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7.0 ENVIRONMENTAL IMPACTS

7.1 Water Management

7.1.1 Impacts on the Elliot River

The initial concept for this site involved extraction of water from Elliot River via pumping, and disposal to the river on falling tides.

A considerable amount of work was done early in the project to establish the feasibility of this approach including:

- Deployment of a tide gauge in the river near the proposed intake / disposal point to establish the true tidal behaviour of the system;
- Spot measurement of current velocities in the river in conjunction with the tide gauge measurement; and
- Modelling of the exchange characteristics of the estuary using the MIKE II computer package. This modelling used tide data for Abbot Point as a surrogate for Elliot River levels. Field survey of the river bed was carried out and incorporated into the model.

Modelling included assessment of:

- The impacts of discharge rates and quality on river water quality;
- The impacts of the timing of discharge relative to the tidal cycle on river water quality; and
- Estimation of the concentrations of nitrogen, phosphorous, chlorophyll a and suspended solids upstream and downstream of the discharge point.

The modelling indicated that the impacts of discharge from the farm would be such that it is highly unlikely that water quality criteria for acceptable discharge could be satisfied. This result was a significant factor in deciding to explore alternative water supply and disposal options for the project.

7.1.2 Impact on Salt Pan Area

The salt pan area immediately to the north of the development will be impacted during construction of the intake and supply pipelines, mainly as a result of disturbance during trench excavation and backfill. As discussed in Section 4.2, trench excavation and backfill will be undertaken in a manner that will minimise the risk of any long term impacts. This will include appropriate treatment and removal of PASS, the use of selected backfill material if required, backfilling to the original surface profile, and revegetation of disturbed areas.

As shown in Figure 4-1 (Section 4.1) the footprint of the area to be developed will encroach on areas currently below HAT (2.0m AHD) near the salt pan. These are areas of active erosion, as described in Section 6.3. Approximately <1 ha will be involved.

Within these areas, where existing surface levels are above the excavation depth required to enable placement of the 0.5m thick clay lining for settlement ponds or drains (1.5m AHD), the areas will be excavated to the required depth and overlain with clay lining material. Where existing levels are below the required depth they will be backfilled with clay placed as ordinary fill up to the required depth, and then overlain with clay lining.

These works will reduce the water storage capacity of the salt pan by a very small amount, and will therefore have no impact on the tidal hydrology of the salt pans. The areas involved are currently badly degraded, with little vegetative or faunal value. Runoff of eroded soil and sediment into the salt pan would currently occur following rain. The proposed works will eliminate this runoff, and will stabilise the area.

A 15m wide buffer will be provided between the outside of the proposed earthworks and the property boundary to minimise the risk of sediment in runoff from outer banks entering the salt pan area. Stabilisation of the outer batters of banks will also be undertaken to reduce potential for erosion. Ongoing maintenance of this protection will be part of the erosion management program for the site.

7.1.3 Effects of Natural Hazards

7.1.3.1 Beach Erosion Risk

The intake pump station will consist of a below-ground concrete caisson wet-well, approximately 8m in diameter. It will be located approximately 60m inland from the front toe of the primary dune. Intake and disposal pipelines will be laid below-ground from the pump station. The pipelines will be laid deep enough to ensure a minimum of 2.0 m of cover over the top of the pipes across the beach area.

There is a risk of exposure of either the pump station or the pipeline due to beach erosion. Such erosion may occur as a result of long term coastal processes (refer to Section 6.4), as a result of short term extreme storm events, or as a result of a combination of both.

The coastal geomorphology assessment of the area indicated that long term cyclic erosion / accretion processes are occurring along this section of the Abbot Bay coastline. It is surmised that the coast in the vicinity of the pump station is nearing the end of a 30 year erosion period, and that the current erosion rate of 0.9m/year could continue for several more years before a recovery cycle commences. In the absence of any severe storm events, this suggests that the proposed location of the intake pump station is well clear of anticipated erosion zone.

