DRAFT

ENVIRONMENTAL IMPACT STATEMENT
POINT CEYLON AQUACULTURE ESTATES
BYNOE HARBOUR, NORTHERN TERRITORY

July 2003

VOLUME 1
MAIN REPORT

SUNTAY AQUACULTURE PTY LTD

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EcOz Environmental Services and specialist consultants have prepared this Draft Environmental Impact Statement for the Point Ceylon Aquaculture Estates at Point Ceylon. The Draft EIS has been prepared in accordance with Guidelines issued by the Northern Territory Office of Environment and Heritage, and in accordance with accepted professional standards. The EIS has been prepared on the basis of information provided and available at the time of preparation, and the validity of the findings and recommendations is dependent on this information. Much of the information was provided by other parties, and was therefore beyond the control of the consultants.

No warranty is made with respect to the findings, observations and conclusions in the Draft EIS.

DISCLAIMER

EcOz has conducted the studies and prepared the report with utmost care, using professionally qualified people, and relied on the most accurate information and professional advice available to EcOz. We do not take responsibility for errors, omissions and findings not available to EcOz at the time of study.

INVITATION FOR PUBLIC COMMENT

Suntay Aquaculture Pty Ltd proposes to develop a land-based aquaculture project to produce marine prawns at a site on the peninsula leading to Point Ceylon near Bynoe Harbour, Northern Territory. The project will eventually cover around 180 hectares, including access roads and infrastructure, and will be designed as a closed operating system with zero to minimal discharges to the environment.

In accordance with the provisions of the Northern Territory *Environmental Assessment Act* a draft Environmental Impact Statement which describes the project and the potential environmental impacts has been prepared by Suntay Aquaculture Pty Ltd. The EIS will be available for public review and comment from Saturday 26th July to Saturday 23rd August.

The EIS will be available for public review at the following locations during this period:

- Casuarina Public Library, Bradshaw Terrace, Darwin.
- Palmerston Public Library, Civic Plaza, corner University Avenue and Chung Wah Terrace, Palmerston.
- Litchfield Shire Offices, 7 Bees Creek Road, Bees Creek.
- Northern Territory Library, Parliament House, Darwin.
- Northern Territory University Library, NTU Casuarina Campus.
- Department of Infrastructure, Planning and Environment, Ground Floor, 38 Cavenagh St Darwin (Corner of Cavenagh Street and Knuckey Street).

The Draft EIS will also be available for viewing on the internet at the Department of Infrastructure, Planning and Environment site: http://www.ipe.nt.gov.au/

The Draft EIS can be purchased as CD-ROM copies, at a cost of $25.00 each, or in hard bound copy (Vol 1 only) for $100.00.

Copies of the EIS may be purchased from:

EcOz Environmental Services
GPO Box 381
Darwin NT 0801
Phone 08 89811100
Fax 08 89811102
Email: ecoz@ecoz.com.au

People and organisations who are interested in making comments on the Draft Environment Impact Statement for the Point Ceylon Aquaculture Estates are invited to make written submissions by the close of business on xxx 2003 to:

Office of Environment & Heritage
Northern Territory Department of Infrastructure Planning & Environment
Darwin Plaza
Smith Street Mall
Darwin City NT 0800

Submissions will be treated as public documents, unless confidentiality is requested. Copies of all submissions will be sent to Suntay Aquaculture Pty Ltd and addressed when preparing the final EIS.

1 EXECUTIVE SUMMARY

1.1 THE PROPOSAL

Suntay Aquaculture Pty Ltd proposes to construct "Point Ceylon Aquaculture Estates", a land-based aquaculture development at Point Ceylon, Bynoe Harbour. The project plans initially to grow Black tiger prawns *Penaeus monodon* and species of finfish in contained aquaculture ponds, using leading technology which allows for zero operational discharges from the aquaculture ponds.

1.2 THE PROPONENT

Suntay Aquaculture Pty Ltd
PO Box 36444
Winnellie, Darwin, Northern Territory 0820

Suntay Aquaculture Pty Ltd (SAA) is an Australian registered company and an affiliate of ASL Group of Companies from the Philippines. SAA is a member of the Global Aquaculture Alliance of which its sister company FCE Agricultural Research & Management Inc. is a founding member.

1.3 EXPERIENCE OF PROPONENT AND KEY PERSONNEL

Suntay Aquaculture Pty Ltd has among its directors a combined 60 years of experience in the aquaculture industry. SAA is committed to and experienced in fostering the healthy co-existence between aquaculture enterprise and the environment. Company management is composed of individuals from different countries involved in aquaculture and other closely related industries. They bring a wealth of knowledge and experience to the project.

Marketing & Human Resource Director
Nenita Suntay-Tanedo is Chair of the ASL Group of Companies with interests in aquaculture, agriculture, countryside banking, and construction and property development and represents the Aguinaldo-Suntay family, who has over 70 years of aquaculture experience since building one of the first fish farms in the Philippines in the 1930s. Nenita Suntay-Tanedo was an accomplished entrepreneur with diverse experience in project development for multinational companies.

Managing Director
Emilio A. M. Suntay III
Emilio Suntay is a Director of ASL Group of Companies with interests in aquaculture, agriculture, countryside banking and property development in the Philippines and comes from the family that built one of the first fish farms in the Philippines in the 1930s. Mr. Suntay is a Management and Economics major with extensive aquaculture training from Thailand and the USA, HACCP certified, and years of experience as chief operating officer for FCE Corporation, an ASL aquaculture company.

Resident Director
Michael Joseph McElwee
Michael McElwee is Resident Director of Suntay Aquaculture Pty. Ltd. and General Manager of Aqua-treat Pty. Ltd. Mr. McElwee has extensive experience in the related industry of water treatment and sewage systems and has won environmental awards. Mr. McElwee has had experience in the tourism and entertainment industry and has interests in other businesses such as construction and development and real estate.

Technical Director
Dr. George W. Chamberlain
George Chamberlain is Technical Director of Suntay Aquaculture. He is currently the President of the Global Aquaculture Alliance, a world-wide industry coalition of producers and distributors committed

to developing and practising responsible and sustainable aquaculture practices worldwide. He has previously held positions as the Director for Aquaculture at Ralston Purina International, and was President of the World Aquaculture Society. Mr. Chamberlain has also published widely on aquaculture nutrition and on the potential benefits of low-water exchange systems for shrimp aquaculture.

Manager
Loy Reginald Markham has extensive experience in aquaculture having worked for the past 30 years in Latin America and the United States. Reginald Markham has been working on intensive systems in all stages for many years now.

The project has involved and will continue to involve experts in related fields for continuous improvement and development but for the purposes of Intellectual Property security details will not be included in this EIS.

1.4 AIMS AND OBJECTIVES OF THE PROJECT

SAA aims to build a revolutionary world-class aquaculture farm that is environment-friendly, commercially sustainable, highly productive, efficient, and socially responsible - one that will serve as a hub and stimulate the growth of a progressive, sustainable, and invaluable land-based aquaculture industry in the Northern Territory.

1.5 BACKGROUND AND NEED FOR THE PROJECT

Aquaculture is a rapidly developing industry that is geared towards supplementing limited fisheries output. According to the Food and Agriculture Organisation (FAO), seafood supply will fall from 4.5 M kg to 18.2 M kg less than demand by 2010. Aquaculture contributes 30% of global seafood supply rising by 200% in value since 1985 to more than US$33.5 Billion in value in 1994.

Marine shrimp and salmon are the biggest value contributor holding the largest markets. Global marine shrimp production rose from 2,151,156 metric tonnes in 1985 to 3,080,402 metric tonnes 1994. During this period, farmed marine shrimps rose from 9.9% to 29.9% of total global marine shrimp production.

Aquaculture is growing more rapidly than all other animal food producing sectors; its contribution to global supplies of fish, crustaceans and molluscs increased from 3.9% of total production by weight in 1970 to 27.3% in 2000, according to FAO's State of World Fisheries and Aquaculture 2002 report (SOFIA). The contribution from aquaculture increased further to 29% in 2001

The rapid growth of aquaculture, however, has not been exempt from issues, most notably environmental. This project aims to address this issue by becoming a world-class showcase and providing a blueprint for future modern aquaculture farms to follow.

1.6 ECONOMIC AND OTHER BENEFITS OF THE PROJECT

The project will contribute significant economic and social benefits to the local economy ranging from employment, technology development and transfer, and revenue generation from the economic multiplier effects of local enterprise building.

1.7 STRUCTURE, SCOPE AND LEGISLATIVE BASE OF EIS

The EIS is a requirement under the *Environmental Assessment Act 1984*.

This document is structured into sections as detailed below.

Volume 1
Executive summary
Table of contents
Introduction
Description of the proposed development
Environmental constraints and issues
Environmental impacts and safeguards
Glossary

Volume 2
Appendices

The Draft EIS will be exhibited for public review and comment for a minimum of 28 days, during which time advisory bodies will also comment on the document.

Comments are forwarded to the proponent, who addresses issues in a Supplement to the Draft EIS. The Supplement is reviewed by advisory bodies.

The NT Office of Environment & Heritage (OEH) then, within 35 days, prepares an Environmental Assessment Report and Recommendations based on the Draft EIS and Supplement. If the Minister approves the Report and Recommendations, they will be forwarded to the responsible Ministers for inclusion in permit, lease or license conditions and in relevant management procedures (e.g. Environmental Management Plans).

The Assessment Report and Recommendations will be included on the OEH website and hard copies will be provided to respondents and selected public libraries and viewing sites.

1.8 ALTERNATIVE SITE OPTIONS

The project was originally commenced in 1998 on one of the properties owned by the Suntay family in the Philippines. It was not pursued, however, because of the deteriorating economic and political conditions prevalent at the time. Further analysis and projections of the near-term economic and political outlook for the Philippines and the contrasting growing potential of aquaculture for Australia prompted the decision to establish the farm and relocate all aquaculture interests of ASL Group.

Since then the company has investigated a number of sites in North Queensland and the Northern Territory bringing along an expert team from overseas to evaluate the features and viability of these sites.

In general the sites in Cairns and Mossman in North Queensland had adequate rainfall but more prolonged minimum temperatures were not ideal for high growth rates of the identified tropical culture species. A large site in Cooktown had serious lack of infrastructure and labour to support the project.

In the Northern Territory, the company was first offered a 40-hectare site near Channel Island but closer investigation exposed serious legal and ownership challenges as well as a limited area for expansion. The company then spent a year investigate sites in Melville Island but found logistical issues overwhelming.

1.9 SIMILAR PROJECTS UNDERTAKEN BY THE PROPONENTS ELSEWHERE

This project is inspired by encouraging results from the proponents' experiences with environment-friendly practices on the farms previously owned in the Philippines.

Dr. Chamberlain and Mr. Markham have also been involved in projects in other parts of the world.

Some specific features that make this project revolutionary and pioneering have been inspired by advancements made in research across the globe including in Israel, North Carolina, United States, Belize and Venezuela for species such as Tilapia and *Penaeus vannamei.*

1.10 PROOF OF LEASE OF PROJECT AREA

A letter of offer to purchase from the Northern Territory Land Corporation (owners of the property) was presented to the proponent on 28th August 2002, and the offer is subject to a number of conditions, including the requirement to complete a satisfactory environmental assessment and obtaining the appropriate environmental approvals. The details of the offer are confidential, but the letter authorises the proponent to undertake this Environmental Impact Assessment for the project on the property, Portion 3192.

1.11 DESCRIPTION OF THE PROPOSAL

The Point Ceylon Aquaculture Estates project is on elevated land on the Peninsula leading to Point Ceylon at the southern end of Bynoe Harbour. It is planned to be developed in two or three phases with the aim of developing a closed system aquaculture farm with minimal to zero-discharge. Phase 1 will involve the development of a total area of about 25 hectares including 9 hectares of ponds, 4 hectares of recirculation and harvest ponds, supporting supply pipes, saltwater intake pipe from Wheatley Creek, 8 hectares for the freshwater weir storage, 500 square metres for the 1st phase breeding facility, 1,350 m^2 for the maturation area, warehouse for storage and 1st phase of processing shed, 1st phase of staff accommodation, and office and laboratory facility.

Phase 2-3 (over a period of 3 to 5 years) will involve the total development of about 115 hectares including 50 hectares of ponds, 16.5 hectares of recirculation and harvest ponds, supporting supply and drain pipes, 30 hectares of freshwater storage, 2nd phase breeding facility, 2nd phase processing shed, and 2nd phase of staff accommodation. Total area to be utilised for all phases will be around 180 hectares.

Initially, the development will produce prawns. Future aquaculture will include fin-fish.

Suntay Aquaculture Pty Ltd aims to conform to the latest Food and Agricultural Organisation (FAO) code of responsible aquaculture, and apply recently developed principles to achieve the following outcomes:

- a "closed" system with minimal to zero-discharge;
- low saltwater and freshwater consumption;
- no soil leaching;
- no salinisation of groundwater;
- no impact on mangroves; and
- low phosphorous and nitrogen in pond water.

1.12 EXISTING ENVIRONMENT

The land on which the Aquaculture Project is proposed, Portion 3192, is characterised by gently undulating plains and low rises mainly of Darwin stringybark *Eucalyptus tetrodonta* and Darwin

Woollybutt *Eucalyptus miniata*. Dissecting the upland terrain to the mangrove habitats of Bynoe Harbour are minor drainage depressions of *Melaleuca nervosa*. Soils of the upland areas are generally light textured, shallow and underlain by weathered granite, quartz gravel or ferricrete. Seasonally waterlogged sandy soils distinguish the drainage depressions.

Small pockets of native Cypress pine *Callitris intratropica* communities exist on the portion. They are generally fire sensitive and only located in a small number of pockets protected from fire and adjacent coastal islands. Mangroves front most of the coast of the estate, and mangroves of Bynoe Harbour are important breeding habitats for marine species. It is not expected that any mangroves will be disturbed. Monsoon vine forests occur in patches throughout the project area, confined to coastal sandy fringes between mangroves and forest, and along wetter areas such as creeks. Monsoon vine forests are considered to be important communities in the region due to their species composition, scarcity and distribution, as well as their importance to fauna.

A freshwater creek, Wheatley Creek, runs through the southern and western section of the property. Some of the waterholes appear to be permanent. A number of fish species was recorded in the creek, but none are considered of conservation significance. An ephemeral creek also runs on the eastern fall of the property.

No threatened or endangered species or habitats are known to occur on the property. Cycads and orchids are found throughout the property. They are protected and considered significant, and often have limited distributions. Disturbance of these requires a permit. The Emu is found in the project area, and is identified as being 'near-threatened'. The Northern Quoll was noted approximately 20 km to the east of the project area and may occur there. This species is listed as 'lower risk - near threatened'.

1.13 HAZARD AND RISK ANALYSIS

Environmental risks from the development were assessed using the Australian Standards for Risk Management. This was an iterative process which identified all known and anticipated risks to the environment and risks to the enterprise from the local environment.

The analysis identified some potential high risk areas, including the risk of overflow of the ponds and the consequent introduction of pathogens and pollutants to the local environment which could affect the pearl oyster operations off Point Ceylon in Bynoe Harbour, among other sensitive receptors. Significant risks were also considered to exist to the enterprise from the source waters, and from aerial or other introduction of disease pathogens to the prawns.

The facility has been designed in consideration of these risks in order to eliminate, mitigate or minimise the likelihood of these risks occurring. Monitoring of the relevant environmental aspects has been planned to ensure that advance warning of these risks occurring is obtained so that preventative measures can be undertaken in a timely manner.

1.14 POTENTIAL ENVIRONMENTAL IMPACTS

It is anticipated that the most significant environmental impact from the project will result from the clearing of vegetation from the site and the access roads. Total clearing works for the initial Phase 1 development, including reservoirs, will be around 46.5 ha, and additional clearing for Phase 2 & 3 ponds will be about 136 ha. Part of the peninsula to Point Ceylon has been cleared in the past for mining and aquaculture activities and Acacia and other shrub regrowth has now established in these areas.

The project does not contribute to any nutrient loading into the Harbour or creeks as there will be no open access to the harbour or creeks. Groundwater salinization normally associated with open pond aquaculture is prevented by using lined ponds.

Other direct impacts include a low weir across Wheatley Creek to harvest freshwater during the wet season to fill the off-stream storage ponds at the production area. Wheatley Creek lies on the west of the estate area, and the weir will be located some 50 to 100 metres south of the edge of the mangroves The water will provide top-up water to maintain salinity balances in the production ponds. The creek is a natural waterway with ephemeral flows and appears to hold water in some waterholes throughout the year. Freshwater fish are common in the waterholes and creek. The weir will be designed to self-drain over fewer than five days to eliminate mosquito breeding habitat and to minimise inundation of trees and other vegetation to natural recurrent inundation.

Harvesting saltwater from Bynoe Harbour and Wheatley Creek to fill the production ponds and breeding facility ponds will also be required. This is a one-off event in normal operating circumstances, and the inlets and pumps will be temporary structures which will be removed after filling. No excavation will take place. Wheatley Creek runs into Port Patterson to the west of Indian Island and Bynoe Harbour. These marine areas are essentially natural, with very little disturbance from human activities and with good water quality. They contain a variety of reefs, seagrass beds, mudflats, sandy coasts, rocky coasts and deeper channels which are considered to be in a near natural state. Pearl Oyster leases operate within Bynoe Harbour, and this is one of the major considerations in the design of the project.

1.15 ENVIRONMENTAL MANAGEMENT, MONITORING AND REPORTING

Environmental management is paramount in the development and operation of the project. Environmental management will be implemented in a programmed way from the beginning of the project, and continue through operation. Details of the management practices designed to minimise impacts or reduce risks are provided in Chapter 7 of the EIS. These include monitoring and reporting procedures. In summary, management of the project to protect the environment includes limiting work areas to reduce impacts outside the development footprints, control of contractors' actions and practices, installing erosion control devices to limit sediment transport off-site, construction of ponds to eliminate groundwater and off-site effects, detailed attention to quarantine and health management to prevent diseases, monitoring of water quality parameters, and contingency and management plans for any areas of risk which may affect the environment adversely, or which may affect the project from external environmental factors.

1.16 STUDIES, SURVEYS AND CONSULTATIONS FOR THE EIS

Specific studies were commissioned for the project to ensure that the project meets engineering standards, and to provide a basis for environmental assessment of the project. Studies included engineering designs, hydrological studies, a geotechnical study, an archaeological study, fauna and flora studies and an environmental risk assessment.

Consultations with experts in government and private enterprise were conducted throughout the development of the project concept and the EIS development. A table of people consulted is provided in Chapter 8. These consultations included obtaining advice and information on many aspects of the project, and peer review of some of the modelling to test assumptions. These latter were specifically of the hydrological modelling, and of the potential diseases tables of prawns and molluscs.

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2 INTRODUCTION

2.1 THE PURPOSE OF THIS DOCUMENT

This document is an Environmental Impact Statement (EIS) prepared for a proposal to develop a land-based aquaculture estate at Point Ceylon in Bynoe Harbour, Northern Territory (**figure 1.1**). The document is submitted by Suntay Aquaculture Pty Ltd (the proponent) with the purpose of presenting information which will allow all stakeholders to consider the environmental implications of the proposed development. It is the aim of this document to provide a basis on which stakeholder concerns about aspects of the proposed development can be raised and alleviated prior to the development proceeding.

The EIS is a requirement under the *Environmental Assessment Act 1984*. Guidelines for preparation of the EIS were approved in February 2003 by the NT Office of Environment and Heritage (**Appendix 1**). The guidelines state that the draft EIS aims to provide:

- *a source of information from which individuals and groups may gain an understanding of the proposal, the need for the proposal, the economic and other benefits that might arise from the project, the alternatives, the environment that it would affect, the impacts that may occur and the measures taken to minimise those impacts;*
- *a basis for public consultation and informed comment on the proposal; and*
- *a framework against which decision-makers can consider the environmental aspects of the proposal, set conditions for approval to ensure environmentally sound development and recommend an environmental management and monitoring program.*

The object of these Guidelines is to identify those matters that should be addressed in the draft EIS. The Guidelines are based on the initial outline of the proposal in the Notice of Intent. Not all matters indicated in the Guidelines may be relevant to all aspects of the proposal. Only those matters that are relevant to the proposal should be addressed. The Guidelines however are not necessarily exhaustive and should not be interpreted as excluding from consideration any matters which are currently unforeseen that emerge as important or significant from scientific studies or otherwise during the preparation of the draft EIS, the public consultation process and the preparation of the Supplement to the draft EIS (response to submissions).

The draft EIS should be a self-contained and comprehensive document written in a clear, concise style that is easily understood by the general reader. Cross-referencing should be used to avoid unnecessary duplication of text. Text should be supported where appropriate by maps, plans, diagrams or other descriptive material. Detailed technical information and baseline surveys should be included as appendices.

Content in the draft EIS should include both quantitative and qualitative analysis as appropriate. Impacts should not just be treated as adverse: beneficial effects should also be identified.

The justification of the project in the manner proposed should be consistent with the principles of ecologically sustainable development. Assessment of the environmental impacts of the proposal and alternatives should be comprehensive. For the purpose of these Guidelines, the "principles of ecologically sustainable development" are as follows:

- *the precautionary principle - namely, that if 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;*

- *inter- and intra-generational equity - namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations;*
- *conservation of biological diversity and ecological integrity; and*
- *improved valuation and pricing of environmental resources.*

2.2 STRUCTURE OF THIS DOCUMENT

This document is structured into sections as detailed below.

Volume 1
Executive summary
Table of contents
Introduction
Objectives and benefits of the proposed project
Description of the proposed development
Alternative proposals
Environmental constraints and issues
Environmental safeguards, management and monitoring
Public involvement and consultation
Information sources and bibliography
Glossary

Volume 2
Appendices

2.3 TITLE OF THE PROJECT

Suntay Aquaculture Pty Ltd proposes to construct "Point Ceylon Aquaculture Estates", a land-based aquaculture development near Point Ceylon, Bynoe Harbour.

2.4 NET BENEFIT AND PROJECT JUSTIFICATION

The project was intended for an overseas country some five years ago but has been postponed because of the political and economic situation in that country. The company has spent about six years trying to establish the project in Northern Australia having been invited by DPIF of North Queensland but finally settling for the Northern Territory because of the more favourable climate regimes.

Aquaculture

- The World Food and Agriculture Organisation (FAO) estimates aquaculture to grow by 14% annually in Australia. Aquaculture now accounts for over 20% of the total value of Australia's fisheries production.

- Commercial fisheries are currently managed on a species basis to enable sustainable harvesting within each fishery. At present overseas market demand for high value species are not met and aquaculture is the only solution.

- According to the FAO, seafood supply will fall from 10 to 40 million pounds (4.5 M kg to 18.2 M kg) less than demand by 2010. This is mainly because global seafood catch has reached a plateau in terms of production. Most of the world's seas have been fished beyond that which can be considered sustainable. For the few countries that do practice sustainable fishing, such as Australia, the supply simply cannot cope with the demand.

- The only way therefore to augment this peak or diminishing supply is by modern and sustainable Aquaculture.

- As a result, Aquaculture presently contributes 30% of global seafood supply rising by 200% in value since 1985 to more than US$33.5 Billion in value in 1994.

Australian Advantage

Geographical
- Unique ability to culture a large variety of species from both temperate and tropical regions.
- Northern Australia has a similar climate as the major producing countries in Asia and Latin America.
- Unique advantage of having the opposite season from 'markets' in the northern hemisphere. This allows the country to produce when other competitor countries are having difficulty because of climate patterns.

Reputation
- Established a reputation as a supplier of high quality seafood and farm products, which enhances the marketability of Australian aquaculture products.
- Natural environment.
- Relatively clean and unpolluted waters due to strictly implemented legislation and policies.

Isolation
- Free from many of the serious diseases that impact on aquaculture in other countries. This is mainly the result of well-protected environment and geographical isolation.

Research
- Well developed research infrastructure that supports rural industry and is rapidly catching up on its Northern Hemisphere counterparts. The government has funded and built the most modern research facilities for aquaculture including the prawn industry despite the latter being at its infancy. Most nations which have developed modern aquaculture industries have benefited from excellent research and development done by those nation's universities. The United States alone has spent US$60 million for aquaculture in a 5-year development plan.

Government Support
- Large and thriving agriculture industry that is also one of the most modern and highly productive in the world providing a strong framework for the developing aquaculture sector.

Business Environment
- Stable peace and order
- Stable political system
- Developed country environment.

The Northern Territory

The biggest attraction for the northern part of the Northern Territory is its year-round warm climate. The warm tropical climate is conducive to tropical aquaculture enabling faster growth rates. Such an idyllic environment does not come without a challenge, however, including the high evaporation rates and relatively low rainfall. Hence, freshwater supply becomes a critical component of any land based aquaculture project in the Northern Territory.

While the United States is a good example of a developed country where tropical aquaculture is being strongly pursued, they do not have the luxury of a 'real' tropical climate as in the Northern Territory of Australia. Nevertheless, due to the tremendous market potential, the United States government and

private sector have continued to invest greatly in very expensive 'greenhouse' aquaculture systems, or have moved their operations to nearby Latin America in pursuit of warmer and more tropical climate.

2.5 THE PROPONENT

Suntay Aquaculture Pty Ltd
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Winnellie, Darwin, Northern Territory 0820

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Fax: (02) 9487-2575
Email emilsun@ozemail.com.au

Suntay Aquaculture Pty Ltd (SAA) is an Australian registered company and an affiliate of ASL Group of Companies from the Philippines. SAA is a member of the Global Aquaculture Alliance (GAA) of which its sister company, FCE Agricultural Research & Management Inc., is a founding member.

2.6 PROOF OF LEASE AND OTHER AUTHORISATIONS

A letter of offer to purchase from the Northern Territory Land Corporation (owners of the property) was presented to the proponent on 28th August 2002, and the offer is subject to a number of conditions, including the requirement to complete a satisfactory environmental assessment and obtaining the appropriate environmental approvals. The details of the offer are confidential, but the letter authorises the proponent to undertake this Environmental Impact Assessment for the project on the property, Portion 3192.

2.7 SCOPE AND OBJECTIVES OF THE PROPOSED PROJECT

The objectives of the Point Ceylon Aquaculture Estates project are to develop a world-class aquaculture facility which produces high quality prawns for the domestic and international market. Planned in two or three phases, the project aims to develop a closed system prawn farm with minimal to zero-discharge on elevated land on the peninsula to Point Ceylon at the southern end of Bynoe Harbour. Phase 1 will involve the development of a total area of about 25 hectares including 9 hectares of ponds, 4 hectares of recirculation and harvest ponds, supporting supply pipes, saltwater intake pipe from Wheatley Creek, 8 hectares for the freshwater weir storage, 500 square meters for the 1st phase breeding facility, 1,350 m^2 for the maturation area, warehouse for storage and 1st phase of processing shed, 1st phase of staff accommodation, and office and laboratory facility.

Phases 2 to 3 (over a period of 3 to 5 years) will involve the total development of about 115 hectares including 50 hectares of ponds, 16.5 hectares of recirculation and harvest ponds, supporting supply and drain pipes, 30 hectares of freshwater storage, 2nd phase breeding facility, 2nd phase processing shed, and 2nd phase of staff accommodation. Total area to be utilised for all phases will be around 180 hectares.

Initially, the project will produce prawns. Future aquaculture might include fin-fish.

Suntay Aquaculture Pty Ltd aims to conform to the latest Food and Agricultural Organisation (FAO) Code of Responsible Aquaculture and related codes identified in this EIS, and apply recently developed principles to achieve the following outcomes:

- a “closed” operating system with minimal to zero-discharge;
- low saltwater and freshwater consumption;
- no soil leaching;
- no salinization of groundwater;
- no impact on mangroves; and

- low phosphorous and nitrogen in pond water.

2.8 ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The proposed development was referred to Environment Australia (Referral number 2002/737) to determine if assessment was required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. On 22nd August 2002 'a decision that action is not a controlled action' was returned.

In August 2002 a Notice of Intent for the proposed development was submitted to the Office of Environment and Heritage. On 13th September 2002 the Minister returned a decision that the proposal required assessment under the *Environmental Assessment Act 1984* at the level of an Environmental Impact Statement (EIS). The environmental assessment process will therefore be facilitated wholly under NT legislation.

2.9 INITIAL CONSULTATIONS, INVESTIGATIONS, FEASIBILITY STUDIES

Consultations with experts and Northern Territory Government were undertaken by the proponent over a period of six years. In 2001/02 the NT Government offered the site to the proponent for development of the concept.

A feasibility study of the project was originally undertaken by the proponent before initial attempts at establishment in the Philippines, and over the subsequent six years of investigation the project has remained viable. In summary, the feasibility study found the project financially viable based on the following assumptions:

- *Production and Operations:*
  - Reasonably intensive production of at least 10,000 kilograms per hectare;
  - Establishment of a Breeding Facility from the very start of operations for a consistent supply of 'clean and healthy' animals;
  - Clean and pollution-free environment as well as pristine and uncontaminated marine- and fresh-water sources.
- *Markets:*
  - Reasonable product price of about A$14.00 per kilogram from local and overseas markets;
  - Current trend of tightening and stricter quality control from overseas markets;
  - Current stature of prestige of Australian produce among overseas markets;
  - No adverse trade sanctions or restrictions against Australian products.
- *Labour:*
  - Availability of skilled workforce both local and overseas;
  - Current environment of allowing companies to sponsor and use overseas expertise for local technology development;
  - Existence and support from Charles Darwin University (Northern Territory Uni) as training ground for future stakeholders and employees.
- *Services*:
  - Availability of power from government supplied power grid for Phase 2 development and subsequent expansions;
  - Availability of year-round road access to the project site;
  - Availability of incentives to primary producers;
  - Development and growing significance of Darwin port for overseas trade;
  - Government support and encouragement of the aquaculture industry.

A number of specialist studies were undertaken to provide the information necessary to undertake a full assessment of the potential environmental impacts associated with the proposed development. Studies were undertaken by consultants with the specific expertise for certain aspects of the project.

Table 2.1 Investigations for the EIS

Study	Report title	Consultant
Engineering	Engineering design and layout – Chapter 4 components	Glenn Allen
Archaeology	Archaeological Survey for the proposed Point Ceylon Aquaculture Estates at Point Ceylon, Bynoe Harbour	Christine Crassweller, Begnaze Pty. Ltd.
Preliminary Geotechnical Investigation	Geotechnical site investigation report, Proposed Aquaculture Project Suntay Aquaculture Pty. Ltd. Bynoe Harbour N.T.	Lintin Geotechnical.
Hydrology	1. Hydrological and Flood Study of the Point Ceylon Aquaculture Estates Proposal. 2. Point Ceylon Aquaculture Estates Supplementary Report	Fred Barlow
Fauna	Suntay Aquaculture, Suntay Aquaculture Centre Terrestrial Fauna Survey	GHD
Aquatic Fauna	Point Ceylon Aquaculture Estates EIS – Freshwater Aquatic Survey	EWL Sciences
Flora	Point Ceylon Aquaculture Estates, Point Ceylon, Bynoe Harbour, Northern Territory - Study of Terrestrial Flora	EcOz

These reports are provided in the Appendices.

2.10 TERRITORY, COMMONWEALTH AND INTERNATIONAL POLICIES, LEGISLATION AND TREATIES RELEVANT TO THE PROPOSAL

COMMONWEALTH ENVIRONMENTAL LEGISLATION
Environment Protection and Biodiversity Conservation Act 1999
National Environment Protection Council Act 1994
Native Title Act 1993
Ozone Protection Act 1989
NORTHERN TERRITORY LEGISLATION
Environmental Assessment Act 1984
Heritage Conservation Act 1991
Northern Territory Aboriginal Sacred Sites Act 1989
Planning Act 1999
Water Act 1992
Waste Management & Pollution Control Act 1999
Dangerous Goods Act 1994
Territory Parks & Wildlife Conservation Act 2000
NT Weed Management Act 2001
Environmental Offences and Penalties Act 1996
Fisheries Act 1988
Fisheries Regulations
INTERNATIONAL TREATIES
Japan-Australia Migratory Birds Agreement (JAMBA)

China-Australia Migratory Birds Agreement (CAMBA)
RAMSAR Convention on Wetlands of International Importance

2.11 PLANNING ISSUES

The land is leasehold land, Portion 3192, held by the NT Land Corporation (see Fig 1.1). The current zoning over the area of the main facility is 'Rural Living – 8 ha minimum' in the 'Finniss Planning Concepts and Land Use Objectives' document of the NT Government. The northern section where the breeding facility is proposed has been identified as a 'Conservation and Recreation' zone. The whole area proposed for development has been included in an area for 'Possible Aquaculture'.

The project will be developed within a 4 to 5 year timeframe. Thereafter, additional developments will be undertaken upon proper licensing. These additional developments will be open to private enterprise. The project is envisioned to last beyond the lifetime of the proponent or about 80-100 years. This is based on the actual experiences of the proponent whose original farms in the Philippines have operated for about 80 years now.

3 OBJECTIVES AND BENEFITS OF THE PROPOSED PROJECT

3.1 LOCAL, REGIONAL AND GLOBAL MARKETS AND OTHER ECONOMIC ACTIVITIES IN THE AFFECTED AREA

Aquaculture is a rapidly developing industry that is geared towards supplementing limited fisheries output. According to the Food and Agriculture Organisation (FAO), seafood supply will fall from 4.5 M kg to 18.2 M kg less than demand by 2010. Aquaculture contributes 30% of global seafood supply rising by 200% in value since 1985 to more than US$33.5 Billion in value in 1994.

Marine shrimp and salmon are the biggest value contributor with the largest markets. Global marine shrimp production rose from 2,151,156 metric tonnes in 1985 to 3,080,402 metric tonnes 1994. During this period, farmed marine shrimps rose from 9.9% to 29.9% of total global marine shrimp production.

Aquaculture is growing more rapidly than all other animal food producing sectors; its contribution to global supplies of fish, crustaceans and molluscs increased from 3.9% of total production by weight in 1970 to 27.3% in 2000, according to FAO's State of World Fisheries and Aquaculture 2002 report (SOFIA). The contribution from aquaculture increased further to 29% in 2001

This project is projected to enhance the viability of the local fishing industry by helping exert less pressure on wild caught marine resources particularly crustaceans and finfish.

