Point Ceylon Aquaculture Project

Point Ceylon, Bynoe Harbour

Northern Territory

Environmental Risk Assessment

Consultants in

environmental impact assessment

ecological studies

flora

fauna

environmental auditing

GIS

land resources

management planning

development planning

ecotourism

1 EXECUTIVE SUMMARY

The Point Ceylon Aquaculture Project proposed to be constructed at Ceylon Point on Bynoe Harbour is subject to an Environmental Impact Assessment process, as required by the Northern Territory Government under the *Environmental Assessment Act.* The Guidelines for the EIS required an Environmental Risk Assessment of the project, related particularly to the potential impacts on the marine environment of Bynoe Harbour and the adjacent pearl oyster leases.

The Environmental Risk Assessment found that there were a number of high risk aspects related to the project. These include:

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
Hatchery	Fire, major storm, storm-surge, extreme rainfall event
Discharge of hatchery 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 hatchery	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 dams	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

The risk assessment provides guidance on the key issues to be addressed in the assessment of environmental impacts from the project.

All the risks can be managed to minimise the level of risk. The methods to achieve low levels of risk embrace all phases of the project, from the project design and construction through to operation and management. Monitoring of the project is also required to ensure that risks are maintained at low levels.

2 BACKGROUND

Suntay Aquaculture Pty Ltd proposes to construct and operate a shrimp aquaculture project on Ceylon Point peninsula on Bynoe Harbour, Northern Territory. The project plans to grow Black Tiger Prawns *Penaeus monodon* in contained aquaculture ponds, using the latest technology which allows for zero operational discharges from the aquaculture ponds and minimal discharges from a hatchery.

EcOz Environmental Services was commissioned by Suntay Aquaculture Pty Ltd to undertake this environmental risk assessment of the project. The project has been determined by the Northern Territory Office of Environment & Heritage to require the preparation of an Environmental Impact Assessment under the *NT Environmental Assessment Act*, and guidelines were prepared for the project by the Office. The environmental risk assessment addresses those issues identified in the guidelines.

3 INTRODUCTION

Environmental risk management and assessment is an integral part of good management practice. Risk management is the term applied to a logical and systematic method of establishing the context, identifying, analyzing, evaluating, treating, monitoring and communicating risks associated with an activity that will enable a organisation to minimise losses and maximise opportunities.

The environmental risk assessment process has undergone development and has been formalised in a number of standards developed internationally and in Australia. The risk assessment undertaken for the Point Ceylon Aquaculture Project proposal at Ceylon Point on Bynoe Harbour is based on two standards, the Australian Standard *AS4360:1999 Risk Management*, and the guide *Environmental Risk Management HB203:2000*, both published by Standards Australia. Additional guidance was obtained from other publications on the subject, referred to in the references and in the text.

Risk is the chance of something happening that will have an impact on objectives. The risk management and assessment process is iterative, with feedback and modification at each stage of the process. The steps involved in risk assessment are:

- *Establish the context*
- *Identify risks*
- *Analyse risks*
- *Evaluate and prioritise risks*
- *Treat risks*

Throughout the process, integrated feedback mechanisms are:

- *Communicate and consult*
- *Monitor and review*

Environmental risk can be grouped into two categories:

- *Risk to the environment*
- *Risk to an organisation from environment-related issues*

4 SCOPE OF STUDY

The scope of the study is the proposed aquaculture project proposed for NT Portion 3192 at Point Ceylon Bynoe Harbour in the Northern Territory. The study relied on information on the project provided by Suntay Aquaculture Pty Ltd and expert technical advice from subconsultants to the project. Any future variations of a substantive nature from the project's design at the stage of the risk assessment may influence the findings of this risk assessment.

The study is an environmental risk assessment, and does not address other risks except in the context of environmental matters.

The terms of reference are as defined in the guidelines to the Environmental Impact Statement. The Guidelines at section 6.3.2.4 Coastal Water Quality recommended that, at a minimum, the ERA (Hazard & Risk Analysis (HRA) in the Guidelines) should provide the following information:

- the anticipated frequency and volumes of contingent discharges;
- the circumstances under which discharges would occur;
- the likely composition/quality of discharged water at the point of release and when it enters the coastal waters of Point Ceylon, including suspended solids, nutrients, algae, zooplankton, bacteria (and other pathogens);
- the potential impacts on nearshore benthic marine communities
- and the health of pearl oysters off Point Ceylon; and
- recommended measures to avoid or minimise these impacts.

5 METHODS

The methods utilised for this Environmental Risk Assessment follow those described in the Australian Standard AS 4360.

Each step of the risk assessment for this project has been documented in accordance with established practice, and includes assumptions, methods, data sources and results. Environmental risk assessment and management provide a formal set of processes that help when making decisions affecting the environment, and the project design and development, and assists decision-makers to deal with uncertainty. Uncertainty of outcomes in environmental risk assessment is accepted as the normal situation for many aspects relating to environmental aspects, and the risk assessment process is designed to minimise uncertainty. Uncertainty arises from many sources, including those related to individual aspects, through to the combined effects and impacts from multiple aspects.

This Qualitative Risk Assessment aims to assess the risks and identify management practices to mitigate potential impacts with the proposed aquaculture project at Ceylon Point. The objectives for the risk assessment are:

- To identify the hazards and resultant risks to the environment from the project as a whole, and threats from environmental aspects to the project;
- To rank and prioritise risks through a risk assessment process; and
- To identify management measures to mitigate the risks.

Aspects and activities are evaluated against AS4360 by allocating a qualitative measure of likely consequence and likelihood. From these a risk ranking has been developed for each aspect. Risks

with rankings in the extreme and high categories are addressed in particular, and those in the low and moderate categories addressed by accepted practices for each of the activities.

Threat criteria and the basis of assessment of consequences and impacts are tabulated in Table 1 below.

Table 1 Threat criteria and consequence or impact (adapted from Table E1 from AS4360, and Defence Risk Framework 2003 table 8)

Level	Descriptor	Project operation	Environment	Community & sustainability	Safety (Staff & public)	Compliance & reputation	Financial
5	Catastrophic	Project stopped for 12 months; operations cease, significant loss of production capacity; inspectors brought in	Mass mortality of other animals & plants, extinction of species; toxic release off-site with detrimental effect; high potential for permanent damage; actual breach of legislation & licences, reportable; significant remediation costs	Significant, extensive, detrimental long-term impacts on community values or on public health; irreparable damage to cultural or sacred values or artefacts; permanent & significant loss of rare environmental resources	Death of humans; major injuries, acute or chronic occupational illness; multiple injuries; requiring medical assistance, evacuation	Potential prosecution or cancellation of licences resulting in suspension of activities; national adverse publicity; subject of inquiry at parliamentary level; sustained public concern	Huge financial loss to remedy
4	Major	Project operation may be suspended for 3 months or more; loss of production capability; inspectors engaged	Off-site release with significant detrimental effects; moderate probability of permanent damage ; potential breach of legislation and licences, reportable; high remediation costs	Significant detrimental impacts on community values or on public health; major damage to cultural or sacred values or artefacts; significant loss of rare environmental resources	Extensive injuries, medical assistance required	Potential prosecution or suspension of licence; adverse state/territory publicity; Ministerial inquiry; significant public concern	Major financial loss to remedy
3	Moderate	Project inspected, operations continue; proof of modified procedures required by authorities	Off-site release with moderate measurable detrimental effects, low probability to breach legislation or licences; reportable	Detrimental impacts on community values or on public health; damage to cultural or sacred values or artefacts; loss of rare environmental resources	Some injuries, medical treatment required	Potential infringement of licence or legislation; warning from authorities; public concern; bad press	High financial loss to remedy
2	Minor	Project continues; operational procedures reviewed	On- or off-site release immediately contained, minor breach of legislation or licence; reportable in annual reports	Minor impacts on community values or on public health; minor damage to cultural or sacred values or artefacts; minor loss of special environmental resources	First aid treatment required	Concern about detriment to reputation; internal inquiry; no press	Medium financial loss to remedy
1	Insignificant	Project continues as normal; diligence maintained	Negligible release or damage to contained environment; no breach; not reportable; fully recoverable damage	Negligible impacts on community values or on public health; negligible damage to cultural or sacred values or artefacts; negligible loss of rare environmental resources	No injuries	Internal inquiry; no press	Low financial loss to remedy

The likelihood of an event occurring provides a measure of the known or anticipated frequency of occurrences. Combined with the consequences, they provide guidance on risk levels of each aspect and enable ranking of priorities.