An analysis of short term erosion risk has been undertaken by Coastal Engineering Solutions (refer to Appendix P). This study utilised site information on coastal topography, bathymetry and sand particle size distribution as a basis for modelling the impacts of extreme storm events. The SBEACH dynamic finite element model was used to assess erosion and deposition processes for 20, 50 and 100 year recurrence interval storm events. The model used in this investigation had previously been calibrated for cyclone-induced erosion as part of the detailed engineering studies and designs associated with the recently completed major beach re-nourishment of The Strand foreshore in Townsville.

The modelling indicated that the beach in the vicinity of the pump station is likely to recede approximately 15m during a 20 year event, 18m for a 50 year event, and up to 23m in the 100 year event. These estimates include a 40% factor of safety, in accordance with standard Beach Protection Authority allowances.

Inspection of the beach profiles for the 50 year event indicates that the beach face at the level of the top of the pump station would be 10-15m from the pump station. These results suggest that when considered in isolation, long term beach erosion and extreme event impacts are unlikely to expose the pump station.

In reality however, extreme events need to be considered in conjunction with long term coastal processes. It is necessary to assess the likelihood of an extreme event occurring within the life of the project, and the impact of this event when superimposed on the long term coastal processes.

Given the conclusions draw from the coastal geomorphology assessment, and assuming a 50 year project life, a reasonable "worst case" scenario would be:

- Coastal erosion processes continue to see the beach recede a further 9.0 m over the next 10 years, after which beach recovery commences; and
- In Year 10 from now, a 1 in 50 year cyclone occurs.

The combined effect of these two processes would result in the front face of the primary dune receding to within several meters of the pump station. Given that these results are based on a set of relatively conservative assumptions, and include a 40% factor of safety, it is considered that there is a low risk of future exposure of the pump station due to beach erosion.

The results also clearly demonstrate that a 2m cover allowance over pipes across the beach will ensure the risk of exposure of the pipes due to beach erosion is minimal.

The effects of floods, wave surge and storm/heavy rainfall are discussed below.

7.1.4 Surface Water Hydrology

As discussed in Section 6.4, the site is subject to inundation to varying degrees from storm surge, flooding from the Elliot River, and local catchment runoff.

a) Storm Surge

Whilst the development will not materially affect the storm surge characteristics of the Abbot Bay area, storm surge does represent a risk to the development in the long term. Aspects of the development mitigating against storm surge impacts include:

- The bulk of the development area is several kilometres from Abbot Bay, with a coastal dune system between the site and the ocean. This coastal dune system will attenuate storm surges to a significant degree, limiting impacts to flooding rather than wave impact in all but very severe events;
- The water intake pump station, which will be the only significant infrastructure located close to Abbot Bay, will be constructed in a manner to limit the effects of inundation. This includes the use of submersible pumps and below-ground pumping infrastructure. Above-ground works will be limited to power supply and switchgear; and
- The earthworks adjacent to the low lying parts of the site, which will be the most prone to storm surge, will be constructed to at least 4.5 m AHD (and in some areas 6.0 m AHD) to protect against flooding from the Elliot River. This will provide a degree of protection from the effects of elevated water levels as a result of storm surge.

The risk of storm surge cannot be totally mitigated in any coastal development. The siting of the project away from the ocean, and the additional measures described above will, however, ensure that the risks for this development are acceptable.

b) Local Runoff

Local catchment flows pass through the site at a number of locations. These flows constitute a limited risk to the development in terms of flooding because of the relatively small catchment areas upstream, and the fact that the project will intrinsically be immune to local flooding because much of the earthworks will be well above ground surface levels.

It is important however to ensure that the development does not unduly effect the natural drainage characteristics of the local catchments. This requires the development to incorporate features to pass flows without exacerbating upstream or downstream flooding.

The strategy for accommodating these flows involves:

- Construction of a floodway around the eastern boundary of the pond area as shown in Figure 4-1 to divert runoff from Catchments A and B. This floodway will have a design capacity of 3.80 m3/s, which is the 1:5 year peak runoff rate from the combined catchments. It will consist of a broad excavated waterway, typically 5.5 m wide. The floodway will be topsoiled and grassed. The upstream bed level of the floodway will be approximately 7.5 m AHD, which equates to the lowest natural surface level of the watercourses at the upstream boundary of the site. The floodway will have a longitudinal grade of approximately 0.62 m/100 m, with a downstream bed level of 6.0 m AHD. This level equals the natural surface level of the depression at that location; and
- Construction of a floodway eastwards along the southern boundary of the pond area, discharging to the raw water supply dam east of Coventry Road. This floodway will be designed to pass the 1 in 5 year peak flow rate from the catchment of 4.6 m^3/s, and as such, it will be approximately 2m wide, with a bed grade of 2 m/1000 m. Cross-section characteristics will be similar to those described above.