Furthermore, the project in itself may be a tourist attraction in terms of showcasing a world-class and pioneering aquaculture enterprise in the Northern Territory.

Finally, this project serves to lift the standard of future land-based aquaculture enterprises so that the industry does not affect related industries such as pearl farming.

This project depends on the health of the natural environment in which it is located and considers itself a stakeholder in the preservation of the environment, similar to the fishing, pearling, and tourism industries.

3.2 FOREIGN TRADE OBJECTIVES

Ultimately and upon completion of 65 hectares of production ponds, the project is envisioned to generate about A$90 million in gross revenues per year, 98% of which is from foreign trade receipts.

3.3 BENEFIT TO THE LOCAL WORKFORCE LAND USERS AND INDIGENOUS PEOPLE

The project will contribute significant economic and social benefits to the local economy ranging from employment, technology development and transfer, revenue generation from the economic multiplier effects of local enterprise building.

The project will employ initially from 10 to a maximum of 80 people of whom at least 80% will be local Territorians.

Most significantly, the project is envisioned to serve as a hub and nucleus for land-based aquaculture enterprises for the Northern Territory by supplying the management service, technology, inputs, as well as developing and coordinating the marketing of products for overseas buyers. This will result in ‘multiplier’ effects for the local economy.

Finally, the proponent would like to repay the kindness shown by the indigenous people of the Tiwi Islands by offering training opportunities to the Tiwis and other interested indigenous people of the Northern Territory.

3.4 COMMERCIAL OBJECTIVES

When fully developed, the project is projected to produce at least 5,000 tonnes of product a year. This will make it by far the largest land-based aquaculture producer in Australia. However, this output will not even be 1% of the overseas market. We envision this project to be a niche market supply leader in terms of supplying the best size and product.

3.5 OCCUPATIONAL HEALTH AND SAFETY OBJECTIVES

The project will strive to maintain the highest health and safety standards for its employees. It will as well conform to the strictest standards in the seafood production industry including the international food safety standard *Hazard Analysis Critical Control Point* (HACCP) and International Standards Organisation (ISO) (ISO 9000) certifications for Quality.

3.6 LOCAL, REGIONAL AND GLOBAL ENVIRONMENTAL OBJECTIVES

The rapid growth of aquaculture has not been exempt from environmental issues which this project will address by aiming to be a world-class showcase and providing a blueprint for future modern aquaculture farms to follow.

Suntay Aquaculture Pty Ltd and its parent company ASL is a member of the Global Aquaculture Alliance, and subscribes to the Code of Practice and Conduct for Marine Shrimp Aquaculture (Global Aquaculture Alliance 2003a, b) (**Appendix 2**). SAA also adheres to the Guiding Principles for Responsible Aquaculture (Global Aquaculture Alliance 2003c), an international set of guiding principles which set the highest standards in aquaculture. SAA aims to conform to the latest Food and Agricultural Organisation (FAO) Code of Responsible Aquaculture.

When the project is operational, SAA will also become a member of the Australian Prawn Farmers Association (APFA) and will adhere to their *Environmental Code of Practice for Australian Prawn Farmers* (**Appendix 3**). This code, like its international cousin, sets high standards of performance and operation, and mandates appropriate record-keeping, monitoring and auditing. In addition, complaints mechanisms in the Code ensure that prawn aquaculture operations adhere to the codes, and allow for third party interest.

Implications of the project with respect to the National Greenhouse Strategy will be determined when final power and emission outputs are calculated. The project is not expected to make a significant contribution to greenhouse gases, but these will be calculated using established accounting methods. No greenhouse gas monitoring is proposed.

4 DESCRIPTION OF THE PROPOSED DEVELOPMENT

The project is envisioned to be a model of environmental sustainability that is supported and encouraged by the Global Aquaculture Alliance, USA, and sets the benchmark for the latest FAO code of responsible aquaculture as well as the strictest aquaculture codes of practice in any part of the world including Australia.

The project makes use of a novel and pioneering system that is being encouraged by local and state governments in Australia (and many other countries) but has not yet been implemented because of the limitations of existing conventional systems.

The proprietary culture system lends itself well to the subject of ongoing and planned research by CSIRO, AIMS and North Queensland DPIF. Suntay Aquaculture Pty Ltd will coordinate and share our research with these agencies (as well as from overseas) particularly in areas of Culture System, Design and Engineering, and Brood-stock development.

At present, SAA has commenced collaborative research and development with Charles Darwin University (Northern Territory University) Aquaculture Unit to develop a 'clean' local and indigenous species of prawn for commercial purposes. This research and development project is the foundation of a high standard industry and is crucial to the survival of the industry, and the US government, for example, has provided US$8 million for the research and development of closed-systems for their penaeid shrimp aquaculture.

Point Ceylon Aquaculture Estates will only make use of about 180 hectares (including about 65 hectares of ponds) and the proponent envisions leaving the undeveloped area in its natural state. The layout of the project is shown in **Figure 4.1**. This is in line with the vision to create an environment-friendly world-class aquaculture enterprise.

In the long term, the project will grow a variety of crustaceans such as prawns and finfish such as grouper, subject to necessary approvals and further research and development.

This project applies principles successfully demonstrated by Belize Aquaculture (Belize), and research institutions such as Waddell Mariculture Center in North Carolina (USA). These principles have been further developed to incorporate a proprietary pond design and grow-out system that is the first of its kind in any part of the world for these particular species.

Project Features
The following summarizes the features of this innovative project that sets it apart from conventional and traditional open-pond or caged aquaculture activities.

- *Closed system with zero operational discharge* – The project's unconventional intensive closed culture system nurtures and provides for a highly stable pond ecosystem that takes time to establish, making it impractical and costly to exchange pond water with uncultured estuary water. The "Zero Discharge" system is essential for bio-security and provides the added environmental benefit of not creating an impact on the nearby environment. This is different from the normal practice with other open pond or cage aquaculture activities where water exchange is regularly practiced. Hence, there is no discharge from the system except in an extremely abnormal meteorological event where rainfall total exceeds historical records from which our capacity to collect is based. Even in this case, however, discharge water will be directed through several fall-back reservoirs and not directly from ponds, resulting in significant dilution of overflow waters.

- *Low salt-water and freshwater consumption* – a complementary benefit of the closed system is its low water requirements. The saltwater and freshwater requirement is at least 70% lower than

conventional open-pond aquaculture systems. Freshwater will only be used to compensate for evaporation losses and maintain salinity regimes.

- *No soil leaching* – the use of plastic liners or geo-membranes drastically minimizes any alteration or deterioration of soil properties on the area.

- *No salinization of groundwater* – the use of plastic liners or geo-membranes drastically minimizes any brackish-water or salt-water intrusion into the soil strata or any freshwater aquifer in the property.

- *No impact on mangroves* – the project will be situated in areas mostly above 10 to 20 metres of elevation (see **Figure 4.2**). Furthermore, the low water requirement of this closed system allows the use of two small pipelines to draw saltwater from Bynoe Harbour and Wheatley Creek. The designs proposed do away with any mangrove clearing, unlike conventional open-pond aquaculture activities that draw huge amounts of saltwater or brackish water from estuaries using trenches.

- *Low phosphorous and nitrogen content in resultant water from culture operations* – this is another complementary benefit of the closed system as pond organisms strip a great amount of phosphorous and nitrogen from the pond water. This is in contrast with conventional aquaculture systems and most agricultural activities which tend to contribute excessive amounts of phosphorous and nitrogen to nearby bodies of water.

- *Makes high productive use of land of otherwise little agricultural value* – at present there is no use envisioned for the property. SAA aims to achieve the most efficient levels of productivity in Asia in the culture of crustaceans such as black tiger prawns (*Penaeus monodon*) and other high value finfish such as grouper. Annual harvests are projected to be between 10 to 40 tonnes of produce for every hectare due to the stable and continuous production cycle. This needs to be compared to the annual national average of 4 tonnes per hectare and Thailand's annual average of 2.5 tonnes per hectare. This amounts to roughly A$150,000 in gross sales per hectare assuming a 10 tonne harvest for one hectare.

- *Rehabilitates and aesthetically develops an abandoned aquaculture farm and mine* – a complementary benefit of the use of geo-membranes allows the company to rehabilitate what was an abandoned aquaculture farm, agriculture and mining sites. Furthermore, the company will remove all unsightly materials left over from the past activities. The company will encourage the growth of natural vegetation and complementary landscaping.

- *Utilizes 1/10 of the normal area required for the same aquaculture activity* – the closed system requires a smaller area because it does away with open trenches for water intake to each pond. It does not require larger reservoirs because it does not discharge any pond water. Furthermore, to compensate for the high evaporation rates in the Northern Territory, the closed system allows the company to build deeper ponds which otherwise would be inefficient and nearly impossible with conventional semi-intensive aquaculture activities.

- *Better sustainability in the long-term* – using geo-membranes will allow management to concentrate on water quality management without worrying about soil management issues. The company has taken into account the high start-up costs, scarcity of labour and absence of industry critical mass in the Northern Territory and Australia generally compared to other aquaculture-oriented countries, and has designed the project to be substantially mechanized and automated for better production consistency while requiring less management. SAA believes that the capital-intensive nature of the project will work to its advantage in the long-term as the company is able to substantially reduce per-unit and variable costs.

- *Designed to undertake continuous research and development* - as well as address current and future business, social and environmental concerns – the company's phased development gives it room to immediately apply its research knowledge on subsequent areas for development. As part of its production goals, the company aims to achieve the lowest feed utilization rates for its cultured species. In the years to follow, the company aims to be able to develop its own brood-stock suitable to its culture system without relying on wild captured spawners. The company also aims to develop, in coordination with the feed industry, suitable substitutes to fish protein. This should contribute to the conservation of the valuable resources used in today's fish-meal.

Point Ceylon Aquaculture Estates has built on research and development on Minimal to Zero Exchange that has been done in Waddell Mariculture Center in North Carolina, Oceanic Institute of Hawaii, and by Belize Aquaculture Limited (see references). Concepts in intensification have been adopted from Technion in Haifa, Israel.

The project has further refined these concepts particularly in terms of the design and operation enhancing significantly productivity, efficiency and resource utilization, and adapting them to indigenous species (initially *Penaeus monodon*) of the Northern Territory. The techniques have not been adapted to species of the Asia Pacific region including Australia and therefore the project and approach are unique in a global context.

4.1 MAJOR COMPONENTS

4.1.1 Production ponds

A series of production ponds for the maturation stages of prawn development will be constructed as shown in **figure 4.2**. The ponds will be cut-to-fill embankment construction to economise earthworks, and to best utilise the sloping land they on which they will be situated (**figure 4.3**). Embankment walls will be constructed from excavated material and compacted in layers under controlled placement. The soil to be used from excavation is typically a sandy gravel overlying a sandy silt, as described in the geotechnical report in **Appendix 4**, and summarised in section 6.4.1.1. Geotechnical investigation of the soils indicates good potential for the intended use of much of the excavated material (**figures 4.4a; 4.4b**).

Deeper excavation indicates a layer of stiff sandy clayey silt (Section 6.4.1.1; **Appendix 4**). This material will not be incorporated in the construction of the walls. Test holes indicate this less suitable material ranges from 1.2 m to 2.3 m below ground level, and is indicated by a distinct colour change and material property, which is readily identifiable. The limit of excavation for the ponds will generally be above this layer, reducing the quantity for disposal. The soils are well weathered and are not acid producing types. All excavation and soil disturbance for the ponds is above the 8 metre contour, and to a depth of at most two metres. Excavation will therefore be exclusively in weathered material, and will not affect any recent sediments capable of producing acid.

Ponds are to be lined with 2.0 mm High Density Polyethylene (HDPE) to prevent seepage. The liner is UV stabilised and has a working life of 30 years. The material is an industry standard for use as an impermeable pond liner. A product data safety sheet for material properties is included at **Appendix 5**. The soils as inspected do not present a risk to the integrity of the liners, and will be compacted and trimmed prior to laying the liner to remove the risk of puncture.

Water for the ponds will be pumped from the saltwater intake on Wheatley Creek and retained in the water storage ponds (reticulation basins). Fresh water will be pumped from the freshwater weir only during high flow periods and retained in the freshwater storage ponds for the whole year.

The normal operating depth at which the ponds will be commissioned prior to the beginning of each wet season is 1.3 m. A freeboard depth of 0.7 m to overflow spill level will provide an expected factor

of safety for release of 1 in 10 years as described in the hydrology section 6.4. Top of bank level will be 200 mm above this to provide protection against wave action, with the bund crest crowned to prevent longitudinal runoff and hence erosion. Surface runoff from the bunds and access roads internally is directed into the ponds, and minor overtopping due to strong winds (cyclonic) is fully contained.

Anti slip rubber matting will be provided at the ends and midpoints of the pond sides to allow easy access and exit from the ponds.

Typically, an operating production volume of 4,989 kilolitres per hectare of ponds at 1.3 m depth, and total holding volume of 8,436 kilolitres at maximum working depth of 2.0 m is available. The redundant storage volume of 3,447 kilolitres per hectare above the operating level of 1.3 m in the production ponds and freeboard of 700 mm precludes uncontrolled discharge for the maximum daily rainfall event on record. Data from 1941 to the present recorded at Darwin Airport site *014015* indicates the highest daily rainfall event was 310 mm.

The initial stage of development will be the construction of approximately 9.3 ha of production ponds and 3.0 ha of recirculation and harvest basins, plus space between ponds for walkways and bund wall footprints, covering an area of 17.5 ha. At full development, including berms and access between ponds, the production pond area will cover around 105 ha.

4.1.2 Harvest Basin

An additional 16,713 kilolitres of storage is available per set of production ponds in the harvest basin, which will double as the overflow receiving basin in large storm events. The harvest basin is a lined cut-to-fill pond constructed in the same manner as the production ponds. The harvest basin acts as a transfer pond during prawn harvesting, sludge de-watering and overflow conditions. Discharge from the harvest basin during large events – anticipated to be less frequent than 1 in 10 year events – is as sheet flow across the weir face.

4.1.3 Settlement/recirculation ponds

The construction method is as for the production ponds, using cut-to-fill embankment ponds lined with 2.0 mm HDPE. The harvest basin doubles as an overflow routing pond, allowing transfer of pond overflow to the recirculation ponds or the off-stream storage reservoirs. Pond contents are transferred via pipe work under gravity. All water is contained within the ponds and re-used. Water from harvest operations, including any pond overflow during large storms, is pumped from the harvest basin to the recirculation ponds or the off-stream storage reservoirs. The recirculation ponds provide 15,834 kilolitres of storage per set of production ponds.

An unlined treatment pond receives sludge and uninfected waste biomass for drying and processing for use as fertilizer on or off site. This is a bunded area, with no surface discharge to the environment. An excavated base will be constructed with a sand filter layer overlying a coarse gravel drainage layer, which will prevent ponding of water during the wet season, therefore removing the chance of mosquito breeding. The waste treatment bunds are sized to prevent uncontrolled overflow during the wet season.

The bunds will be modular to suit the expansion of the production ponds, typically 5 sets of 50 m by 250 m areas. It is expected that for Stage 1 approximately 8.4 m^3 of sludge (at 30% by volume) will be transferred to the treatment bunds every 1-2 days. The sludge is washed with fresh water before transfer, resulting in no contamination of groundwater at the site with saline water. This transfer rate allows for 150 days retention at a sludge depth of 100 mm before reuse.

4.1.4 Freshwater Catchment Weir

A low level embankment weir will be constructed across the natural gully of Wheatley's Creek, at the point shown on Figure 4.1, and as drawn in **Figure 4.5,** with a curve radius of approximately 160 m. The weir crest is at RL 6.0 m AHD, and the toe level at approx. RL 4.0 m AHD. The weir has a storage capacity of approx. 90,000 kilolitres, covering an area of 12 ha when full. The length of the weir wall is 215 metres. The weir footprint will be between 50 m and 100 m upstream of mangrove lines and the upper limit of tidal influence, subject to detail survey on site to determine location upstream from mangroves. The area to be disturbed and cleared under the weir footprint is about 2,000 m^2.

As a portion of the site is below 5 m above mean high water, the potential for acid sulfate soils to occur in the location was investigated. This is reported in section 6.4.1.1 and 6.4.3. Management of these soils will be undertaken on site during construction, in accordance with recognised practice.

The weir will be constructed from low permeability materials sourced from pond excavations. Embankment slopes are to be at 1:3, with a 2 m wide crest. All embankment material will be placed in layers and compacted in accordance with engineered design. In line with recommendations stemming from the initial geotechnical investigation at the site, excavation to soft bedrock/dense gravel sand-silt at approximately 2-3 m below ground level will be undertaken to provide an effective impervious curtain wall beneath the weir wall. As groundwater flow can be expected, a piping failure at the toe of the weir will be avoided by this construction method.

The leading and trailing face of the weir (upstream & downstream) and crest will be protected from scour during run off by facing with Ecocell HDPE cellular confinement system, stapled together and staked to the embankment in accordance with the manufacturer's specifications. The downstream face of the weir will be protected from scour and storm surge by extending the Ecocell panels 4 m past the toe of the weir. The Ecocell panel on the upstream face will extend from the crest so that a 1 m depth from crest is protected during overflow. The panels are placed on a layer of geotextile fabric, to prevent migration of soil fines. Backfill material of the type used in construction of the wall is placed and compacted into the cells' compartments, allowing for revegetation to occur.

No spillway structure is required, as the weir wall acts as a full width spillway or weir during flow events. Estimation of flow volume at 1 in 100 year storm events for the weir catchment indicates a water depth of 0.5 m at 2.0 m/s across the weir crest. The outfall is not concentrating the run off, hence no adverse impacts on the downstream channel should result. Detailed hydraulic analysis of the spillway will be undertaken to design the full extent of scour protection on the downstream face of the weir.

Water will be pumped from the freshwater weir during high flow periods and retained in the freshwater storage ponds in the main facility area (see **Figure 4.6**). Water will be drained from the weir during low flow periods over less than five days.

The panels will not corrode in the marine environment, and will withstand water velocities up to 4.0 m/s. Regular inspection and maintenance will ensure long term performance of the panels. As the Ecocell panels are filled with compacted soil, a measure of fire protection is imparted to the HDPE panel. A burn down through the panel walls is not possible as the presence of backfill prevents the fire becoming established once any surface fuel load is consumed. Maintenance of the backfill before the onset of the wet season will ensure no cell exposure for the following dry season.

The Vipac Report 'Greater Darwin Cyclone Storm Surge Risk' August 1994 estimates a 1 in 100 year peak tropical cyclone tide level for Bynoe Harbour of 5.3m AHD, and 1 in 1000 year level of 6.6 m. The initial pond development will include the construction of the weir with Ecocell panel protection. Retro fitting primary and secondary armour rock to the downstream face of the weir to provide the 100 year storm surge protection may be undertaken on development of Phases 2 & 3 of the project.

4.1.5 Saltwater intake and discharge channels and pipelines

An intake pipeline will be provided at the weir site for transfer of fresh water to the off-stream storage ponds adjacent the production ponds. A small intake gallery will be constructed with gabion baskets to provide protection from debris during rainfall events. The transfer pump and diesel tank will be housed in a lockable weatherproof building, complete with sump in the event of fuel/oil leaks from the pump or fuel drums.

An intake pipe and floating pontoon will be provided off Point Ceylon for the transfer of sea water to the breeding facility ponds. The pump with screened intake will be located to intercept the median tidal range – i.e. intake at 0 m AHD. No removal of mangroves or excavation in mangrove muds will be necessary. A test hole at Point Ceylon is proposed to determine if the breeding facility water requirements can be served from a new bore, in lieu of the pumped line from Bynoe Harbour. The estimated water makeup for the breeding facility will be about 10,000 L/day to 15,000 L/day at full development. This water will be sea water. The quality of an existing well/bore at Point Ceylon indicates sea water quality and characteristics.

A similar salt water intake through the mangroves to the channel of Wheatley's Creek will be provided to initially fill the production ponds to operating levels. Thereafter, all make up water to cover evaporative losses is provided from the off-stream storage reservoirs.

No discharge pipes or channels are required. In the event of a discharge from the production ponds to the harvest basins which exceeds design capacity, the resulting overflow will be a sheet flow for the full length of the harvest basin, effectively a shallow low velocity weir. A minimum flow distance of 75 m, and typically 150 – 200 m, through undisturbed vegetation occurs before any discharge enters the harbour. Refer to Section 4.1.12 for further detail.

4.1.6 Water supply pipelines

Fresh water supply from the weir to the off-stream storage reservoirs is pumped via a 1.6 km pressure pipe - the route is shown on **Figure 4.1**. A pipeline access corridor will be provided as part of the installation works, allowing single vehicle access to the pump house and weir wall. Mobile transfer pumps will be used to deliver water from the reservoirs to the production ponds as required. All pipeline routes will be identified with markers indicating location and content.

Water distribution from the off-stream reservoir to the production ponds is via pressure pipe and mobile pump. It is unknown whether a significant turbidity problem is likely to occur with water pumped from the weir, so the ability to provide an in-line sand filter will be allowed for. Backwash water will be directed back to the off-stream reservoir, as required. It is expected that adequate settling will occur in the off-stream reservoirs due to the large volume and low rate of expected draw-down during the wet season.

Sea water supply to the breeding facility will be pumped via a 200 m pressure pipe from the intake pontoon to an elevated storage tank. The breeding facility operations will be gravity fed from this tank.

The seawater supply line from Wheatley Creek will be a flexible pressure pipe from the intake pontoon to the production ponds for initial filling of the ponds.

4.1.7 Water storage ponds

The main water storage for the production ponds is the off-stream storage reservoirs. The method of construction and materials are as for the production ponds – i.e. lined cut-to-fill embankment ponds. The reservoirs will act to receive overflow from the production ponds in the event of large rainfall events, augmenting the recirculation ponds. The first module will be a 380 megalitre storage, with a bund to provide separated fresh water only volume of approximately 100 megalitres.

It is proposed that one module of reservoirs be restricted to receiving fresh water from the weir only, i.e. removed from the recirculation loop. This allows for the provision of freshwater for human consumption and washing of produce for preparation for packaging and sale. This water supply will be transferred to a separate food grade water tank adjacent to the proposed employees' compound, and will be treated to the appropriate level required by national guidelines for safe human consumption and use via filtration, UV sterilisation and chlorination.

Potable water requirements for the breeding facility will likely be served from the treated water stored at the main employee compound, delivered under piped gravity system along the upgraded access road to an elevated break tank. Chlorine dosing to this line will be used to ensure a safe product. Information provided by Water Resources (DIPE) indicates groundwater is available in low to limited amounts. Should it be deemed economically viable, a single bore for provision of potable water would be developed at the breeding facility site in lieu of the pipeline. Water treatment for consumption would still apply.

Two 200,000 litre seawater storage reservoirs are required at the breeding facility and maturation compound. An economic feasibility assessment will be completed to determine whether lined cut-to-fill embankment ponds with pressure pump are better than modular elevated tanks.

Seawater for the production ponds is pumped directly to the ponds from the source, and allowed to settle and then treated. The process is described in section 4.6.4.

All water used throughout the development will be subject to testing for water quality, to ensure it is fit for purpose – aquaculture, discharge and consumption. Potable water will be treated as necessary in accordance with NT Health Department requirements for consumption and for processing of prawns.

The initial development will be supported by the construction of a 9 ha off-stream storage basin, with an additional basin of similar size required for each additional 15 ha of production ponds.

4.1.8 Buildings

There will be permanent buildings for the production pond area, breeding facility and main transfer pump at the weir site. All buildings will be designed to comply with Australian Standards loading requirements, NT Deemed to Comply, and the Building Code of Australia, and all buildings will be certified by a qualified building practitioner. The breeding facility is described in section 4.1.10.

4.1.8.1 Production Pond buildings

The compound will comprise accommodation, meals/mess and ablutions facilities for full time employees as shown in the preliminary drawings in Figure 4.7. These are typically expected to be 'demountable' style buildings, with covered areas provided by steel framed shade cloth areas, as well as light steel frame corrugated iron clad areas. The main processing/packing area will likely comprise slab on ground, with a steel portal frame industrial sized shed over built-in offices. All structures will be engineered for cyclonic conditions. It is expected that the compound (including car-parking and vehicle movement) will require approximately 2 ha.

On site sea water reservoirs are required, two each of 200,000 litre volume. An economic assessment will be undertaken to determine whether two lined cut-to-fill embankment ponds with pumps or large elevated modular tanks are suitable.

The total compound area including two reservoirs is estimated to require 4,500 m^2.

4.1.8.2 Weir & Seawater Pumphouse

The pumps will be diesel powered; preliminary sizing indicates 50 L/s capacity at the weir site, 1 L/s at the breeding facility seawater intake, and 20 L/s at the ponds seawater intake site. The weir pumps will be housed in a block building constructed to Code, with sump collection to safeguard the environment in the event of a fuel or oil spill or leakage.

4.1.9 Access roads and parking

An existing informal unsealed road from Fog Bay Road to Point Ceylon currently provides the access for the site. This road is not an official road, and runs through properties Section 2609 and 2620. The officially gazetted 20m road corridor is some 800m to the east.

The existing road will be unsuitable for development as the permanent access to the site, due to the proximity of the proposed backwater surface at the weir site, and the crossing of a tributary branch of Wheatley's Creek. Full year access is not guaranteed with the road in this location, without substantial culvert works.

The gazetted road corridor is on higher ground, nearer the natural ridge, and as such requires no major culverts. It is anticipated that two low level floodway crossings will be constructed, and several single pipe culverts under the road will be required in order to facilitate all year access to the site. The road will be to DIPE standards for unsealed gravel roads - an 8m pavement formation with table drains each side. An intersection with Fog Bay Road will be constructed, with appropriate signage in accordance with Road Authority requirements. All pavement, culvert and scour protection works will be in accordance with DIPE standards.

The road will be constructed primarily from materials won from pond excavations, which are suitable for use as sub-grade materials. Where insufficient suitable material is available from excavation for road base material, a conforming product will be sourced commercially.

An 8.2 km road will be constructed from the intersection at Fog Bay Road along the gazetted corridor, then following the ridge across the development site to the main production compound. A 20 m corridor will be cleared for these works, resulting in some 16.4 ha being cleared. The existing access road will be used as a temporary road for construction and site access, alleviating the need for additional clearing.

A similar standard of road will be constructed from the main compound to the breeding facility at Point Ceylon. A road has been previously constructed, following the natural ridge. No drainage structures are anticipated, nor major clearing. Realignment of 1.1 km of road from the main compound is required to connect with the proposed road, resulting in some 2.2 ha of clearing. The existing road will have table drains upgraded and constructed where required, and an upgrading of the surface to all weather gravel where required.

Car-parking at the two compounds will be provided, utilising the same material as for the road base. Heavy vehicle movements are not expected to be continuous, however monitoring of the performance of the area with regard to truck turning movements will be undertaken during farm operations. Should it be deemed necessary, areas associated with heavy vehicle movements within the compound will be sealed to prevent dust pollution and erosion.

4.1.10Breeding facility

The total compound area as shown in **Figure 4.8** will include two buildings for larvae & algae rearing, spawning and maturation, each with the means to collect spills and wash-down water via sumps and pipes. Included within one building will be ablutions facilities. These buildings will likely be of block construction, with an estimated floor area of 400 m^2 each. A steel framed shade cloth covered

area over slab on ground housing the brood-stock tanks will be attached as an annex to the maturation building. The shade cloth is removable in the event of cyclone. Estimated floor area will be 1,350 m^2. Two small buildings of approximately 9 m^2 each will house the blowers, filtration & UV filters, and the generator and fuel storage respectively. A separate pump house enclosure to house the seawater transfer pump will be located adjacent the foreshore. Both the breeding facility and the pump house will be built above the 1 in 1000 year surge zone, i.e. above AHD 6.6 m. They will be designed and built in accordance with the Cyclone Code.

An economic feasibility study will be undertaken to determine the long term cost effectiveness of supplying power to the breeding facility compound via overhead lines from the main compound, or to use a smaller on-site generator. It is anticipated that hybrid diesel generators/solar power systems will be used.

4.1.11Electricity and communications

There are currently no PowerWater or Telstra assets into the site, provision of which is uneconomic for the preliminary stages of the project.

Power will be provided to the main and breeding facility compounds by a hybrid diesel/solar power generation system. Detailed design will be undertaken once all loads are assessed. Individual diesel powered mobile transfer pumps will be used around the production ponds, and as stated previously, stand alone diesel powered pumps will be used at the weir site and sea water intake.

Communications into and out of the site can be achieved using the Telstra mobile network, as advice from Telstra is that coverage is available under the CDMA network, and likely under the GSM network. Internal communications across the site are likely to be via two way radio. All necessary licences will be sought.

All installation will be undertaken by licensed contractors to the relevant Australian Standards.

It is anticipated that PowerWater will have extended the grid along Fog Bay Road by the end of 2004. A detailed economic analysis will be undertaken for the whole-of-life costs of providing power on site versus connection to the grid.

4.1.12Stormwater drainage

Rainfall over the area of pond development is expected to be captured by the ponds as part of the water balance. In the event of a heavy wet season, pond overflow will be directed to the harvest basin by gravity flows. From the harvest basin, water can be pumped to the recirculation ponds if required. The water balance modelling for these events is shown in section 6.4.1.4, and details provided in **Appendix 9**. Overflow from the harvest basins is via overtopping of the downstream face of the embankment wall. The freeboard of 700 mm in the production ponds is maintained by controlled release to the harvest basin prior to transfer to the recirculation ponds and off-stream storage reservoirs, thus uncontrolled overflow will only occur during extended periods of exceptionally wet weather.

With an operating production volume of 4,989 kilolitres per hectare of ponds at 1.3 m depth, and total holding volume of 8,436 kilolitres at maximum working depth of 2.0 m provides a redundant storage volume of 3,447 kilolitres per hectare above the operating level of 1.3 m in the production ponds. With a freeboard of 700 mm this precludes uncontrolled discharge for the maximum daily rainfall event on record. An additional 16,713 kilolitres of storage is available per set of production ponds in the harvest basin, which will double as the overflow receiving basin in large storm events. Data from 1941 to present recorded at Darwin Airport site 014015 indicates the highest daily rainfall event was 310 mm.

The embankment walls will be faced with Ecocell HDPE soil confinement panels to prevent erosion, and facilitate vegetation growth, as per the weir construction. Peak 1 in 100 year storm event discharge per harvest basin is 3000 L/s, for a storm duration of 5 minutes. The effective resulting sheet flow is comparable to the present undeveloped discharge, as no additional catchment area is contributing to the discharge along Wheatley's Creek. Flow velocity over the embankment is approximately 0.75 m/s at a depth of 20 mm, for a weir length of 200 m.

Additional protection from erosion is provided in the form of an undisturbed natural vegetation buffer between the ponds and the mangrove edge which will be at least 75 m wide and up to 600 metres wide. There is no concentrated point of discharge from the production ponds into Wheatley's Creek.

The same design philosophy applies to the off-stream storage reservoirs, where when peak design rainfall events coincide with the full capacity of the reservoir, a design spill of 4500 L/s is expected. Similarly, this results in a spill velocity of 0.75 m/s for a depth of 25 mm over a 260 m weir face.

Additionally, the vertical overflow stand pipes in the production ponds are screened with fine mesh to prevent the release of any large biological matter to the environment. The amount of mixing taking place between the rainwater and the pond contents during a spill event is minimal due to the stratification in the ponds between fresh rainwater and saline pond contents. During storm events when it is likely that overflow will occur, the aerators will be stopped to allow adequate stratification. Effectively a freshwater sheet flow across the pond surface to the overflow pipes takes place, greatly reducing the release to the environment of the contents of an otherwise operational pond.

Site grading works will be undertaken at each of the compounds to ensure free drainage. Any concentration of run-off from roof areas will be treated to dissipate energy and prevent localised erosion from occurring.

4.1.13Waste Management Infrastructure

Waste generated on site falls into two categories: waste that is able to be treated on site, and waste requiring treatment and disposal off site. On site treatment will be limited to sewage.

Off-site waste treatment will be required for any fuel/oil spills collected in the generator and pump buildings' sumps. Waste generated by employees will be collected in bins, with standard practice for clean work areas requiring that all rubbish be disposed of properly. A regular waste collection service for fuel/oil and rubbish will be entered into with a commercial third party.

4.1.14Sewerage

Ablutions facilities will be provided for employees at the main compound and the breeding facility, in accordance with the requirements of the Building Code of Australia. All wastewater from sinks, showers and toilets will be collected and treated in an extended aeration wastewater treatment package plant at each site. Wash-down and overflow water from within the breeding facility and processing/packing buildings will be collected in sumps and transferred to the same sewerage plant for treatment. Where gravity mains are impractical, rising mains shall be provided. Sludge and biomass from the production ponds will be removed to an on-site bunded drying bed before being prepared for use as fertilizer on or off site. Treated wastewater from the STP will be disposed of by sub-surface irrigation to a fenced area near the facilities area, in accordance with the requirements of the *Code of Practice for Small On-Site Sewerage & Sullage Treatment Systems* (Territory Health Services, 1996).

The proposed plant ("AquaTreat" package sewage treatment plant) has current Type Approval from PowerWater Corporation, and discharge from these plants in use throughout the Northern Territory has been shown to fall within Government guidelines for release of treated wastewater. Regular on-going monitoring of the effluent quality will be undertaken to confirm the plant is operating correctly

with regard to nutrient and bacteria removal. No wastewater will be released without treatment to ensure compliance with government regulations.

4.2 LAYOUT OF MAJOR COMPONENTS

The farm will be developed in the middle body of the property (**Figure 4.1)**. Ponds will be developed within areas with elevation of 8 m to 20 m above MSL while recirculation and harvest basins will be developed in areas with elevation of 8 m to 10 m above MSL.

4.3 OVERVIEW OF KEY PROCESSES INVOLVED IN PRODUCTION

These have been addressed in section 4.6.4 below.