Table 2 Qualitative measures of likelihood (adapted from table E2 of AS 4360 & Defence Risk Framework 2003, table 6)

Rating	Likelihood The potential for risks to occur and lead to the assessed consequences			
5	Almost certain	Is expected to occur at least several times per year	p>0.8	A similar outcome has arisen several times per year in the same location, operation or activity
4	Likely	High, may arise about once per year	0.5<p<0.8	A similar outcome has arisen several times per year in related projects
3	Possible	May arise at least once in a one to ten year period	0.1<p<0.5	A similar outcome has arisen some time in related projects
2	Unlikely	Likely to occur at some time during next ten to twenty-five years	0.04<p<0.1	A similar outcome has arisen previously in related projects, but mitigation has reduced the chance of recurrence
1	Rare	Very low, may occur in exceptional circumstances, very unlikely in next 25 years	p<0.04	A similar outcome has arisen world-wide

Risk levels & priorities

Significance of a risk is a result of analysis of the risks, both in a quantitative and qualitative sense. Assigning risk values to risk provides some guidance to the level of risk inherent in any action or aspect, but should always be used with caution as the risk level is based on subjective assessment, and assigning numerical values to subjective assessment may mask actual risks in some instances. Nevertheless, in determining risk levels, assigned values can provide reliable guidance to appropriate mitigation and management measures.

The next step in risk assessment after having identified and analyzed all the risks is to determine how to respond. In order to do this, risk levels have to be assessed. This then gives guidance in how to rank risks and provide management and mitigation solutions. Risk levels can be assessed by the level of risks resulting from:

1. the highest level of risk in any measure, and
2. by a combination of risks across all measures or criteria.

These two measures are expressed as a combination of its consequences and likelihood, either as numerical values or as categorical values (e.g. High, Medium, Low as described in AS 4360 and HB203:2000). The numerical value approach provides more guidance to the level of risk than the categorical values, because the numerical values, if used conservatively, can be used to incorporate levels of assessed risk across more than one category, or criterion. The approach used below is modelled on that used by Defence (Defence 2003).

The two measures of risk level used are:

Primary Risk level (PRL) – a conservative measure of risk, based on the most severe consequences across all relevant criteria. It is calculated as:

PRL = (likelihood rating) x (maximum consequence rating)

Secondary Risk Level (SRL) is a less conservative measure of risk, incorporating all relevant criteria, not just the most severe ones. It is calculated as:

SRL = (likelihood rating) x (average consequence rating)

The PRL is used for primary assessment as it focusses on the maximum risk to be expected and is therefore conservative. The SRL provides a secondary measure which indicates how significant the perceived or anticipated risks are likely to be across the relevant criteria. As the SRL is averaged, the highest risk levels are reduced by the lower levels, and therefore may be masked by the averaging process.

Table 3 Risk levels and management action (adapted from Defence Risk Framework 2003, table 7)

Risk Level (PRL or SRL)	Descriptor	Indicative management action
16-25	Extreme	Top priority action, senior management decisions, contingency plans, external authorities involved
9-15.9	High	Senior planning & action, specific management actions required, external advice may be sought
4-8.9	Moderate	Expert planning & management, exceedance of accepted standards
1-3.9	Low	Good planning & management, accepted standards

Consultation and review

Consultation is a key part of risk assessment. Consultation with the project proponents, and with the regulators (the NT Government) has been held at several stages, particularly at key points where the criteria were established and the determining authorities identified. These consultations were in the form of face-to-face interviews with the support of documented scopes and identified issues for discussion and consideration.

Consultation was also held on key elements of the hydrological study, with peer review by experts within the Department of Infrastructure, Planning and Environment, and on the diseases ad pathogens of shrimps and molluscs with international experts and experts from the Northern Territory to establish whether the approach taken was of an internationally accepted standard and whether the findings were considered correct.

Review and revision of the risk assessment were undertaken in the process.

6 RISK MANAGEMENT CONTEXT

The proponent has stated the policy relating to the risk assessment. This is documented below.

The guidelines for preparation of the Environmental Impact Statement (EIS), issued by the NT OE&H (28th February 2003), identified the specific context for this risk assessment.

Objectives and Scope:

> ***Guidelines: 6.3.2.4 Coastal Water Quality***
>
> *Although the facility is being designed as a "zero- or near-zero discharge" operation, because of significant rainfall in the wet season (with occasional cyclones) and the potential for failure of bund walls, pumps or other infrastructure, the proponent should anticipate at least occasional discharges.*

> *The potential for unacceptable impacts on the quality of the coastal waters adjacent to the development site is considered a crucial issue for the proponent to address. Discharge of significant amounts of suspended solids, nutrients, algae and/or pathogens could threaten the viability of benthic nearshore habitats (seagrasses, corals, sponges, etc., and their associated fauna) and the important pearl aquaculture operations immediately offshore from the lease area.*
>
> *Hazard and risk analysis for **contingent discharges***
>
> *In order to enable an adequate assessment of these risks and development of effective safeguards to avoid or minimise unacceptable impacts, the proponent should conduct a thorough **hazard and risk analysis (HRA).** Because the outcome of this analysis will identify the level of risk associated with all relevant hazards, this information will be crucial to identifying the type and comprehensiveness of information required to assess the environmental acceptability of the proposal, in addition to designing baseline and on-going monitoring studies of an appropriate scope and intensity for early detection of marine impacts.*
>
> *It is in the proponent's interest to complete this as soon as possible, because **the outcome could be used to eliminate the need for extensive baseline studies and on-going monitoring of coastal water quality indicators**.*

In particular, it was noted in section 6.4.1.2 of the Guidelines that the scope and extent of information identified in that section could be reduced if the outcome of the hazard and risk assessment (described in Section 6.3.2.4) indicates that contingent discharges are likely to be infrequent, of limited duration/volume or involve effluent of a quality that is unlikely to impact nearshore benthic communities or the pearling operations off Point Ceylon.

Table 4 Context of Risk Evaluation Criteria for the Point Ceylon Aquaculture Project

Legislation	*Environmental Assessment Act NT* *Water Act* *Fisheries Act* *Waste Management and Pollution Control Act* *Soil Conservation & Land Utilization Act*
Regulatory policy.	Coastal Policy Mangroves Policy
Corporate policy.	Our environmental friendliness is not only a public responsibility but also a responsibility to ourselves. We strongly believe (and have experienced) that whatever waste, disease, contamination, or adversity we put into the harbour will come back to haunt us. Hence, we have painstakingly endeavoured in our designs to cause the least impact on the harbour and environment. Our aquaculture operation lives and dies with the environment it operates in.
Project objectives.	To produce farm-shrimp for export and domestic consumption at a competitive price To eliminate or minimise environmental, social and economic impacts To be a model of commercial success, production efficiency, sustainability, and environment-friendliness
Ethical guidelines.	Codes of Practice for Aquaculture
Standards, guidelines and codes of practice.	"Belize Model" ANZECC Water Quality Guidelines GAA Standards GAA Code of Practice FAO Code of Practice
Experience and professional judgement.	Suntay NT Fisheries Water Resources/Controller Marine biologists NT

Table 5 Issues to Consider in Risk Assessment Criteria

General Issues	**Specific Sunrise Aquaculture Issues – some example for discussion**
What are the appropriate endpoints?	Project proceeds in timely fashion, with reasonable/minimal cost Zero to near-zero discharges Optimal necessary baseline studies Minimal necessary monitoring
How severe is the risk?	

