmental objectives for cultural heritage values if it fulfils its commitments and obligations as set out in the EIS.

Residual impacts to cultural heritage values expected from the Project, as determined by the Native Title holders and their representative bodies, should be negotiated under the terms of the ILUA.

5.7 Decommissioning

The EIS listed potential post-closure land uses for the Project site in the event of planned or unplanned closure including: adaptation for other aquaculture, e.g. barramundi farming; pastoral use (cattle grazing); rehabilitation to 'natural' conditions or a combination of these. The EIS indicated that the final land use would depend on the potential for stable land-vegetation-water systems, and could include strategic use of Project structures for pastoral or other uses. The NT EPA considers that any post-closure land use would need to be determined in consultation with government and as agreed to by the Native Title holders.

The EIS contained rehabilitation objectives with criteria to gauge success, and proposed the implementation of a trial of rehabilitation methods for pond and channel infrastructure following commencement of Project operations,

The Proponent has committed to preparing a site decommissioning and rehabilitation plan to detail procedures and methods to use should the Project close, and to adapt the plan based on findings during the operation of Stage 1. The detailed plan would be completed after the requirements of the various approvals and agreements are finalised. The NT EPA supports this approach and considers that the post-closure land use should be agreed and the decommissioning and rehabilitation plan be developed within the first

year of commencement of earthworks for the Project. The plan can be adapted subsequently depending on the results of rehabilitation trials.

If deemed necessary, a financial assurance may be required under the WMPC Act for reinstatement of the Project site in the event of closure. Such an assurance will be determined by the NT EPA through the EPA/EPL application process.

Recommendation 12

The Proponent shall develop a decommissioning and rehabilitation plan for the Project site within one year of commencement of Project works. In developing the plan, an appropriate post-closure land use should be agreed with key stakeholders.

The decommissioning and rehabilitation plan will be adapted during Project operations to take account of results from rehabilitation trials to be established by the Proponent on the Project site within the one year period.

5.8 Environmental management

Volume 4, Chapters 2 and 3 of the draft EIS included the Proponent's Environmental Management System and draft environmental management plan (EMP) respectively. The Supplement provided an updated draft EMP to account for amendments made in response to comments on the draft EIS. The EMP is considered a sub-plan under the Proponent's overarching Environmental Management System, which is modelled on AS/NZS ISO 14001.

The draft EMP included the following management strategies (* applicable to construction only):

- Acid Sulfate Soil Management*
- Air and Noise Management
- Bushfire Management
- Cultural Heritage Management
- Effluent Management
- Erosion and Sediment Control*
- Fauna Management
- Groundwater Management
- Hazardous Materials Management
- Land and Soils Management
- Social Impact Management
- Surface Water Management
- Traffic Management
- Vegetation Management
- Waste Management
- Weeds and Pests

A biosecurity plan will be developed during the detailed design phase in consultation with the DPIR. As discussed in Section 5.7, a decommissioning and rehabilitation plan will be prepared following approval of the Project.

These environmental management strategies and plans consolidate and summarise the commitments made as part of the EIS. The Proponent intends to use the strategies to develop site specific management procedures and has committed to updating the draft EMP to be stand-alone and reflect approval requirements, upon approval. The EMP would then be implemented on the Project site.

While the Proponent refers to audits, both internal and external, in its EMS Manual, there is no explicit requirement for audits mentioned. The EMP and its procedures and controls should be audited by the Proponent throughout the Project; during construction and operation. The audits should compare on-ground works with management commitments and performance objectives. Any non-conformance with these criteria should trigger the implementation of corrective actions, and associated reporting.

The NT EPA considers it essential to the performance of the Project that the requirements in the EMS, management strategies and procedures are incorporated into the Proponent's tendering and contracting procedures. The Proponent is responsible for ensuring that all employees, subcontractors and agents associated with the Project are familiar and comply with the elements of the approved EMP, which should address all relevant requirements under environmental legislation and relevant licences. The information should be provided to all personnel as part of an induction process.