4.4 LOCATION DETAILS

The project is located north of the Fog Bay Road about 120 kilometres west of Darwin (**Figure 1.1**) at the southern edge of Bynoe Harbour. The nearest port facility is at East Arm Port which is on Darwin Harbour, about 100 km from the site. Dundee Beach on Fog Bay lies approximately 30 kilometres to the west of the turn-off from the Fog Bay Road, and Crab Claw Island Resort is about 7 km east of Point Ceylon.

4.5 CONSTRUCTION PHASE

4.5.1 Timing of construction activities (include a time-line for all activities).

Phase 1 will involve the development of a total area development of about 25 ha including 9.3 ha of ponds, 3 ha of Recirculation and Harvest ponds, supporting supply pipes, saltwater intake pipe from Wheatley Creek, 8 ha for the Freshwater Weir storage, 500 m^2 for the 1st phase breeding facility, 1,350 m^2 for the maturation area, warehouse for storage and 1st phase of processing shed, 1st phase of staff accommodation, and office and laboratory facility. A draft timetable for Phase 1 is presented in **Figure 4.9.**

Phases 2 to 3 (over a period of 3 to 5 years) will involve the total development of about 115 ha including 50 ha of ponds, 16.5 ha of reticulating and harvest ponds, supporting supply and drain pipes, 30 ha of freshwater storage, 2nd phase breeding facility, 2nd phase processing shed, and 2nd phase of staff accommodation.

The sequence of construction for future stages is similar to that for Stage 1, with the exception of the major infrastructure items such as the weir, roads and processing/breeding facility compounds.

The works required for Stage 1 are as follows:

Preliminary Works:

- Clearing of production compound area for use as site compound during construction;
- Construction of permanent ablutions and sewage treatment system for use during construction and production;
- Construction of temporary power generation & fuel storage, typically 8 kVA genset, potable water storage tanks;
- Construction of vehicle/plant service bays, temporary and permanent accommodation.

Detail Works

- Clearing of: gazetted road corridor, Stage 1 production ponds and off-stream storage, weir footprint and large trees in backwater, sludge drying pond, breeding facility compound;

- Construction of bulk earthworks items above, lining as required;
- Construction of concrete batch plant and bulk aggregates bays;
- Installation of pipework and fittings;
- Construction of footings & slabs for production & breeding facility compounds, pumphouses;
- Construction of larval, broodstock and grow out tanks;
- Construction of permanent sheds and buildings for breeding facility & production compounds;
- Construction of permanent generator buildings and fuel storage;
- Construction of permanent potable water storage and treatment.

4.5.2 Infrastructure

All earthworks to be undertaken on site will be cut-to-fill, associated with the construction of the ponds and storage structures. Initial geotechnical inspection of the sub-surface materials indicates suitability for use in the works (section 6.3.1). Additional base-course gravel for road works may be required, pending an assessment of the excavated materials as fit for purpose. Topsoil and excess excavated materials will be stockpiled on site along the natural ridge.

Construction of the ponds is above the 1 in 1000 year storm surge level for Bynoe Harbour, and above the 1 in 100 year (Q100) flood level for the site (**Figure 4.5**). Some disturbance of potential acid sulfate soils will occur for the portion of the weir constructed at 5 m AHD, including the cut off trench. On site management during this phase of construction will ensure that the works are undertaken in such a manner as to prevent the exposed soils drying and being left exposed. The weir is located 50 m to 100 m upstream of the mangroves, while the production ponds have a minimum 75 m buffer from the mangrove edge and are over 8 m above sea level at natural ground level. Batter slopes are set at a maximum grade of 1:3 to reduce runoff erosion.

The ponds are constructed allowing for the operating depth and a portion of additional storage to be in cut natural ground (excavated to a maximum depth of approximately 2 m). The fill embankment comprising the remainder of the depth accounts for approximately 40% of the available storage volume. It is expected that this volume will not be used during average wet seasons, but provides for excess capacity to limit pond discharge during unusual wet seasons. Hence in the extremely unlikely event of a failure of the embankment wall, the potential discharge to the environment is reduced. The weir and pond embankments will be engineered to Australian Standards for seismic potential in the region, as well as an appropriate factor of safety against failure.

<u>Pipework & Pumps</u>

Pipework will be required for most of the facility, to import water, to move it around the site, and to pump air for pond aeration. These include:

- Pressure pipeline and pump for delivery from weir and seawater intakes;
- Pressure pipeline for delivery of freshwater from off-stream storage reservoirs to production ponds and potable supply treatment;
- Pressure pipeline for recirculation of water during harvest operations and transferring rainfall overflow;
- Gravity pipework for pond overflow standpipes and harvest operations;
- Internal potable and sewerage pipework for operations;
- Pressure pipeline for compressed air delivery to aerators

Pipework installation includes stop valves, one way valves, meters as required for transfer and recirculation operations associated with development of Phase 1.

4.5.2.1 Materials required for construction

All materials required for earthworks, including weir core and all weather access road, will be sourced from pond excavations. Preliminary geotechnical investigations indicate that much of the material to be excavated is suitable for intended use. Should a shortfall in suitable gravel for road base be encountered, material will be sourced commercially. There is no intention to bring in clay material from off-site for use in the pond bunds.

Gravel aggregates and sands for use in concrete elements will be sourced commercially and stockpiled on site. A small mobile concrete batch plant will be erected to provide for all concrete on site, minimising movement of concrete agitator trucks along Fog Bay Road. The aggregate bulk storage bins will have silt fences installed to minimise the impact from un-seasonal rainfall during construction.

All other materials – liners, pipes, fittings, pumps, building materials – will be sourced commercially.

4.5.2.2 Water supply and management

Potable water will initially be trucked to site, stored and treated to provide a safe product in accordance with national guidelines during the construction phase. Once the construction is complete – weir, off-stream storage, water storage and treatment – the project will be self sufficient for water.

Water will also be trucked in for dust suppression during construction activities.

Information from Water Resources (DIPE) indicates an existing bore adjacent to the proposed production compound which can be developed to augment on-site water requirements. The bore RN23176 will be checked to ensure estimated pumping regime of 0.6 L/s for 16 hours, 1 L/s for 8 hours. Estimated daily water requirements are of the order of 70-80,000 L/day, primarily for dust suppression, concrete and soil conditioning. Initial estimates indicate that during peak construction the bore should supply 90% of water requirements. The bore logs are provided in **Appendix 6**. The makeup volume will likely be one haul of 20,000 litres every 2 days for a period of 6 weeks, sourced commercially.

Potable water use on completion will be of the order of 1000 to 2000 L/day, depending on staff. This will be fully serviced from the off-stream storage.

4.5.2.3 Power supply

Power generation during the construction phase will be supplied via diesel generators for the provision of general office/workshop power requirements. It is expected that a transportable 8 kVA genset will be sufficient. The concrete batch plant is a fully self-contained plant, complete with its own power supply.

Power provision for the production phase will be via diesel generators with 100% failsafe backup. Requirements are estimated to be 1 MW for Stage 1, increasing to 4-6 MW at full development of the project.

4.5.2.4 Construction methods and materials for water storage areas

The weir construction design and materials are described in section 4.1.4 above. Construction will be undertaken using an excavator to complete the earthworks. The intake pressure pipeline from the weir to the ponds will be installed to a depth of 30 cm in a trench constructed using a trenching machine and back-filled and compressed in increments of 15 cm to ensure adequate compaction. Particular regard will be given to mounding the back-filled trench to avoid washout, and to installing diversion

embankments at intervals appropriate to the slope, to minimise overland flow velocity and to shed water from the trench line.

The off-stream storage ponds and production ponds will be constructed with a scraper and an excavator, and the excavated ponds will be rolled and compacted to remove obstacles and eliminate any sharp material which could puncture the HDPE liners.

4.5.2.5 Bunds in mangroves & marine muds

No bunds will be constructed in mangroves and marine muds.

4.5.2.6 Contingency plans

The ponds will be excavated from the site, and bund walls built above ground level. The water retention levels are generally below the natural earth levels, and in operating circumstances are not likely to fail. The bunds will be constructed in accordance with best practice engineering design as described in section 4.1.3. The bunds will be constructed to Australian Standards for loading, including seismic loadings appropriate for the region. Failure in extreme situations is unlikely, but in such extreme events, the design layout of the ponds results in the harvest basin being constructed immediately downstream from the production ponds, for the full width of the pond set. There is sufficient capacity within the harvest basin to contain 80% of the production pond operating capacity in the extremely unlikely event the entire bund wall collapses. The harvest basin is predominately constructed in cut natural earth, and as such cannot fail.

A contingency plan (ASS Management Plan) for disturbance of potential acid sulfate soils will be prepared prior to construction of the weir wall (see section 6.4).

4.5.2.7 Avoiding problems with biting insects

During the construction period, work on the site will be performed during daylight hours from 0700hrs to 1830 hrs. Biting insects including midges and mosquitoes are not normally a problem after an hour after sunrise and before an hour prior to sunset. Biting insects are more fully discussed in section 6.

Accommodation and eating facilities will be screened from insects. Personal repellents will be provided for workers, and suitable clothing will be required to protect workers from insect bites.

4.5.3 Utilities and temporary facilities required during construction

Temporary accommodation and ablution blocks will be provided during construction in the typical form of a mine camp – demountable buildings with light steel framed shade areas. The permanent buildings will be an extension of this, with additional block construction for elements of the breeding facility/maturation compound.

Vehicle and machinery service bays will be on concrete pads with sumps for collection of fuel/oil leaks. All fuel stored on site for the temporary and permanent operations will be in bunded areas.

4.5.3.1 Communications

Communications will be via mobile phone. Site communication will be by hand-held radio. Relevant licenses and approvals will be sought

4.5.3.2 Site construction office(s) & Personnel/briefing/induction facility

Site construction offices will be demountable style buildings. They will double as a personnel briefing and induction facility.

4.5.3.3 Warehouse

The warehouse will be constructed with a reinforced concrete slab with sump and grated drains to capture wash-down, and will be steel framed and corrugated iron clad. Lockable enclosures for office/stores will be block infill. All will be to NT Deemed to Comply and relevant Australian Standards.

4.5.3.4 Batch plant and material yard

A temporary mobile concrete batch plant is required during the construction of concrete elements associated with Stage 1 – tanks, thrust blocks, building slabs, etc. Bulk aggregate bins will be made from pre-cast panels, and silt fences will be installed to minimise runoff impact. The batch plant will be brought on site at the commencement of subsequent future stages.

4.5.3.5 Bulk materials lay-down yard

Bulk materials such as aggregates will be delivered direct to the bins. The future production compound doubles as the temporary site for construction activities, with sufficient space for storage of pipework, fittings and liners. The compound will be fenced for security.

4.5.3.6 Vehicle and equipment repair shop

The repair shop will be a steel-framed iron clad shed on a concrete slab with sump collection for fuel/oil spills. The shed will be retained for servicing vehicles and equipment during the production operations.

4.5.3.7 Vehicle and equipment parking areas

Vehicle car-parking areas will be constructed to all weather compacted gravel within the compound. Sufficient space for truck turning movements for fuel and water delivery will be provided. The condition of the site will be monitored as production increases, with a view to sealing areas with heavy traffic and turning movements.

4.5.3.8 Fire-fighting equipment

Fire fighting equipment will be held on site. It will consist of a trailer-mounted spray unit, and back-pack spray units for grass fires, and commercial fire extinguishers for equipment and building fires in accordance with legislative requirements.

4.5.4 Site preparation and initial works

4.5.4.1 Area of land to be cleared

Under Interim Development Control Order 12, a permit is required to clear in excess of 1 hectare of vegetation. This permit will be obtained prior to any works commencing.

Clearing

Clearing of the site will include a number of elements. Clearing will be restricted to the areas necessary for the proposed development. Specific clearing includes:

- Approximately 2,000 m^2 under weir footprint;
- Removal of large trees subject to die-back when inundated behind weir wall for approximately 1.5 ha;

- Initial production pond area of 17.5 ha;
- Off-stream storage reservoir 300 m long x 260 m wide (9.0 ha including batter slopes);
- New access road along gazetted corridor, 3,900 m x 20 m wide (7.8 ha); continuation of access road through to main compound, 3,300 m x 20 m wide (6.6 ha); continuation to breeding facility compound requires new portion 1,100 m x 20 m wide (2.2 ha) connecting to existing cleared road corridor;
- Main production compound: car-parking and heavy vehicle movements, accommodation & ablution/mess facilities, production & packing shed. Comprises approximately 2 ha of development, remnant bushland retained where possible;
- Breeding facility compound: car-parking and heavy vehicle movements, accommodation & ablution/mess facilities, rearing & quarantine/testing buildings, reservoirs. Comprises approximately 4,500 m^2 of development;
- Pipeline corridor and vehicle access from weir to off-stream storage, 700 m x 6 m wide (4,200 m^2);
- Pipeline corridor and vehicle access from seawater intake to breeding facility reservoir, 160 m x 6 m wide (960 m^2);
- Pipeline corridor from saltwater intake for ponds from Wheatley Creek, approximately 260 m x 6 m (1560 m^2).

Total clearing works for initial development: 46.5 ha.
Additional clearing for Phase 2 & 3 ponds, including reservoirs: 136 ha.

Earthworks

- Construction of weir across Wheatley's Creek, crest at 6.0 m AHD, toe at 4.0 m AHD, length 215 m, face slopes 1:3, lined with Ecocell for erosion protection. Full operating conditions with backwater covering 12 ha, capacity 90 ML. A permit will be obtained under the *Water Act* prior to construction;
- Construction of cut to fill embankment pond for off-stream storage, batter slopes at 1:3, interior of pond lined with HDPE, total storage volume at 5 m operating depth 380 ML;
- Construction of two sets of production ponds as cut to fill embankment ponds, lined with HDPE, operating volume at depth of 1.3 m is 9.1 ML/ha, total storage volume at 2.0 m depth is 15.4 ML with 200 mm freeboard;
- Construction of two seawater reservoirs (option) in the same manner as the production ponds, at the breeding facility compound, volume of each 200 kilolitres;
- Construction of seawater intake well on rocky foreshore at Point Ceylon;
- Construction of sea-water intake at Wheatley Creek for production ponds – simple anchored floating pontoon to hold intake pipe and pump in deeper water, flexible pressure pipe to ponds across mangroves;
- Construction of unlined sludge waste drying bed;
- Construction of all weather gravel access road within existing gazetted corridor, servicing production compound and breeding facility compound;
- Construction of all weather gravel service road along pipeline routes from weir and seawater intake;
- Site grading for production and breeding facility compounds.

No additional extraction is required on the site except in areas immediately associated with the works. The ponds are to be constructed as cut-to-fill embankments, with excess cut material used in the construction of the weir and access road.

Excavation & construction of the bunds will be by elevating scraper, excavator and roller. All heavy construction vehicles will be confined to site for the duration of works, hence there will be no increase in traffic along surrounding roads, nor any increase in the risk of transporting seeds and weeds from outside the lease area. At commencement and completion of construction there will be a small increase in traffic due to the transport of the equipment.

A concrete splash pad with grated floor will be constructed to allow wash-down of any equipment leaving the site. Earthmoving plant and equipment will be required to be clean and weed free before entering the site. Transport vehicles will also be expected to be clean before entering the site and leaving access roads.

Road access requirements are serviced by the existing informal access to the site. As vehicle movements along this road are limited to start up, and are thereafter very low movements, a maintenance program will be undertaken as required. Construction of the permanent access within the gazetted corridor will be to a standard appropriate to the expected vehicle movements.

Work areas will be delineated by construction flagging tape, so that construction machinery do not enter or damage any areas not identified for the required construction works. The flagging tape will be monitored and maintained by the works superintendent. Cleared vegetation from the development area will be shredded or chipped and stockpiled for use as mulch for revegetation and landscaping.

4.5.4.2 Erosion and sediment control

Erosion and sediment control will be an integral part of the construction process. Natural drainage lines occur on the site. During construction there is an increased likelihood of sediment transport along these lines, hence a series of hay bales wrapped in Bidim geotextile fabric, or sediment fences, will be staked across the drainage lines at regular intervals to trap any sediment. Excavation of the ponds and weir will be separated from the surrounding areas downstream by installation of a silt fence at the limits of excavation. Sediment control devices will be installed prior to construction, in accordance with NT guidelines for erosion and sediment control (Sedman 2000). An erosion and sediment control plan is identified in the Environmental Management Plan, section 7.3.

4.5.4.3 Headworks to be built by NT Govt

No headworks are required. The intersection of the new access road with Fog Bay Road will be to NT DIPE standards.

4.5.5 Waste generation and management

Waste generated during the construction phase is from two sources: human and machinery.

- Ablutions for the construction camp will be a permanent construction for later use during production. Human waste collected from ablutions blocks, sinks and showers (grey and black water) will be collected and treated in an extended aeration package treatment plant complying with the Territory Health Service requirements for on site sewerage treatment guidelines. The treated effluent will comply with government and national guidelines covering the quality and release requirements to the environment. These treatment plants are in use throughout the Northern Territory, and have "type approval".
- Human generated rubbish – food stuffs, wrappers etc. Collection in bins, with transport to a landfill tip via third party commercial operator, in accordance with DIPE and/or Shire requirements.
- Diesel/oil leaks and spills from generators, earthmoving equipment and tanker trucks. A dedicated hardstand area for vehicle servicing with interceptor trap and sump will be provided. Pumphouse and generator buildings will be constructed with floor sumps to collect leaks. Fuel storage will be within lined bunds in accordance with legislative requirements. Transfer of waste oil/fuel offsite will be via licensed commercial third party.
- CO & CO_2 discharge from on site generators and vehicles can be reduced by maintaining service levels to the plant.

4.5.6 Other Construction Details

4.5.6.1 Construction workforce

Construction requirements can be met from the Territory workforce, including all plant. The project will involve a typical medium scale earthmoving and placement operation requiring elevating scrapers, excavator/loader, side tipper trucks, grader, roller, water cart. Estimated construction workforce of 10 – 15 plant operators, 10 general labourers and 3 – 4 specialist plastic welders will be contracted. Service installation will require licensed plumbers and electricians.

Proximity to rural and urban residential areas makes commuting for staff possible, and accommodation will be provided on site. Heavy vehicle movement will be limited to initial delivery and demobilisation of plant, and a limited on going delivery of fuel and water, and removal of trade wastes and rubbish.

It is expected that there will be one movement per week for each of the above.

4.5.6.2 Occupational health and safety, and emergency response details

Induction of all staff will be conducted prior to their commencing work on site. Induction will include environmental management responsibilities, work safety, avoidance of and protection against mosquitoes and biting midges, and their related problems, fire prevention and response and first aid response.

Contamination of the site and of workers is limited to contaminants normally expected on a construction site. Operating procedures will be specified, and clean up and personal protection and handling procedures will be specified in standard operating procedures. Contamination response plans will be developed to provide details of how to respond to spills and leaks of contaminants, confined mostly to hydrocarbons (diesel, oil, lubricants).

Human disease introduction is possible should overseas workers be brought onto site for the project. In instances where this occurs, a medical examination and clearance of the workers will be required before they are introduced to the site. This will prevent the introduction of diseases such as malaria.

It is expected that the earthworks contractor will have in place operating procedures for safe work practice, including relevant training for plant operators, safety inductions, and a first aid officer.

Communications is possible from the site via mobile phone, and on site communications will be via 2-way handsets.

Fire breaks will be maintained around the lease in accordance with Bushfires Council requirements. The water cart for dust suppression will also double as initial response in the event of any fire outbreak, primarily to ensure worker safety until the Bushfire Council crews can attend.

On-site first aid is the first response for all incidents, with transfer to the nearest medical facility by site vehicle in the case of minor injury, or stabilisation on site before transfer via ambulance.

Standard worker safety practice extends to sun awareness, use of sunscreen and mosquito repellent, re-hydration and appropriate safety equipment.

The management structure will be simple, with a works supervisor and superintendent responsible for all works, construction, occupational health and safety issues, including training and inductions of new staff. Communication will be through the works supervisor or superintendent.

4.5.6.3 Construction fleet and traffic/freight requirements

The number and types of plant will be dependant upon the particular contractor, but it is expected that the following will be required:

Elevating scraper: 2
Excavator: 2
Front end loader: 2
Side tipper trucks: 4
Grader: 2
Roller: 3
Water cart: 2

Light vehicles for on site will likely include foreman's vehicle and site manager's vehicle.

Transport on site for fuel and water will be via tanker truck, and transport offsite for waste will be via tanker and garbage trucks.

All fuel will be stored on site in lined bunded areas. All used tyres will be transported off site as trade waste and disposed to licensed landfills. No burning of rubbish on site will occur.

4.6 OPERATIONAL PHASE

4.6.1 Water management

Water requirements for the production ponds are detailed in section 4.1.1. The processes of transfer and management of operational waters are also described in sections 4.1.1 to 4.1.7. Details of water quality parameters for operating conditions are provided in section 4.6.4.8 and 4.6.4.9 below. Monitoring of water quality will be conducted on a daily basis as described in section 4.6.4.12 below.

The project is designed as a zero discharge system for the production ponds. This means that after the ponds are filled from seawater the first time, no further intentional exchange nor discharge takes place. During extreme rainfall events, the production ponds may overflow into the harvest basins and pumped to the recirculation ponds and then could overflow across open forested ground to the creeks east and west of the development. This has been modelled in section 6.4.1.4 under hydrology. It is unlikely to occur more than one day in ten years or so, according to historical records and will result in a highly diluted outflow.

The project will develop detailed operating procedures and contingency plans for lock down and management during extreme rainfall events. This will include the stoppage of water aeration, lock-down of buildings, ensuring that recirculation and harvesting ponds are held empty as overflow reservoirs, and other procedures to minimise the chance, volumes and impacts from overflow. This is addressed in more detail in Chapter 7, on impacts and mitigation.

Surface waters will be retained behind the weir on Wheatley Creek for a limited time. Calculations from the hydrological modelling (Sect.6.4.1.4 and Appendix 9) suggest that the harvest rate from the natural flows will be less than 10% during the wet season, and will occur only once in normal conditions for each phase, that is to fill the ponds one initial time.

4.6.2 Erosion and sediment control

The risk of erosion could be significant should concentrated discharge occur. However, the design of the harvest basin and off-stream storage ponds, which provide the only points for discharge, is such that any overflow is in the form of low velocity sheet flow. As the vegetated buffer is an important part of the overall discharge treatment, it is vital that any erosion in the channels be monitored and controlled in order to maintain the integrity of the vegetation. This forms an important part of the operational environment management plan.

The batter slopes of the ponds will be constructed at a slope of 1:3 to reduce scour velocities. No overflow from the ponds occurs on these faces. The weir portions will be protected with Ecocell soil confinement panels and vegetated. The upstream and downstream faces of the weir will be protected in the same manner. Additionally, the low flow drainage pipe for the weir will outlet to a rip rap protected channel to ensure no erosion occurs.

Relief drainage along the access road will be designed to keep velocity low, and will not interfere with natural drainage lines across the site. The road follows high ground for the whole distance. The volumes are anticipated to be low as the location of the road has little catchment upstream.

The philosophy of the layout is not to change the status with regard to discharge points across the site. The water requirements of the production ponds due to a net evaporative loss each year will result in no concentrated release of water at any location, and infrequent (less than 1 in 10 yearly) low velocity sheet flow from the ponds during unusually heavy wet seasons.

An erosion and sediment control plan is provided in the Environmental Management Plan, section 7.3.

4.6.3 Waste management

Waste types which will be generated during the operational phase will include
- Sewage and domestic effluent
- Sludge and biosolids
- Washdown water from vehicles
- Washdown water from processing plant
- Used cooking brine
- Diseased prawns or other product
- Used parts, sump oil, etc
- Miscellaneous items such as feed bags
- Domestic garbage

Each of these wastes will be treated in appropriate ways, as follows.

Sewage will be treated in a treatment plant as described in section 4.1.14. Treated liquor will be irrigated to land in accordance with Department of Health Guidelines. The irrigated area will be fenced off from open access. Other domestic effluent ('grey water') will be treated in the same plant.

Sludge and biosolids will be treated and disposed of generally in accordance with the standards for biosolids disposal, including the National Water Quality Management Strategy on Biosolids Management (NRMMC 2002), in sludge drying beds located north of the ponds area as shown on **figure 4.2**. The dried sludge from the ponds and sewage sludge (biosolids) will be dried in these drying beds. Details of the drying beds are provided in section 4.1.2.

Vehicle and plant wash-down will be conducted on a vehicle hardstand which has a sump for catchment of oils, fuels, grease, sediment and weed propagules. The sump will be directed to an interceptor which will be routinely pumped out by a commercial contractor.

Washdown water from the processing plant will be routed through a sump which will be directed to a separate extended aeration package treatment plant. Disposal of the treated effluent is as per domestic effluent on site in Section 4.5.4.

Used cooking brine will also be treated in this manner. All water generated during wash down and cooking operations will be collected and directed under gravity or rising main (location dependant) to the treatment plant.

Diseased prawns or finfish will be incinerated on site, not burnt freely. None will be removed off site nor disposed to marine environments.

No waste dumps from previous land use have been identified to date, although some waste materials, mostly iron metals and building materials, have been identified. These will be collected and removed to a suitable landfill. Should a waste dump be uncovered, a risk assessment for contamination potential will be carried out by an environmental consultant, and remedial actions determined.

Air emissions from the power house will be minimised by using appropriate exhaust scrubbers and maintaining the equipment in good operational condition. Estimates of the contribution of the power plant to greenhouse gas emissions will be made using the National Greenhouse Gas Emissions (NGGI) methodology.

Other waste, including used parts, sump oil, filters, cleaning rags, feed bags, domestic garbage and others will be segregated into labelled collection bins and disposed routinely by a commercial contractor to licensed landfills and other licensed disposal points (such as used oil collection facilities).

4.6.3.1 Collection, storage, treatment, analysis and disposal of wastewater

Three types of wastewaters are potentially associated with intensive shrimp ponds. For the Point Ceylon Aquaculture Estates, the following measures apply:

1. Effluent from pond overflow

No water is exchanged during the course of a production cycle. The only situations where overflow are possible are due to perhaps 1:100 year extreme rainfall events, and abnormally heavy and persistent rains, which may result in water levels in the ponds exceeding the overflow level. In order to minimise these overflows, the ponds will be retained with significant freeboard of 0.7 m during normal operating cycles. From the production ponds, overflow, should it occur, will be directed towards the harvest basins which can hold 16.7 ML. The harvest basins are normally kept dry between harvest cycles. From the harvest basin, the waters are pumped to the two recirculation ponds which can hold 7.9 ML each. Overflow after this will be by overtopping the harvest basin bund walls and laminar or overland flow to natural ground, and water will be allowed to overflow across land and through natural vegetation by which means it will be diluted significantly by direct rainfall and natural overland flow.

Since overflow water is drawn from the very surface of ponds, it is naturally lower in suspended solids and other nutrients. During a heavy rainfall event, the aeration system will be stopped, both to maintain correct operating levels for the production ponds, and to limit mixing of the fresh water from the rain and the saltwater from the ponds. Models of the volumes of discharge and dilution ratios are provided in section 6.3.2.3 Hydrology.

2. Effluent from drainage at pond harvest

All water from the harvest ponds will be pumped to the recirculation ponds and retained for continuous use in the ponds. It is not pumped out.

3. Organic sediment from pond bottom

Most of the organic sediment can be re-used in the production ponds. Disposal of some organic sediment will be required from time to time (de-sludging) and this material will be carted to the sludge drying beds for use as fertiliser on site.

4.6.3.2 Hazardous wastes

The only hazardous wastes held on site will be chlorine and chlorine containers. These will be retained in a storage area for periodic removal by a commercial contractor.

4.6.3.3 Sludge treatment practices

Any organic sediment from the pond bottom at harvest will be drained to the recirculation basin, while any sludge will be treated at the sludge drying beds. Research has shown that most of this material is actually inorganic particles eroded by water currents created by aerators. It is not necessary to remove it. In the case of Suntay Aquaculture, the procedures involve ample aeration for digestion of much of the organic load within the pond. The small amount of organic material remaining on the bottom at harvest is simply flushed or drained to the recirculation basin. Sludge drained from the ponds will be treated, dried, composted and oxidized in the drying beds and applied as agricultural complement either on the property or sold.

4.6.4 Key Processes involved in Production - Product stock and harvest

Flow diagrams providing a simplified outline of the full production process are provided in **Figure 4.6**.

4.6.4.1 Hygiene and Quarantine

Diseases do not originate from the aquaculture facility unless introduced from the outside environment, either from the wild stock or from stock supplied from other aquaculture facilities. The Point Ceylon Aquaculture Estates will not source any stock from other aquaculture facilities, and will source only local endemic stock from the wild. A quarantine facility has been set-up in coordination with the Charles Darwin University to screen wild brood-stocks from all known viruses. This will ensure that stocks are free from any known viruses found in the wild or even the adjacent waters of Bynoe Harbour.

The quarantine section of the Breeding Facility will consist of small holding tanks to hold the animals during the 60-day period they are being tested. This facility will only be utilized for about two years until such time as the farm is not dependent on wild stocks from the Northern Territory waters anymore. This degree of quarantine ensures that the project is 'cleaner' and relatively more 'virus-free' than Bynoe Harbour itself.

The project will not contaminate the surrounding marine areas because the farm will screen diseases from the wild before introducing prawns to the ponds. All wastes from dead and diseased prawns will be destroyed on site by incineration, and none will be transported off site. There are no discharge outlets from the facility to the external environment, unlike most other prawn farms, as it is designed as a closed operating system. The only possible discharges are likely to be during extreme rainfall events, which are discussed in other sections of this EIS, particularly sections 6.4 and subsections. The Environmental Risk Assessment evaluated the risks related to the project. The results of this risk assessment are summarised in section 6.2 and Appendix 7.

Hygiene is addressed in the packaging and processing section below, section 4.6.4.15.

4.6.4.2 Infectious diseases and parasites

Viral diseases have been recognised as the most detrimental to prawn or shrimp aquaculture as no vaccines nor treatments are currently available (OIE Fish Diseases Commission 2000). Bacterial and other parasitic infections, and predators can be treated by various means including chemicals and drugs. Diseases of prawns can be introduced by several means, including infected culture prawns, contaminated feed, vectors such as birds, and through the water supplies.

There are two directional pathways of concern, the infection of wild stock from cultured prawns, and the infection of cultured prawns from wild stock. The Joint Subcommittee on Aquaculture (JSA) of the United States National Science and Technology Council has modelled pathways for shrimp virus sources (USEPA 1999). **Figure 4.12** shows these pathways. Native wild stock can be exposed to viruses through a number of pathways, including overflow and discharges of contaminated pond effluents, escape of infected species, spills or losses through transport to and from the site, disposal of pond sediment and through other means such as through contaminated waste.

A conceptual model was developed by the JSA showing the potential virus sources and pathways for shrimp processing, and the pathways by which wild shrimp can be infected, and is reproduced in **Figure 4.13**. Infected processed shrimp may infect wild shrimp via infected material from the processing used in shrimp feed, from effluents, bait shrimp, and solid wastes. Contaminated feed, for instance, which has not been adequately heat treated and which is subsequently used for shrimp feeding can, through discharge of pond waters, infect wild stocks.

In the assessment of these risks, mitigation planning should consider potential exposure pathways including project siting, discharges factors, seasonal factors, sources of potentially contaminated prawns for processing, and the treatment of wastes.

A number of diseases have been recognised as important in prawn aquaculture. Some of these diseases have not yet reached Australia, and some are absent from the Northern Territory. Known diseases of prawns are shown in **Table 4.1**.

Table 4.1 Infectious Diseases and Parasites

SHRIMP & PRAWNS (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans *Notifiable**** & Significant Diseases - (OIE 2003)
Baculoviral Midgut-gland Necrosis (BMN) of Penaeid Shrimp		Baculoviral midgut gland necrosis (viral/penaeid shrimp)
Baculovirus penaei (BP Virus Disease) of Penaeid Shrimp		Nuclear polyhedrosis baculoviruses (*Baculovirus penaei* and *Penaeus monodon-type* virus) viral/penaeid shrimp)
Black Gill Syndrome of Shrimp and Prawns		
Black Spermatophore Disease of Penaeid Shrimp		
Chitinolytic Bacterial Shell Disease of Shrimp and Prawns		
Ciliate Disease of Penaeid Shrimp		
Filamentous Bacterial Disease of Shrimp and Prawns		
Fusarium sp. (Fungus Disease) of Shrimp and Prawns		
Gregarine Disease of Penaeid Shrimp		
Gut and Nerve Syndrome (GNS) of Penaeid Shrimp		
Haplosporidian Infections of Penaeid Shrimp		
Hematodinium-like Organism of Pandalid Shrimp		
Hepatopancreatic Parvovirus (HPV) Disease of Shrimp and Prawns	Hepatopancreatic Parvovirus (HPV) Disease of Shrimp and Prawns	
Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) of Penaeid Shrimp**		Infectious Hypodermal and Haematopoietic Necrosis (viral/penaeid shrimp) **
Larval Bacterial Necrosis of Freshwater Shrimp		
Larval Mid-cycle Disease (MCD) of Freshwater Shrimp		
Larval Mycosis of Shrimp and Prawns		
Lymphoid Organ Vacuolization Virus (LOVV) of Penaeid Shrimp		
Lymphoidal Parvo-like Virus Disease of Penaeid Shrimp		
Microsporidiosis (Cotton Shrimp Disease) of Shrimp and Prawns		
Mid Crop Mortality Syndrome MCMS		Spawner-isolated mortality virus disease (SMV) (viral/penaeid shrimp) (MCMS-related)
Monodon Baculovirus (MBV) Disease of Penaeid Shrimp	Monodon Baculovirus (MBV) Disease of Penaeid Shrimp	
Mycobacteriosis of Penaeid Shrimp		
Necrotizing Hepatopancreatitis of Penaeid Shrimp		
Nematomorph Parasitism of Pandalid Shrimp		
Red Disease of Penaeid Shrimp		
Reo-like Virus (REO) Disease of Penaeid Shrimp		
Rhabdovirus Disease of American Penaeid Shrimp		
Rickettsial Infection of Penaeid Shrimp		
Rickettsia-like Infection of Pandalid Shrimp		
Sylon (Rhizocephalan Disease) of Shrimp and Prawns		
Taura Syndrome Virus of Penaeid Shrimp	Taura Syndrome Virus of Penaeid Shrimp*	***Taura syndrome (viral/penaied shrimp)****
Vibrio penaeicida of Cultured Kuruma Prawns		
Vibrio spp. (Vibrio Disease) of Cultured Shrimp		
White Spot Syndrome Baculovirus Complex of Penaeid Shrimp	White Spot Syndrome Baculovirus Complex of Penaeid Shrimp*	***White spot disease (viral/penaied shrimp)****

SHRIMP & PRAWNS (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans** ***Notifiable**** & Significant Diseases - (OIE 2003)
Yellow-head Virus Disease (YHD) of Penaeid Shrimp	Yellow-head Virus Disease (YHD) of Penaeid Shrimp*	***Yellowhead disease (viral/penaeid shrimp)****
	Yellowhead-like Virus	

* Aust prawn farmers have not suffered from these diseases (CAFNEC 1999)
** (not in Australia) (CAFNEC 1999)
***** Notifiable diseases on the OIE register of notifiable diseases

4.6.4.3 Disease control procedures

Section 4.6.4.8 describes how ponds are prepared to control predators, using tea-seed cake and alkalinity.