General Issues	Specific Sunrise Aquaculture Issues – some example for discussion
How many people is it likely to affect? What is the ecosystem impact likely to be?	
Who is determining acceptability, and for whom?	Northern Territory Office of Environment & Heritage Northern Territory public; Northern Territory businesses
What process is used to decide acceptable risk over what defined or flexible time frame, etc.	EIS – affected businesses, competing businesses, fishermen, community; regulators, politicians and scientists
Have all relevant guidelines and regulations been considered and where necessary complied with?	
What is best practice? Are there any overseas regulations or guidelines which could be regarded as best practice?	Belize model ANZECC Water Quality Guidelines GAA Standards GAA Code of Practice
What form should the criterion take; fixed numerical levels or incorporating statistical considerations? Has the decision been based on a comprehensive review of the available accepted criteria and/or case studies?	
What level of conservatism should be used to accommodate uncertainty?	With the focus on risk management, the phased development will minimize fatal costly mistakes; for example, broodstock development from the outset will minimize reliance on low quality seed and disease introduction from uncontrollable sources such as interstate hatcheries. Some redundancies will be built-in in the initial stages of development to allow greater flexibility and control.
Have the risk management implications of each criterion option been considered?	
Have the costs and benefits of each management option been estimated?	
Have the criteria been compared against other criteria for comparable risks and is a similar level of benefit/cost achieved? Will resources be allocated in proportion to risk if the recommended criterion is adopted? Potential for mis-allocation of resources.	
Has the practicality of monitoring and enforcement been considered? This is important to address at the assessment stage otherwise the criterion will be meaningless.	

The following criteria were developed for the Point Ceylon Aquaculture Project from the above process of documentation and review, in consultation with the NT Office of Environment and Heritage and with the proponent, Suntay Aquaculture Pty Ltd.

Table 6 Risk Evaluation Criteria Determined for Point Ceylon Aquaculture Project

Project components (sources and receivers)	**Matters/Aspects specified in Guidelines and otherwise**	**Criteria and Guiding References**	
• Inlets • Pipelines and pumps • Sea Water settling ponds	• Input Water quality • Failures	Australian Design Standards for rising mains, pumps, non-return valves, pipework, etc. Australian Standards for non-permeable HDPE Australian Design Codes for engineered ponds	ANZECC Water Quality Guidelines for Marine Water Quality (ANZECC 2000)
• Hatchery Sheds • Processing Sheds	• Storage of materials	Australian & NT (e.g. Cyclone standards) design codes	
• Hatchery • Aquaculture ponds • Recirculation ponds	• The anticipated frequency and volumes of contingent discharges;	Frequency & volumes	AWBM Catchment Water Balance Model; HEC-RAS River Analysis System Version 1.2 Apr 1996; 2Dam (Barlow 1990); Aust Rainfall & Runoff; RORB Ver 4 Runoff Routing Program
	The circumstances under which discharges would occur;	As above	As above
	• The likely composition/quality of discharged water at the point of release and when it enters the coastal waters of Point Ceylon, including: • suspended solids, nutrients • algae • zoo-plankton • bacteria • (and other pathogens);	*Water Act* – Waste Discharge Licence *Waste Management & Pollution Control Act* Best Practice from published literature 'Belize' model GAA Codes & standards AWQG 2000 for Marine Water Quality FAO Code Of Responsible Aquaculture AFPA Code of Practice HACCP	ANZECC Water Quality Guidelines for Marine Water Quality (ANZECC 2000) Global Aquaculture Alliance Codes of Practice (Global Aquaculture Alliance 2003a, b, c) Belize Aquaculture Evaluation and Code of Practice (Boyd & Gautier 2000; Boyd & Clay 2002; Boyd *et al*. 2002) Environmental Code of Practice for Australian Prawn Farmers (Donovan 2001) Shrimp Farm environmental management principles (Preston & Rothlisberg c2003)

Project components (sources and receivers)	Matters/Aspects specified in Guidelines and otherwise	Criteria and Guiding References	
			Draft Aquaculture Policy (Cairns and Far North Environment Centre 1999) Mid-crop mortality syndrome (Anderson 1996) International Aquatic Animal Health Code (OIE Fish Diseases Commission 2000b)
	• The potential impacts on nearshore benthic marine communities, and • the health of pearl oysters off Point Ceylon; and	*Water Act* – Waste Discharge Licence Pearl Oyster Health Survey criteria	Pearl Oyster Aquaculture Survey NT, WA, Qld (Shelley 1994) Commercial Shellfish diseases and parasites (Bower & McGladdery 1996) Diagnostic Manual for Aquatic Animal Diseases (OIE Fish Diseases Commission 2000a)
	• Recommended measures to avoid or minimise these impacts.	Best Practice from published literature 'Belize' model GAA Codes & standards	Global Aquaculture Alliance Codes of Practice (Global Aquaculture Alliance 2003a, b, c) Belize Aquaculture Evaluation and Code of Practice (Boyd & Gautier 2000; Boyd & Clay 2002; Boyd *et al.* 2002) Environmental Code of Practice for Australian Prawn Farmers (Donovan 2001) Shrimp Farm environmental management principles (Preston & Rothlisberg c2003) Draft Aquaculture Policy (Cairns and Far North Environment Centre 1999)
• Fresh Water Storage reservoir	• Input water quality	AWQG for fresh water	ANZECC Water Quality Guidelines for Fresh Water Quality (ANZECC 2000)
• Fertilizer and supplement	• Leaks, escapes, accidents	*Dangerous Goods Act*	

Project components (sources and receivers)	Matters/Aspects specified in Guidelines and otherwise	Criteria and Guiding References	
chemicals stores • Fertilizer and supplement chemical supply pathways • Sterilizing and water treatment agents (eg lime, chlorine)		ADGC for Transport of Dangerous Goods	
• Fuel supplies	Spillages, leaks	*Dangerous Goods Act* AS 1940 for construction of tanks, bunds and pipeworks ADGC for Transport of Dangerous Goods	
• Power station and reticulation	Spills, leaks, emissions	Australian codes, standards	

7 RESULTS

The results of the analysis of risks attached to the Point Ceylon Aquaculture Project are documented below in Tables 7 and 8.

Table 7 Risk Sources and Impacts for the Point Ceylon Aquaculture Project

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Planning & concept phase					
Financial resources	Insufficient funds to build, operate or maintain	All	Bank guarantees; robust finances – Suntay submitted financial statements to DBIRD. Project will be built in stages with each being self-sufficient and financially viable. Phase 1, which is the least expensive, is already viable in itself based on financial modelling	N/a	Failure of project at any stage of planning, development, operation resulting in multiple impacts
Design phase					
Baseline study access	Vehicle incident Fire	Soil, water Vegetation	Safety procedures Volume (low) Fire equipment	Soil, water Vegetation	Vegetation & soil damage Cultural site damage
Site investigations	Drill-rig incident Vehicle incident Vegetation & soil disturbance Fire	Soil Site drainage & runoff Waterways	Distance from receptors Soil & vegetation Maintenance Fire equipment	Soil & vegetation Waterways Marine environment Oyster leases	Vegetation & soil damage Aquatic & marine biota damage

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Construction phase					
Construction transport	Fuel & oil spills Weed introductions Vegetation damage Fire	Soil, water, overland flow	Maintenance & management Washdown before entering site Monitoring of weed introductions Fire prevention	Soil, water Marine environment Vegetation	Vegetation & soil damage Aquatic & marine damage
Washdown water from vehicles, equipment & plant	Daily washdown	Soil, waterways	Washdown area design & construction	Soil, water	Weed introductions Pollution from detergents, grease & sediment
Earthworks	Clearing of habitat Vegetation & soil damage Weed introductions Drainage alteration Fire	Soil, water Overland flow Waterways Vegetation	Limits on clearing Control of vegetation clearing Washdown of plant before entering site Control of earthworks Sediment control Fire prevention	Terrestrial, aquatic & marine environment	Loss of vegetation Cultural site damage Smothering of native vegetation Changed species composition Changed fire effects
Construction materials	Spillage Fire	Soil, water vegetation	Safe operating procedures Fire prevention & control equipment	Soil, water Vegetation	Contaminated soil Sediment increase Vegetation damage
Extractive materials	Spillage rainfall Weed introductions	Soil, water	Source from weed-free extraction areas Install erosion controls Treatment of weeds	Vegetation Soil, water	Weed infestation Sediment increase in waters
Liquids – e.g. diesel, lubricants	Spillage, leakage	Soil, water	Operating procedures Appropriate equipment Storage design & construct to Australian Standards Management	Soil, water Vegetation Soil, marine & aquatic biota	Contamination Injury & death