All management strategies and procedures developed for the Project must be finalised and approved by, or developed to, the satisfaction of relevant Government agencies and stakeholders. It is recommended that, as a minimum, the Northern Land Council and the Native Title holders it represents should be key stakeholders to which management strategies are submitted for comment prior to finalisation. These approved strategies and procedures will be one of the primary tools by which the Proponent will implement management and monitoring commitments made in the EIS and the recommendations detailed in this Report.

Recommendation 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.

In preparing the Environmental Management Plan, for construction and operation, the Proponent should include any additional measures for environmental protection and monitoring contained in this Assessment Report 80.

The Environmental Management Plan should include management strategies for:

- **acid sulfate soils**
- **air and noise pollution**
- **bushfires**
- **cultural heritage**
- **effluent**
- **erosion and sediment control**
- **fauna**
- **groundwater**

- **hazardous materials**
- **land and soils**
- **social impact**
- **surface water**
- **traffic**
- **vegetation**
- **waste**
- **weeds and pests.**

The Proponent shall provide public access to the Environmental Management Plan and a reporting mechanism to inform compliance with the plans. An independent audit of compliance against the Environmental Management Plan shall be conducted at the end of five years after commencement of the Project and reported to the NT EPA and DPIR.

The NT EPA acknowledges the Proponent will be required to report to the NT EPA in accordance with the reporting obligations prescribed in the EPL under the *Waste Management and Pollution Control Act*. The NT EPA makes Recommendation 13 to ensure that environmental outcomes of the EIA are incorporated into compliance investigations, audits and reporting of the environmental performance of the Project. It is the NT EPA's expectation that any reporting on the implementation of the EMP should demonstrate that environmental impacts from the Project are no greater than those predicted in the EIA. This should be done through reporting performance of environmental commitments, including the effectiveness of the environmental safeguards and mitigation measures applied in respect of the Project, and an assessment of the accuracy of the predictions of the potentially significant environmental impacts of the Project.

6 Conclusion

In making this Report, the NT EPA had regard to the information provided by the Proponent, submissions on the draft EIS and Supplement, advice from specialists from across the NT Government and the NT EPA's appointed independent experts, and relevant guidelines and standards. The NT EPA assessed the Project against the NT EPA's objectives for the key environmental values of: water quality in marine, estuarine and freshwater systems; freshwater aquatic, floodplain and estuarine ecosystems; waterbird aggregations; Matters of National Environmental Significance under the EPBC Act; and cultural and spiritual values of marine and estuarine waters, fresh waters and floodplains, including ecosystems and biota.

While the NT EPA considers the potential impacts and risks have been adequately identified and are relatively well-understood, there is inherent uncertainty in predicting with any great precision the magnitude of impacts in impact assessment due to limitations of numerical models and the complexity and variability of natural systems. In such situations, it is important to acknowledge that uncertainty remains and manage this with suitably robust monitoring and management frameworks that can respond with appropriate mitigation and contingency measures and can accommodate new knowledge and understanding as it becomes available.

The NT EPA acknowledges some uncertainty with respect to the nature and extent of a number of potential impacts, including:

- the area of influence and potential impacts of prawn pond effluent discharge on water quality in Alligator Creek
- the potential impacts to significant waterbird aggregations from alterations to the hydrology of the Legune floodplain, particularly through the proposed cessation of Dry season flows from Forsyth Dam.

These uncertainties are largely due to the high variability in aspects of the receiving environment including the macro-tidal waters of the estuary and the transient nature of avifauna populations in freshwater habitats at Legune, and a lack of understanding of this variability and the likely response of the environment to threats and change. Such variability presents challenges for baseline data collection, impact prediction, monitoring and management.

The Proponent has committed to continuing data collection prior to Project commencement and operation, to develop a significant baseline dataset and build its understanding of background conditions in the receiving environment of the Project area. The baseline dataset will form the basis for comprehensive monitoring and mitigation programs that will underpin environmental management of the site.

The NT EPA has made recommendations in this Report for review of water quality information and monitoring programs, and the establishment of a scientific advisory group for development of a waterbird monitoring and mitigation program. The recommendations, if incorporated into relevant conditions and actioned by the Proponent, should see acceptable environmental outcomes for the environmental values at Legune.