The most significant disease control strategy is to eliminate the need for water-exchange throughout the production cycle preventing diseases from the wild from entering the farm. Strategies to control diseases are as follows:

1. Fill the reservoirs with water from intake pipe and filter using 100-150 micron screens
2. Disinfect the water in the reservoirs from any predator using tea-seed and hold water for about 14 days before transferring to the ponds.
3. In the extreme rare event of viral outbreak in one or a number of ponds, the ponds will be disinfected with organic pesticides such as tea seed and chlorine and kept for a number of days. Subsequently, water will be transferred to the reservoirs through UV filters. Any leftover (most minimal by experience) animal carcass is collected and burned.
4. Solid and liquid wastes generated from the processing of harvest will be stored and dried properly before being used as agricultural complements.

Instances of disease which may occur at the facility will be reported to the NT Fisheries Division.

4.6.4.4 Target species

Initially for the first few years the company will undertake the culture of Black Tiger or Leader Prawns (*Penaeus monodon*) before we embark on the culture of other crustaceans and finfish.

4.6.4.5 Breeding

Post-larvae (PL) will be sourced from the company's own breeding facility.

The project proponent will be producing brood stock on site, rather than relying on captured wild stocks, which is the common practice throughout Australia and the Pacific Region. Breeding in captivity offers the opportunity to maintain clean stocks, which are continually improved through genetic selection. Selection goals include disease resistance and growth rate. The heritability for disease resistance is low (0.1) as compared to that of growth rate (0.4). In addition, disease priorities continually change, which creates a moving target for a breeding program. Consequently, the primary breeding objective for Suntay Aquaculture is increased growth rate, which equates to larger shrimp or more production cycles per year.

The selection program will be based on mass selection of the largest animals from each pond for further grow-out in dedicated brood stock ponds. This protocol obviates the need for family-based selection, which requires individual tagging. A growth improvement of 5% per year is expected.

4.6.4.6 Breeding Facility

The breeding facility will include two buildings for larvae & algae rearing, spawning and maturation, each with the means to collect spills and wash-down water via sumps and pipes. Included within one

building will be ablutions facilities. A steel framed shade cloth covered area over slab on ground housing the brood-stock tanks will be attached as an annex to the maturation building. The shade cloth is removable in the event of cyclone. Two small buildings will house the blowers, filtration & UV filters, and the generator and fuel storage respectively.

Water is proposed to be pumped from Bynoe Harbour to fill holding ponds before being pumped into the hatching and maturation tanks. An alternative is being considered to utilise a saltwater bore at the site. The water will be filtered, analysed and treated to ensure that living animals and propagules, and other biological matter and toxicants do not enter the system. All water after being used will be pumped through a 1 micron cartridge filter (to remove solids) to a holding tank where it will then be chlorinated at 2 ppm. After 24 hours of aeration to remove chlorine this water will be pumped to a second tank containing bio-filters and nitrogen strippers which will lower ammonia and nitrates to acceptable levels. At this time the water is pumped back to the breeding facility through a UV filter and reused again.

Larvae will be produced and grown in the breeding facility and transferred to the farm in about 30 days. Production will be done in tanks inside the covered facility. The breeding facility is planned to be used at full capacity for about nine out of twelve months.

4.6.4.7 Growing

Prawns and finfish will be grown in rectangular lined ponds described in detail in section 4.1.1.

4.6.4.8 Pond Preparation

It is important to stress that the process of pond preparation described below will be undertaken only once for all the cycles to come because of the closed nature system of the project.

Once the pond environment has been stabilized there is no further need to repeat the same process. After every cycle, chemical composition of pond water is measured to determine any deficiencies or discrepancies with ideal standard and appropriate adjustments or additions are made.

Pond preparation is important to provide a proper environment for prawn culture prior to stocking. After filling with recycled water, the pond is fertilized with urea, triple super phosphate and rice bran at dosages 40 kg/ha, 3.9 kg/ha and 500 kg/ha, respectively. If the secchi transparency does not decrease to less than 45 cm, urea and triple super phosphate are applied at 3.3 and 0.3 kg/ha/day, respectively. After initial fertilization, rice bran application continues at 25 kg/ha/day until day 60 to help sustain a strong plankton bloom.

Tea-seed cake is applied one week before stocking at a rate of 250 kg/ha for the purpose of controlling predators. The tea-seed cake is soaked for one day, and only the liquid is poured into the pond. Alkalinity is important to improve plankton blooms, reduce stress, and increase resistance to viruses. As a standard procedure, alkalinity is adjusted to 100 mg/I before stocking. Lime is typically used to minimize cost. However, if alkalinity is not increasing fast enough, 200 kg/ha/day of sodium carbonate is added.

Typical resultant water characteristics for the production ponds are shown in **Table 4.2** below.

Table 4.2 Recommended Range of Water Quality Parameters for Shrimp Culture

Water Quality Parameter	Recommended Range	Belize mg/l	SAA Growout Only	SAA Breeding facility
Temperature	28 - 32 C	23 - 32.5 C	22 - 32 C	26 - 32 C
Dissolved Oxygen	5.0 - 9.0 ppm	4	3.5-9.0 ppm	5.0 - 7.0 ppm
Carbon Dioxide	= 20 ppm		= 20 ppm	= 20 ppm
pH	7.0 - 8.3	7.4	7.5	7.8 - 8.0
Salinity	0.5 - 35 ppt	16 - 39 ppt	15-30ppt	30 - 35 ppt
Chloride	= 300 ppm		= 300 ppm	= 300 ppm
Sodium	= 200 ppm		= 200 ppm	= 200 ppm
Total Hardness (as CaCO3)	= 150 ppm		= 150 ppm	= 150 ppm
Calcium Hardness (as CaCO3)	= 100 ppm		= 100 ppm	= 100 ppm
Magnesium Hardness (as CaCO3)	= 50 ppm		= 50 ppm	= 50 ppm
Total Alkalinity (as CaCO3)	= 100 ppm	35	= 100 ppm	= 100 ppm
Unionized Ammonia (NH3)	= 0.03 ppm	1.6	0.9 ppm	= 0.03 ppm
Nitrite (NO2)	= 1 ppm	9.5	0.3 ppm	= 1 ppm
Nitrate (NO3)	= 60 ppm	4.5	= 60 ppm	= 60 ppm
Hydrogen Sulfide (H2S)	= 0.002 ppm		= 0.002 ppm	= 0.002 ppm
Chlorine	= 0.01 ppm		= 0.01 ppm	= 0.01 ppm
Cadmium	< 10 ppb		< 10 ppb	< 10 ppb
Chromium	< 100 ppb		< 100 ppb	< 100 ppb
Copper	< 25 ppb		< 25 ppb	< 25 ppb
Total Iron	= 1.0 ppm		= 1.0 ppm	= 1.0 ppm
Lead	< 100 ppb		< 100 ppb	< 100 ppb
Mercury	< 0.1 ppb		< 0.1 ppb	< 0.1 ppb
Zinc	< 100 ppb		< 100 ppb	< 100 ppb
Total Phosphorus		7	5 ppm	0.02 - 0.05 ppm

4.6.4.9 Stocking process and rates

To minimize stress during stocking, salinity acclimation is begun in the breeding facility at PL3 by reducing salinity by 1-2 ppt/day. Alkalinity of breeding facility water is adjusted to approximately 100 ppt before transport. In addition, post-larvae are acclimated for 23 hours at pond bank before stocking. To determine if the acclimation procedure is adequate and that post-larvae are healthy, a sub-sample of 500 PL's is held for 48 hours after stocking in a 'happa' net suspended in the pond. Survival of those animals should be greater than 80%. The stocking density is between 50 to 100 PLs per square metre or 500,000 pieces to 1,000,000 PLs per hectare.

4.6.4.10 Aeration

Aeration is employed to prevent low dissolved oxygen. Long-arm paddlewheels are used to provide aeration in the most efficient manner possible. These aerators are constructed on site using 3 hp motors with 95-rpm gear reducers. The axle consists of two 20-foot galvanized pipes with 16 impellers. Two paddlewheels are installed in each pond during preparation, four paddlewheels (12 hp/ha) are installed at stocking, and six paddlewheels (18 hp/ha) are used beginning around day 60-90.

4.6.4.11 Feeding

Feed represents the single greatest operating cost. It is important to reduce feed waste to save money and also to reduce the organic load on the pond. Little feed is offered to the ponds for the first few days, because the plankton bloom is thought to be sufficient. Then, a series of crumbled feeds in progressively increasing sizes is distributed two times per day. After the first month, feed is offered four times per day - 8am, 11:30am, 4pm and 10pm, and feed consumption is carefully monitored through use of 4 feeding trays per pond. Feeding trays are used to carefully monitor consumption of feed and adjust feeding rates accordingly.

At present, a variety of commercially available pelleted feeds are used. In the future, however, feed formulations will be customized to take advantage of the lower carbon to nitrogen ratio (C:N) required in a zero water exchange system.

Several research groups have demonstrated recently that recycling of feed waste by aerobic bacteria can increase protein efficiency by a factor of two to three. In the case of *Litopenaeus vannamei,* feed protein levels have been reduced from 35% to 22% with no decrease in performance at production levels as high as 15 MT/ha/cycle. It remains to be seen if *Penaeus monodon* can adapt as well to low protein feeds. If so, this will offer a significant reduction in feed cost, because protein is the most expensive component of shrimp feeds.

4.6.4.12 Water Quality Monitoring

Water quality parameters are monitored on a regular basis. The frequency of measurements varies with the parameter and the stage of production as follows:

Before Stocking:
- Reactive Phosphorus.
- Total Nitrogen

Daily:
- Temperature
- Salinity
- Dissolved Oxygen
- pH

4.6.4.13 Shrimp health monitoring

To monitor shrimp health and performance, technicians will walk around every pond every morning looking for problems. Shrimp body weight is measured weekly in every pond. Weight measurements are plotted over time against a standard curve. Survival rates are estimated based on feed consumption. All data are stored in easily accessible form in a custom-designed database system.

4.6.4.14 Harvesting

Mature prawns are taken from the production pond under gravity through a pipe after the water level has been drawn down sufficiently such that pressure head does not force the animal through at speed. The denser prawn/water remaining is pumped through a special dewatering tower, separating the animal from the water. The prawns are transferred to hoppers for unloading at the packing shed. All water separated during the harvest operations is directed to the harvest basin, where it is transferred to the recirculation ponds or off-stream storage reservoirs as necessary.

4.6.4.15 Processing and packaging

Packaging and processing will be done in a room in the facility, and will be designed and built according to NT Health standards for food processing and handling. The facility will be air-conditioned and equipment will be stainless steel and similar materials utilised in food handling areas. Staff are all required to meet food handling standards and clothing and cleanliness standards are required to be met. Grading and handling equipment will also be according to Health standards. Water for washing and rinsing of prawns will be treated to Health standards for human consumption.

The entire farm will be designed for certification under Aquaculture Certification Council (ACC), which requires certification of the whole process from production (breeding to harvest) through handling to transport and delivery. Each step requires product traceability through records, quality

standards, and monitoring to be in place. Monitoring includes water quality parameters, animal health and history, pond parameters, and other aspects to ensure quality for the seafood buyers. Certification is reviewed annually by auditors.

Upon development of the Phase 1 and Phase 2 (60 hectares at 4 cycles per year), Point Ceylon Aquaculture Estates will generate around 500 pond harvests per year or approximately 9 harvests per week. Assuming an average yield of 40 t/ha (metric tonnes per hectare), the processing shed must be capable of handling 2400 t/year or an average of 7.5 t/day.

It is expected that shrimp will be processed primarily as frozen heads-on shell-on and the same equipment and labour can be used to package head-on shrimp. If IQF (individually quick frozen) peeled and de-veined shrimp are needed, additional equipment will be installed. Some cooked shrimp will be processed initially during early stages for specific markets.

Head-on whole shrimp is sold primarily in Japan and southern Europe. These shrimp are graded and packed in 2 kg cartons and frozen. It is important that the shrimp be adequately packaged in order to prevent breakage of appendages. The most common method employed is referred to as Semi-IQF (individually quick frozen). The shrimp are finger packed (laid side by side) in the carton, and then frozen with only the naturally adhering water giving them a light glaze.

Except for cooking, no other processing will be done on the farm considering the labour scarcity and limitations. Product will simply be graded by a grading machine and packed for transport to the markets.

The packaging and processing facility and related facilities will be certified by HACCP to ensure they meet or exceed international best practice.

4.6.4.16 Grading

Prawns will be machine graded to ensure uniformity of size and a resulting "good pack". The grading machine is based on actual weight of each conveyed prawn as they pass over a scale. The prawn is then pushed off the conveyor by piston-activated levers at the appropriate point according to the weight of the prawn. This type of grading system is rather slow in throughput, but accurate in size separation.

4.6.4.17 Frozen Storage

After individual cartons are master packed, the containers are palletised and moved with a forklift to the cold storage room. Temperatures will be maintained at -30°C or colder to retain maximum quality. Doors to the storage room are draped with plastic barriers to reduce heat transfer when opened. The capacity of the two cold storage rooms will accommodate more than 30 production days or 90 MT of prawn. This will cater for any contingencies such as access being cut by road for a few days due to extreme events. The rooms will hold the cold for sufficient time to keep the stock frozen for power outages should these occur, although the power system is designed for 100% failsafe.

4.6.4.18 Transport and Marketing

Products from the farm will be transported by land or air depending on market requirements.

4.6.5 Other operational phase information

4.6.5.1 Utilities and related infrastructure

Many of the utilities, including hardstand, water and sewerage treatment, access roads, and accommodation will be designed and built during the construction phase, and retained in the operational phase. The exception is the power generation required for the production stage of the project. The power required for the aerators is much greater than the general lighting and power required during construction, and hence the generator during the construction phase will be a temporary one. The housing, fuel storage and bunding will, however, will be utilised in later developments.

4.6.5.2 Operational workforce

The project will employ initially from 10 to a maximum of 80 people, of whom at least 80% will be local Territorians.

4.6.5.3 Occupational health and safety, and emergency response details

Occupational health practices during construction will be continued during the operational phase. Site inductions and continuous on-site training will be provided to staff in occupational health, safety and emergency procedures.

4.6.5.4 Operational fleet and traffic/freight requirements

Service and farm vehicles will be used on the farm. About six vehicles are anticipated. Staff will normally provide their own transport to and from the site, and will live in for periods of about 10 days. A tractor-trailer will be used to transport refrigerated containers to the port or airport, initially once a week, and to bring feed to the farm.

4.7 DECOMMISSIONING AND REHABILITATION DETAILS

4.7.1 Decommissioning objectives

The Point Ceylon Aquaculture Estates is considered to be a permanent facility which, from our experience, will have a life of at least 80 years. If there are requirements at some stage in the future to decommission all or some of the facility, decommissioning will be in accordance with the requirements of the NT authorities at the time. It is difficult to predict rehabilitation techniques or potential use of infrastructure so far in advance, but general practices similar or better to those detailed below will be followed.

4.7.2 Decommissioning and removal of aquaculture infrastructure

Should abandonment of the Point Ceylon Aquaculture Estates be required then the intake well at Point Ceylon, sea-water intake and pontoon at Wheatley Creek and all flexible pipe will be decommissioned and removed. The production and treatment ponds will be levelled with a D8 dozer or similar. Concrete and piping will be removed. Miscellaneous materials such as power lines, pumps, above ground storage tanks and small concrete structures will be removed from the lease area. All buildings and equipment will be removed.

If required, the wall of the freshwater weir, which is about 2 m in height above the valley floor, will be levelled by dozer back to the surrounding ground level.

4.7.3 Rehabilitation and monitoring

Rehabilitation will be carried out during the dry season when little or no rain is expected. The ground surface will be restored to its original profile in most cases including the service road, bunds and contour which will be ripped and keyed into the surrounding surface to enable reinstatement to prevent water from accumulating.

On sloping terrain, small diversion banks will be constructed across the disturbed area. These will have a minimum height of 20 cm and extend far enough for discharge water well clear of the disturbed area. This will help reduce runoff velocity and avoid rill and tunnel erosion. The ground will be further compacted and stabilised using a sheeps-foot roller or a grooved roller to stabilise the surface and increase water penetration, reducing overland flow, and providing a good base for germination and regrowth.

To avoid the transfer of weeds during rehabilitation all vehicles will be thoroughly cleaned and sterilised before entry to the site. A weed management plan will be developed and monitoring will occur by visual inspection initially each 3 months in the first year, and then once yearly.

Photo monitoring points can be established to monitor the rehabilitation process and any erosion. Once yearly field inspection of the regeneration will occur until the site is vegetated to a state similar to when the project was established.

Replanting and re-seeding will be planned in conjunction with experts in natural revegetation techniques such as Greening Australia, DIPE, and DPIF.

4.7.4 Past experiences (personal or otherwise) relating to decommissioning of similar ventures

The proponent has not decommissioned any farms to date, despite having owned and operated aquaculture facilities for 80 years in the Philippines.

5 ALTERNATIVE PROPOSALS

The project was intended for an overseas country some seven years ago but has been postponed because of the political and economic situation in that country. The company has spent about six years trying to establish the project in Northern Australia having been invited by DPIF of North Queensland but finally settling for the Northern Territory because of the more favourable climate regimes. This site was offered by the Northern Territory Government, and various layouts and designs have been considered for the site.

5.1 ALTERNATIVE LOCATIONS FOR INTAKE AND DISCHARGE STRUCTURES

No discharge structures are proposed for the project. Alternative intake structures considered have included sumps, fixed pipes and floating pontoons, anchored by stay lines. The floating pontoon structure is currently considered the best option because it provides access to clean water at all tides. The supply pipes will be laid across the surface soils which will result in minimal disturbance to the soils, and eliminate any issues with acid sulfate soils. Currently, the company is investigating the feasibility of using bores instead of pipes to supply its intake water requirements for the breeding facility at Point Ceylon. The project will continually evolve to take advantage of latest developments in the area of environmental management.

5.2 ALTERNATIVE DESIGNS FOR PRODUCTION AND SETTLEMENT PONDS

The project will continually evolve to take advantage of latest developments in the area of environmental management.

Currently, the company is studying the feasibility of using new equipment that would minimize the use of settlement ponds and turn these wastes into a value-added commodity.

5.3 ALTERNATIVE SPECIES

As part of its continuous learning philosophy and constant research and development, the company is considering other species of crustacean and finfish to augment its product line.

This is one of the goals and objectives of the current project of the company with the Charles Darwin University (formerly Northern Territory University).

5.4 ALTERNATIVE ENVIRONMENTAL MANAGEMENT TECHNIQUES

The project has reviewed and considered many alternative operations from around the world, and has chosen the closed system model as the most desirable from an environmental perspective. SAA is aware of many of the problems caused by open systems, which are still the most common system used around the world, and has tried, through good design, construction and monitoring to avoid most of these problems. Some of the elements of the proposed project are pioneering and will be monitored for performance and effectiveness, especially in the environmental management area. The project will continually evolve to take advantage of latest developments in the area of environmental management.

5.5 ALTERNATIVE POWER SUPPLY

The company will consider the economic feasibility of alternate sources of energy during every stage of development but for reasons of availability and practicality has initially decided on diesel generator sets pending its application for a power grid to be established for the Dundee District. It is anticipated that power will be provided along the Fog Bay Road by 2005 or earlier, and an economic feasibility study of the option of connecting to this grid will be made at the time.

5.6 ALTERNATIVE STAGING

There is a reasonable degree of flexibility designed in the project development so that the company has the discretion to build numbers of ponds during its development period of 5 to 6 years depending on factors such as organizational learning curves, market conditions, production issues, and economic conditions.

6 ENVIRONMENTAL CONSTRAINTS AND ISSUES

6.1 PRELIMINARY

This section describes in detail the areas potentially impacted by the project. A number of specialist studies were undertaken for the project, and detailed analysis of the scale and types of impacts expected determined. These studies form the basis for the assessment of impacts from the project.

6.2 HAZARD AND RISK ANALYSIS

An Environmental Risk Assessment (ERA) was undertaken for project, with particular reference to the potential risks to the marine environment and the pearl oyster leases in Bynoe Harbour. The detailed ERA is provided in **Appendix 7**.

Risks from the development were assessed using the Australian Standard for Risk Management. The risk assessment was an iterative process which identified all known and anticipated risks to the environment and risks to the enterprise from the local environment.

The analysis identified some potential high risk areas, including the risk of overflow of the ponds and the consequent introduction of pathogens and pollutants to the local environment which could affect the pearl oyster operations off Point Ceylon in Bynoe Harbour, among other sensitive receptors. Significant risks were also considered to exist to the enterprise from the source waters, and from aerial or other introduction of disease pathogens to the prawns.

Specific aspects with associated high levels of risk, and their potential impacts are summarised in **Table 6.1**. Only those aspects carrying significant levels of risk are shown here. The full analysis is provided in the appendix.

Table 6.1 Summary of high risks related to Point Ceylon Aquaculture Estates

Aspect	Potential impacts
Earthworks	Clearing of habitat, Vegetation & soil damage, Weed introductions, Drainage alteration, Fire
Diverted surface waters	Loss of downstream aquatic habitats, Flooding of upstream habitats
Breeding facility	Fire, major storm, storm-surge, extreme rainfall event
Discharge of breeding facility water	Discharge to marine environment
Production, Harvest & Recirculation ponds	Overflow in extreme events
Discharge of pond water	Discharge to marine environment
Washdown water from processing plant	Daily washdown escaping to environment
Disease introduction	Disease from vectors, Supply of prawns, through feeds
Diseased prawns and other product	Daily disposal escaping to environment
Lighting of production area	Impacts on birds
Lighting of breeding facility	Impacts on birds & turtles
Financial resources	Funds to build, operate or maintain
Access	Loss of access due to flooding of main road
Sludge from production, harvest & water treatment ponds	Overflow in extreme events
Ponds and weir	Erosion from storms, Changes to flows and natural storage, Water body creation, Acid Sulfate Soil disturbance
Supply and Drain pipes & trenches	Erosion from storms
Dead prawn/shrimp	Daily disposal escaping to environment

All of these potential impacts have been addressed in the design and construction of the facility with the intention to minimise or eliminate the potential risks wherever possible. These management and mitigation strategies are detailed in Chapter 7.

Monitoring of the relevant environmental aspects has been planned to ensure that advance warning of these risks occurring is obtained so that preventative measures can be undertaken in a timely manner.

6.3 LAND ADMINISTRATION

6.3.1 Size of project area

Portion 3192 covers an area of approximately 1,997 hectares. The project itself will eventually cover around 183 hectares.

6.3.2 Land tenure

The land proposed for development, NT Portion 3192 Point Ceylon, Hundred of Milne, Dundee District, in the Northern Territory, is Crown Lease Term, held by the NT Land Corporation. The southern access corridor is an undeveloped Crown road reserve which runs between freehold land from Fog Bay Road. A copy of the title is provided in **Appendix 8**.

6.3.3 Existing land-uses

The land proposed for development, Portion 3192, is currently not used for any formal activities. A single vehicle track allows access to the Point Ceylon area, and some minor tracks allow access around the point. Some minor tracks at various locations also exist. The land is used principally by amateur fishers, and possibly by hunters, but both at low levels of use. A shack at Point Ceylon is used by occasional recreational fishers.

The land may be accessed from time to time by local indigenous people for hunting, fishing, collecting native foods, and recreation, but this usage appears to be at a low level.

6.3.4 Claims under Native Title Act 1993 & Aboriginal Land Rights (NT) Act 1976

NT Portion 3192 has been claimed under the *Native Title Act 1993* by the traditional Larrakia owners of the area. The claim application was filed on 15th August 2002, and is currently identified for registration testing pre-notification. The application numbers are D6024/02 (Federal Court number), and DC02/20 (National Native Title Number).

No claims under the *Aboriginal Land Rights Act (Northern Territory) Act 1976* were recorded on the Record of Administrative Interests and Information obtained from the NT Land Titles office on 30th June 2003. A copy of the record is provided at **Appendix 8**.

6.3.5 Aboriginal Areas Protection Authority Certificate

An Authority Certificate was obtained from the Aboriginal Areas Protection Authority. The Authority found there were no Sacred Sites which might affect the proposed development. A copy of the certificate is held by the proponent, and will be included in contracts as required.

6.3.6 Acquisition requirements

A letter of offer from the Northern Territory Land Corporation (owners of the property) was presented to the proponent on 28th August 2002. The details of the offer are confidential. The offer is for Crown Lease Term, convertible to freehold.

6.3.7 Access requirements

Access roads have been described in section 4.1. The access corridor from Fog Bay Road to Portion 3192 is a Crown road reserve which enters the property in the south-east corner.

6.4 PHYSICAL ENVIRONMENT

6.4.1 Existing environment

6.4.1.1 Topography, geology, soils and bushfires

The topography of the development area is generally undulating, rising from sea level to around 34 metres above sea level at the highest point along a peninsula which leads from the Finniss Road to Point Ceylon. There are no steep escarpments on the site. The area proposed for the development of the aquaculture ponds is generally between ten and twenty metres above sea level. The peninsula falls away to the east to an unnamed creek and to the west to Wheatley Creek and Mackenzie Arm. To the north lies Bynoe Harbour. **Figure 4.1** shows the topography of the area with the proposed developments superimposed.

The site is underlain by the Welltree Metamorphics and adjacent Finniss River Group which together consist of a range of rock types including quartz, feldspar, biotite gneiss, shales, siltstone and phyllite. A local intrusion of Two Sisters Granite, consisting of granite, granodiorite and pegmatite, occurs in the vicinity of the site. The bedrock is overlain by unconsolidated sands, and ferruginous, clayey, sandy and gravelly soils, and laterites (Pietsch 1986). The southern part of Bynoe Harbour, including Point Ceylon, is predominantly a lateritic capping with some exposures of the underlying weathered granite and some fine-textured sedimentary rocks (Brocklehurst and Edmeades, 2003). Brocklehurst and Edmeades (2003) have summarised the soils of Bynoe Harbour catchment as highly weathered, low in plant nutrients with acid to neutral pH and dominated by kaolinitic clays. Ironstone gravels are characteristic of soils associated with lateritic parent materials.

Brocklehurst and Edmeades in their Mangrove Survey of Bynoe Harbour (2003) summarised the geology of the harbour as *ria* coast formed by post-glacial flooding of a dissected plateau. The morpho-hydrological character is a branched bay with no off-channel embayment and with a multiple unconstricted mouth (Saenger & Bucher 1989). Sedimentary infill has resulted in the development of narrow embayments, broad embayments, islands and sand spits. Soils of the estuary are generally bioturbated and root structured muds, homogeneous muds or muddy sands. The upper parts of the sedimentary accumulations are interpreted as Holocene (Semeniuk 1985). Drainage from the catchment occurs through a series of minor creeks and minor rivers, mostly with relatively steep gradients (Brocklehurst and Edmeades, 2003).

Soils have been mapped for the area of the development (Portion 3192) (Hill *et al.* 2002). The soils present mostly a low to moderate erosion risk. Slopes are generally mild, of the order of 3% and less, and two small areas a high erosion risk, with slopes to about 7%, with the more elevated areas requiring some erosion control during construction or disturbance. The project is likely to avoid the high risk areas due to construction difficulties caused by the steepness of the terrain. **Figure 6.1** shows the mapped soil types of the area.

Acid sulfate soils have also been mapped for the area (Hill *et al.* 2002) (**figure 6.2**). The two locations likely to be disturbed for the aquaculture development are the upper reaches of Wheatley Creek, and at Point Ceylon. The upper reaches of Wheatley Creek exhibit potential acid sulfate soils up to the upper saline zone, which is one or two hundred metres north of the proposed fresh water weir site. The potential acid sulfate soils are not likely to be disturbed by this construction, but assessment of the potential for acid sulfate soils will be required prior to construction as the weir site is lower than 5 metres above the mean high water mark and probably of recent (Holocene) geological age, as well as other indicators (ASSMAC 1998). At Point Ceylon itself, the potential acid sulfate soils are found around the point. Specific mitigation and management measures will be taken to minimise disturbance to these soils.

A detailed geotechnical investigation of the site proposed for the ponds and the weir options was undertaken by Lintin Geotechnical in September 2002. Their report is provided at **Appendix 4**. The investigations showed that there is a good amount of material suitable for pond construction on site. The engineering characteristics of the soils are summarised in **Table 6.2**. Atterberg Limits were also tested for the Silty Sands, and Silts and results are provided in the report in Appendix 4. The report also includes details of grain sizes in each of the materials.

Bedrock was encountered across the site in four of six test pits, at depths from 2.0 to 3.0 metres. The bedrock was distinctly weathered siltstone and sandstone.

Two proposed weir sites were investigated, one at Wheatley Creek (Weir Site A) and one about 1.4 km to the east of the first (Weir Site B). Sandy silt in the test holes in Wheatley Creek had characteristics similar to those at the pond locations. Weir site B is reported in the investigation report at Appendix 4, but was not suitable for other reasons.

Table 6.2 Engineering characteristics of substrate at ponds and weir site A

Soil type	Engineering characteristics	CBR	MDD at OM
Sand	Fair workability as construction material Semi-pervious when compacted Low compressibility when compacted		
Silty sand - ponds	Fair to good workability as a construction material Impervious when compacted Low compressibility when compacted	35-90	2.0-2.06t/m^3 at 9.7-11.0%
Sandy silt – Weir site A (Wheatley Ck)	Fair to good workability as a construction material Impervious when compacted Low compressibility when compacted	45	1.92/m^3 at 12.8%
Silt	Poor to fair workability as a construction material Impervious when compacted Low compressibility when compacted		

CBR = California Bearing Ratio; MDD = Maximum dry density; OM = Optimum moisture

In summary, material on site is generally suitable for the proposed works. Geotechnical investigations are proposed prior to construction to address specific aspects of the works.

Bushfires are prevalent throughout northern Australia. They occur throughout the dry seasons from March or April each year to the end of the dry in about November or December. Early dry season fires are usually of less intensity than the later fires when the conditions are hotter and drier, and winds are stronger. The site experiences fires on an annual basis, and half the natural vegetation may burn each year. This is typical of the area (Russell-Smith 2000).

6.4.1.2 Meteorology, air quality and noise

The climate of the lower Finniss Region is similar to that of Darwin. The climate is monsoonal with an average rainfall of 1,500 mm, falling between December and March. It experiences long dry season from May to October. The mean maximum temperature ranges between 30-34^{o}C and mean minimum temperature ranges from 19-27^{o}C. Cyclones are a periodic occurrence during the wet season. The coolest month is July and the hottest November. Graphs of the key weather patterns for the Darwin Airport, the closest weather station to Bynoe, are provided in **Figure 6.3.**

Prevailing winds are from the southeast during the months of May to October and northwest between October and April, coincident with the north-west monsoon (Bureau of Meteorology data and maps at http://www.bom.gov.au/). Wind roses for the general area are provided in **Figure 6.4**.

Cyclones occur in the region during the wet season, and may occur between November and April. On average, about 10 cyclones occur each year in the northern Australian region, around half of which may be considered severe. Since 1970, about five tropical cyclones have passed within 100 kilometres, of Point Ceylon, Bynoe Harbour, and three of these within 50 kilometres. Four of the five cyclones were described as Category 2 cyclones, causing minor house damage, significant damage to signs, trees and caravans, heavy damage to some crops, risk of power failure, and small craft may break moorings (Bureau of Meteorology data and maps at http://www.bom.gov.au/). Wind speeds may range between 125 and 169 (max) km/h. One cyclone (Cyclone Tracy in 1974) was a Category 4 cyclone and passed within 50 km of Bynoe Harbour, causing extensive damage to Darwin. Category 4 cyclones may cause significant roofing loss and structural damage, many caravans destroyed and blown away, dangerous airborne debris, and widespread power failures.

Flooding of the development area is possible to a limited extent in the wet seasons. Because the aquaculture pond location is elevated (10-20 metres on average) and above all floodplains and creeks, it will not be flooded directly by flood flows. The freshwater weir will be flooded every wet season, and will be designed to accommodate these floods. The main water harvesting periods will be during the wet season, leaving low volumes in the weir during the dry season. The access road from the Finniss Road follows elevated ground the whole way, so will not be flooded by creeks. The main Finniss Road may be cut in several places for short periods, including at River Annie and River Charlotte. These floods usually subside within a day or two.

Air quality for the area is very good, with no sources of industrial pollution for 40 km. During the dry season, fire smoke contributes particulate matter to the atmosphere. The impact of this smoke will depend on the distance the site is from fire. Ambient noise levels are very low, with only natural noise occurring within the region, except along roads and in residential areas.

6.4.1.3 Oceanography and coastal water quality

Bynoe Harbour tides are macrotidal reaching 7.5 m (Saenger & Bucher 1989). Mean sea level (Local Chart Datum Darwin) is approximately 4.5 m (Brocklehurst and Edmeades, 2003). Maximum tides in the Darwin region can reach 8 metres (National Tidal Facility web site http://www.ntf.flinders.edu.au/TEXT/TIDES/ntbook.html).