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Water supplies during construction	Spillage	Soil, waterways	Operating procedures	Soil, water	Increased sediment
Construction activities	Rainfall, Storms Dust generation	Waterways Air	Dust control Construction during dry season to avoid storms Erosion control Revegetation	Air waterways	Siltation Smothering of vegetation (marine, aquatic & terrestrial)
Ponds and dams	Erosion from storms Changes to flows and natural storage Water body creation ASS disturbance	Waterways Soil	Site management practices Sediment control ASS management practices	Soil, waterways, marine environment Humans	Changes to waterways, marine environment Mosquitoes/biting insects Acid leaching & death, disease to biota
Supply and Drain pipes & trenches	Erosion from storms	Soil, waterways	Construction during dry season Rehabilitation	Waterways, marine environment	Changes to waterways, marine environment
Water intakes	ASS disturbance Erosion	Soil Water	Avoidance of PASS Site works appropriate	Marine environment	Death, damage and injury to marine biota
Electricity generation	Start-up Operation Lighting	Air	Filters, scrubbers Light shielding	Air Vegetation Turtles & night birds	Polluted air Vegetation damage Deaths & injuries of turtles Disorientation of fauna
Portable toilets	Spillage, leakage	Soil, water	Maintenance & operating practice	Soil, water, vegetation Biota	Pollution of biota Increased nutrients
Wastes during construction	Spillage Fire	Air, soil, water	Management, appropriate disposal	Air, soil, water, vegetation	Pollution of air, soil, water
Bio-hazards	nil				
Diseases	Diseased staff	Air, water, contact	Disease control, medicines	Humans	Damaged health

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Operational Phase					
Power Failure	Failure due to extreme event, failure of generators, loss of mains supply	Power reticulation and supply	Power provision for the production phase will be via diesel generators with 100% failsafe backup; design will take this into account	Production ponds and facility	Loss of aeration; Loss of crop (dead stock); Financial loss
Access	Loss of access due to flooding of main road	Access routes to and from estates	Reserve cold storage; Road cut infrequent and for short periods of only a few days maximum – below frequency of supply (say once or twice weekly)	Markets; Production ponds; stocks	Stock unable to get to markets; emergency maintenance unable to access; financial implications
Water sources – saltwater – Bynoe Harbour	Pump failure Backflow Polluted intake water	Bynoe Harbour marine environment Intake pipes	Pump maintenance Non-return valves Intake water quality testing	Bynoe Harbour Hatchery and ponds	Backwash causing turbulence Pollution of ponds & hatchery Sediment impact on marine biota & Pearl Oysters
Water sources – saltwater – Wheatley Creek	Pump failure Backflow Polluted intake water	Wheatley Creek marine environment Intake pipes	Pump maintenance Non-return valves Intake water quality testing	Wheatley Creek Hatchery and ponds	Backwash causing turbulence Pollution of ponds & hatchery Sediment impact to marine biota
Water sources – - freshwater	Dam wall failure Pump failure Backflow Polluted intake water	Upper Wheatley Ck catchment Wheatley Creek MacKenzie Arm Intake pipes	Civil engineering design standards for dams Pump maintenance Non-return valves Intake water quality testing	Wheatley Ck & MacKenzie Arm Ponds	Erosion of upper Wheatley Creek, sediment load Pollution of ponds Sediment impact to marine biota
	Insufficient fresh	Wheatley Ck to off-stream	Reserve capacity based on	Production ponds	Increasingly saline ponds

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
	water for pond top-up	storage	modelling of catchment, rainfall and pond requirements; Contingency import of freshwater from other source		
Diverted surface waters	Loss of downstream aquatic habitats Flooding of upstream habitats	Creek lines	Optimum dam size Adequate assessment of aquatic habitats	Wheatley Ck habitats	Loss of habitat
Lighting of production area	Lighting every night	Air	Light shielding Appropriate lighting	Birds	Distraction of birds to production area
Disease introduction	Disease from vectors	Birds, cane toads, other animals	Preventative devices against birds landing on ponds	Aquaculture prawns Wild prawns	Disease of aquaculture and wild prawns
Production ponds - sediment - organic matter - pathogens	Overflow in extreme events	Overflow channel/drain	8-20 m ASL providing significant elevation and distance from creeks and marine habitat Overflow waters from surface, low in SS & nutrients, low in potential pathogens; Excess water moved to harvest basins; Harvest & Recirculation basin capacity; Contingency plans	Harvest ponds	Loss of overflow water from production ponds
Harvest ponds - sediment - organic matter - -pathogens	Overflow in extreme events	Overflow channel/drain	8-20 m ASL Overflow from surface, low in SS & nutrients, low in potential pathogens	Recirculation basin	Loss of overflow water from Harvest ponds

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
			Excess water moved to harvest basins; Harvest & Recirculation basin capacity Contingency plans		
Recirculation Ponds - sediment - organic matter - -pathogens	Overflow in extreme events	Natural drainage surface	8-20 m ASL From surface, low in SS & nutrients, low in potential pathogens Excess water overflows pond walls as sheet flow; High dilution during extreme rainfall events Contingency plans; active water management	Wheatley Creek & unnamed eastern creek to Bynoe Harbour Mangroves Marine environment & biota Fisheries Aquaculture oysters	Pollution from nutrients and sediment Pathogen release to aquatic & marine environments Pathogen release to Pearl Oysters
Discharge of pond water	Discharge to marine environment	Overland to marine waters	8-20 m ASL From surface, low in SS & nutrients, low in potential pathogens Excess water overflows pond walls as sheet flow; High dilution during extreme rainfall events Contingency plans; active water management	Wheatley Creek & unnamed eastern creek to Bynoe Harbour Mangroves Marine environment & biota Fisheries Aquaculture oysters	Death or disease to Pearl Oysters Death or disease to wild crustaceans Death or disease to marine biota
Supply Pipes	Failure of pipes	Across land and into creek and drainage lines	Regular maintenance Adequate manufacture standards	Soil, water, vegetation	Saltwater damage to soil, vegetation & freshwater creeks
Drain & transfer pipes between production ponds	Failure of pipes	Across land and into creek and drainage lines	Harvest Basins; Regular maintenance; Adequate manufacture standards	Harvest Basins; Soil, water, vegetation	Saltwater damage to soil, vegetation & freshwater creeks Pollution from nutrients,

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
					pathogens to soil, aquatic and marine environments
Lighting of hatchery area	Lighting every night	Air	Light shielding from Bynoe Harbour Appropriate lighting	Birds Marine turtles	Distraction of birds to production area; distraction of marine turtles from breeding beaches
Hatchery	Operations; Fire; Storm-surge; Major storm; Extreme rainfall event	Across land to Bynoe Harbour	Location of hatchery outside storm-surge zone; Design & Construction parameters; Evaporation and soakage basin to receive excess water; Preventative maintenance, equipment; Contingency plans	Marine biota & environment	Pollution from nutrients and sediment Pathogen release to aquatic & marine environments Pathogen release to Pearl Oysters
Discharge of hatchery water	Discharge to marine environment	Overland to marine waters	Location of hatchery outside storm-surge zone; Design & Construction parameters; discharge will be rarer than discharge from the pond water as more than ample area for recirculated water will be provided; Evaporation and soakage basin to receive excess water; Preventative maintenance, equipment; Contingency plans	Bynoe Harbour Mangroves Marine environment & biota Fisheries Aquaculture oysters	Death or disease to Pearl Oysters Death or disease to wild crustaceans Death or disease to marine biota

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Processing shed	Fire Extreme Storm	Soil, water	Adequate design & construction Preventative mtce, equipment Contingency plans	Soil, water Marine environment	Nutrient overload/pollution of soil, water & marine environment
Staff accommodation & Office	Fire Extreme Storm	Surrounding environment	Adequate design & construction Preventative maintenance, equipment Contingency plans	Surrounding environment	Site pollution Gross pollutants
Laboratory facility - preservatives for specimens	Fire Extreme storm	Soil, water	Adequate design & construction; Appropriate storage; few chemicals (preservatives etc.); Preventative maintenance of equipment Contingency plans	Soil, creeks Marine environment	????
Quarantine facility	Fire Extreme storm	Water	Adequate design & construction; storage tanks for untested animals are sealed and the facility will include a controlled and disinfected entry point; Preventative maintenance of equipment; Contingency plans	Marine biota	Pollution from nutrients Pathogen release to aquatic & marine environments Pathogen release to Pearl Oysters
Disease introduction	Supply of prawns	Prawns sourced from external sources	Adequate quarantine; Prawns sourced from Bynoe Harbour and local	Aquaculture prawns Wild prawns	Disease of aquaculture and wild prawns