Notwithstanding the above, the NT EPA considers that the Project can be managed in a manner that is highly likely to meet the NT EPA's objectives and avoids significant or unacceptable environmental impacts. The NT EPA makes 13 recommendations as an outcome of the EIA of the Project. These recommendations are primarily for the Proponent to address when entering into the next stage of the Northern Territory and Commonwealth approval processes and for the implementation of the proposed action. The NT EPA considers it essential that the commitments, safeguards and recommendations detailed in the final EIS, this Report, and in the final environmental management plan and underlying strategies, approved by the NT EPA and the Agency responsible for administering the *Fisheries Act*, are implemented and subject to regular reporting and compliance auditing.

7 References

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

Bennett, D., & George, R. (2014). *Goomig Farmlands development: baseline water quality in the lower Keep River, Resource management technical report 393.* Perth: Department of Agriculture and Food, State of Western Ausralia.

Burford, M. A., Revill, A.T. Palmer, D.W. Clementson, L., Robson, B.J., Webster, I.T. (2011). River regulation alters drivers of primary productivity along a tropical river-estuary system. *Marine and Freshwater Research,* 62, 141-151.

Burford M.A., Webster I.T., Revill A.T., Kenyon R.A., Whittle M. and Curwen G. (2012). *Controls on phytoplankton productivity in a wet/dry tropical estuary.* Estuarine, Coastal and Shelf Science, (2012) http://dx.doi.org/10.1016/j.ecss.2012.07.017.

Chatto, R. (2003). The distribution and Status of Shorebirds around the coast and coastal wetlands of the Northern Territory. Northern Territory Parks and Wildlife Commission Technical Report **73**, Darwin, Northern Territory.

Chatto, R. (2006). The distribution and Status of Waterbirds around the coast and coastal wetlands of the Northern Territory. Northern Territory Parks and Wildlife Commission Technical Report **76**, Darwin, Northern Territory.

Dear, S.E., Ahern, C.R., O'Brien, L.E., Dobos, S.K., McElnea, A.E., Moore, N.G. and Watling, K.M. (2014). *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines*. Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Department of Environment Regulation (DER) (2015). Treatment and management of soils and water in acid sulfate soil landscapes. State of Western Australia. Viewed at: https://www.der.wa.gov.au/your-environment/acid-sulfate-soils/69-ass-guidelines

Department of Primary Industries and Fisheries (DPIF) (2006). Australian Prawn Farming Manual: Health Management for Profit. The State of Queensland.

Donovan, D.J. (2001). Environmental code of practice for Australian prawn farmers. Australian Prawn Farmer's Association, September 2001. Available from: https://ntepa.nt.gov.au/__data/assets/pdf_file/0019/290080/appendix3.pdf.

Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M., Lynch, B. (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, the Arts and Sport, Darwin, NT.

Northern Territory Environment Protection Authority (NT EPA) (2015). Terms of reference for the preparation of an Environmental Impact Statement: Project Sea Dragon Stage 1 Legune Grow-out Facility, Project Sea Dragon Pty Ltd. Available at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0011/290486/term_reference_sea_dragon.pdf.

Robson, B.J., Gehrke, P.C., Burford, M.A., Webster, I.T., Revill, A.T., Palmer, D.W. (2013). The Ord River estuary: a regulated wet-dry tropical river system. In: *Estuaries of Australia in 2050 and beyond.* Ed. E. Wolanski, Springer, pp. 131-152.

Tickell, S. and Hill, J. (2001). Soil Salinity on Legune Station NT. Report NR 2001/47. Natural Resources Division, Dept. Infrastructure, Planning and Environment, Palmerston, NT.

Webster, I.T., Ford, P.W., Tillman, P. (2005). Estimating nutrient budgets in tropical estuaries subject to episodic flows. Marine Pollution Bulletin 51, 165-173.

Wetlands Internation (2012). Waterbird Population Estimates, Fifth Edition. Summary Report. Wetlands Internation, Wageningen, The Netherlands.