The currents in Bynoe Harbour near Point Ceylon can run at up to 2.2 knots during a spring tide and up to 0.8 knots during a neap tide. Tidal streams were recorded for two points in Bynoe Harbour and Port Patterson, one about 15 km north of Point Ceylon, and one about 34 km north. The tidal flows and other data derived from AUS 29 Chart are shown in **Table 6.3**.

Table 6.3 Tidal streams from AUS 29 Marine Chart of Bynoe Harbour

Geographical position		**A** 12°23'.6S 130°31'E			**B** 12°33'.7 S 130°32'.7 E		
Hours		Directions of stream (degs)	Rates (Knots) Spring tides	Rates Neap tides	Directions of stream (degs)	Rates (Knots) Spring tides	Rates Neap tides
Before high water	-6	256	0.1	0.1	288	0.2	0.1
	-5	129	0.4	0.1	144	0.9	0.3
	-4	128	0.8	0.3	174	1.4	0.5
	-3	125	1.2	0.4	180	2.1	0.8
	-2	122	1.2	0.5	178	1.9	0.7
	-1	118	0.9	0.3	185	1.2	0.4
High Water	0	109	0.3	0.1	215	0.4	0.1
	+1	308	0.4	0.2	325	0.8	0.3
	+2	306	1.0	0.4	357	1.7	0.6
	+3	305	1.4	0.5	004	2.2	0.8
	+4	305	1.3	0.5	359	2.1	0.8
	+5	302	0.8	0.3	353	1.2	0.4
After high water	+6	289	0.3	0.1	038	0.3	0.1

Depths of the Bynoe Harbour channel range from around 19 metres off Point Ceylon, 23 metres near tidal flow point B (15km north), to over 30 metres north and east of Indian Island. South east of Point Ceylon the waters become shallower. The tidal flats at Point Ceylon are exposed at Lowest Astronomical Tide (LAT) by 1.1 metres for about 650 metres, gradually sloping to more than 6 metres deep over the next few hundred metres.

MacKenzie Arm feeds into Port Paterson. Indian Island separates Port Paterson to the west from Bynoe Harbour to the east for around 17 kilometres. No tidal flow data were available for the MacKenzie Arm which is fed by Wheatley Creek to the west of the peninsula and west of Indian Island. It would be expected that tidal flows would be of a similar magnitude to those of the Bynoe Harbour channel, although channel depths are less. Limited survey data were available from the chart (AUS 29) for MacKenzie Arm, but the maximum depth of MacKenzie Arm is 17 metres at one point, and the general channel depth ranges from 5 to 10 metres. Strong flows would be expected during ebb and flow. The narrow channel which separates Indian Island from the mainland to the south is about 250 metres wide at its narrowest. Measured depths of the channel are about 1 metre below Chart Datum (LAT). Tidal flows in this channel would be considerably less than for the main channels to the east and west, although there would be some exchange of water.

Water quality is regarded as essentially natural (Brocklehurst and Edmeades, 2003). No significant potential sources of pollution have been identified (Saenger and Bucher, 1989), and foreshores are largely undeveloped with the exception of rural block development at the heads of Milne Inlet and Mackenzie Arm.

There is very little data on water quality in Bynoe Harbour (Mike Lawton, DIPE, pers. comm.). A study of Darwin Harbour water quality (Padovan 2000) provides a surrogate set of values which provide guidance to the water quality of Darwin Harbour. The catchment of the peninsula to Point Ceylon is undisturbed in the catchment to the east, and rural for at least part of the Wheatley Creek catchment. The water quality of these catchment types for Darwin Harbour, with water quality for urban and industrial catchments for comparison, is shown in **Table 6.4**.

Paspaley Pearling Company Pty Ltd, whose oyster leases occur in the southern sections of Bynoe Harbour adjacent to Indian Island and to Point Ceylon, carry out regular measurements of temperature, salinity and turbidity. They have provided some information which has been summarised in **Table 6.5.** Secchi readings, which measure the visibility of a secchi disk below the surface have also been taken from 1998, periodically. The values, which provide an indication of suspended solids, showed a maximum of 8 metres, a minimum of 0.3 m, a median value of 1.6 m, and an average of 1.8 m. The readings tended to increase in the dry season, and decrease in the wet season.

Table 6.4 Export coefficients for contaminants for each land use category in Darwin Harbour. Values represent the mass per unit area per wet season (From Table 1 -Padovan 2000)

Land use		TP	TN	As	Cd	Cr	Cu	Pb	Ni	Zn	TSS	VSS
		kg/ Ha	g/ Ha	g/ Ha	g/ Ha	g/ Ha	g/ Ha	g/ Ha	g/ Ha	kg/ Ha	kg/ Ha	kg/ Ha
Un-disturbed	Min	0.04	0.69	0.47	0.13	2.23	5.97	1.34	1.54	2.77	47.91	8.32
	Max	0.50	6.58	9.34	1.31	13.83	58.26	11.96	9.81	39.85	288.16	63.57
	Mean	0.28	3.87	4.51	0.64	7.84	28.70	6.77	6.04	21.31	163.25	40.30
Rural	Min	0.04	1.46	1.42	0.45	2.54	4.69	1.85	1.81	24.09	57.00	16.17
	Max	0.29	5.20	4.82	0.72	13.00	21.00	13.00	16.00	116.18	204.02	54.54
	Mean	0.11	2.81	2.67	0.60	6.68	12.87	5.56	6.15	88.47	97.75	29.68
Urban	Min	0.40	5.00	13.54	1.74	14.10	38.00	320.00	8.95	331.00	610.00	218.34
	Max	2.27	16.94	14.26	4.97	81.00	144.51	361.00	66.00	1900.00	956.00	320.81
	Mean	1.33	11.37	13.90	3.36	41.76	86.24	345.88	28.21	898.92	775.18	255.72
Industrial	Min	5.10	16.50	41.18	7.55	246.71	233.59	337.93	40.28	3749.98	923.21	188.49
	Max	14.92	71.91	253.13	21.57	1723.37	793.88	900.84	138.20	9326.59	1802.42	421.97
	Mean	8.58	35.79	113.81	16.00	812.95	442.44	596.51	79.45	5867.81	1507.73	304.51

Table 6.5 Data on water quality in Bynoe Harbour for 2002, from Paspaley Pearls Pty Ltd

Year	Month	Temp (Deg C)	Salinity (%)
2002	January	32	3.20
	February	30.9	3.04
	March	32.0	2.98
	April	31.0	3.03
	May	28.6	3.11
	June	25.2	3.50
	July	26.3	3.93
	August	27.2	4.00
	September	29.1	3.48
	October	32.1	3.29
	November	33.2	3.34
	December	33.1	3.39

6.4.1.4 Hydrology

Hydrological modelling of the catchment and ponds was undertaken for this project (**Appendix 9**). Modelling of the historic rainfall, catchment and pond characteristics demonstrated a number of aspects important to the project. The model was based on historic rainfall records which for Darwin are continuous from 1941. Records for the closer weather stations are much more recent, as shown in **table 6.6.**

Table 6.6 Rainfall Records Bynoe Harbour Area

Station No	Station Name	Location Relative to Development	Period of Wet Season Record
014015	Darwin Airport		Jan 1941 – Jan 2003
014277	Dum In Mirrie AWS	22km NW	1990, 1993 - 2002
014241	Dum In Mirrie	22km NW	1996,1999 – 2002
014013	Geriatric Park	10km WSW	1998 - 2002
014010	Dundee Beach School	18km W	1999 - 2002

Stations 014013 and 014010 were considered to be the most representative of the four local stations, being closer and situated on the mainland. Monthly wet season (December to March inclusive) rainfalls at these stations were compared to Darwin records for the same period. These comparisons are shown in **table 6.7**.

As shown, the local stations have generally recorded 10 to 20% more rainfall than Darwin. It should be noted however that the records for the local stations are for very brief periods and may not be indicative of

longer-term trends. The modeling is therefore based on conservative estimates of maximum rainfall events, and therefore provides a substantial margin of error for the pond designs and overflows.

Table 6.7 Rainfall Comparisons Darwin and Bynoe Stations

Season	Station	Dec	Jan	Feb	Mar	Total	Factor
1997-1998	Darwin	588	670	404	474	2136	
	Dundee School	N/A	N/A	N/A	N/A	N/A	
	Geriatric Park	598	727	251	843	2419	1.13
1998-1999	Darwin	598	360	524	375	1857	
	Dundee School	384	599	905	385	2273	1.22
	Geriatric Park	433	701	549	497	2180	1.17
1999-2000	Darwin	250	441	662	368	1721	
	Dundee School	249	476	712	537	1974	1.15
	Geriatric Park	373	443	747	537	2100	1.22
2000-2001	Darwin	206	262	417	257	1142	
	Dundee School	354	240	357	440	1391	1.22
	Geriatric Park	272	516	649	588	2025	1.77
2001-2002	Darwin	182	147	407	247	983	
	Dundee School	178	112	552	196	1038	1.06
	Geriatric Park	244	300	570	152	1266	1.29

Fresh water supplies

The weir proposed for Wheatley Creek has been designed on the basis of the hydrological modelling. Initial modelling suggested that the weir and off-stream storage would have to be substantial to provide sufficient water to the ponds. The more detailed model described in the report gives an estimate of inflows required to provide makeup water for the growing ponds. Requirements were found to be significantly less than previously estimated. These revised inflows were applied to the catchment/dam/off-stream storage model and it was found that off-stream storage capacity could be reduced by about 50% from the original estimates.

The proportion of catchment discharge required to be diverted to supply the initial proposed development is less than 1% over the period of record. The final requirement is estimated to be less than 10% of total discharge.

Overflows

The initial hydrological study (March 2003) suggested substantial freeboard would be required to limit overflows to once in 10 years or less frequently. The pond designs and overflows were re-modelled to account for this potential overflow and the supplementary modelling showed that a freeboard of about 800 mm would limit overflows to less than one in 10 years, provided that the recirculation ponds, harvest ponds and production ponds were utilised to maintain levels during extreme rainfall events. The circulation and management system has been designed to account for this.

The supplementary and more sophisticated model was run for a number of different pond sizes and depths to determine the best arrangement to minimise overflow. In general it was found that if a rainfall factor of 1.2 is used it is almost impossible to prevent overflow in particularly wet years. For the inputs shown in the report, overflows occurred in 9 years of the 62 on record. These were 1975, 1976, 1977, 1991, 1995, 1997, 1998, 1999 and 2000. If the rainfall factor is reduced to 1.1, overflow occurs only in 1977, 1997 1998 and 1999. If un-factored Darwin rainfall is used, overflow occurs only in 1998. This demonstrates that a relatively small increase in rainfall has a significant effect on overflows. In the previous report it was recommended that a factor of 1.2 be used based on comparisons of short term local rainfalls with Darwin records. This is still considered to be a reasonable assumption. Dilution of the overflow by catchment runoff is modelled in **Table 6.8**.

Table 6.8 Overflow modelling results

Date	Rain	O'Flow kL	Dilution Ratio *	Date	Rain	O'Flow kL	Dilution Ratio *
2/03/1975	38.6	2113	255750				
3/03/1975	79.6	6867	162283	5/03/1997	131.4	11717	157003
4/03/1975	8	161	695652	6/03/1997	11.2	461	340130
2/03/1975	21.4	1136	263732	1/03/1998	24.4	1148	297561
3/03/1975	7.8	143	763636	2/03/1998	224.6	20446	153790
4/03/1975	12.8	611	293290	3/03/1998	82.2	7110	161857
5/03/1975	12.6	592	297973	4/03/1998	23.8	1641	203047
9/03/1976	49.8	3616	192810	5/03/1998	21.4	1416	211582
5/03/1976	19.6	939	292226	2/03/1998	112	7715	203240
1/03/1977	174.6	5764	424080	6/03/1998	45.8	2766	231815
2/03/1977	72.8	6230	163596	7/03/1998	49.8	4076	171050
3/03/1977	41.4	3289	176224	9/03/1999	41	2116	271267
6/04/1977	90	2480	508065	3/03/1999	34.6	2185	221693
8/02/1991	47.2	335	1972537	/03/1999	14.2	742	267925
1/03/1991	64.4	5443	165644	7/03/1999	23.6	973	339568
4/03/1991	25.6	1067	335895	8/03/1999	37.2	2896	179834
6/03/1991	26.8	1410	266099	0/03/1999	8	61	1836066
3/03/1991	27.4	357	1074510	1/03/1999	13.4	667	281259
6/03/1995	83	5082	228650	3/03/1999	23.4	1111	294869
7/03/1995	32.6	2465	185152	4/03/1999	18.2	1117	228111
8/03/1995	77	6623	162766	3/04/1999	38.4	854	629508
0/03/1995	24.8	1186	292749	4/04/1999	26.8	1918	195620
5/04/1995	68	3627	262476	8/04/1999	83	6346	183107
6/04/1995	8.8	232	531034	9/04/2000	50.8	1561	455605
4/03/1997	94.6	4075	325006	1/04/2000	123.4	10823	159623

* Note: dilution ratio is the ratio of catchment flow to a unit volume (1); that is, for example, 255750 to 1 as in the first row

In many years volumes of overflow are very much less than those mentioned above. This was calculated by assuming 80% runoff from the 17.5 km^2 weir catchment. As **Table 6.8** shows, many of the daily overflows are of the order of 1000kL or less and dilution is greater that 100,000 to 1. The results from the model indicate that frequency of overflow is comparable to that predicted by the earlier simpler model. Frequency of overflow, even with the assumed 1.2 rainfall factor is of the order of 1 in 10.

It is proposed to investigate the use of a bore for water supplies during construction. Details of the bore log are provided in **Appendix 6**. Water Resources records indicate an existing bore adjacent to the proposed production compound which can be developed to augment on-site water requirements. The bore RN23176 will be checked to ensure estimated pumping regime of 0.6 L/s for 16 hours, 1 L/s for 8 hours. Estimated daily water requirements of the order of 70-80,000 L/day, primarily for dust suppression, concrete and soil conditioning are anticipated. Initial estimates indicate that during peak construction the bore should supply 90% of water requirements.

6.4.2 Impacts on the physical environment

6.4.2.1 Soils & bushfires

Erosion risk is moderate to low over most of the proposed development site. Erosion control devices, including silt fences will be installed where erosion risk warrants them around the worksites. These silt fences and other erosion control devices will be in accordance with established practice, including the NT Guidelines for Soil Erosion and Sediment Control (Sedman 2000). Site definition for works operation will

be established using construction flagging tape. This will limit the area disturbed to that necessary for works, thereby minimising avoidable disturbance to soils and vegetation.

Acid sulfate soils (ASS) and potential acid sulfate soils (PASS) occur at Point Ceylon and in the lower reaches of Wheatley Creek near the upper tidal level (Hill *et al.* 2002). ASS and PASS soils have the potential to cause acidification of waters and soils, deaths of fish, diseases in fish and crustaceans, destruction of fish eggs, destruction of vegetation, release of toxic levels of metals, particularly iron and aluminium, and damage to construction materials such as steel and concrete, amongst other effects (ASSMAC 1998). The best options for management are to avoid disturbing them. Where it is necessary to cross ASS soils, minimal disturbance is required. Assessment of the actual locations of ASS and PASS soils is necessary before any disturbance is undertaken.

Preliminary assessment of the soils on site will be undertaken prior to works. The assessment process is detailed in the *Acid Sulfate Soil Manual* (ASSMAC 1998), and includes site assessment, some basic testing, works assessment and description, and management and remediation measures. An Acid Sulfate Soils Management Plan, in accordance with the Manual, will be prepared before works commence. It may be necessary to supply lime on site prior to works to ensure that if acid is generated it can be treated immediately. Acid soils will require treatment immediately if they are encountered, and if necessary, a site will be set aside on the property for treatment.

The aquaculture facility is unlikely to affect the occurrence and frequency of bushfires. Conversely, bushfires may affect the facility. Fire management will be undertaken in accordance with NT Bushfires Council guidelines.

6.4.2.2 Air quality and noise

Impacts from the project on air quality and noise are likely to be insignificant. During construction, air pollution sources will include dust from construction works and emissions from power sources and plant. Dust suppression will be by water truck until surfaces are hardened. Emissions from power sources and plant will be in accordance with normal emissions from such sources, and will be within acceptable limits. Noise will be normal for such activities, and noise receptors are located a long way from the work site, and so impacts should be negligible.

The only sources of air and noise pollution during operation will be the power station and pumps for water supplies. These will be designed in accordance with acceptable standards to ensure that emissions of noise and pollutants are kept to a minimum.

6.4.2.3 Hydrology

The weir on Wheatley Creek will impede natural flows, and harvest less than 10% of the annual flow of the creek. Water will be pumped from the weir only during periods of high flow, and stored in the production area freshwater ponds. At this harvest rate, it is unlikely to significantly affect groundwater re-charge due to the significant volumes and excess overland flow during the wet season. The greatest impact is likely to be during low flow periods. The weir will be designed to drain over three or four days so that a permanent water body is not created, minimising negative impacts on local groundwater regimes, and minimising risks of creating mosquito breeding sites.

Overflows from the ponds are anticipated to be less frequent than 1 in 10 years. Many of the daily overflows are of the order of 1000 kL or less and dilution is greater that 100,000 to 1. These overflows will be during very high rainfall events, when the volume of water running of the catchment is very substantial. The impacts from overflows are therefore expected to be negligible.

6.4.2.4 Coastal Water Quality

It is unlikely that the contingent discharges, as described in the hydrology section, will significantly increase levels of suspended solids and nutrients in near-shore waters to an extent that could lead to algal blooms or smothering of benthic marine communities. Contingent flows will occur only when extreme rainfall events occur. (There are no drains from the ponds to external areas for normal operations.) During such extreme rainfall events, the volumes of water which are likely to flow will provide massive dilution of the pond overflow, and the overflow will run across ground and through natural forest and into mangroves on the Wheatley Creek side and into MacKenzie Arm. The actual volumes of overflow are an extremely small proportion of both the natural overland flow and of the waters in MacKenzie Arm. These have been modelled in the hydrological report. The dilution ratios on all modelling scenarios are very high, resulting in very diluted overflow water from the production ponds. Anecdotal evidence from Neil Schmidt (DIPE, pers. comm. 2003) suggests that the reefs and sponge beds in Bynoe Harbour are well developed due to the higher velocity flows compared with those in Darwin Harbour. The same situation is likely to occur in MacKenzie Arm. For these reasons, it would be expected that smothering and algal blooms are unlikely to occur as a result of contingent discharges from the aquaculture ponds.

The Environmental Risk Analysis (ERA) shows that the likelihood of species-specific bacterial pathogens from the prawn farm affecting the pearl oysters is very low. The ERA does identify that some 'environmental' organisms (some of the bacterial agents) may be opportunistic pathogens capable of infecting both molluscs and crustaceans. In order for bacterial loads to affect the pearls in Bynoe Harbour, significant nutrient and bacterial loads would need to be discharged directly to the pearl beds. As the majority (>2/3) of the contingent flows from the production ponds are to be directed to MacKenzie Arm, which separates contingent discharges from the oyster beds by at least 10 km by the shortest route via the shallow channel south of Indian Island, and that the most likely path for the contingent discharges is via the main channel to the west of Indian Island, and then north to Port Patterson, a distance of over 20 km north, the risks of bacterial loads from the prawn farm being any threat to the oyster beds is probably negligible. The ponds which lie on the eastern side of the ridge may discharge water in extreme events to the eastern creek which flows eventually towards the Bynoe Harbour and near the oyster beds. Dilution of these waters is likely to be very high, with flows across open vegetated land before they reach the tidal creek, and then significant dilution within the creek.

Nutrient loads from contingent overflows from the prawn farm are also likely to be very low, as the incident rainfall is unlikely to stir up the nutrients in the ponds, and is more than likely to sit in a laminar fresh water layer on top of the saline ponds. The resultant overflow will be a diluted solution which will be directed to flow to empty recirculation and harvest ponds, be further diluted by the incident rainfall, and then across the open forest floor through a series of open rollover structures to mangrove wetlands and then into MacKenzie Arm and the unnamed eastern creek. The nutrients will be diluted many thousand-fold (see Appendix 9), and are therefore unlikely to affect nutrient loads on the pearl oyster beds.

6.4.3 Proposed Mitigation

6.4.3.1 Fire management

Fire breaks as required by the NT Bushfires Council will be constructed on the property and a fire management plan for prescribed burns and vegetation management will be prepared.

6.4.3.2 Soil management

Soil erosion will be limited by installing erosion control devices such as sediment fences and by limiting works outside the required development footprints. The details are provided above and in Chapter 7.

6.4.3.3 Contingency plans for storms

Operational procedures and contingency plans to prepare for storms will be prepared for the farm. This will include pond preparation and close down procedures prior to storms. These procedures will address the maintenance of coastal water quality. The details are addressed in Chapter 7 under 7.1.11.1.

6.4.4 Monitoring and reporting

Monitoring of marine water quality is required to ensure that poor quality or contaminated water is not introduced to the production ponds. Monitoring of water quality for impacts from the aquaculture project is not straight-forward. Detecting impacts from a facility such as the Point Ceylon Aquaculture Estates would be very difficult as there are no regular discharges during normal operations, and therefore no parameters which could reasonably be selected for monitoring. Monitoring during contingent events such as major storms and cyclones which would cause overflow is not likely to be possible, due to access difficulties and problems with identifying suitable monitoring points which would detect impacts. There is also the problem of baseline data, in that none exist. Only long-term monitoring of a number of points would provide data on impacts which could be separated from background variation in water quality.

In order to overcome this lack of data to some degree, without committing to very expensive research and monitoring, SAA has accepted a proposal from Paspaley Pearls Pty Ltd to develop a joint monitoring program. Paspaley conducts monitoring of water quality in Bynoe Harbour and supplied some data for this EIS (see table 6.4). It is proposed to develop a cooperative monitoring program among stakeholders of Bynoe Harbour to provide mutually beneficial data on water quality as part of a long-term program to preserve and maintain the health of Bynoe Harbour. The details are yet to be worked out, but the monitoring proposed will assist in ensuring that both aquaculture projects maintain optimal conditions for their operations. It is in both parties' interests to ensure this is done. The program will be developed with the advice of the Department of Infrastructure Planning and Environment.

Monitoring and reporting will address the following issues:

- Vegetation damage outside development footprint
- Soil erosion off site
- Freshwater flow and quality in Wheatley Creek (monitoring of aquatic fauna)
- Bore water quality and pumping rate records
- Coastal water quality (basic parameters from pond data).

These are detailed in the Environmental Management Plan in section 7.

6.5 BIOLOGICAL ENVIRONMENT

6.5.1 Existing environment

6.5.1.1 Terrestrial Flora

A flora survey of the area was undertaken for this project (**Appendix 10**). The survey consisted of two field visits. The first comprised a verification of the mapped vegetation of the area a described in the Lower Finniss Land Resources Study (LFLRS) (Hill *et al.* 2002). The second was a study of the areas proposed to be cleared for the project, including the access road corridors, the weir site, the ponds area and the breeding facility area. The vegetation communities on the project area are shown in **Figure 6.5**.

Woodlands
The project lease area is mostly upland habitats which are dominated by open woodlands of *Eucalyptus spp.* The dominant species in the upper stratum is typically Darwin Woollybutt *Eucalyptus miniata,* which occurs in association with Ironwood *Erythrophleum chlorostachys* and *Corymbia bleeseri*. Species dominance, however, varies according to changes in local topography. On rocky laterite ridges Darwin Stringybark *Eucalyptus tetrodonta* becomes co-dominant to dominant, in association with *Corymbia bleeseri*.

The mid-stratum of the upland woodland habitats is comprised of a mixture of tree and shrub species, but is typically dominated by Sand Palm *Livistona humilis* and the cycad *Cycas maconochei.* Other species that commonly occur in the mid-storey include Billy Goat Plum *Terminalia ferdinandiana,* Screw Palm *Pandanus spiralis, Planchonia careya, Petalostigma pubescens, Persoonia falcata* and *Canarium australianum.* The grassy understorey is typically comprised of *Eriachne spp., Heteropogon spp*. and *Sorghum spp*., and a variety of herbaceous species. This community is widespread across the Top End and constitutes 44% of the total area of the Lower Finniss Region
Woodlands dominated by *Melaleuca spp.* fringe the landward edge of mangrove forests in the project lease area. This community occurs in areas subject to seasonal inundation and is typically dominated by *Melaleuca viridiflora*, which often forms pure stands over a grassy understorey of *Eriachne spp.* and *Sorghum spp.* A diverse mid-storey is present at some locations, which commonly includes species such as *Acacia spp., Livistona humilis,* and *Pandanus spiralis*.

Woodlands of *Melaleuca spp.* are the second most dominant vegetation type in the project lease area. In the western half of the project lease area and along the peninsula out to Point Ceylon, this community forms a continuous fringe along the landward edge of the mangroves and in some locations covers large areas up to 27 ha in size. A number of old dams that occur at Point Ceylon have been colonised by *M. leucadendra*. The Melaleuca communities found on the project area are common and constitute 6.4% of the Lower Finniss Region.

Monsoon vine forests
Monsoon vine forests occur in patches throughout the project area. The most diverse patches in terms of structure and composition occur on old beach ridges that fringe the mangroves, and in association with freshwater streams. Some small patches of less well developed monsoon vine forest occur on shallower, gravelly soils.

The monsoon vine forests in the project lease area can generally be classified as 'dry' forests. The structure and composition of this community varies but is typically comprised of a high proportion of semi deciduous species. Common canopy species include: *Acacia auriculiformis, Canarium australianum, Brachychiton diversifolius.* Other species include: *Acacia spp., Bridelia tomentosa, Buchanania obovata, Capparis umbonata, Cycas maconochei, Denhamia obscura, Drypetes deplanchei, Exocarpus latifolius, Ficus opposita, Flueggea virosa, Grevillea spp., Livistona humilis, Pandanus spiralis, Persoonia falcata,*

Petalostigma pubescens, Planchonia careya, Pouteria sericea, Strychnos lucida, Stenocarpus acacioides, Terminalia spp.

Large patches of monsoon vine forest are mapped in the north-east of the project lease area. The presence of monsoon vine forest on the ground has been verified at one location in this part of the lease area during ground-truthing work undertaken as part of the Lower Finniss Land Resource Study. This area will not be affected by the proposed development and therefore further ground-truthing of the mapped extent of rainforest in this area was not undertaken during this study.

Monsoon vine forest patches occur at Point Ceylon, confined to a narrow 100-200 m wide zone landward of the mangrove forests. The mapped distribution of monsoon vine forest in this area extends 800 m south along the peninsula, which is a substantial over-representation of its actual distribution. The hinterland vegetation that occurs on the peninsula does comprise a substantial incursion of rainforest elements, however, it has a low open woodland structure. The vegetation map included as Figure 2 of the report has been adjusted to reflect the actual distribution of monsoon vine forest at Point Ceylon.

A number of monsoon vine forest patches also occur in the south-east of the project lease area. The largest mapped patches occur on the landward fringe of mangrove forests on the western side of Wheatley Creek. The presence of these patches has been verified on the ground with 5 sites surveyed during the surveys undertaken for this project and 6 sites surveyed as part of the LFLRS. The extent of the patches, however, has not been verified. Monsoon vine forests (rainforest) are well represented in the Lower Finniss Region covering 5.6% of the total vegetated area, compared to their coverage of only 0.2% of the NT.

Riparian woodlands

Tall mixed species riparian forest occurs in association with the seasonal freshwater reaches of Wheatley Creek in the south-west of the project lease area. 400-500 m upstream of the extent of the tidal influence the Wheatley Creek forks into two channels each supporting a 100-200 m riparian corridor, which is distinctly different in structure and composition from the surrounding vegetation. Typical canopy forming species include: *Corymbia bella, Acacia auriculiformis, Erythrophleum chlorostachys, Melaleuca nervosa, Lophostemon lactifluus* and *Xanthostemon eucalyptoides*. Common mid-storey species include *Terminalia ferdinandiana, Livistona humilis, Ficus opposita, Barringtonia acutangula, Canarium australianum, Cycas maconochiei, Drypetes deplanchei, Buchanania obovata, Vitex glabrata, Diospyros calycantha and Petalostigma pubescens* occurring over a mixed grassy understorey.

A number of broad drainage basins across the project lease area support mixed species low open woodland. These areas are subject to seasonal inundation and contain species typically adapted to this situation. Species typically recorded in these seasonally inundated areas include: *Melaleuca viridiflora, Eucalyptus polysciada, Calytrix exstipulata, Grevillea pteridifolia, Pandanus spiralis, Terminalia ferdinandiana, Acacia aulococarpa, Buchanania obovata, Owenia vernicosa, Persoonia falcata, Acacia latescens, Alphitonia excelsa*. Riparian communities comprise only 1.3% of the Lower Finniss Region.

Other communities

The transitional zone between the upland Eucalyptus woodlands and lowland Melaleuca swamps supports a variety of community types, which typically occur as small patches, and are variable in structure and composition. A brief description of transitional communities mapped and surveyed in the lease area is provided below.

Callitris intratropica forest (Northern Cypress Pine)

Tall open forests of *Callitris intratropica* occur along the landward edge of mangroves associated with Wheatley Creek in the south-west of the project lease area. These forests typically occur as mono-specific stands, however, a number of rainforest elements were also recorded at the surveyed sites representative of this community. The mapped distribution of this community identifies four patches ranging in size from 1.2

– 4.6 ha. The presence of the two patches that occur on the eastern side of Wheatley Creek has been confirmed during field surveys.

Large patches of *Callitris intratropica* up to 39 ha in size are also mapped as occurring on an island of vegetation isolated by mangrove forests in the north-west corner of the project lease area. These patches are topographically protected from fire by the surrounding mangrove forests. This area is not accessible from the areas proposed for development as part of this project, and will not be affected by the proposed development.

This community has a limited distribution across the NT and in the Lower Finniss Region is represented only by the patches that occur in the project lease area.

Tall open shrubland of Calytrix exstipulata
Tall open shrublands of *Calytrix exstipulata* occur in association with isolated laterite outcrops in the woodland floodplain transitional zone along Wheatley Creek. Survey at site ECOZAL1, which is representative of this community, identified a number of rainforest elements occurring in association with *Calytrix exstipulata*. The outcropping rock provides a natural barrier to fire allowing for colonisation by rainforest species.

The mapped distribution of this community identifies one large patch in the south-west of the project lease area. Ground survey did not confirm the presence of a large patch at this location, however, a number of small patches were observed in the woodland-floodplain transitional zone along the eastern side of Wheatley Creek.

Low open woodland of Petalostigma pubescens
Low woodlands to mid high open woodlands of *Petalostigma pubescens* are mapped as occurring at two locations within the project lease area. Common mid-storey species in this community include *Livistona humilis* and Pandanus *spiralis,* which occur over a grassy understorey commonly comprised of *Ectrosia spp., Pseudopogonatherum contortum, Sorghum spp*. and *Themeda triandra*. The locations within the project area have not been confirmed by ground survey.

Low open woodland to mid high open woodland of Lophostemon lactifluus
This community does not exist as a distinct community on the project lease area. Sites mapped as this community type are, according to ground surveys, more correctly classified as mixed species low open woodland. This community occurs in association with broad drainage lines throughout the project lease area.

Grassland of Sorghum sp. and Eriachne sp.
This community is mapped as occurring in the southern part of the project lease area as isolated patches within the *Eucalyptus* dominated open woodland. Open grasslands were not identified at these locations, which were typically associated with seasonally inundated broad drainage lines vegetated by mixed species low open woodland (refer to description above).

Mangrove vegetation
The project lease area is located on a narrow peninsula which is fringed to the north, east and west by extensive mangrove forests. All development associated with the proposed project is to take place at elevations above 10-20 m and therefore will not require clearing of any mangrove vegetation. Despite there being no direct impact on mangrove environments, this proposal is being developed on a site with substantial mangrove resources which must be protected from any potential impacts. The mangrove vegetation that fringes the project lease area is described below based on information collated in the Mangrove Survey of Bynoe Harbour (Brocklehurst and Edmeades, 2003).

Mangroves are discussed below in the marine and estuarine section.

6.5.1.1.1 Vegetation communities of conservation significance

Mangroves

The project lease area is surrounded by extensive areas of mangrove forest covering an area of approximately 150 ha. The mangroves of Bynoe Harbour have remained relatively intact through limited foreshore development in the region and are considered to be a significant resource both locally and globally (Brocklehurst and Edmeades, 2003). The mangrove forests fringing the project lease area constitute 0.6% of the total area of Bynoe Harbour/Tapa Bay mangrove communities which represent approximately 6% of the mangrove areas of the NT and 0.1% of remaining world mangrove regions.

The construction of the proposed project will not require direct removal of any mangrove vegetation. Saltwater intakes for the production ponds and breeding facility complex are constructed of flexible piping, which will allow the intakes to pass through the mangrove forests with minimal disturbance. The intake for the breeding facility complex will be located approximately 500 m south of the breeding facility site where there is an existing clearing through the narrow mangrove fringe. The construction and operation of the proposed project is not expected to have any significant impacts on the surrounding mangrove environments.

Rainforest

Patches of dry monsoon vine forest ranging in size from 0.3 ha to 5 ha are located in the project lease area. Rainforest patches (incorporating monsoon vine forest) are generally small in area and contain distinct plant species assemblages which warrant conservation measures. Rainforests occupy only 0.2% of the land area of the Northern Territory (Bach *et al.* 1999). Comparatively, rainforest patches in the Finniss Region cover a total area of 47.7 km^2 comprising 5.6% of the region's vegetation (Hill *et* al., 2002). Rainforest communities are typically species rich (Liddle *et al.* 1994) and often contain species which are considered to be rare.

Rainforest patches also provide significant habitat for a variety of fauna species. Research has found that an important relationship exists between frugivorous birds (birds that feed on fruit) and monsoon rainforests. Rainforests provide fruit resources required by frugivorous birds, which in turn assist in the dispersal of seed between monsoon rainforest patches to maintain gene flow (Price *et al.* 1999). Some bat species may also play an important role in maintaining patchy rainforest habitats in the seasonal tropics of northern Australia (Palmer 2000).