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
			waters – 60 days quarantine; Broodstock held on site		
Aeration system	breakdown	Damaged & used parts	Waste stockpile	landfill	Waste inert material
Warehouse - minor chemicals, lime and chlorine, feeds etc.	Fire Extreme Storm	Soil, water	Adequate design & construction; Contingency plans	Soil, water, marine environment	Pollution from chlorine, fertilisers, , urea, rice bran, tea-seed cake, feed stocks, POL
Fertilisers, stock feed in storage & in transit ▪ urea ▪ triple super-phosphate ▪ rice bran ▪ tea-seed cake ▪ feeds	Spillage Fire Extreme storm event	Soil, water	Appropriate storage Safe transport Contingency plans	Soil, vegetation, aquatic biota Marine biota Fisheries Aquaculture oysters	Nutrient overload – pollution
Feeds	Disease introduction through feeds	Introduction into ponds	Quarantine & testing	Aquaculture prawns	Introduction of disease to aquaculture prawns Introduction of disease to wild prawns
Chlorine, disinfectants in storage and transit	Spillage Fire Extreme storm event	Soil, water Air	Appropriate storage Safe transport Contingency plans	Soil, vegetation, aquatic biota Marine biota Fisheries Aquaculture oysters	Death to soil, aquatic and marine biota
Water conditioners - lime - sodium carbonate	Spillage Fire Extreme storm event	Soil, water	Appropriate storage Safe transport Contingency plans	Soil, vegetation, aquatic biota Marine biota Fisheries Aquaculture oysters	Death to soil, aquatic and marine biota

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
Sediment from operational area	Rainfall Wind	Air, water	Sediment control and vegetation management	Vegetation, waterways, marine environment	Smothering of vegetation Smothering of marine habitats Infilling of creeks
Sediment from access and other areas	Rainfall Wind	Air, water	Sediment control and vegetation management	Vegetation, waterways, marine environment	Smothering of vegetation Smothering of marine habitats Infilling of creeks
Sewage and domestic effluent	Overflow Storm rainfall Tank & pipe failure Pump failure Creation of breeding habitat for biting insects	Soil, water Air	Appropriate system design Management and maintenance Contingency plans	Soil, waterways, marine environment	Pollution of soil, water, marine environment
Sludge from production, harvest and water treatment ponds	Overflow in extreme events	Channels, drains or pipes to recirculation basin Loss from roto-tilling equipment to ground	Contained in recirculation basin and sludge drying beds Cleaning/washdown of roto-tillers on contained site Design of sludge drying beds Treatment of sludge	Soil, vegetation, aquatic biota Marine biota Fisheries Aquaculture oysters	Dynoflagellate intros Bacterial overload, viral introductions Death, poisoning, detriment to oysters, marine fauna & flora
Washdown water from processing plant	Daily washdown escaping to environment	Soil, waterways	Washdown treatment; Direction of washdown waters to sewerage treatment plant	Sewerage treatment plant Soil, water, marine environment Marine biota	Pollution of soil, waters; Death, poisoning, detriment to pearl oysters, marine fauna & flora
Used cooking brine	Daily disposal	Soil, waterways	Treatment of effluent through sewage system – only about 1% of prawns	Soil, water, marine environment Marine biota	Pollution of soil, waters Death, poisoning, detriment to pearl oysters,

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
			will be cooked, resulting in very small volumes		marine fauna & flora
Dead prawn/shrimp	Daily disposal escaping to environment	Soil, waterways	Burnt on site Treatment of discarded prawns	Soil, water, marine environment; Marine biota	Pollution of soil, waters Death, poisoning, detriment to pearl oysters, marine fauna & flora
Diseased prawns and other product	Daily disposal escaping to environment	Soil, waterways	Treatment of discarded prawns: discharge to external environment not likely since diseased prawns are not disposed but dried and not on daily basis but after 15 days by which time they should have decomposed; excess undecomposed material incinerated on site	Soil, water, marine environment Marine biota	Pollution of soil, waters Death, poisoning, detriment to pearl oysters, marine fauna & flora
Used parts, sump oil, filters, rags etc.	Regular disposal	Soil, waterways	Adequate disposal to landfill or alternative	Soil, water Vegetation, biota	Pollution
Miscellaneous items – fertiliser bags, feed bags, lime bags, etc.	Regular disposal	Soil, waterways	Adequate disposal to landfill or alternative	Soil, water Vegetation, biota	Pollution
Domestic garbage, food waste	Regular disposal	Soil, waterways	Adequate disposal to landfill or alternative	Soil, water Vegetation, biota	Pollution
Other wastes	Regular disposal	Soil, waterways	Adequate disposal to landfill or alternative	Soil, water Vegetation, biota	Pollution
Air emissions, incl Greenhouse gases & Power supply emissions	Daily emissions	Air	Design & construction to Australian Standards & Power efficiency standards	Air Vegetation	Pollution
Native stock	Accidental release	Waterways	Design to prevent	Marine environment	Genetic mixing with local

Source		Pathway	Barrier/mitigator	Receptor	Impact
Hazard/Aspect	**Event**				
	Deliberate release		accidental release Security to prevent deliberate release Appropriate transport practices		province species
Power supply – fuels	Leaks, spillage, failure of reticulation systems	Soil, waterways	AS1940 design & construct Maintenance & inspection	Soil, waterways & marine environment	Pollution

Table 8 Likelihood & Consequence of Risks Occurring – and Ranking of Risks for the Point Ceylon Aquaculture Project

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Planning & concept phase										
Financial resources	Insufficient funds to build, operate or maintain	4	2	2	4	4	4	2	8	6.7
Design phase										
Baseline study access	Vehicle incident Fire	1	1	1	1	1	1	1	1	1.0
Site investigations	Drill-rig incident Vehicle incident Vegetation & soil disturbance Fire	1	1	1	1	1	1	1	1	1.0
Construction phase										
Construction transport	Fuel & oil spills Weed introductions Vegetation damage Fire	1	2	1	3	3	3	2	6	4.3
Washdown water from vehicles, equipment & plant	Daily washdown	1	1	1	1	1	1	2	2	2.0
Earthworks	Clearing of habitat Vegetation & soil damage Weed introductions Drainage alteration Fire	2	3	2	2	3	2	5	15	11.7

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Construction materials	Spillage Fire	2	2	1	3	2	2	2	6	4.0
Extractive materials	Spillage Rainfall Weed introductions	1	2	1	1	1	1	2	4	2.3
Liquids – e.g. diesel, lubricants	Spillage, leakage	1	2	2	2	2	2	2	4	3.7
Water supplies during construction	Spillage	1	1	1	1	1	1	2	2	2.0
Construction activities	Rainfall, Storms Dust generation	2	1	1	1	1	1	2	2	2.3
Ponds and dams	Erosion from storms Changes to flows and natural storage Water body creation ASS disturbance	3	3	2	1	3	3	3	9	7.5
Supply and Drain pipes & trenches	Erosion from storms	3	3	2	1	3	3	3	9	7.5
Water intakes	ASS disturbance Erosion	2	3	3	1	3	2	2	6	4.7
Electricity generation	Start-up Operation Lighting	1	2	1	3	1	1	2	6	3.0
Portable toilets	Spillage, leakage	1	1	1	2	1	1	1	2	1.2
Wastes during construction	Spillage Fire	2	2	1	2	1	2	2	4	3.3
Bio-hazards	nil	N/a								
Diseases	Diseased staff	2	0	3	3	1	1	2	6	3.3