No rare plant species were identified in any of the monsoon vine forest patches that occur in the project lease area. The condition and integrity of the patches varies. Most of the patches surveyed had been impacted to some extent by weed invasion, fires and feral animal activity. The monsoon vine forest that occurs in the project area is not of outstanding conservation significance, however, the regional significance of this community through its role in maintaining the regional network of rainforest patches should be noted. All rainforest patches are significant in a regional context because of the high level of patch interdependence (Price *et al.* 1998).

The construction of the proposed project will not result in the removal of any monsoon vine forest vegetation. The proposed breeding facility site at Point Ceylon is located in close proximity to a large patch of monsoon vine forest and the saltwater intake for the complex runs south along a sand spit vegetated by monsoon vine forest elements. Construction activities at the breeding facility site will require strict management to ensure that the development does not encroach on the monsoon vine forest that occurs at Point Ceylon. The saltwater intake will be a flexible pipe to allow for the intake to be put into position with limited disturbance to the vegetation on the sand spit.

Weeds and fire are the factors that have the greatest potential to cause negative impacts on the monsoon vine forests that occur in the project lease area. Degradation of patch integrity has already been observed in a number of monsoon vine forests at the site as a result of weed invasion, fires and feral animal activity. Construction and operation of the proposed project has the potential to exacerbate the impacts of weeds and fire on these patches. Implementation of weed and fire management programs will minimise these impacts

and may actually enhance the protection of these sites. Recommendations on weed and fire management are further discussed in below in section 6 and in Chapter 7.

Riparian

The upper reaches of Wheatley Creek are vegetated by a dense 100-200 m wide corridor of riparian forest. Riparian vegetation communities comprise only 1.4% of the total vegetation of the Finniss Region (Hill *et al.*, 2002). Each community plays a direct role in maintaining the ecological stability of the particular watercourse with which it is associated. Riparian communities also provide movement corridors and seasonal refuges for fauna.

Clearing of any riparian vegetation has potential to cause significant impacts, which can extend beyond the immediate site. Impacts may include destabilisation of banks and erosion and siltation of rivers and creeks. Construction activities may also disturb fauna utilising riparian areas as habitat. This may have specific impacts on species of fauna and impacts on ecosystem health in general.

The proposed development will result in the periodic wet season inundation of 12 ha of riparian forest at the site of the freshwater weir. Inundation may result in the death of some trees, however, it is expected that most of the riparian forest vegetation will survive this inundation due to the following:

- clearing at the weir site prior to construction will involve minimal vegetation removal;
- during the wet season, water will be pumped from the weir to off-stream storage, which will reduce the area inundated;
- off-stream storage in storage ponds will hold water pumped from the creek. The maximum period of inundation is during the wet season, corresponding with natural inundation patterns experienced by this community. The weir will self-drain over a period of less than 5 days resulting in near normal flow conditions; and
- no vegetation will be permanently inundated.

Northern Cypress Pine communities (Northern Cypress Pine)

Tall open forests of *Callitris intratropica* occur along the landward edge of mangroves associated with Wheatley Creek in the south-east of the project lease area. In the Finniss Region this community is confined to remnant pockets on Point Ceylon and adjacent coastal islands that are protected from bushfires (Hill *et al.*, 2002). The mapped distribution of *C. intratropica* forest in the project lease area covers a total area of approximately 8 ha which is the entire regional extent of this community. The patches that occur in the project lease area are therefore of high regional conservation significance.

The proposed development will not result in clearing of any *Callitris intratropica* forest. Construction of the production ponds will be taking place in close proximity to the patch of *Callitris intratropica* forest that occurs on the on the eastern side of Wheatley Creek. Construction activities will need to be managed to ensure that this community is not impacted.

The community is highly susceptible to fire, and therefore fire management at the site must incorporate strategies to protect this community from fire.

6.5.1.1.2 Plant species of conservation significance

Threatened species

No threatened species have been recorded in the project lease area.

The LFLRS recorded 12 species within the Lower Finniss Region that are considered to be of conservation significance. Two of these species, *Callitris intratropica* and *Cycas maconochiei*, have been recorded in the project lease area. These species do not have any formal conservation status.

Of the other 10 species of conservation significance identified in the LFLRS, four have been recorded on landunits or in vegetation groups that occur in the project lease area. These species are listed below:

Chamaecrista grisea
Located at only one site on a hillslope (6a2) close to the River Annie. This landunit is represented by a small area (<1ha) in the project lease area.

Indigofera schultziana
Predominantly found in the ground layer of tall open woodlands of *Eucalyptus miniata* and *E. tetrodonta* (Veg Group A1). It has been located at six sites in the Lower Finniss Region where its distribution is confined to within the Finniss Range and a peninsula between the Annie and Charlotte Rivers. The vegetation group in which this species is found dominates the upland areas of the project lease area.

Polymeria pusilla
This species was found only at one site near Crab Claw Island, in a low open woodland of *Melaleuca viridiflora* (8j1). The *Melaleuca* woodlands in the project lease area occur on landunit 8ji, which is widespread.

Tephrosia crocea
This species was wide spread, occurring in mid high open to tall woodlands with *Eucalyptus miniata*, *E. tetrodonta*, *Erythrophleum chlorostachys*, *Xanthostemon paradoxus* and *Corymbia polysciada* (A1, A3, C1, J1). These communities are widespread in the project lease area.

Surveys of the project lease area did not identify the presence of these species, however, the possibility that they do occur there should be noted.

Cycads

There are 11 recognised *Cycas* species in the Northern Territory, most of which are endemic and are considered of conservation significance (PWCNT, 1997). *Cycas maconochiei* is a species of Cycad which is a common mid-storey species in the project lease area. The distribution of this species is confined to the coastal areas west of Darwin from the Cox Peninsula to Fog Bay. It is locally abundant, however, is under threat of substantial population decline through land clearing (PWCNT, 1997).

All Cycads in the Northern Territory are protected under section 43(2) of the *Territory Parks and Wildlife Act* 2000. The legislation does not preclude development in areas where Cycads occur but requires that Cycad plants may not be 'taken or interfered with' without a permit from PWCNT. Construction of the proposed project will result in inadvertent clearing of Cycad plants. The number of plants affected will be low in the context of its abundance in the region. A permit will be required. Salvage of Cycads prior to construction should be considered.

Orchids

All flora species belonging to the family Orchidaceae (Orchids) are protected under section 43(2) of the *TPWC Act* (2000). The orchid *Dendrobium affine* was commonly identified on the trunks of Cycad plants throughout the project lease area during ground surveys. This species has a widespread distribution and is

common in the Top End. Construction of the proposed project will result in the inadvertent destruction of some orchid plants. Statutory listing of orchids is mainly to protect them from illegal trade. As with Cycads, the presence of orchids does not preclude development, however, it does impose the requirement that a permit from PWCNT be sought prior to construction.

6.5.1.2 Terrestrial Fauna

A study of the fauna on the site was undertaken during November 2002 and February 2003 for the project, and the complete report is provided in **Appendix 11**. Survey locations are shown the report. A total of 7 mammal species (1 introduced), 65 bird species, 9 amphibian species and 22 reptile species (1 introduced) were recorded in quadrats during the two surveys.

Nine species of amphibians were recorded during the survey, three in November, and all nine species during February 2003. Amphibians were commonly associated with wetter habitats and more readily detected just before, during or immediately after rainfall. The Jabiru toadlet *Uperoleia arenicola* and Bilingual frog *Crinia bilingua* were the most common species. Only one site contained standing water (Site 8a in the centre of the property) and had by far the highest diversity of frogs (8 species). Frog spawn of the Marbled Frog *Limnodynastes convexiusculus* was also recorded at this site during February. Although recorded relatively infrequently within the quadrats, large numbers of Giant Frogs *Cyclorana australis* could frequently be heard in the vicinity of many sites during spotlighting.

A total of 22 reptile species was recorded within the survey area, with 17 identified within quadrats and an additional 5 species recorded incidentally. The surveys revealed a taxonomically diverse reptile fauna with 9 skinks, 2 monitors, 2 snakes, 2 geckos, 3 dragons and one blind snake recorded. The Douglas Skink *Glaphyromorphus douglasi*, Port Essington Ctenotus *Ctenotus essingtoni* and the Red-sided Rainbow Skink *Carlia rufilatus* were the most abundant species. All species for which there were several records were recorded at numerous sites. Reptiles were recorded in all habitats with the highest diversity in open woodland sites. The majority of reptiles was recorded during active searches during the day although many of the larger species (monitors) were captured in either Elliot, pitfall or cage traps.

Birds were the most diverse group of vertebrates recorded during the study with 61 species recorded within quadrats, and an additional four species recorded incidentally in the study area. A total of 46 species was recorded in November and 48 during the February survey. The most abundant species were those that commonly inhabit the dry open woodlands that are widely distributed across northern Australia. Most species were recorded across a range of habitats, with similar species richness between sites. The mangroves, and to a lesser extent the vine forest, were the only habitats with a specialised bird fauna. Seven species were recorded only in the mangroves while the Orange-footed Scrubfowl and Green-backed Gerygone were recorded only in vine forest. Four nocturnal bird species, Tawny Frogmouth *Podargus strigoides*, Southern Boobook Owl *Ninox boobook*, Barking Owl *Ninox connivens* and Bush Stone-Curlew *Burhinus grallarius* (reported as *B. reinwardt* in study report), were recorded during spotlighting within the study area. An additional nocturnal bird, Spotted Nightjar *Eurostopodus argus* (reported as *E. guttatus* in study report), was recorded roosting in vine thickets at site 8b. Five diurnal raptors were recorded within the site, the two most commonly seen; Osprey *Pandion haliaetus* and White-breasted Sea Eagle *Haliaeetus leucogaster* were associated with the mangrove / mudflat ecotone. The only bird species recorded on the site with listed conservation status was Emu *Dromaius novaehollandiae* (Garnett and Crowley 2000), which was seen during both surveys in the dry open woodland.

Mammals were the least diverse vertebrate group on the study area, with only eight species recorded. They included two species of macropod, three rodents, one dasyurid, one possum and one fruit bat. Five species were recorded during both surveys, the brushtail possum *Trichosurus vulpecula* was recorded only in November and the Red-cheeked Dunnart *Sminthopsis virginiae* and Western Chestnut mouse *Pseudomys nanus* only in February. The Black Flying-fox *Pteropus alecto* was recorded incidentally in the study area during February. Few (particularly small) mammals were recorded during the survey and the sites where

small mammals were captured relatively consistently did not yield high abundances. The wetter habitats contained the most species, and no mammals were recorded at five sites. A late wet season bat survey using the Anabat detector was conducted, and no calibration tones could be found on the early wet season tape. Survey results can therefore only be presented for the late wet season survey. Species recorded included *Taphozous kapalgensis, Scotorepens greyii, Chalinolobus nigrogreseus, Pipistrellus westralis, Miniopteris schreibersii, Nyctophilus walkeri, Nyctophilus sp.* The Arnhem Sheath-tail bat *Taphozous kapalgensis* is considered 'near-threatened' under the *Territory Parks & Wildlife Conservation Act.*

Several sightings were made of wild pig *Sus scrofa* in the study area and additional evidence included tracks, scats and rootings in all habitats, particularly along drainage lines and in monsoon vine forests. Pigs are likely to be the most numerous and significant introduced vertebrate species within the study area. The Asian House Gecko *Hemidactylus frenatus* was also recorded in the study area.

6.5.1.2.1 Significant Terrestrial Fauna Species

The majority of species recorded within the study area are widespread in tropical Australia and no species are listed in the *Environment Protection and Biodiversity Conservation Act 1999*. There are also no records of fauna of conservation interest in the area on the Biodiversity Assessment Unit (DIPE) database, although this probably reflects a lack of surveying in the area.

Amphibians
The frog species recorded within the study area are predominantly those that have a known distribution across the tropical and semi-arid regions of northern Australia. All species recorded are generally common throughout the Top End and most have been recorded in conservation reserves in the region (Griffiths *et. al.* 1997). No species are listed in the *Environment Protection and Biodiversity Conservation Act 1999*. There are also no records of fauna of conservation interest in the area on the Biodiversity Assessment Unit (DIPE) database, although this probably reflects a lack of surveying in the area.

Reptiles
Although there is a paucity of survey data from this general region, the majority of species that were recorded are more than likely common in the area and none are considered to have threatened status (TPWC Act 2001; EPBC Act 1999; Cogger *et al.* 2000).

Birds
The Emu was the only bird species with listed conservation status. It is listed as 'of least concern' by Garnett and Crowley (2000) and it is believed to be in decline in the Northern Territory (Storr 1977). It is listed as 'near threatened' under the *Territory Parks & Wildlife Act.* The atlas of Australian birds (Emison *et al.* 1987) shows it is more common along the Northern Territory coast to the south of Darwin, than elsewhere in the Top-End. Emu scats found on the study area contained a large proportion of Sand Palm *Livistona humilis* seeds. These plants are very common on the southern end of the study area, and in the broader (off-site) area. Although this project covers a small proportion of this habitat in the region, continued land clearing in the area could threaten this population.

Mammals
Very few mammals were recorded throughout the study, with recordings of most species occurring from one or two trapped individuals, none of which are considered to have threatened status (*TPWC Act 2001*; *EPBC Act 1999*; Strahan 1995). Although not recorded within the study area, one mammal of significance, the Northern Quoll *Dasyurus hallucatus* was noted approximately 20 km to the East (during the November survey). This species is listed as 'lower risk - near threatened' (*TPWC Act 2001*) and its range is becoming increasingly restricted and disjunct (Braithwaite & Griffiths 1994). This reduction in range has been attributed directly to habitat disturbance, suggesting this species is intolerant of sub-optimal habitats that have been disturbed. The Northern Quoll is likely to occur in study area.

Migratory Species
Two species covered by migratory international migratory bird agreements (CAMBA, JAMBA) and migratory provisions of the *EPBC Act* were noted and probably occur sporadically along the mangrove edges at different times of the year. These are the White-breasted Sea Eagle *Haliaeetus leucogaster* (CAMBA) and Whimbrel *Numenius phaeopus*.

Two further species that are covered by migratory provisions of the *EPBC Act* are likely to occur within the mangroves in the area; the Estuarine Crocodile *Crocodylus porosus*, and the Rufous Fantail *Rhipidura rufifrons*.

6.5.1.2.2 Significance of Habitats to Terrestrial Wildlife

Cypress Pine Woodland
Fauna Site 9 on the western side of Point Ceylon on Wheatley Creek consists of Cypress Pine *Callitris intratropica* dominated habitat, very close to tidal influences adjacent to mangroves. Although no threatened species were found in this habitat during this study, stands of this size are uncommon in lowland areas of the Top End. This is discussed more fully under the Flora section 6.5.1.1.

Riparian Woodlands and Associated Wetlands
The wetter habitats, particularly those dominated by *Lophostemon lactifluus* contained high levels of diversity and may be important dry season refuges for many species. The majority of amphibian species were recorded in these habitats and they are probably important breeding sites. Almost all records of small mammal species; Dusky Rat *Rattus colletti*, Delicate Mouse *Pseudomys delicatulus*, Western Chestnut Mouse *Pseudomys nanus* and Red Cheeked Dunnart *Sminthopsis virginiae* were from either riparian or wetter habitats.

Monsoon Vine Thickets
Point Ceylon contains a number of scattered patches of monsoon vine thicket, the largest of which is 57 ha. This patch is also the most isolated, being situated in the far north-east of the eastern arm of the peninsula and accessible only by a heavily regenerated 4wd track. Although not highly diverse in its faunal assemblage, patches of this size are rare in the Top End due probably to existing burning practices. Because of it relative size and isolation, this patch is worthy of retention and protection from future fire events. It will not be affected at all by the project.

Eucalypt Dominated Vegetation Groups
Mixed eucalypt communities including *Eucalyptus tetrodonta/ E. miniata* woodlands are the most common habitat within the study area and support a large number of locally and regionally common birds, reptiles and large mammals. These complexes provide potential habitat for the threatened Northern Quoll and are likely to attract large numbers of certain species (predominantly bats and birds) during canopy flowering events.

6.5.1.3 Aquatic (freshwater) Fauna

A study of freshwater aquatic habitats and fauna (vertebrates and invertebrates) was conducted for an Environmental Impact Statement being prepared for the proposed Point Ceylon Aquaculture Estates at Point Ceylon in Bynoe Harbour. The report is provided in **Appendix 12.** Survey locations are shown on **figure 6.6.** The purpose of the study was to collect baseline data that will facilitate a description of the existing freshwater aquatic environments and assess the potential impacts of the proposed development on aquatic habitats and species. Four sites were surveyed on a small ephemeral stream in the Project Area during late April 2003. Aquatic habitats were described and fauna identified using both capture and observational techniques.

The survey stream, Wheatley Creek, supports a healthy population of aquatic plants and a total of 8 species of aquatic/semi-aquatic vertebrates (including 6 fish species) and 30 macro-invertebrate taxa were recorded. Site 4, about two kilometres upstream from the proposed weir on the south-east branch of Wheatley Creek,

had the highest diversity (5 species), with both non-fish vertebrate observations being at this site. It is likely that the permanent pools observed at Site 4 act as a dry season refuge when the remainder of the creek system dries out. Black-lined rainbowfish were the most abundant species, and were recorded at all sites. Empire gudgeon recorded at Site 1 are common in coastal waters around Australia and are known to tolerate near-brackish conditions (Larson and Martin 1989). Site locations are shown in the report.

Table 6.9 Freshwater vertebrate fauna recorded at sampling sites 1-4

Species	Common Name	Site			
		1	2	3	4
Hypseleotris compressa	Empire gudgeon	✓			
Mogurnda mogurnda	Purple-spotted gudgeon			✓	✓
Melanotaenia nigrans	Black-lined rainbowfish	✓	✓	✓	✓
Toxotes chatareus	Common archerfish		✓		
Megalops cyprinoides	Tarpon		✓		
Neosilurus hyrtlii	Eel-tailed catfish				✓
Liasis fuscus	Water python				✓
Varanus mertensi	Water monitor				✓
	Total species	2	3	2	5

The insect order Coleoptera (beetles) was the most diverse group of invertebrates (Table 3 of the report). A total of 237 individual animals were collected at the four sites. The most consistently abundant group across all sites were mayflies from the order Baetidae. Diving beetles from the order Dytiscidae were also common at most sites. Site 3 had the highest taxonomic richness of any the sites, with 20 taxa recorded.

Although there have been no known surveys of macro-invertebrates in the Bynoe Harbour catchment, a comparison (at the same taxonomic resolution) with coastal systems surveyed in the Darwin Harbour catchment (Dostine 2002) shows that diversity in the stream surveyed in this study is slightly lower (mean number of taxa = 15) than that recorded from similar systems in the Darwin Harbour catchment (mean number of taxa = 20). However, this may be due to there being some considerably larger systems included in the Darwin Harbour surveys, which generally had higher numbers of taxa than the smaller systems (Dostine 2002).

The number of species and composition of the fish community recorded in the survey stream are similar to other freshwater systems in the region, as indicated by NT Museum database records. None of the vertebrate or invertebrate aquatic fauna or habitats identified during the survey is listed for conservation significance under local, national or international conventions. The system does not appear to be significant in a regional context, with diversity of both vertebrate and invertebrate fauna being relatively low. However, the permanent waterholes in the vicinity of Site 4 in the upper reaches of the creek offer refuge habitat to aquatic fauna when most of the stream dries late in the dry season, and are therefore of conservation interest at a local level.

6.5.1.4 Biting Insects

Four studies of biting insects have been undertaken in the region adjacent to the proposed development at Point Ceylon (Booth *et al.* 1987a; Booth & Whelan 1987; Booth *et al.* 1987b; Whelan & Dobson 1987). These studies were of a range of habitats which are similar to those encountered at Point Ceylon and environs.

Recommendations on mitigation and management are documented and synthesised for this report. It is considered that the previous studies provide sufficient information on the likely types and abundances of biting insects to be found on the peninsula to Point Ceylon, and that additional studies of the specific location are unwarranted.

Biting Insects in the Northern Territory

In the Northern Territory there are approximately 100 different species of mosquitoes. Only about forty of these species are known to bite people, and only about twenty species occur in numbers large enough to be problematic. Ross River virus, Barmah Forest virus and Murray Valley encephalitis are the arbo-viruses (arthropod-borne viruses) known to cause human disease in the Northern Territory (Whelan 1997c). The Aquaculture development has the potential to provide additional sites for breeding for a number of 'pest' species. These are tabulated below along with their pest status, disease vector status and habitat breeding requirements, in **Table 6.10**. Mitigation measures are described in the sections on impacts and mitigation.

Biting midges are also common in the Northern Territory, and major pest midges of the Top End are tabulated in **Table 6.11**.

Previous reports

The four previous studies undertaken in the adjacent region were between 10 to 20 kilometres to the west, one between 6 and 15 kilometres south and south-east, one 3 to 4 km west, and the other 8 km north-east of the centre of the proposed development area. The study locations are mapped in **figure 6.7**. The species of biting insects reported are shown in **Table 6.12**.

Table 6.10 Major Pest and Vector Mosquito Species in the Top End of the NT (* 'problem' mosquitoes).

Species/ (common name)	Pest Status	Vector Status	Habitat breeding requirements
Aedes funereus	Local pest near breeding grounds, does not disperse. Common only near tidal creeks or brackish swamps.	Potential arbovirus vector	Eggs laid on moist substrate, usually shaded with some salt influence; do not disperse far from breeding habitat.
Aedes kochi	Local pest at breeding sites, does not disperse	No diseases	Breeding in axils of *Pandanus* leaves.
Aedes normanensis * (Floodwater mosquito)	Major pest, bites in evening and night within 3 km of breeding sites. Plagues in inland areas a week after widespread flooding rains in wet season. Will fly up to 5 km in pest numbers.	Major vector of Ross River and Barmah Forest viruses. Potential vector of Murray Valley encephalitis virus. Potential vector of many other arboviruses.	Eggs deposited in drying mud substrate in poorly drained floodways.
Aedes notoscriptus * (Container mosquito)	Local urban pest, container or tree hole breeder, bites persistently, anytime in cool shade. Found in forest areas.	Potential Ross River virus vector. Major vector of heart worm in dogs.	Eggs laid in tree holes and containers. Does not disperse widely.
Aedes tremulus	Local urban pest, container or tree hole breeder, in forest areas; do not disperse from feeding habitat	No diseases	Tree hole and container breeder; in *Eucalyptus* forests
Aedes vigilax * (Salt marsh mosquito)	Major pest, within 5km of breeding sites; plagues associated with high dry season tides in late dry season, early wet season. Fly up to 60km in pest numbers.	Major vector of Ross River and Barmah Forest virus diseases and dog heart worm. Potential vector of many other arboviruses.	In mud or near plant stems in suitable habitats; breeds in tidal pools and marshes, upper tidal zone of *Schoenoplectus* or landward ill-draining mangroves.
Anopheles annulipes	Widespread pest, bites at night and will enter houses. Flies up to 2 km from breeding site.	Potential malaria vector.	Eggs laid on water surface, temporary or permanent, some containers, sewage ponds.
Anopheles bancroftii * (Black malaria mosquito)	Major pest, widespread, bites anytime near breeding site, nightly or shaded areas elsewhere. Flies up to 4 km from breeding site.	Potential malaria vector.	Eggs laid at water surface. Found in heavily shaded fresh to brackish ground pools or swamps especially in paperbarks or *Eleocharis* reed swamps
Anopheles farauti species complex * (Australian malaria mosquito)	Local pest, bites at night. Uncommon except near mostly sub-coastal and freshwater and brackish swamps. Will fly up to 2 km from breeding site.	Major potential vector of malaria.	Eggs laid on surface. 2 species of the complex breed in fresh water swamps and pools. Larval habitat often sunlit.
Anopheles hilli	Coastal pest, bites at night, enters houses. Common near brackish water swamps; disperses up to 4km from breeding site.	Potential malaria vector	Eggs laid on surface; sunlit or shaded brackish to saline ground pools or swamps; numerous in *Schoenoplectus* reed swamps near coast

Species/ (common name)	Pest Status	Vector Status	Habitat breeding requirements
Anopheles meraukensis	Local pest, bites after dark. Very common near extensive freshwater swamp.	Not potential malaria vector.	Eggs laid on surface of water, usually in freshwater *Eleocharis* reed swamps, sunlit or shaded.
Culex annulirostris * (Common banded mosquito)	Major pest, very common and widespread in both urban and rural areas. Bites mainly in the evening and night. Will fly up to 10 km from breeding site, common up to 4km from breeding site.	Major arbovirus vector of Murray Valley Encephalitis, Kunjin, Ross River and Barmah Forest virus and dog heartworm. Vector of numerous other arboviruses.	Eggs deposited on water surface in fresh water pools and swamps with emergent vegetation temporary or permanent. Will colonise domestic containers and breed readily in semi-polluted water in storm drains and sewage ponds.
Culex quinquefasciatus * (Brown house mosquito)	Major urban pest, populations common with polluted water in dry season. Flies up to 1 km	Potential arbovirus vector. Vector of heartworm of dogs.	Polluted to fresh domestic waters, including spetic tanks, leach drains, primary sewage ponds and other polluted ground waters.
Culex sitiens	Localised coastal pest. Disperses widely, will fly up to 5km but common within 2km of breeding site.	Probably no diseases. Possible Ross River Virus disease.	Breeds in brackish or tidal waters.
Coquillettidia xanthogaster * (Golden mosquito)	Major localised pest near extensive reed swamps. Strong fliers and will disperse widely up to 3-5 km. (Roper River area only)	No diseases.	Semi-permanent to permanent swamps with emergent vegetation; associated with *Eleocharis* and *Typha* reeds.
Mansonia uniformis * (Waterlily mosquito)	Localised severe pest. Generally does not fly more than 1-2km from breeding sites. Strongly attracted to light.	No diseases	Semi-permanent to permanent swamps with emergent vegetation.

Adapted from (Whelan 1997c)

Table 6.11 Major Pest Biting Midge Species in the Top End of the NT

Species/ (common name)	Pest Status	Vector Status	Habitat breeding requirements
99% (Ref 1)			
Culicoides ornatus	Bites people readily and a serious human pest; can disperse up to 1.5 km from tidal flats (Ref 2); over 240 per trap night presents a pest problem, greater than 1000 per trap night is a major pest problem; present all year round; massive emergence around neap tides	No diseases	Mud under dense mangrove cover in neap tide zone, in close association with the mangrove *Rhyzophora stylosa* and in the presence of *Aegiceras corniculatum*; in widest areas of neap tide zone facing open water, away from freshwater drainage lines; mangroves penetrated by narrow creeks, with low variation in salinity

Species/ (common name)	Pest Status	Vector Status	Habitat breeding requirements
Culicoides sp. near *hewitti*	Occasionally bites people	No diseases	Upper estuary, brackish influenced mangrove areas
Other 1%			
Culicoides marksi	Occasionally bites people	No reported diseases	Breeds in margins of fresh water lakes and streams
Culicoides narrabeenensis	Rarely bites people	No reported diseases	Breeds at edge of fresh water
Culicoides pallidothorax	NT species rarely bites people	No reported diseases	? Breeds near fresh water
Culicoides ?pangkorensis	Occasionally bites people	No reported diseases	Upper estuary
C. austropalpalis *C. brevitarsis* *C. immaculatus* *C. magnesianus* *C. sp. nr. ornatus A* *C. sp. nr. ornatus B* *C. sp. nr. ornatus C* *C. sp. nr. ornatus D* *C. subimmaculatus*	No published information		

1 (Whelan 1995)
2 (Shivas *et al.* 1997)

Table 6.12 Biting midges and mosquitoes reported from previous studies in the Bynoe/Finniss region

STUDY	1	1	2	3	4
SPECIES/ (common name)	**Finniss Inland**	**Finniss Coastal**	**Bynoe Sn 2883**	**Finniss Sn 2881**	**Crab Claw**
MOSQUITOES					
Aedomyia catasticta	-	U			
Aedes alboscutellatus					U
Aedes alternans				R	R
Aedes daliensis	-	R		U	C
Aedes elchoensis			R	U	
Aedes funereus				U	
Aedes normanensis * (Floodwater mosquito)				R	
Aedes notoscriptus * (Container mosquito)				U	U
Aedes purpureus				R	
Aedes reesi	-	R			
Aedes sp 76	-	U		U	C
Aedes tremulus			U	U	
Aedes vigilax * (Salt marsh mosquito)	-	U		C	A
Anopheles annulipes	U	U	U		C
Anopheles bancroftii * (Black malaria mosquito)	A	A	U		
Anopheles farauti species complex * (Australian malaria mosquito)	U	C			R
Anopheles hilli	-	C	R	R	R
Anopheles meraukensis	U	U	R	R	
Anopheles novaguinensis	U	U			
Coquillettidia xanthogaster * (Golden mosquito)	A	A	A	U	
Culex annulirostris * (Common banded mosquito)	A	A	A	U	U
Culex bitaeniorhynchus	U	-	R		
Culex fraudatrix var. annulata	R	-			
Culex pullus	U	-			
Culex sitiens	U	C		U	C
Culex sp. 32	-	U			
Culex sp 167	U	R		U	
Culex squamosus	U	U			
Culex vicinus	U	R			

STUDY	1	1	2	3	4
SPECIES/ (common name)	**Finniss Inland**	**Finniss Coastal**	**Bynoe Sn 2883**	**Finniss Sn 2881**	**Crab Claw**
Mansonia uniformis *(Waterlily mosquito)	A	A	R		
Tripteroides magnesianus	R	-			
Uranotaenia nivipes	U	R			
Uranotaenia novaguinensis	-	R			
BITING MIDGES					
Culicoides austropalpalis				U	R
Culicoides brevitarsis			U		
Culicoides hewitti			C	U	C*
Culicoides immaculatus				R	
Culicoides magnesianus				U	R
Culicoides marksii			C	R	
Culicoides ornatus			A***	C	A**
Culicoides pallidothorax				U	
Culicoides sp (unknown)			U		R
Culicoides sp. nr. ornatus A				R	
Culicoides sp. nr. ornatus B				R	
Culicoides sp. nr. ornatus C				U	
Culicoides sp. nr. ornatus D				U	
Culicoides subimmaculatus				U	U

Key:

A = Abundant (on most sites greater than 100 per trap night - standard maximum acceptable level of species *Culex annulirostris* in a residential area; for midges >240/trap night)

C = Common (present on more than half the sites, usually in low numbers); U = Uncommon (a few sites in low numbers); R = Rare (one site only)

* = two traps with over 240/trap night; ** greater than 1000/trap night in three of nine traps; *** greater than 1000/trap night in three of six traps

Studies:

1. (Booth *et al*. 1987b)
2. (Booth *et al*. 1987a)
3. (Booth & Whelan 1987)
4. (Whelan & Dobson 1987)

6.5.1.5 Description of Marine/estuarine biota & habitats

Bynoe Harbour has not been well studied and little or no literature exists on many scientific aspects of the harbour including formal fish surveys (Helen Larson, MAGNT, pers. comm.), molluscs (Richard Willan, MAGNT, pers. comm.), and hard and soft corals (Phil Alderslade, MAGNT, pers. comm.).

Neil Schmidt (DIPE, pers. comm.) has extensively surveyed Bynoe Harbour recently, including habitat mapping (including underwater video techniques), fish surveys and trammel netting. He has also taken acoustic measurements for a hydrographic survey of Bynoe Harbour. His results will include some information on the habitats adjacent to Point Ceylon and Toss Point which appear to include soft coral and hydroid gardens. Preliminary information also suggests patchy seagrass beds to the south east of Indian Island near to Point Ceylon. The hydrographic survey will include Mackenzie Arm. No work was done in Wheatley Creek.

Schmidt's report will not be available until at least mid year 2003. Some preliminary observations (Schmidt, pers. comm.) include that Bynoe Harbour appears to have more reef development than Darwin Harbour including mature reef development. All reef development is sub-tidal. The reason for this better reef development is probably because the flow through Bynoe Harbour is stronger than in the broad Darwin Harbour, allowing sediment to be held in suspension, and not smothering any potential reef building. It is unlikely that marine pests will be found in the southern Bynoe Harbour area. It is not possible to make a judgement at this stage on the conservation significance of the Bynoe Harbour habitats and species.

While dugongs and turtles are known to occur in the Fog Bay area (S. Whiting, pers. comm. 2003) no detailed surveys have been carried out in Bynoe Harbour. One aerial survey which flew over the southern Indian Island and Point Ceylon area in November 2002, did not sight any dugongs or turtles (Whiting, pers. comm.). It is likely, however, that Green Turtles and Hawksbill Turtles will occur in the area since they frequent rocky reefs to feed on algae (Whiting, pers. comm.). Rocky reefs are known to occur off Toss Point (Schmidt, pers. comm.). There are no beaches at Ceylon Pt which are known to provide breeding habitat for turtles.

6.5.1.5.1 Mangroves

The mangroves of Bynoe Harbour have been recently extensively mapped (Brocklehurst & Edmeades 2003). The information for this section has been drawn extensively this report. There are approximately 24,000 ha of mangroves in Bynoe Harbour, the Islands and north to Charles Point (**Figure 6.8)**. No mangroves occur below mean low water neaps (Local Chart Datum Darwin) at approximately 3 metres. Mangrove vegetation occurs up to the 7.5 m tidal level. Mangrove zonation is strongly influenced by tidal elevation. Brocklehurst and Edmeades (2003) mapped a total of 26 main mangrove communities basing their classification and terminology on the National Vegetation Information System classification hierarchy (National Land and Water Resources Audit 2001).

Ceriops tagal forest is the most widespread community of Bynoe Harbour, forming 36% of mangrove area. *Rhizophora stylosa* closed forest is also common, making up 30% of mangrove area. It is the dominant community in the Point Ceylon area, along the tidal Mackenzie Arm and Wheatley Creek, and on the seaward edge of the main tidal flat. Common species found with *R. stylosa* include *Avicennia marina, Bruguiera spp., Camptostemon schultzii* and *Aegiceras corniculatum. Sonneratia alba* open forest and open woodland occurs on the seaward edge of mangrove forests including around Point Ceylon itself.