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Operational Phase										
Power Failure	Failure due to extreme event, failure of generators, loss of mains supply	3	2	2	1	2	3	2	6	4.3
Access	Loss of access due to flooding of main road	3	3	2	1	2	3	3	9	6.5
Water sources – saltwater – Bynoe Harbour	Pump failure Backflow Polluted intake water	4	2	1	2	3	2	2	8	4.7
Water sources – saltwater – Wheatley Creek	Pump failure Backflow Polluted intake water	4	2	1	2	3	2	2	8	4.7
Water sources – - freshwater	Dam wall failure Pump failure Backflow Polluted intake water	4	3	2	3	3	4	2	8	6.3
	Insufficient fresh water for pond top-up	2	1	1	1	1	1	2	4	2.3
Diverted surface waters	Loss of downstream aquatic habitats Flooding of upstream habitats	1	3	3	1	3	1	5	15	10.0
Lighting of production area	Lighting each night	3	3	2	3	3	2	4	12	10.7
Disease introduction	Disease from vectors	4	2	2	1	3	3	3	12	7.5
Production ponds - sediment	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
- organic matter - pathogens										
Harvest ponds - sediment - organic matter - pathogens	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5
Recirculation Ponds - sediment - organic matter - pathogens	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5
Discharge of pond water	Discharge to marine environment	4	4	4	1	4	4	3	12	10.5
Supply Pipes	Failure of pipes	4	2	2	1	3	4	1	4	2.7
Drain & transfer pipes between production ponds	Failure of pipes	4	2	2	1	3	4	1	4	2.7
Lighting of hatchery	Lighting each night	2	3	2	2	3	2	4	12	9.3
Hatchery	Operations; Fire; Major storm; Storm-surge; Extreme rainfall event	4	3	1	3	1	4	3	12	8.0
Discharge of hatchery water	Discharge to marine environment	4	4	4	1	4	4	3	12	10.5
Processing shed	Fire Extreme Storm	4	3	1	3	2	4	2	8	6.0

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Staff accommodation & Office	Fire Extreme Storm	4	2	1	4	4	4	2	8	6.3
Laboratory facility	Fire Extreme storm	2	2	2	1	1	1	1	2	1.5
Quarantine shed	Fire Extreme storm	3	4	4	1	4	2	2	8	6
Disease introduction	Supply of prawns	4	2	2	1	3	3	3	12	7.5
Aeration system	breakdown	4	3	1	1	2	3	2	8	4.7
Warehouse	Fire Extreme Storm	3	3	1	3	2	3	2	6	5
Fertilisers, stock feed in storage & in transit ▪ urea ▪ triple super-phosphate ▪ rice bran ▪ tea-seed cake ▪ feeds	Spillage Fire Extreme storm event	3	3	2	2	3	2	2	6	5.0
Feeds	Disease introduction through feeds	4	2	2	1	3	3	3	12	7.5
Chlorine, disinfectants in storage and transit	Spillage Fire Extreme storm event	3	3	3	4	3	2	2	8	6.0
Water conditioners - lime - sodium	Spillage Fire Extreme storm event	3	2	3	3	3	2	2	6	5.3

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
carbonate										
Sediment from operational area	Rainfall Wind	1	2	1	1	2	1	2	4	2.7
Sediment from access and other areas	Rainfall Wind	1	2	1	1	2	1	2	4	2.7
Sewage and domestic effluent	Overflow Storm rainfall Tank & pipe failure Pump failure Creation of breeding habitat for biting insects	2	2	2	2	2	1	2	4	3.7
Sludge from production, harvest and water treatment ponds	Overflow in extreme events	2	3	3	2	3	3	3	9	8.0
Washdown water from processing plant	Daily washdown escaping to environment	3	3	2	1	3	2	4	12	9.3
Used cooking brine	Daily disposal	1	1	1	1	1	1	1	1	1
Dead prawn/shrimp	Daily disposal escaping to environment	2	3	3	1	3	3	3	9	7.5
Diseased prawns and other product	Daily disposal escaping to environment	3	4	4	2	4	4	3	12	10.5
Used parts, sump oil, filters, rags,	Regular disposal	1	1	2	1	1	1	2	2	2.3

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
etc.										
Miscellaneous items – fertiliser bags, feed bags, lime bags, etc.	Regular disposal	1	1	1	1	1	1	2	2	2.0
Domestic garbage, food waste	Regular disposal	1	1	1	1	1	1	2	2	2.0
Other wastes	Regular disposal	1	1	1	1	1	1	2	2	2.0
Air emissions, incl Greenhouse gases & Power supply emissions	Daily emissions	1	1	1	1	1	1	2	2	2.0
Native stock	Accidental release Deliberate release	3	3	3	1	3	2	2	6	5.0
Power supply – fuels	Leaks, spillage, failure of reticulation systems	3	3	2	3	3	3	2	6	5.7

7.1 RANKING AND TREATMENT

The risks identified and ranked in the process of this environmental risk assessment mostly fall into the low to medium ranking categories. Those considered to have the highest areas of risk are shown in Table 9, and all fall into the High category at the PRL. Areas of risk can be managed by appropriate design, construction, monitoring and maintenance, and will be described in detail in the EIS. Issues such as diseased prawn residue, for instance, can be resolved by appropriate disposal mechanisms which for this project will be by incineration.

Table 9 Ranked High Risks from Point Ceylon Aquaculture Project

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Earthworks	Clearing of habitat Vegetation & soil damage Weed introductions Drainage alteration Fire	2	3	2	2	3	2	5	15	11.7
Diverted surface waters	Loss of downstream aquatic habitats Flooding of upstream habitats	1	3	3	1	3	1	5	15	10.0
Hatchery	Operations; Fire; Major storm; Storm-surge; Extreme rainfall event	4	3	1	3	1	4	3	12	8.0
Discharge of hatchery water	Discharge to marine environment	4	4	4	1	4	4	3	12	10.5
Production ponds - sediment - organic matter - pathogens	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5
Harvest ponds - sediment - organic matter - pathogens	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5
Recirculation Ponds - sediment - organic matter - pathogens	Overflow in extreme events	3	3	3	2	4	2	3	12	8.5

Source		Consequences						Likelihood	Ranking	
Hazard/Aspect	**Event**	**Project operation**	**Environ-ment**	**Community & sustain-ability**	**Safety (Staff & public)**	**Compliance & reputation**	**Financial**		**PRL**	**SRL**
Discharge of pond water	Discharge to marine environment	4	4	4	1	4	4	3	12	10.5
Washdown water from processing plant	Daily washdown escaping to environment	3	3	2	1	3	2	4	12	9.3
Disease introduction	Disease from vectors	4	2	2	1	3	3	3	12	7.5
Disease introduction	Supply of prawns	4	2	2	1	3	3	3	12	7.5
Feeds	Disease introduction through feeds	4	2	2	1	3	3	3	12	7.5
Diseased prawns and other product	Daily disposal escaping to environment	3	4	4	2	4	4	3	12	10.5
Lighting of production area	Lighting each night	3	3	2	3	3	2	4	12	10.7
Lighting of hatchery	Lighting each night	2	3	2	2	3	2	4	12	9.3
Financial resources	Insufficient funds to build, operate or maintain	5	2	2	5	4	5	2	10	7.7
Access	Loss of access due to flooding of main road	3	3	2	1	2	3	3	9	6.5
Sludge from production, harvest & water treatment ponds	Overflow in extreme events	2	3	3	2	3	3	3	9	8.0
Ponds and dams	Erosion from storms Changes to flows and natural storage Water body creation ASS disturbance	3	3	2	1	3	3	3	9	7.5
Supply and drain pipes & trenches	Erosion from storms	3	3	2	1	3	3	3	9	7.5
Dead prawn/shrimp	Daily disposal escaping to environment	2	3	3	1	3	3	3	9	7.5

The risks identified through the risk assessment process will need to be considered in detail in the EIS and the design, construction, operation and management of the project. Those areas of highest risk will require more detailed attention than the lower risk areas, but all risks are contingent on appropriate treatment. Inadequate attention to any component of risk management can result in the risks elevating to a higher level.

The highest level of risks were attached to earthworks and diverted surface waters. Both these are inevitable consequences of development of a project such as the Point Ceylon Aquaculture Project. The EIS addresses the detail of these consequences.

Two issues which were identified in the Guidelines as key issues, those of contingent discharges and the resultant possible distribution of pathogens and diseases to the surrounding marine environment will also be addressed in detail in the EIS. In this risk assessment process, however, the evaluation of the residual risks related to contingent water discharges and likelihood and consequences of organic matter, disease causing organisms and related matters escaping to the environment and causing undesirable impacts are discussed here.

A hydrological study of the ponds and other water storages required for the project was undertaken by Fred Barlow in March 2003 (see Appendix 9 of the EIS), and reviewed internally by the Department of Infrastructure Planning and Environment. A supplementary study was also prepared to model the contingent overflows, catchment characteristics and dilution ratios, based on changed pond design parameters, management and layout. With appropriate design of the ponds, overflows of the ponds may occur less frequently than around one occasion in ten years (1:10), depending on final design. While there is a level of uncertainty in the prediction of frequency, the resultant overflow will have two important characteristics. The overflow waters will be very diluted concentrations of the pond solute and suspended solid waters. Many of the daily overflows are of the order of 1000 kL or less and dilution is expected to be greater than 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 waters will not mix well from direct rainfall (the waters are likely to stratify with fresher water lying on top of the denser saline waters), and the operation of the aeration of the ponds will be stopped to ensure that the ponds do not lose their nutrient and solutes concentration balance. It is important to maintain these balances for the survival and health of the prawns. These observations are important also because they relate to the potential for diseases and pathogens to affect the surrounding marine biota. The very high dilution ratios should minimise the impacts. The impacts from overflows are therefore expected to be negligible.

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.

The potential for diseases and pathogens to affect the surrounding marine biota was assessed against international standards, and data from sources around the world. The results are provided in Table 10.

Table 10 Infectious Diseases and Parasites

OYSTERS (Bower & McGladdery 1996 - worldwide)	**Pearl Oysters** Pinctada maxima NT, WA, Qld - Humphreys et al 98	**Pearl Oysters** Pinctada maxima WA Hine & Thorne 2000	**SHRIMP & PRAWNS** (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans** ***Notifiable**** & Significant Diseases - (OIE 2003)
Ancistrocoma-like Ciliates of Oysters		Ancistrocoma ciliates in gut			
Assorted Viruses Detected in Oysters and of Unknown Significance					
Bonamia exitiosus (Bonamiasis of New Zealand Dredge Oysters)					
Bonamia ostreae of Oysters					
			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 baculoviroses (*Baculovirus penaei* and *Penaus monodon-type* virus) viral/p enaeid shrimp)
			Black Gill Syndrome of Shrimp and Prawns		
			Black Spermatophore Disease of Penaeid Shrimp		
	Cornebacterium (Bacteria & bacterial diseases)				
		Coccidian oocyst			
			Chitinolytic Bacterial Shell Disease of Shrimp and Prawns		
			Ciliate Disease of Penaeid Shrimp		
Digestive Tract Impaction of Larval Oysters					
Extracellular Giant "Rickettsiae" of Oysters	Erwinia hebicola (Bacteria & bacterial diseases)				
			Filamentous Bacterial Disease of Shrimp and Prawns		
			Fusarium sp. (Fungus Disease) of Shrimp and Prawns		

OYSTERS (Bower & McGladdery 1996 - worldwide)	**Pearl Oysters** Pinctada maxima NT, WA, Qld - Humphreys et al 98	**Pearl Oysters** Pinctada maxima WA Hine & Thorne 2000	**SHRIMP & PRAWNS** (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans** ***Notifiable**** & Significant Diseases - (OIE 2003)
Gill Disease of Portuguese Oysters					
Gill Trichodinids of Oysters					
Gregarine Parasitism of Oysters	Gregarines (Protozoa & Protozoal diseases)		Gregarine Disease of Penaeid Shrimp		
			Gut and Nerve Syndrome (GNS) of Penaeid Shrimp		
Haemocytic Infection Virus Disease of Oysters					
Haemocytic Neoplasia of Oysters					
Haplosporidium costale (SSO) of Oysters	Haplosporidium (Protozoa & Protozoal diseases)	Haplosporidium (Protozoa & Protozoal diseases)	Haplosporidian Infections of Penaeid Shrimp		
Haplosporidium nelsoni (MSX) of Oysters					
Haplosporidium sp. of Pearl Oysters					
			Hematodinium-like Organism of Pandalid Shrimp		
Herpes-Type Virus Disease of Oysters					
			Hepatopancreatic Parvovirus (HPV) Disease of Shrimp and Prawns	Hepatopancreatic Parvovirus (HPV) Disease of Shrimp and Prawns	
Hexamitiasis of Oysters					
Hinge Ligament Disease of Juvenile Oysters					
			Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) of Penaeid Shrimp**		Infectious Hypodermal and Haematopoietic Necrosis (viral/penaeid shrimp) **
Invasive Ciliates of Juvenile Oysters					
Juvenile Disease of Eastern Oysters					
Kidney Coccidia of Oysters					
			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		

OYSTERS (Bower & McGladdery 1996 - worldwide)	**Pearl Oysters** Pinctada maxima NT, WA, Qld - Humphreys et al 98	**Pearl Oysters** Pinctada maxima WA Hine & Thorne 2000	**SHRIMP & PRAWNS** (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans** ***Notifiable**** & Significant Diseases - (OIE 2003)
Malpeque Disease of Oysters	Mixed bacteria (Bacteria & bacterial diseases)				
Marteilia sydneyi of Oysters					
Marteilioides branchialis of Oysters					
Marteilioides chungmuensis of Oysters					
Marteiliosis (Aber disease) of Oysters					
Microsporidiosis of Dredge Oysters			Microsporidiosis (Cotton Shrimp Disease) of Shrimp and Prawns		
				Mid Crop Mortality Syndrome MCMS	Spawner-isolated mortality virus disease (SMV) (viral/penaeid shrimp) (MCMS-related)
Mikrocytos mackini (Denman Island Disease) of Oysters	Mikrocytos sp. (Protozoa & Protozoal diseases)		Monodon Baculovirus (MBV) Disease of Penaeid Shrimp	Monodon Baculovirus (MBV) Disease of Penaeid Shrimp	
Mikrocytos roughleyi (Australian Winter Disease) of Oysters			Mycobacteriosis of Penaeid Shrimp		
Minchinia armoricana of Oysters					
Mytilicola intestinalis (Red Worm Disease) of Oysters					
Mytilicola orientalis (Red Worm) of Oysters					
Nematode Parasitism of Oysters			Necrotizing Hepatopancreatitis of Penaeid Shrimp		
Nocardiosis of Oysters			Nematomorph Parasitism of Pandalid Shrimp		
Ostracoblabe implexa (Shell Disease) of Oysters					
Oyster Egg Disease					
Oyster Gill Turbellaria					
Oyster Trematode Diseases					
Oyster Velar Virus Disease (OVVD)					
Papova-Like Virus Infection of Pearl Oysters	Papovavirus-like (Viruses & viral diseases)				
Parasitic Copepods on Oyster Gills	Photobacterium (Bacteria & bacterial diseases)				
Pea Crabs in Oysters	Pseudomonas putrefaciens (Bacteria & bacterial diseases)				
Perkinsus marinus ("Dermo" Disease) of Oysters	Perkinsus sp. (Protozoa & Protozoal diseases)	Perksinsus sp.			

OYSTERS (Bower & McGladdery 1996 - worldwide)	**Pearl Oysters** Pinctada maxima NT, WA, Qld - Humphreys et al 98	**Pearl Oysters** Pinctada maxima WA Hine & Thorne 2000	**SHRIMP & PRAWNS** (Bower & McGladdery 1996 - worldwide)	**Prawns** (Farmed) (CAFNEC 1999)	**Crustaceans** ***Notifiable**** & Significant Diseases - (OIE 2003)
Pyramidellid Snails of Oysters	Perkinsus-like sp. (Protozoa & Protozoal diseases)				
	Protistan-like bodies (Protozoa & Protozoal diseases)				
			Red Disease of Penaeid Shrimp		
			Reo-like Virus (REO) Disease of Penaeid Shrimp		
			Rhabdovirus Disease of American Penaeid Shrimp		
Rickettsia-like and Chlamydia-like Organisms of Oysters		Rickettsia-like Organisms	Rickettsial Infection of Penaeid Shrimp		
			Rickettsia-like Infection of Pandalid Shrimp		
Shell-boring Polychaetes of Oysters			Sylon (Rhizocephalan Disease) of Shrimp and Prawns		
Shell-burrowing Sponges of Oysters					
Sirolpidium zoophthorum (Larval Mycosis) of Oysters					
Sphenophrya-like Ciliates of Oysters					
		Tylocephalum metacestodes	Taura Syndrome Virus of Penaeid Shrimp	Taura Syndrome Virus of Penaeid Shrimp*	***Taura syndrome (viral/penaied shrimp)***
Vibrio spp. (Larval and Juvenile Vibriosis) of Oysters	Vibrio harveyi (Bacteria & bacterial diseases)		Vibrio penaeicida of Cultured Kuruma Prawns		
	Vibrio sp. (Bacteria & bacterial diseases)		Vibrio spp. (Vibrio Disease) of Cultured Shrimp		
	Vibrio sp. (Bacteria & bacterial diseases)				
	Vibrio pelagicus (Bacteria & bacterial diseases)				
	Vibrio mediterranei (Bacteria & bacterial diseases)				
	Vibrio alginolyticus (Bacteria & bacterial diseases)				
	Vibrio anguillarium (Bacteria & bacterial diseases)				
	Vibrio splendidus II (Bacteria & bacterial diseases)				
	Vibrio parahaemolyticus (Bacteria & bacterial diseases)				
Viral Gametocytic Hypertrophy of Oysters	Virus-like agent (Viruses & viral diseases)	Virus-like inclusions (eosinopholic intranuclear)			
			White Spot Syndrome Baculovirus Complex of Penaeid Shrimp	White Spot Syndrome Baculovirus Complex of Penaeid Shrimp*	***White spot disease (viral/penaied shrimp)***