Mixed species low closed forests and closed-forests occur as narrow bands on the landward edge of the mangrove zone and include *Lumnitzera racemosa, Exoecaria ovalis* and *Ceriops tagal.*

Brocklehurst and Edmeades (2003) have, amongst other things, broadly categorised mangroves of Bynoe Harbour into shoreline forest, tidal creek forest, transition forest and hinterland forest communities. The shoreline around Point Ceylon itself (not including Toss Point) and Wheatley Creek is characterised by *R. stylosa* shoreline forest communities. *R. stylosa* low closed-forest occurs around Point Ceylon in a narrow band. Along Wheatley Creek there are extensive stands of *R. stylosa* low closed-forest.

In Bynoe Harbour, three tidal creek communities have been identified, separated by the abundance of *Bruguiera parviflora*. Two of these communities, with *B. parviflora* as a minor component and with *B. parviflora* as dominant to co-dominant with *R. stylosa* (the other community has *B. parviflora* dominant to mono-specific) characterise the tidal creeks of Mackenzie Arm, the inlet in between Point Ceylon and Toss Point and the eastern inlet of Milne Inlet. These communities are the most species-rich of all the mangrove communities of Bynoe Harbour. Thickets of *Camptostemon schultzii* and *Aegiceras corniculatum* line the creek banks, particularly in the higher reaches of these inlets and also the highest reaches of Wheatley Creek. *Avicennia marina, Ceriops decandra, C. tagal* and *Camptostemon schultzii* are also common in these tidal communities. In some cases, particularly west of Point Ceylon, where it continues into Mackenzie arm, *Avicennia marina* and *C. tagal* are co-dominant.

Except for Point Ceylon itself, the tidal creek communities grade into widespread transition zone forests characterised by *R. stylosa* with *Ceriops tagal* with *C. tagal* becoming dominant moving away from the creeks and inlets. *Bruguiera exaristata* is co-dominant in the mid-stratum. Emergents include *Exoecaria ovalis, Lumnitzera racemosa* and *Avicennia marina*. Species common to the littoral fringe include *Diospyros littorea, Melaleuca cajuputi* and *Melaleuca spp.* This mixed species closed forest forms the boundary between mangrove and terrestrial vegetation around most of the Portion.

Other communities include salt-flats and some minor communities of mixed species of low woodland and samphire, scattered along the landward edge of the mangrove communities.

6.5.2 Potential and Anticipated Impacts

6.5.2.1 Impacts on and from biting insects

Most major Northern Territory pest mosquito species (see **Table 6.10**) occur in the region, and many minor ones also are found. The construction of the Point Ceylon Aquaculture Estates will be carried out during the dry season, so there is little potential for the creation of mosquito breeding sites during construction. Creation of breeding sites for pest species of mosquito is possible, however, if any depressions allowing the pooling of water are created and are not removed during construction and reinstatement phases. Mosquitoes will breed in depressions which contain water for five days, particularly if those pools do not have any biological control agents such as fish, aquatic beetles and bugs, dragonfly and damsel-fly nymphs. The most serious impacts will occur near settlements, within 5 kilometres of any potential breeding site.

The presence of mosquitoes and biting midges can potentially cause problems in managing the aquaculture ponds. Impacts may include nuisances to personnel operating the facility, and potentially impacts on the water quality in the ponds, retention weir and water supply. One common treatment for juvenile midges is the use of temephos, a larvacide (trade name "Abate") which has been found to be only partially successful due to increased resistance, but importantly is also reported to cause adverse effects in crustaceans and molluscs, particularly in the early stage of development. Adult midges have been treated with aerial fogging, but this requires substantial effort and frequent application, and the insecticides used, Maldison and Bioresmethrin, are non-specific and hence have an effect on non-target animals (Whelan 1995).

Mosquito control may be achieved by the use of the mosquito larval insecticide *Bacillus thuringeniensis* var. *israelensis*, commonly known as "Bti". This insecticide avoids any deleterious effects on non-target animals. Treatment of breeding sites requires monitoring to determine where the breeding sites are, and the cost of treatment. Treatment can be undertaken by a small team using ground application equipment (Whelan 1995). The use of insecticides such as Maldison for mosquito control near the aquaculture project should be avoided due to the potential impacts on the prawns, particularly at the hatching, post-larval (PL) and juvenile stages. An efficient larval control program should reduce the need to adult mosquito control programs.

6.5.2.2 Impacts on flora

Clearing and other direct impacts associated with construction and operation

Construction of the production ponds, freshwater weir, breeding facility, production areas and access roads will result in the clearing of up to a total of 182.5 ha of vegetation in the project lease area. 46.5 ha of this will be cleared for the construction of Stage 1. Further clearing up to a maximum of 136 ha will take place to accommodate Stage 2-5 expansion of the project.

6.5.2.2.1 Vegetation communities traversed by the access road

The main access track to the site will be off the Fog Bay Road. Construction of the track will require the removal of a 20 m wide corridor of vegetation in areas where a new alignment is required. Approximately 3.4 km of the access track follows existing track alignments. Where this is the case further clearance will be required to widen the track to a total width of 20 m.

A new road alignment will be cleared from the Fog Bay road north to an existing track alignment. This new alignment will cover a total distance of 6.3 km and will require clearing of 12.6 ha of vegetation. The vegetation of the country traversed by the new road alignment is generally *Eucalyptus* dominated woodland to open woodland, with a mixed species understorey. The vegetation corresponds to map units C1 and A3, which do not occur as distinct communities as indicated on the vegetation map but rather grade into each other. Dominant species include: *Eucalyptus polysciada, E. tetrodonta, E. miniata and Erythrophleum chlorostachys.* Common species recorded in the mid-storey include: *Cycas maconochiei, Livistona humilis, Petalostigma pubescens, Planchonia careya, Pandanus spiralis* and *Grevillea spp*. The alignment traverses a number of broad drainage lines mapped as vegetation group B1. The vegetation of these broad drainage lines is structurally distinct but similar in species composition to the surrounding vegetation.

The proposed access road follows an existing track alignment west for 1 km from (669460E, 8587740N) to (668450E, 8587760N). The vegetation traversed by this section of the proposed alignment is tall open woodland of *E. tetrodonta*. In some areas *E. polysciada* is a co-dominant species in this community. The mid storey of this community was typically comprised of *Cycas maconochiei, Livistona humilis, Petalostigma pubescens, Planchonia careya, Acacia auriculiformis, Timonius timon* and *Vitex glabrata.* Construction of this section of the access track will require the removal of 1.7 ha of vegetation.

From the southern boundary of Portion 3192 (668450E, 8587760N) a new access track alignment will be cleared north for a distance of 5.5 km. This new track alignment traverses through the middle of the production ponds and meets up with an existing track alignment at (667740E, 8592760N). Construction of this section of the access track will require clearing of 11 ha of *Eucalyptus spp*. dominated woodland to open woodland. Dominant species include: *Eucalyptus miniata, Erythrophleum chlorostachys, Corymbia bleeseri,* and *E. tetrodonta*. Species dominance in the upper and mid layers of this community varies according to local variations in topography. A detailed description is provided in section 4.1.1 of the report.

The access track follows an existing track alignment from (667740E, 8592760N) to the proposed breeding facility site at Point Ceylon. Construction of this section of the access track will require

clearing of 4.4 ha of vegetation. The vegetation along the existing alignment is characterised by a low mixed-species woodland with an incursion of monsoon vine forest elements. Dominant species in this community include: *Acacia auriculiformis, Acacia latescens, Eucalyptus polycarpa, Eualyptus miniata, Alstonia actinophylla, Terminalia ferdinandiana, Persoonia falcata, Buchanania obovata, Grevillea dryandri, Grevillea heliosperma, Stenocarpus acacioides, Strychnos lucida, Cycas maconochiei*. There are a number of old dirt mounds along the track, which have been colonised by weed species.

6.5.2.2.2 Vegetation communities at the proposed breeding facility site

The proposed breeding facility complex is located on the hinterland peninsula at Point Ceylon. The removal of 0.35 ha of vegetation will be required to construct Stage 1 of the breeding facility complex. Progressive removal of up to an additional 4.8 ha of vegetation will be required during Stages 2-5 to accommodate expansion of the breeding facility.

The vegetation at the proposed breeding facility site is mixed species low open woodland with an incursion of monsoon vine forest elements. The site has been significantly disturbed by historic development and exploration activities as is evidenced by the presence of numerous un-rehabilitated excavations, old dams and infrastructure. Most of the site has been previously cleared and therefore the vegetation present at the site is largely regrowth. Dominant species in this community include: *Acacia auriculiformis, Acacia latescens, Eucalyptus polycarpa, Eualyptus miniata, Alstonia actinophylla, Terminalia ferdinandiana, Persoonia falcata, Buchanania obovata, Grevillea dryandrii, Grevillea heliosperma, Stenocarpus acacioides, Strychnos lucida, Cycas maconochiei*.

6.5.2.2.3 Vegetation communities at the proposed pond site

Construction of the production ponds, accommodation compound and sludge drying beds will require clearing of 0.6 ha of vegetation during Stage 1. Progressive removal of up to a further 2.4 ha will occur at Stages 2-5. The vegetation that will be cleared is predominantly *Eucalyptus spp.* dominated woodland to open woodland. Dominant species in this community include: *Eucalyptus miniata, Erythrophleum chlorostachys, Corymbia bleeseri*, and *E. tetrodonta*. Species dominance in the upper and mid layers of this community varies according to local variations in topography. A detailed description is provided in section 4.1.1 of the report.

The saltwater and freshwater intakes for the production ponds are flexible pipes which can be put into place without removing any vegetation.

6.5.2.2.4 Vegetation communities inundated by the freshwater weir

The proposed freshwater weir is located upstream of the extent of tidal influence on Wheatley Creek. The weir during high flows will result in the temporary inundation of 12 ha of riparian forest upstream of the weir. The vegetation of the area proposed for the freshwater weir is characterised by tall closed forest where the dominant species include: *Acacia auriculiformis, Erythrophleum chlorostachys, Lophostemon lactifluus, Melaleuca nervosa and Xanthostemon eucalyptoides*. The mid storey of this community is dominated by: *Exocarpos latifolius, Canarium australianum, Cycas maconochiei, Drypetes deplanchei, Barringtonia acutangula, Terminalia ferdinandiana, Livistona humilis, Petalostigma pubescens, Diospyros calycantha, Vitex glabrata, Buchanania obovata*, and *Timonius timon*, which occur over grass and sedge species such as *Eulalia spp., Scleria spp., Flagellaria indica* and *Imperata cylindrica*.

The impacts on the flora as a result of construction and operation of the freshwater weir will depend on the management of construction activities and the nature and duration of flooding. Construction of the weir will involve substantial disturbance of the creek banks in the immediate area. The potential for this disturbance to cause erosion and siltation of the creek should be minimised by ensuring that the weir is constructed in the dry season so that rehabilitation is well advanced prior to the onset of the first wet season rains.

The freshwater weir will alter the wet season flow regime of the creek and may result in the death of some riparian vegetation. However, the potential impacts on riparian vegetation have been minimised by the following aspects of the weir's design and operation:

- the freshwater weir will not be used for permanent water storage, but to collect water for transfer to off-stream storage;
- clearing at the weir site prior to construction will involve minimal vegetation removal;
- during the wet season, water will be pumped from the weir to off-stream storage, which will reduce the area inundated;
- off-stream storage in storage ponds will hold water pumped from the creek. The weir will self-drain over a period of less than 5 days resulting in near normal flow conditions; and
- no water will be retained during the dry season.

6.5.2.2.5 Introduction and spread of weeds

Weeds are abundant in those parts of the project lease area that have been disturbed by previous development and exploration activities. Point Ceylon, which has been most intensely disturbed by previous activities, is probably the area most affected by weeds. Infestations have also been recorded along existing access tracks.

Eight weed species were recorded in the project lease area. Six of these species are classified as 'declared weeds' under the NT *Weeds Management Act 2001*. Each of the recorded species and their statutory classification is documented in **Table 6.13**. It should be noted that these classifications are currently under review.

Table 6.13 Weed species recorded in the project lease area. Notes taken from (Smith 2002) and (Parsons & Cuthbertson 2001).

Weed species		Classification in project area	Notes
Species name	**Common name**		
Andropogon gayanus	Gamba Grass	Not to be introduced	A highly productive annual grass that increases fuel loads, cures later than the native annual grasses and produces intense late dry season fires which seriously damage native woody species.
Bidens pilosa	Cobbler's Peg	Not to be introduced	
Passiflora foetida	Wild Passionfruit	Not to be introduced	A fast growing species that spreads quickly, choking native vegetation.
Hyptis suaveolens	Hyptis	D & C	Forms dense thickets rendering infested areas unproductive.
Pennisetum pedicellatum	Annual Mission Grass	D & C	Cures later than native annual grasses and produces late dry season fires.
Sida obtusifolia	Sicklepod	D & C	Competes with and excludes native species.
Themeda quadrivalvis	Grader Grass	E & C (only C applicable to project site)	Can invade native pastures or grasslands and seriously reduce diversity.
Pennisetum polystachion	Mission Grass	E & C (only C applicable to project site)	Competes with and displaces native species. Remains green until late in the dry season and provides fuel for very hot fires.

Key: Class C – not to be introduced.
Class D – not to be spread by human means.
Class E – species under an approved strategy. Note: No strategies are currently in place for the project lease area.

The *Weeds Management Act 2001* places obligations on land owners and occupiers to manage the introduction and spread of declared weeds, and to comply with approved weed management plans relating to declared weeds that occur on their land. The proponent of the proposed Point Ceylon Aquaculture Estates must take all reasonable measures to prevent the spread of Class D weeds that currently occur in the project lease area, and to ensure that declared weeds of any class are not introduced into the project lease area during construction and operation of the project. A list of weeds declared under the *Weeds Management Act 2001* is included at Appendix 4of the report, however, it should be noted that this list is currently being reviewed and changes are likely.

Management of weed species not declared under the *Weeds Management Act 2001* is encouraged in order to minimise the potential impacts of these species on the environment and on the efficient operation of the project. Management of Gamba Grass is especially recommended, as this species provides fuel for hot, late season fires, which have the potential to negatively impact on the environment and to place project personnel and infrastructure at risk.

The greatest risk of weeds being introduced and spread will occur during the construction phase of the proposed project. Parts of the proposed access road, and the site of the breeding facility complex at Point Ceylon are infested with weeds. Construction activities in these areas especially have the potential to spread weeds across the project area. Furthermore, the movement of plant onto and off the site has the potential to introduce new weeds into the project lease area, and to transport weeds off the project area. A weed management program that covers the construction and operation of the proposed project is recommended.

6.5.2.3 Impacts on Terrestrial Fauna

The habitats and associated fauna of the area are typical of those from the western Top End coast but the impact of the development needs to be considered in the context of other habitat modification that has occurred or is planned in the surrounding area. Although a single development may not greatly affect populations of fauna species, a series of developments will. With this in mind, vegetation clearance should be kept to a minimum and appropriate fire regimes should be developed and regulated, and feral animal and weed populations should be controlled. These issues have been addressed in Chapter 7 and in the design and management of the project.

Habitat loss
The primary impact from the proposed development will be the loss of habitat as a direct result of land clearance for pond and infrastructure creation. This habitat is primarily open *Eucalyptus tetrodonta/ E. miniata* woodland in which a large proportion of species was recorded. None of these species is considered to be of conservation significance, and this is the most common habitat in the Top-End. The project will clear up to 183 ha of the 1997 ha of the property. Disturbance outside the development requirements will be limited by appropriate works control measures identified in Chapter 7 and the EMP.

Another impact will be associated with the weir across Wheatley Creek which will cause temporary inundation of nearby riparian vegetation and altered wet season flow downstream. This may temporarily impact upon the riparian habitat for fauna in these areas. The weir has been designed to take less than 10% of the annual flow from the creek during the wet season only, and to self drain in less then 5 days. These measures are specifically made to minimise the impacts.

Fire
With amplified activity on Point Ceylon, particularly during the construction phases, potential for fire activity may increase. Many habitats throughout the site are fire sensitive, especially the Cypress Pine forest and monsoonal vine thickets. A fire management plan will be prepared for the project.

Sedimentation
Sedimentation can cause significant impact upon aquatic environments such as streams and mangroves. During the construction phases there would be potential sedimentation impacts on frog species. The duration of the construction phases could result in the generation of sediment pulses into the local streams, albeit in response to significant rainfall events. The impact of increased suspended sediment could be a significant stress upon these species. Specific erosion and sediment control measures have been identified to avoid these potential problems.

Mangroves
The majority of the peninsula at Point Ceylon is surrounded by highly productive mangrove systems, which could be susceptible to degradation from increased sediment loads and altered water regimes from the proposed development. The project has been designed and planned to minimise or eliminate potential impacts on mangroves, as identified in Chapters 4 and 7.

Weeds and Feral Animals
The spread of weeds during and after the construction phases could contribute to the overall degradation of fauna habitat on the site, particularly adjacent to construction sites. Increased feral pig populations may further compound this problem by moving problem species further afield. Feral pigs also cause considerable damage to native, particularly riparian, vegetation. A weed management program has been outlined in Chapter 7 and the EMP, and weed management will be a specific focus during construction activities. Feral pig control is not proposed at present.

Water Tables
Changes to water tables would have negative consequences for fauna habitats, particularly paperbark swamps and monsoon vine forest. These are species rich habitats, and may also be important refuges for many species during the driest times of year. Loss of these habitats could result in a large reduction in vertebrate diversity on the site. One bore is proposed at Point Ceylon for the future, but as it is saline and some distance away from the bore, it is unlikely to affect the monsoon vine forest at the north-west edge of the point. Monitoring of the bore yield will ensure that excessive draw-down does not occur.

Migratory Species
White-bellied Sea Eagles and Whimbrels probably utilise the mangrove fringes of the study area and would not be affected to any great extent by the proposed development unless tidal regimes were altered or excess sediment / nutrient loads were released into the harbour.

Night-lighting
Although the effects of night lighting have been to shown to be hazardous to migratory birds in other places (Evans Ogden 1996), this is not considered to be a threat in northern Australia at present.

Marine turtles can be distracted during breeding seasons by lighting on shore, and hatchlings can be diverted towards the lights instead of out to sea. There are no known breeding beaches at or near Ceylon Pt, but turtles may swim past the point from time to time. The design of the lighting will be developed in order to minimise potential impacts. This is likely to be an issue at the breeding facility only, and only moderate risk is expected. Monitoring will be implemented to ensure there are no detrimental impacts on turtles.

Bird-landing control
Birds can be vectors of disease for prawns. Birds will be prevented from landing on the waters of the ponds by netting or by other devices found to be effective in the prevention of birds landing on the ponds.

Cane toads
Cane toads are not yet in the area. They may have the potential to enter ponds. Measures to prevent their entry into ponds will be developed when necessary.

6.5.2.4 Impacts on aquatic fauna

The most likely impacts of the proposed development on this freshwater aquatic system are associated with the construction of roads and a freshwater weir. Unless appropriate erosion and dust control measures are implemented (e.g. silt fences, revegetation of disturbed areas, dust suppression), the initial construction of these infrastructures could lead to increased turbidity and sedimentation in the creek during the first rains following construction. Increased turbidity over a prolonged period could negatively impact macrophytes by reducing their photosynthetic capacity. The design and construction of the project have been planned to minimise potential impacts, and the EMP provided in Chapter 7 details management actions to prevent such impacts.

The construction of a freshwater weir at the lower freshwater reaches could prevent some marine-breeding species from migrating upstream of the estuarine system. Localised flooding is also likely to result in the loss of riffle (shallow, fast flowing) habitats and invertebrate species that may prefer these habitats. A dam which held water for long periods may alternatively provide more habitats for species of macrophytes (eg waterlilies) and aquatic fauna that prefer deeper water. The construction of a relatively large permanent freshwater body could also have the positive effect of attracting water birds to the area. As the weir is designed to not retain water for a long period, these benefits will not be realised. The annual flooding of the creek will not be affected greatly by the weir, although some backup of water will occur above the weir. The water holes identified in the upper reaches of Wheatley Creek's south-east arm may be partially inundated due to this back-up during the wet season high flows, but these inundations will be similar to natural flooding events and the waterholes are unlikely to be otherwise affected by the weir. These water holes are about two kilometres upstream from the weir wall. Water will be pumped from the weir only during high flow periods, and the weir is designed to self-drain over a period of less than five days. It is anticipated that significant effects will be minimal.

6.5.2.5 Impacts on marine biota and habitats

The risk analysis shows that impacts on the marine environment are considered to be very low. No operational discharges are expected, and the only discharges are likely to be during extreme storm events, under which circumstances the additional nutrient and biotic load on the marine environment is likely to be undetectable. This is due to the volumes from the ponds compared with the volumes from rainfall and overland flow, and the much greater volumes in the Wheatley Creek arm and the creek to the east of the facility. The very strong flows experienced in the harbour are also likely to cause significant rapid mixing of any substances entering the sea water.

6.5.3 Mitigation measures

6.5.3.1 Mitigation of biting insect issues

Biting midges are most active for an hour before and after sunrise and sunset. As insecticide treatment of breeding sites is not desirable for the aquaculture project, alternatives are required. Mitigation measures proposed include:

- work activities avoid the peak activity times
- a buffer zone or zones along the margins of the ponds, providing a 'wind belt' and open space, ideally up to 500 metres wide, depending on monitored impacts
- mown verges
- diversionary lights to attract midges away from the work areas
- personal protective clothing
- personal repellents
- insect screens on premises
- light-proof curtains.

Measures that improve the drainage of construction areas and poorly draining floodways are likely to reduce the numbers of mosquitoes. The area developed for the Aquaculture project will be firmly compacted and rehabilitated to ensure that it is free-draining during the wet season.

Any artificial containers such as tyres, drums, dsused machinery and any rubbish items that can collect rainwater are potential mosquito breeding sites. All such material will be removed.

Construction and operation practices will take into consideration the Territory Health Services Publication "Drainage considerations for mosquito control" (Whelan 1997a).

Specific mitigation measures against mosquitoes proposed for the aquaculture project are described in **Table 6.14**. They are based on recommendations from Territory Health Services (Whelan 1987; Whelan 1995, 1997a, b, 1998).

Table 6.14 Mitigation against mosquitoes

Aspect	Mitigation Measures
Ponds, off-stream storage and sedimentation basins	All off-stream water storages will be lined with HDPE and have steep sides (between 1:1 and 1:1.5 slopes). Deep water is retained in the growing ponds (1.5 to >2 metres deep). This creates an environment unsuitable for mosquito larvae.
Drains and stormwater drains	Few open drains will be constructed. Those constructed will be designed to avoid pooling and open water surfaces, especially during low flow periods.
Construction activities – siltation and erosion	Construction will be undertaken mostly during the dry season to avoid rain wash. Should construction be carried out when rain is likely, erosion control fences will be installed and monitored to ensure silt is not washed to creek and drainage lines. Siltation of creeks can destroy habitat for mosquito-eating fish, and create pooling.
Borrow pits and depressions	Borrow pits for the ponds will be sourced on the actual sites by excavation. Old borrow pits which hold water will be located and filled. Monitoring and maintenance will be required.
On-stream water harvesting weir	The water levels in the harvesting weir will be kept at low levels. The stream is semi-perennial, and retains fish, aquatic bugs and beetles, and should therefore not be a significant source of mosquitoes. Design guidelines from Territory Health Services will be used.
Waste Water Treatment Plant	Package treatment plants are not generally suitable for mosquitoes. Treated effluent will be disposed by irrigation and could create pooling and changes to natural water bodies. Effluent disposal will be designed in accordance with Territory Health Services Guidelines (1997)
Roadside drainage	The access and internal roads will be designed to be free-draining so that pools are not retained. Drains will be 'U' shaped where possible and self-cleansing. Maintenance will be required.
End point for 100-year flood events	Overland flood flows from the harvest basins are through a minimum undisturbed vegetation buffer of 75m, prior to entering the mangrove flats in the creek arms.
Buffer zones	The buffer zone designed for biting midges will assist with the management of mosquitoes. While the recommended width of a buffer zone from mosquito breeding habitats is 1.6km, this is not possible due to the location of the ponds. In some places, the ponds will be as close as 500 metres, while others will be up to 1.5 km from brackish water.
Chemical control	'Bti' (*Bacillus thuringiensis* var. *israelensis*) may be used after investigation of the potential impacts on prawns is made. Other non-personal insecticides will not be used on the property, except where it is demonstrated that impacts will be tolerable.

Aspect	Mitigation Measures
Personal protection	Protective clothing and personal repellent containing DEET (*diethyl toluene*) will be provided for staff.
Screening	Accommodation, office, preparation and eating areas will be screened from biting insects.
Lighting diversion	Many mosquitoes and biting midges are attracted to light. Yellow incandescent and yellow fluorescent lights will be used where people work as they are much less attractive to these insects. Incandescent or UV lights will be installed between breeding areas and work and living areas to attract insects away from people and ponds.

The site layout is in keeping with the Department of Health & Community Services guidelines to prevent mosquito breeding.

Of particular note with regard to ponds and reservoirs:

- All ponds are lined with HDPE which will prevent emergent weed growth. The sides slope at 1:2, and operating depth is 1.8 m;
- The prawns growing in the ponds will control any larvae by eating them;
- Water is constantly aerated and recirculated;
- The sludge drying bund will have a sand filter layer overlying a gravel drainage bed to prevent ponding and weed growth;
- The rare occasions when discharge occurs from the production ponds will be during large rainfall events. While having a nutrient content higher than ordinary runoff, it is still less than the general mixture within the ponds due to stratification. The discharge will also be significantly dilute due to ambient conditions, and the whole area flushed, resulting in no net increase of nutrient level;
- Materials required for construction come from the resulting excavation, and there is no need for borrow pits;
- The freshwater weir will be constructed with low flow sump drainage pipes to drain standing water between pumping and rainfall inflow events within five days, which will minimise the potential for mosquitoes to breed in it.

No excavation will be undertaken in the tidal zones, and care will be taken to ensure surface run off is not impeded by spoil. The new road will have table drains cut to grade, with relief culverts to prevent water ponding behind the road formation.

The weir site is situated on soil which is determined to be permeable in the undisturbed state. Water transfer from the weir will be continuous to maintain the off-stream storage capacity, hence ponding for medium to long periods is minimised. The constant natural grade of the tributary arms is likely to have no localised ponding areas which will breed mosquitoes. A detailed inspection of the area to be inundated will be undertaken to identify any pre-existing sumps, and appropriate works undertaken to re-grade them, while maintaining natural waterholes which naturally retain fish.

The size of the catchment contributing, and the small capacity of the weir will result in regular flushing of the area. There will be minimal clearing of vegetation upstream, minimising any increase in silt load in the run off.

Construction will be undertaken in the dry season, thus minimising the potential for random ponding in wheel ruts etc. The production compound is situated on the ridge, some 700 m from the tidal flat area. Although this is closer than the recommended 1.6 km to avoid mosquitoes, the area contributing to potential mosquito breeding is relatively small.

All water retaining structures such as septic tanks and potable water tanks will be designed to prevent mosquito ingress.

6.5.3.2 Mitigation of impacts on flora

Work areas will be delineated by construction flagging tape, so that construction machinery do not enter or damage any areas not identified for the required construction works. The flagging tape will be monitored and maintained by the works superintendent. Cleared vegetation from the development area will be shredded or chipped and stockpiled for use as mulch for revegetation and landscaping, as described in section 4. Contractors will be required to avoid disturbing areas other than those required for construction.

Cycads and orchids which may be destroyed on site and on the access roads will be offered for salvage and sale under permit.

6.5.3.3 Mitigation of impacts on fauna

Fauna habitat will be disturbed and destroyed by the works. No fauna of significance and no habitats of significance were recorded in the areas to be disturbed for the facility. Damage to faunal habitat will be limited by the installation of construction flagging around work areas to minimise disturbance of areas not required for development.

Potential impacts on marine turtles will be mitigated by appropriately designed lighting at the breeding facility at Point Ceylon.

Potential impacts from birds landing on production ponds will be mitigated by installing preventative devices, such as netting, around the ponds.

6.5.4 Monitoring and Reporting

6.5.4.1 Monitoring

Monitoring of the biological impacts of the project is proposed to provide an understanding of impacts and to ensure that impacts which occur are remediated where remediation is possible. The area proposed for development, the development footprint, will be subject to clearing and complete alteration. Monitoring will therefore be done on some elements outside the development footprint. The elements proposed for monitoring include:

- Biting insects (audit and monitoring of mosquito habitat caused by earthworks)
- Vegetation adjacent to the project footprint (impacts from development, impacts from operations).

The monitoring program is summarised in the EMP in Chapter 7.

6.5.4.2 Biting midges and mosquitoes

Monitoring of biting midges and mosquitoes will be undertaken if there is an issue with these pests during and after construction. As there have been studies undertaken in the region before which have characterised the species variety and abundance, it was not considered necessary to monitor prior to

the development commencing. If monitoring is required, it will be done in accordance with Territory Health Services guidelines.

6.5.4.3 Monitoring of impacts on flora

The works superintendent will supervise the construction project and ensure contractors adhere to their contractual requirements and the requirements of the EMP to minimise damage to flora and vegetation other than that necessary for development.

6.5.4.4 Monitoring of impacts on fauna

Specific monitoring of fauna will include:

- Monitoring of the impacts of bird exclusion devices, and adapting procedures and practices to minimise impacts should they occur. This will be done on the advice of the NT Govt and other experts.
- Monitoring of impacts on marine turtles. This will be by recording all instances of marine turtle and hatchling disturbances at Point Ceylon, and reporting to the Parks & Wildlife Commission. Modified practices will be implemented if it is found that there is any level of disturbance.

6.6 CULTURAL ENVIRONMENT

6.6.1 Existing environment

A detailed study of the archaeological and heritage cultural aspects of the sites was undertaken by Begnaze Pty Ltd in November 2002, and is provided in **Appendix 13**. This section summarises the findings of that report. The geomorphology, geology and vegetation in the area of the proposed development are key factors influencing the type and visibility of any archaeological material and sites that exist in the area. The area is located on the dissected foothills geomorphic unit, which consists of skeletal, gravelly and lateritic soils (Pietsch and Smith 1987), forming undulating rubbly rises and low hills which are dominated by stunted woodlands, mixed scrubland and palm forests. This unit overlays the Proterozoic Welltree Metamorphic Unit of biotite gneiss and quartz-mica schist, which rarely outcrops and when it does it is deeply weathered or silicified. Directly to the west of the proposed study is the remnant of the Koolpinyah Surface which forms the Northern Plains geomorphic unit and contains sandstone, claystone and siltstone which are deeply weathered and exposed in intertidal rock ledges and low coastal cliffs (Pietsch and Smith 1987:22)

Mangrove forests are well developed along the coastline and tidal creeks. Chenier ridges, perched on alluvium, are common in areas facing the open sea and lie parallel to the present coastline. Older chenier ridges are located further inland behind the mangrove belt and lie parallel to the past coastline. In low-lying areas vegetation varies between *Melaleuca* sp, freshwater mangroves and grasslands.

From the past Aboriginal activity in the area, the only items likely to survive in the archaeological record are shell fish hooks, hearths containing cooking stone or termites nests, stone tools such as spear heads, axe heads and knives, and shells used either in the manufacture of implements or large shells such as *Melo amphora*, used as water vessels.

The main European activity, beside pastoral pursuits in the area, was tin mining. High grade tin was found at Bynoe Harbour in 1888. The Leviathan mine was located approximately 20 kilometres south east of Indian Point and other tin mines, such as Hang Gong, Lees and Bells Mona, and a gold mine, the Golden Boulder, were located approximately 25 kilometres east of Point Ceylon and commenced operation around the turn of the century (Jones 1987).

Very little archaeological research has been carried out in the region around Bynoe Harbour. Previous field surveys identified shell mounds, artefact scatters and several stone arrangements which are

unique to the Darwin area. Sites are concentrated in zones which are low-lying and have direct access to rivers or the coast. The coastal areas are dominated by middens while the dissected foothills are dominated by middens and artefact scatters.

A search of the archaeological register at the Heritage Conservation Branch, Department of Infrastructure Planning and the Environment identified 81 sites within the Bynoe 1:100,000 map sheet, 52-5072. It should be noted that a site may be listed as having more than one site type. Also on the Register are one engraving site and one earth mound. No sites have been recorded within the proposed development area. Shell middens and artefact scatters are the most common site type in the area.

A description of the only site found within the study area is provided below in **Table 6.15**

Table 6.15 Description of archaeological site

Name: Point Ceylon 1
Type: Shell scatter
Location: Grid reference: 669207E 8594565N 1:100,000 Map Sheet: Bynoe 5072, 1:100,000, SD 52.
Description: A shell scatter of approximately 40 *Telescopium telescopium* was located half way along a fifty metre chenier ridge that runs south and parallel to the eastern side of Point Ceylon. The ridge is situated on the western side of the mouth of mangrove lined tidal inlet and has been used as an access track for the launching of boats through the mangroves into the inlet. The chenier ridge is presently covered in sand and there are sections on the top where lateritic gravel has been deposited to make the area more accessible to vehicles. Three areas along the western side of the ridge have been eroded by water runoff uncovering large numbers of *Anadarra granosa* in the lower levels of the ridge. The *Anadarra* are extremely water worn suggesting that they have been either re-deposited in the area by storm action or taphonomic processes of tidal movement on the ridge had affected them.
Ground visibility: 98%
Dimensions: 21 x 2 metres
Site's relationship to proposed development The site is located approximately 100 metres south of the proposed development. The proposed plans indicate that this area will not be affected by the development.

6.6.2 Potential and anticipated impacts

No archaeological objects or sites were located within the area of the proposed development. Therefore no archaeological or heritage constraints exist over the site.

Only one archaeological site was identified in the survey, Point Ceylon 1. It is located outside of the proposed development area and is considered of low archaeological significance. Concrete foundations and other objects were located in the area of the proposed breeding facility. As these are of recent construction, they are considered to have no historical significance.

6.6.3 Mitigation measures

The Point Ceylon 1 site, although of low archaeological significance, will be identified and marked with identifying markers to avoid accidental disturbance from construction activities and workforce. Inductions of all work-staff will include instructions to avoid the site and advice on the penalties attached to disturbing the site.