OYSTERS (Bower & McGladdery 1996 - worldwide)	**Pearl Oysters** Pinctada maxima NT, WA, Qld - Humphreys et al 98	**Pearl Oysters** Pinctada maxima WA Hine & Thorne 2000	**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	
Note: *table does not include epiphytic, fouling and boring organisms nor predators reported for pearl oysters Pinctada spp.*				** Aust prawn farmers have not suffered from these diseases (CAFNEC 1999)*	
				*** (not in Australia) (CAFNEC 1999)*	

The table of diseases and pathogens shows that all the diseases and pathogens identified are species-specific – they affect only species within one Phylum. Cross-phylum disease transfer, while not impossible, is not likely (NT, 2003) and not recorded for anywhere in the world, according to the literature and experts in the field (see references and citations). Oysters and prawns belong to two very different phyla in the animal kingdom. According to one peer reviewer:

> 'none of the serious (i.e. OIE listed, USMFC listed, EU listed, etc.) diseases of shrimp and oysters are known to infect and/or cause disease in both crustaceans and mollusks. While some of the "environmental" organisms in the table (i.e. some of the bacterial agents) may be opportunistic pathogens capable of infecting and causing disease in both molluscs and crustaceans, none (to my knowledge) have been documented to do so. In short, I do not see reason for concern (so far as disease transfer issues are concerned) by the oyster farmers or by the shrimp farmer.' (pers. comm. email, 10th April 2003)

Three areas of concern were expressed by some expert advisers. Some bacteria could conceivably cause detrimental impacts to oysters. These include *Vibrio* spp. bacteria when in high concentrations, which can lower resistance for disease. The other concern was high nutrient loads which can cause marine algal blooms which can affect the health of oysters. Another element which may cause concern in high concentrations are toxic dynoflagellates and diatoms, both of which are present in natural waters. The potential impacts from these agents are likely to be reduced to very low due to the dilution factor in any contingent overflows of the ponds.

The potential for prawn diseases to affect wild prawns (and *vice versa*), however, is another matter which must be considered in the context of design and management to reduce risks. These measures need to be incorporated into the designs of the ponds and hatchery, and in the detail of the operation, maintenance and monitoring of the project, in order to reduce the risk of disease transference to wild stocks and introduction of diseases to the ponds and hatchery.

The other high risk aspects include financial capability, lighting, sludge treatment, erosion and disposal of dead prawns. The financial capability of the proponent is a matter to be addressed by the regulatory authority and the proponent, and is of a confidential nature. The means by which this is addressed, however, is important in the context of the proposal. The other aspects must all be addressed in the EIS. The impacts from lighting, for instance, can be addressed by appropriate design and monitoring, and, if necessary, later adjustment.

8 CONCLUSION

The environmental risk assessment process for the Point Ceylon Aquaculture Project has identified the threats, risks and potential impacts from the development and on the project. The majority of aspects result in low to moderate levels of risks, with some presenting high levels of risk. Risks can be managed to reduce risk by appropriate design, management and operation, and the implementation of contingency plans.

Those areas of particular concern, including the potential for diseases of prawns to affect oysters have been addressed and found to present a relatively low level of risk, both from the inherent nature of the diseases and pathogens and from the design and operation of the project. Likewise, the risks attached to the impact of prawn diseases on wild prawns and of wild prawn diseases on cultured prawns can also be addressed and satisfactorily resolved by appropriate management and mitigation.

A number of features which mitigate the risks of the project causing environmental harm are addressed in the design and philosophy of the Point Ceylon Aquaculture Project. These are addressed in brief in Table 7 above, and key measures include:

- a closed operating pond system, with no transfer of production waters to marine environment;
- a one-way closed hatchery water system, with no direct discharge to the marine environment, and very low daily discharges to an evaporation pond;
- procedural controls to minimise mixing of waters during heavy rain and storm events;
- routine scheduled monitoring and maintenance of the operations and water and prawn health and quality;
- location of ponds at high elevation (over 8m AHD) and remote from shoreline (mostly greater than 200 metres, which provides a wide buffer);
- immediate collection and incineration on site of diseased prawns, and no antibiotic treatment;
- prawn stocks sourced locally, not imported;
- routine health checks of prawns;
- quarantine facility for prawn stock on site.

The Point Ceylon Aquaculture Project has also committed to adhere to the relevant Codes of Practice for Aquaculture, identified in the text above and in the EIS and reference list. These codes are generally comprehensive and provide for all aspects related to good practice in aquaculture.

References

Anderson I. G. (1996) *The diagnosis and prevention of the mid-crop mortality syndrome of pond-reared black tiger prawns (Penaeus monodon)*. Fisheries Research and Development Corporation. pp. 4. 96/301.

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Paper No 4: Chapters 1-7*. Australian and New Zealand Environment and Conservation Council, Canberra.

Bower S. M. & McGladdery S. E. (1996) Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish. Fisheries and Oceans Canada.

Boyd C. E. & Gautier D. (2000) Effluent Composition and Water Quality Standards. *The Advocate* October 2000: 61-66.

Boyd C. E. & Clay J. (2002) *Evaluation of Belize Aquaculture Ltd: A Superintensive Shrimp Aquaculture System.* Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment. pp. 17.

Boyd C. E., Hargreaves J. A. & Clay J. W. (2002) *Code of Practice and Conduct for Marine Shrimp Aquaculture*. Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment.

Cairns and Far North Environment Centre (1999) *Draft Aquaculture Policy*. Cairns and Far North Environment Centre, Cairns. pp. 17.

Defence (2003) *Defence Environmental Risk Management Framework*. Assistant Secretary Environment, Heritage and Risk Infrastructure Division, Department of Defence, Canberra.

Donovan D. J. (2001) *Environmental Code of Practice for Australian Prawn Farmers*. Australian Prawn Farmers Association Inc., South Brisbane.

Global Aquaculture Alliance (2003a) Guiding Principles for Responsible Aquaculture pp. 2. Global Aquaculture Alliance.

Global Aquaculture Alliance (2003b) Codes of Practice - Part II - Review of Responsible Shrimp Farming - Fundamentals of Shrimp Farming, Environmental and Social Issues, Environmental Management. Global Aquaculture Alliance.

Global Aquaculture Alliance (2003c) Codes of Practice - Part 1 - Individual Codes of Practice - Food Safety, Mangroves, Site Evaluation, Design and Construction, Feeds and Feed Use, Shrimp Health Management, Therapeutic Agents and Other Chemicals, General Pond Operations, Effluents and Solid Wastes, Community and Employee Relations pp. 2. Global Aquaculture Alliance.

OIE Fish Diseases Commission (2000a) *Diagnostic Manual for Aquatic Animal Diseases*. Office international des épizooties, Paris.
OIE Fish Diseases Commission (2000b) *International Aquatic Animal Health Code*. Office international des épizooties, Paris.
Preston N. & Rothlisberg P. (c2003) The environmental management of shrimp farming in Australia. In: *Australian Prawn Farmers Association* pp. 11.
Shelley C. C. (1994) *Pearl Oyster (Pinctada maxima) Aquaculture: Health Survey of Northern Territory, Western Australia and Queensland Pearl Oyster Beds and Farms*. Fisheries Research and Development Corporation, Darwin. 94/079.