6.6.4 Monitoring and reporting

Monitoring will be undertaken periodically to ensure that the markers are retained.

6.7 SOCIO-ECONOMIC ENVIRONMENT

6.7.1 Existing environment

6.7.1.1 Social profile

The proposed Point Ceylon Aquaculture Estates falls within the Finniss Sub-Region of the Northern Territory Planning Scheme. There are no townships with the Sub-Region. The population of possibly 1000 (Northern Territory Government, 2002) is concentrated in the rural subdivisions of Dundee Beach, Dundee Downs and Bynoe Haven. These subdivisions consist and both permanent residents and temporary weekender populations.

6.7.1.2 Infrastructure and services

Access through the Finniss sub-Region is provided by road, with private access by sea, river and air. Fog Bay Road provides, which is mostly unsealed, provides access from Cox Peninsula to Fog Bay. There is no reticulated power, water or sewerage within the Finniss Sub-Region. There is a temporary waste disposal site at Dundee Downs (Northern Territory Government, 2002), and limited urban services reflecting the small permanent population. Residents rely on services provided in Darwin and Palmerston.

6.7.1.3 *Other socio-economic issues*

The major recreational pursuit within the Finniss Sub-region is fishing which occurs in coastal areas, rivers, lagoons and billabongs. Most activity is focused on the waters of Fog Bay, Bynoe Harbour and Finniss River. Other activities include 4-wheel driving, hunting, camping and sightseeing.

6.7.2 Potential and anticipated impacts and constraints

Portion 3192 is of limited local significance in terms of intrinsic recreational values. Recreational fishermen use the adjacent off-site waterways but it is difficult to get close to the seaward margin of Point Ceylon through the adjacent oyster leases. The Portion is surrounded on three sides by dense belts of mangroves. The Portion shows very little sign of use for hunting camping or 4-wheel driving. As a result, the impacts on recreational use are expected to be minimal to virtually non-existent.

The social impacts of traffic generated are expected to be minimal. Construction traffic will be maintained on site and operational traffic will generally be below 6 daily vehicular movements. Any traffic will move along a gazetted easement and through only four sections which appear to be currently unoccupied.

The Fog Bay Road may be cut during wet seasons for a few days.

Power may be affected by extreme events such as storms and cyclones.

6.7.3 Mitigation

There is a small possibility that future traffic will impact on future residents. At that time, aquaculture farm operations will be organised to minimise the volume of local traffic.

In order to account for access closures or difficulties, the freezer room temperatures, which will be maintained at minus 30°C or colder to retain maximum quality, will have doors draped with plastic barriers to reduce heat transfer when opened. The capacity of the two cold storage rooms will accommodate more than 30 production days or 90 MT of prawn. This will cater for any contingencies such as access being cut by road for a few days due to extreme events. The rooms will hold the cold

for sufficient time to keep the stock frozen for power outages should these occur, although the power system is designed for 100% failsafe.

On-site generation will be designed to accommodate extreme events. The power supply will be designed to provide 100% failsafe backup, in other words, the failure of one part of the power system will be accommodated by surplus power in the other generators.

6.8 SYSTEMS AND HABITATS

Biological systems and habitats have been considered in detail in previous sections.

6.9 HAZARD/RISK TO HUMANS AND FACILITIES

The Hazard and Risk Analysis undertaken by EcOz for the project included analysis of hazards and risks to humans and facilities. These are considered in detail in section 6.2 and Appendix 7.

7 ENVIRONMENTAL SAFEGUARDS, MANAGEMENT AND MONITORING

7.1 ENVIRONMENT SAFEGUARDS AND MITIGATION OF IMPACTS

7.1.1 Clearing of Vegetation

COMMITMENT 1 - MINIMISATION OF CLEARING

A. The required area for development will be identified with markers prior to any earthworks.

B. Construction flagging tape will be installed around the whole site to delineate the maximum limits of vehicle and equipment movement.

C. Contractors will be required in their contracts to guarantee to work within the defined limits of the works areas.

D. Movements of vehicles and equipment will be monitored by the works superintendent to ensure compliance. Damage to vegetation and soils and vegetation outside the defined area will be reported to the contractors and operators.

7.1.2 Flora

COMMITMENT 2 - FLORA MANAGEMENT

A. A permit must be obtained from Parks and Wildlife prior to clearing due to the presence of Cycads and Orchids at the site.

B. Vegetation regrowth should be promoted in areas disturbed during construction. To facilitate this, soil and vegetative matter should be stockpiled near to the area from which it was taken so that it can be respread over the area.

C. Vegetation removed as part of site clearing should be burnt on-site with an appropriate permit from Bushfires Council NT. The vegetation pile should be located as far as possible from areas susceptible to fire, and the burning should be done under supervision with a fire fighting unit present.

D. All construction staff should be briefed about the importance of protecting all vegetation communities, but specifically, monsoon vine forests, riparian forests and *Callitris intratropica* forests. Where these communities are located in areas close to construction activities the boundaries of the community should be clearly marked.

7.1.3 Fauna

COMMITMENT 3 FAUNA MANAGEMENT

A. Lighting will be designed so that it does not jeopardise marine turtle nesting and movement of hatchlings to the sea

B. Lighting will be designed to minimise its attractiveness to birds

C. Monitoring of the impacts of bird exclusion devices, and adapting procedures and practices to minimise impacts should they occur. This will be done on the advice of the NT Govt and other experts

D. Monitoring of impacts on marine turtles. This will be by recording all instances of marine turtle and hatchling disturbances at Point Ceylon, and reporting to the Parks & Wildlife Commission. Modified practices will be implemented if it is found that there is any level of disturbance

7.1.4 Weed Invasion

COMMITMENT 4 - WEED MANAGEMENT

A. Contractors will be required in their contracts to guarantee weed-free plant, vehicles and equipment prior to entering the site.

B. All plant, vehicles and equipment will be subject to random checks for weeds and soil prior to entering the site. The works superintendent will be responsible for ensuring this.

C. A wash-down bay will be constructed on site to enable all plant, vehicles and equipment can be washed down prior to working on site.

D. Any construction materials sourced from outside the project lease area should be inspected for weeds prior to taking it onto the site

E. Weeds infestations will be identified prior to works and after works, and treated in accordance with Weeds Branch guidelines.

7.1.5 Fire management

COMMITMENT 5 - FIRE MANAGEMENT

A. Annual burning of areas of the property will be carried out in accordance with Bushfires Council advice and guidance.

B. A perimeter firebreak will be constructed in accordance with Bushfires Council guidelines.

C. Fire-fighting equipment will be held on site to suppress fires caused during construction and operation in accordance with Bushfires Council guidelines.

7.1.6 Soil Disturbance

7.1.6.1 Acid Sulfate Soils

Potential Acid Sulfate Soils are expected to be found in three locations where development is to occur. The saltwater intakes at Point Ceylon and at Wheatley Creek will not disturb Acid Sulfate Soils as the intake pipes will be laid over the surface and no excavation is required.

The weir wall may disturb Acid Sulfate Soils. Preliminary assessment and an ASS Management Plan will be prepared prior to excavations. Required measures to prevent acid generation will be taken prior to excavation.

7.1.6.2 Erosion and sedimentation

Soil erosion will be minimised by the installation of erosion control structures and by working in accordance with NT soil erosion guidelines. Sediment from all works will be captured by silt fences prior to any works. These will be installed prior to works in accordance with NT soil erosion guidelines and monitored during and after construction. Installation of sediment fences will be required as part of the works contracts.

7.1.6.3 Dust

The access road and the works sites will be regularly watered to minimise dust generation. This will form part of the requirements of the works contracts.

COMMITMENT 6 - MINIMISATION OF SOIL DISTURBANCE

A. Preliminary investigations and an Acid Sulfate Soils Management Plan will be required prior to excavation.

B. Soil erosion and sediment discharge will be prevented by appropriate mechanisms, including soil erosion control devices and sediment fences.

C. Road construction should be undertaken to ensure that natural drainage patterns are not significantly altered, especially where the road traverses broad drainage lines.

D. Water trucks will spray water over the works areas to minimise dust generation during construction and until the access roads and car-parks are stabilised.

E. Excavated soil should either be stored on-site in an area previously cleared of vegetation or taken to an appropriate area off-site. Any on-site or off-site location should be approved by DIPE prior to dumping. Appropriate locations for dumping of spoil should be clearly demarcated to contractors.

7.1.7 Hydrological Regimes

7.1.7.1 Surface Water Hydrology

The weir on Wheatley Creek will be designed to drain over three or four days so that a permanent water body is not created, minimising negative impacts on local groundwater regimes, and minimising risks of creating mosquito breeding sites. The off-take from the weir will be significantly less than 10% of annual flows from the creek, and will occur only during high-flow periods of the wet season. The weir design will result in limited inundation of upstream habitats, little more than natural

inundation. This will result in little impact on trees and it is unlikely that the upstream habitats will be destroyed. Likewise, the potential for mosquitoes to breed will be minimised because the water behind the weir is designed to drain in less than five days, the period required for mosquitoes to breed effectively.

In summary, the impacts on surface water are likely to be minimal.

7.1.7.2 Groundwater

The bore near the production ponds will be tested for pumping rates and monitored over time for pumping rate and persistence.

COMMITMENT 7 - MAINTENANCE OF EXISTING HYDROLOGICAL REGIMES

A. The weir on Wheatley Creek will be designed to drain completely over a period of less than five days during low flow periods.

B. The bore at the production ponds will be monitored for pumping rates over time.

7.1.8 Water Quality

7.1.8.1 Surface Water

Surface water quality is considered to be high. The catchment is essentially naturally vegetated, with no agriculture of any magnitude. The water to be used for the production ponds will be tested frequently for quality to ensure no contaminants that may affect the prawns are introduced. Basic parameters will be tested, plus a range of metals, chemicals and pesticides to ensure no contaminants are introduced.

One module of reservoirs will be restricted to receiving freshwater from the weir only, and separated from the recirculation loop. This allows for the provision of freshwater for human consumption and washing of product for preparation for packaging and sale. This water supply will be transferred to a separate food grade water tank adjacent to the proposed employees' compound, and will be treated to the appropriate level required by national guidelines for safe human consumption and use via filtration, UV sterilisation and chlorination.

Potable water requirements for the breeding facility will likely be served from the treated water stored at the main employee compound, delivered under piped gravity system along the upgraded access road to an elevated break tank. Chlorine dosing to this line will be used to ensure a safe product. Information provided by Water Resources indicates groundwater is available in low to limited amounts.

A critical area of concern expressed in the guidelines was that of contingent overflows and discharges because of their perceived impacts on the receiving environment. The project is designed as a zero-discharge system under normal operating conditions. For extreme events when overflows are possible, the project will develop detailed operating procedures and contingency plans for lock down and management. This will include the stoppage of water aeration, lock-down of buildings, ensuring that recirculation and harvesting ponds are held empty as overflow reservoirs, and other procedures to minimise the chance, volumes and impacts from overflow. The plan and procedures will detail:

- Operating procedures prior to and during the wet season, including skills requirements and authorities and responsibilities;
- Weather alert triggers for taking lock-down and management action;
- Procedures for taking these actions;
- Reporting requirements;

- Monitoring and review procedures.

7.1.8.2 Groundwater

Quality of groundwater will be tested for human consumption in accordance with national guidelines for safe human consumption and use via filtration, UV sterilisation and chlorination.

7.1.8.3 Bynoe Harbour

Saltwater from Bynoe Harbour is considered to be of very high quality regarding low levels of human-generated contaminants. The water is naturally quite turbid, but this is not a significant issue for prawn aquaculture. Water quality in the ponds is monitored daily as follows:

Before Stocking:
- Reactive Phosphorus.
- Total Nitrogen
- Silicate

Daily:
- Temperature
- Salinity
- Dissolved Oxygen
- pH

COMMITMENT 8 - WATER QUALITY MONITORING AND MANAGEMENT

A. Potable water for human consumption and processing of prawns will be treated in accordance with national water quality guidelines.

B. Potable water will be kept out of the recirculation loop in the water storage system.

C. Pond water will be tested daily for the described parameters.

D. Marine water quality will be monitored in conjunction with the monitoring program operated by Paspaley Pearls Pty Ltd at Bynoe Harbour. The details of the monitoring program have yet to be determined, and will be developed in consultation with the DIPE.

E. A contingency plan and operating procedures will be developed for shut-down and water balance management of the ponds prior to storms and intense storms.

7.1.9 Disease and Quarantine

Prawns have been sourced from the local area, reducing the potential for introduction of prawn diseases to the region and to the ponds. The prawns are held in quarantine for 60 days to ensure they carry no diseases. Treatment of the pond waters is carried out in pond preparation, in accordance with the most advanced practices known world-wide. Should any diseases be detected in the ponds, the ponds will be treated with chlorine before the infected and dead prawns are removed from the ponds. The dead prawns will then be incinerated on site in a contained incinerator.

Daily inspections of the ponds are conducted to monitor the health of the prawns.

Health of prawns for consumption is a paramount issue. The growth, processing, packaging and transport of prawns will be conducted under strict NT Health Department requirements, and certification under HACCP guidelines sought and obtained.

COMMITMENT 9 - HEALTH AND DISEASE MANAGEMENT

A. Quarantine for all prawns sourced for the production ponds will be implemented for a minimum period of 60 days. All prawn stock will be obtained from the nearby environment, minimising potential for disease introduction to the quarantine facility.

B. Health standards will be maintained, and HACCP certification sought and obtained for the production of prawns for market.

7.1.10Social Issues

7.1.10.1 Recreational water quality

Recreational water quality is unlikely to be affected by the project, as there are no discharges during normal operating periods, and contingent discharges due to extreme events will be very highly diluted. There are no chemicals which are likely to affect recreational water quality.

7.1.10.2 Site aesthetics

The facilities will be constructed in accordance with established building practices. The grounds will be landscaped and maintained for best presentation. The facilities will mostly not be visible from outside the property.

7.1.10.3 Access

Access to the facility will be maintained along the developed road. Access beyond the production ponds will be restricted to ensure the facility is not subject to risks from uncontrolled activities. All access to the facility by the public or non-staff will be under the control of staff.

Main road access restrictions due to flooding may affect transport of stock to markets and repair and maintenance of breakdowns.

Power may be interrupted by extreme storm events.

7.1.10.4 Public Health and Safety

No public health and safety issues are likely to arise as the facility will be gated at the road entrance. Any public accessing the area will be accompanied by staff, and will not access areas where there is a risk to safety.

COMMITMENT 10 MINIMISATION OF SOCIAL IMPACTS

A. All access to the facility by other than staff will be under supervision of staff.

B. Access restrictions due to flooding will be accommodated by excess freezer storage capacity.

C. Power outages will be minimised by design of power failsafe mechanisms on site.

7.1.11Biting Insects

Aspect	Mitigation Measures
Ponds, off-stream storage and sedimentation basins	All off-stream water storages will be lined with HDPE and have steep sides (between 1:1 and 1:1.5 slopes). Deep water is retained in the growing ponds (1.5 to >2 metres deep). This creates an environment unsuitable for mosquito larvae.

Aspect	Mitigation Measures
Drains and stormwater drains	Few open drains will be constructed. Those constructed will be designed to avoid pooling and open water surfaces, especially during low flow periods.
Construction activities – siltation and erosion	Construction will be undertaken mostly during the dry season to avoid rain wash. Should construction be carried out when rain is likely, erosion control fences will be installed and monitored to ensure silt is not washed to creek and drainage lines. Siltation of creeks can destroy habitat for mosquito-eating fish, and create pooling.
Borrow pits and depressions	Borrow pits for the ponds will be sourced on the actual sites by excavation. Old borrow pits which hold water will be located and filled. Monitoring and maintenance will be required.
On-stream water harvesting weir	The water levels in the harvesting weir will be kept at low levels. The stream is semi-perennial, and retains fish, aquatic bugs and beetles, and should therefore not be a significant source of mosquitoes. Design guidelines from Territory Health Services will be used.
Waste Water Treatment Plant	Package treatment plants are not generally suitable for mosquitoes. Treated effluent will be disposed by irrigation and could create pooling and changes to natural water bodies. Effluent disposal will be designed in accordance with Territory Health Services Guidelines (1997)
Roadside drainage	The access and internal roads will be designed to be free-draining so that pools are not retained. Drains will be 'U' shaped where possible and self-cleansing. Maintenance will be required.
End point for 100-year flood events	Overland flood flows from the harvest basins are through a minimum undisturbed vegetation buffer of 75m, prior to entering the mangrove flats in the creek arms.
Buffer zones	The buffer zone designed for biting midges will assist with the management of mosquitoes. While the recommended width of a buffer zone from mosquito breeding habitats is 1.6km, this is not possible due to the location of the ponds. In some places, the ponds will be as close as 500 metres, while others will be up to 1.5 km from brackish water.
Chemical control	'Bti' (*Bacillus thuringiensis* var. *israelensis*) may be used after investigation of the potential impacts on prawns is made. Other non-personal insecticides will not be used on the property, except where it is demonstrated that impacts will be tolerable.
Personal protection	Protective clothing and personal repellent containing DEET (*diethyl toluene*) will be provided for staff.
Screening	Accommodation, office, preparation and eating areas will be screened from biting insects.
Lighting diversion	Many mosquitoes and biting midges are attracted to light. Yellow incandescent and yellow fluorescent lights will be used where people work as they are much less attractive to these insects. Incandescent or UV lights will be installed between breeding areas and work and living areas to attract insects away from people and ponds.

COMMITMENT 11 - BITING INSECT MANAGEMENT

A. The mitigation measure described in the above table will be implemented for the facility.

7.1.12Archaeological and Heritage Sites

COMMITMENT 12 - MANAGEMENT OF ARCHAEOLOGICAL AND HERITAGE SITES

A. The Point Ceylon 1 archaeological site will be fenced off and access prohibited prior to any works commencing.

B. Any archaeological sites, including middens, burial sites, and artefacts observed or disturbed during construction will halt construction at that site and be reported to the Office of Environment

and Heritage. Works at the site will not re-commence until clearance is obtained from the relevant authorities.

7.1.13Aboriginal Sacred Sites

No Aboriginal Sacred Sites were recorded on the site, and so no monitoring is required.

7.1.14Decommissioning and Rehabilitation

COMMITMENT 13 - DECOMMISSIONING AND REHABILITATION

A. The project is expected to have a lifetime of over 80 years. Decommissioning will be done in accordance with Northern Territory Government guidelines.

B. Should abandonment be required, all structures will be removed and the weir and ponds levelled.

C. The site will be rehabilitated using state-of-the-art techniques to a state similar to that at the initiation of the project.

7.2 MONITORING AND REPORTING

Records on all monitoring commitments will be retained on site for a period of at least 5 years. Reporting will be in accordance with the Aquaculture Licence under the *Fisheries Act*, and the Discharge Licence under the *Water Act*.

7.3 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan provided below is designed to stand alone, but is based on the detail provided in the EIS. The EMP provides a concise summary of all the issues which have been identified as carrying a risk, and the measures to be taken to minimise or eliminate those risks. The EMP will provide an auditable document for assessment of compliance with the EIS when it is approved.

Table 7-1 Summary of Environmental Impacts, Safeguards and Monitoring.

Issue	Objective	Commitment	Monitoring
Dust will be caused during construction. In car-parks areas associated with heavy vehicle movement may cause dust .	Minimise dust.	Dust will be suppressed by water cart during construction until areas are hardened.	Dust generation is expected to be localised and not impact on local residences. Dust will be monitored by the works superintendent.
Noise and vibrations will cause minimum impact and receptors are a long way from the site.	Minimise noise and vibration.	Equipment causing noise such as pumps and power generation will be designed in accordance with acceptable standards.	The impact of noise is expected to be negligible. Noise receptors are several kilometres away. The superintendent will ensure that all pumps and power generation equipment is maintained in good working order.
Maintenance of natural vegetation outside the development footprint is critical to the project's long-term management. Clearing from the site will include a number of elements: ❑ Approximately 2,000 m^2 under weir footprint; ❑ Removal of large trees subject to die-back when inundated behind weir wall for approximately 1.5 ha; ❑ Initial production pond area of 17.5 ha; ❑ Off-stream storage reservoir 300 m long x 260 m wide (9.0 ha including batter slopes); ❑ New access road along gazetted corridor, 3,900 m x 20 m wide (7.8 ha); continuation of access road through to main compound, 3,300 m x 20 m wide (6.6 ha); continuation to breeding facility compound requires new portion 1,100 m x 20 m wide (2.2 ha) connecting to existing cleared road corridor; ❑ Main production compound: car-parking and heavy vehicle movements, accommodation & ablution/mess facilities, production & packing shed. Comprises approximately 2 ha of development, remnant bushland retained where possible;	Surveys have revealed no flora of conservation significance apart from some cycads and orchids. Clearing will be strictly confined to the area necessary for the works. Areas upstream of the weir will not be disturbed except for necessary tree removal.	Cycads will be offered for salvage and sale under permit for commercial sale. ❑ The required area for development will be identified with markers prior to any earthworks. ❑ Construction flagging tape will be installed around the whole site to delineate the maximum limits of vehicles and equipment movement. ❑ Contractors will be required in their contracts to guarantee to work within the defined limits of the works area. ❑ Movements of vehicles and equipment will be monitored by the works superintendent to ensure compliance. Damage to vegetation and soils and vegetation outside the defined area will be reported to the contractors and operators.	The boundaries will be monitored by the works superintendent. Vegetation outside the area cleared will be monitored using photo-monitoring points.

Issue	Objective	Commitment	Monitoring
❑ Breeding facility compound: car-parking and heavy vehicle movements, accommodation & ablution/mess facilities, rearing & quarantine/testing buildings, reservoirs. Comprises approximately 4,500 m^2 of development; ❑ Pipeline corridor and vehicle access from weir to off-stream storage, 700 m x 6 m wide (4,200 m^2); ❑ Pipeline corridor and vehicle access from seawater intake to breeding facility reservoir, 160 m x 6 m wide (960 m^2); ❑ Pipeline corridor from saltwater intake for ponds from Wheatley Creek, approximately 260 m x 6 m (1560 m^2). Total clearing works for initial development: 46.5 ha. Additional clearing for Phase 2 & 3 ponds, including reservoirs: 136 ha.			
Erosion and sediment control are integral parts of the construction process. Natural drainage lines occur on the site. During construction there is an increased likelihood of sediment transport along these lines.	Minimise erosion	Soil erosion will be minimised by the installation of erosion control structures and by working in accordance with NT soil erosion guidelines. During construction a series of hay bales wrapped in Bidim geotextile fabric, or sediment fences, will be staked across the drainage lines at regular intervals to trap any sediment. Excavation of the ponds and weir will be separated from the surrounding areas downstream by installation of a silt fence at the limits of excavation. Sediment from all works will be captured by silt fences prior to any	Installation of sediment fences will be required as part of the works contracts. Silt fences will be monitored during and after construction. Regular visual observations that erosion control structures are in place, runoff paths from above disturbed areas are being diverted and any runoff that may contain sediment is directed to an appropriate erosion control structure.

Issue	Objective	Commitment	Monitoring
		works. These will be installed prior to works in accordance with NT soil erosion guidelines.	
Effects of spills of fuel, oil: There is a likelihood of diesel/oil leaks and spills from generators, earthmoving equipment and tanker trucks.	Spills of fuel and oil will be minimised and any spills will be cleaned up	The repair shop will have sump collection for fuel/oil spills. A dedicated hardstand area for vehicle servicing with interceptor trap and sump will be provided. Pumphouse and generator buildings will be constructed with floor sumps to collect leaks. Fuel storage will be within lined bunds in accordance with legislative requirements. Transfer of waste oil/fuel offsite will be via licensed commercial third party Contamination response plans will be developed to provide details of how to respond to spills and leaks of contaminants, confined mostly to hydrocarbons (diesel, oil, lubricants)	The superintendent will monitor all aspects of the construction to ensure that spills which occur are immediately cleaned up. Major spills will be reported to the Pollution Response Line for direction on remedial actions.
Impacts of construction on local communities are likely to be minimal. There are no townships near the development and those areas with concentrated populations are not within several kilometres.	Minimise impacts to local communities.	The site will mostly not be visible from outside the facility. Health and safety: access to the public will only be via the developed road and any non-staff visitor will be accompanied by staff.	A complaints register will be created and any complaint followed-up.
Impacts of construction on archaeological site. No sites of archaeological or heritage significance were found on the register at the Heritage Conservation Branch, DIPE. An archaeological survey located a site, a shell scatter of low archaeological significance, within the Portion but this site is 100 metres away from any proposed development.	Ensure that the archaeological site is protected.	The site will be identified and marked to avoid any disturbance from construction activities.	The works superintendent will ensure that no works impact on the site.

Issue	Objective	Commitment	Monitoring
Access restrictions to and from the facility due to flooding	To compensate for access restrictions for a few days	The freezer will hold 30 production days of stock	Frozen stock will be monitored by computer-controlled systems.
Power outages causing loss of aeration of ponds, loss of power to freezers, etc.	To design the power supply to minimise outages	The power supply will be designed as a failsafe system, with backup and excess capacities.	Power supplies will be routinely maintained and monitored for performance and backup capacity.
Creation or aggravation of mosquito breeding sites: The development has the potential to provide additional sites for breeding for a number of 'pest' species.	Ensure no increase in biting insects.	Mitigation measures proposed include: ❑ work activities avoid the peak activity times ❑ a buffer zone or zones along the margins of the ponds, providing a 'wind belt' and open space, ideally up to 500 metres wide, depending on monitored impacts ❑ mown verges ❑ diversionary lights to attract midges away from the work areas ❑ personal protective clothing ❑ personal repellents ❑ insect screens on premises ❑ light proof curtains. A detailed plan for specific measures to mitigate against mosquito breeding will be prepared. The site layout is in keeping with the Department of Health & Community Services guidelines to prevent mosquito breeding.	Monitoring of biting midges and mosquitoes will be undertaken if there is an issue with these pests during and after construction. As there have been studies undertaken in the region before which have characterised the species variety and abundance, it was not considered necessary to monitor prior to the development commencing. If monitoring is required, it will be done in accordance with Territory Health Services guidelines.
Weeds and introduced fauna:	Avoid introduction and spread of weeds and introduced fauna.	Contractors will be required in their contracts to guarantee weed-free plant, vehicles and equipment prior to entering the site. A wash-down bay will be constructed on site to enable all plant, vehicles and	All plant, vehicles and equipment will be subject to random checks for weeds and soil prior to entering the site. The works superintendent will be responsible for ensuring this. Weeds infestations will be identified

Issue	Objective	Commitment	Monitoring
		equipment can be washed down prior to working on site.	prior to works and after works, and treated in accordance with Weeds Branch guidelines.
Bushfires and other fires: The site experiences fires on an annual basis, and half the natural vegetation may burn each year. This is typical of the area.	Ensure that there are no uncontrolled fires and that accidental fires are extinguished immediately.	Annual burning of areas of the property will be carried out in accordance with Bushfires Council advice and guidance. A perimeter firebreak will be constructed in accordance with Bushfires Council guidelines. Fire-fighting equipment will be held on site to suppress fires caused during construction and operation in accordance with Bushfires Council guidelines.	Records of fire break maintenance, prescribed burns and wildfires on the property will be kept by the project manager.
Saltwater intake water: A flexible pressure intake pipe and floating pontoon will be provided off Point Ceylon for the transfer of sea water to the breeding facility ponds. A similar salt water intake to the channel of Wheatley's Creek will be provided to initially fill the production ponds to operating levels. No discharge pipes or channels are required.	Minimise any disturbance to mangroves.	The pumps with screened intake will be located to intercept the median tidal range – i.e. intake at 0m AHD. No removal of mangroves or excavation in mangrove muds will be necessary.	During construction the works superintendent will ensure no unanticipated impacts occur. During operation, the saltwater intakes will be monitored as part of routine maintenance for defects and sub-standard operations.
Production pond operation: It is planned to be developed in two or three phases with the aim of developing a closed system prawn farm with minimal to zero-discharge.	The aim is to minimise discharge from the ponds to zero.	Maintain operating levels to ensure no contingent discharges in all situations.	Since this is a major design aim of the development detailed monitoring is inherent in the construction and operation of the project. Records of operating water levels and any contingent discharges will be maintained. Contingent discharges will be reported to NT OE&H.
Hydrology & water quality	To minimise impacts on groundwater and surface water flows. To ensure production waters in	The weir on Wheatley Creek will be designed to drain over three or four days so that a permanent water body is not created, minimising negative	The project manager will monitor the weir levels after rainfall events. Bore records will be maintained for the project.

Issue	Objective	Commitment	Monitoring
	ponds are maintained at appropriate operating levels.	impacts on local groundwater regimes, and minimising risks of creating mosquito breeding sites. The bore near the production ponds will be tested for pumping rates and monitored over time for pumping rate and persistence. Water quality in the production ponds will be maintained at the documented levels.	Daily monitoring of the water quality of the production ponds will be conducted. Marine water quality will be monitored in accordance with a monitoring plan to be developed in conjunction with NT OE&H and possible consultation with Paspaley Pearls Pty Ltd.
Waste management: waste types which will be generated during the operational phase will include - Sewage and domestic effluent - Sludge and biosolids - Washdown water from vehicles - Washdown water from processing plant - Used cooking brine - Diseased prawns or other product - Used parts, sump oil, etc - Miscellaneous items such as feed bags - Domestic garbage	All relevant legislation requirements, by-laws and codes of practice with respect to waste disposal will be adhered to.	Sewage will be treated as described in section 4.1, in a treatment plant. Treated liquor will be irrigated to land in accordance with Department of Health Guidelines. The irrigated area will be fenced off from open access. Other domestic effluent 'grey water' will be treated with the same plant. Sludge and biosolids will be treated and disposed of generally in accordance with the standards for biosolids disposal, including the National Water Quality Management Strategy on Biosolids Management (NRMMC 2002), in drying beds. Vehicle and plant wash-down will be conducted on a vehicle hardstand which has a sump for catchment of oils, fuels, grease, sediment and weed propagules. The sump will be directed to an interceptor which will be routinely pumped out by a commercial contractor. Washdown water from the processing plant will be routed through a sump	Routine monitoring of all operating components of the project will be conducted and a monitoring register maintained.

Issue	Objective	Commitment	Monitoring
		which will be directed to a separate extended aeration package treatment plant. Disposal of the treated effluent is as per domestic effluent. Used cooking brine will also be treated in this manner. All water generated during wash down and cooking operations will be collected and directed under gravity or rising main (location dependant) to the treatment plant. Air emissions from the power house will be minimised by using appropriate exhaust scrubbers and maintaining the equipment in good operational condition. Estimates of the contribution of the power plant to greenhouse gas emissions will be made using the National Greenhouse Gas Emissions (NGGI) methodology. Other waste, including used parts, sump oil, filters, cleaning rags, feed bags, domestic garbage and others will be segregated into labelled collection bins and disposed routinely by a commercial contractor to licensed landfills and other licensed disposal points (such as used oil collection facilities).	
Hazardous wastes: the only hazardous wastes held on site will be chlorine and chlorine containers.	Zero contingent dis charges of hazardous wastes.	These will be retained in a storage area for periodic removal by a commercial contractor	Records of storage and disposal of hazardous waste material will be maintained.
Three types of wastewater are potentially associated with the production side of the project - effluent fro m pond overflow; effluent from	Zero discharges to the environment	No water is exchanged during the course of a production cycle. All water from the harvest ponds will	Monitoring is incorporated as part of the day to day management of the farm.

Issue	Objective	Commitment	Monitoring
drainage at pond harvest; organic sediment from pond bottom.		be pumped to the recirculation ponds and retained for continuous use in the ponds. It is not pumped out. Most of the organic sediment can be re-used in the production ponds. Disposal of some organic sediment will be required from time to time (de-sludging) and this material will be carted to the drying beds for use as fertiliser on site.	
Quarantine and disease	To eliminate potential prawn diseases from the facility To ensure the health of the product for market is up to Health standards	Quarantine of locally sourced wild prawns will be a minimum of sixty days. No prawns will be sourced from other areas or facilities without approval of the relevant authorities. Certification of the facility under the HACCP standard will be obtained prior to distribution of the first prawns to market.	Monitoring of the health of prawns will be undertaken on a daily basis. All diseases detected will be reported to the Fisheries Dept. HACCP Certification is subject to periodic audit by certified auditors.
Acid sulfate soils are expected to be found in three locations where development is to occur.	To minimise or avoid disturbance of acid sulfate soils	The saltwater intakes at Point Ceylon and at Wheatley Creek will not disturb Acid Sulfate Soils as the intake pipes will be laid over the surface and no excavation is required. The weir wall may disturb Acid Sulfate Soils. Preliminary assessment and an ASS Management Plan will be prepared prior to excavations. Required measures to prevent acid generation will be taken prior to excavation.	Monitoring of the saltwater intakes will be carried out to ensure that construction does not impact on acid sulfate soils. Monitoring of the weir site during construction will be carried out to ensure that acid is not generated during construction, and remedial action is taken immediately should acid be generated.

8 PUBLIC INVOLVEMENT AND CONSULTATION

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10 GLOSSARY

AHD	Australian Height Datum – considered 0 m for survey purposes
APFA	Australian Prawn Farming Association
AIMS	Australian Institute of Marine Science
ASS	Acid Sulfate Soils
'Bti'	*Bacillus thuringiensis* var. *israelensis* – insecticide against mosquitoes
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIPE	Department of Infrastructure, Planning and Environment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ERA	Environmental Risk Assessment
DPIF	Department of Primary Industry and Fisheries
FAO	Food and Agriculture Organisation
GAA	Global Aquaculture Alliance
HDPE	High Density Polyethylene
HACCP	Hazard Analysis Critical Control Point
LAT	Lowest Astronomical Tide
MAGNT	Museum and Art Gallery of the Northern Territory
OE&H	NT Office of Environment and Heritage
PL	Post-larvae – a stage in shrimp growth
Shrimp	Known as prawns generally in Australia
SAA	Suntay Aquaculture Pty Ltd
SOFIA	State of World Fisheries and Aquaculture
STP	Sewerage Treatment Plant