The environmental impacts of these provisions are expected to be minimal. The floodways will be designed to mimic the natural runoff conditions of the area. Excavation of deep drains that would potentially accelerate flows through the area, and hence cause possible erosion problems downstream, will not be undertaken. Topsoiling and revegetation of the floodways will be undertaken to minimise the potential for soil erosion.

c) Elliot River Flooding

Parts of the site are subject to flooding under significant Elliot River flood events. Much of the area at risk is located east of Coventry Road. The strategy proposed to address these flood risks includes:

- Raising of the area east of Coventry Road that will be used for administration/processing/housing etc. to 4.5 m AHD, to provide clearance above the 1:100 year flood level. Earth fill will be used from the excavation for the Settlement Pond 1; and
- Construction of all external pond banks to a height that exceeds the 1:100 year flood level, to minimise the risk of breaching by flood waters during extreme events.

Any development on a river floodplain that involves raising of surface levels via earthworks or banks has the potential to increase flooding in other areas of the floodplain. The extent of any impact is primarily determined by whether the development is on a significant flow path, and is hence likely to hinder the passage of flows and to a lesser extent whether the development is large enough to significantly reduce floodplain storage.

Investigation of the floodplain characteristics of the lower Elliot River indicates that the area proposed for development is not on a major overflow path of the river, and will not therefore directly hinder the passage of flood flows. The major river overflow path is to the east of the main Elliot River channel.

The raising of the foundations for the administration/processing/workshop area, and the construction of banks around the settlement ponds to above the 1:100 year flood level will reduce the amount of floodplain storage. However as a proportion of the overall area of the lower Elliot River the amount of storage lost will not be significant. This is demonstrated by comparing the storage volume lost to the volume of flow in the river. Based on the inundation modelling and mapping undertaken for the 1:100 year event, the proposed development will reduce the floodplain storage by approximately 400 to 600 ML. The peak discharge from the 1:100 year event is 2060 m^3/s. Assuming an average discharge of half this peak rate over the peak 24 hour flow period, the maximum daily volume of flow in the Elliot River would be approximately 89 000 ML. The floodplain storage volume lost would therefore be only approximately 0.45% to 0.67% of the total flow over the peak 24 hour period.

7.1.5 Groundwater Quality and Levels

The potential groundwater impacts of the proposed development are associated with the possible leakage of nutrient rich salt water from the ponds and into the underlying aquifer. Once this water has entered the aquifer it will be transported with the groundwater flow and has the potential to spread to neighbouring properties and eventually to the Elliot River where it may cause deterioration in water quality in the river.

Investigations were carried out to address issues relating to the leakage rates in the ponds and subsequent migration of solutes in the underlying aquifer. These investigations are fully described in Appendix O. To assess the impacts of the development, the study included the following elements:

- An assessment of the likely rate of leakage through the pond liners and into the underlying groundwater; and
- Development of a numerical groundwater model to help determine the likely rate of migration of saline, nutrient–rich water leaking from the ponds.

The principal findings of the investigation are summarised as follows:

- Regional groundwater flow is generally from south to north and north east towards the coast. Beneath the proposed site the groundwater is moving to the east towards the Elliot River;
- The leakage rate expected through the base and sides of each of the ponds is controlled by the permeability of the clay pond liner and on the depth of water in the pond. With the available information on pond design and on the measured permeability of remoulded samples, it is concluded that leakage rates are expected to be in the order of 0.25 m^3/day per pond. Expected leakage rates are extremely low reflecting the low permeability of the clay liners;

- Slug tests carried out on four investigation bore holes indicated hydraulic conductivities of between 0.01 and 0.08 m/day. Hydraulic conductivities in this range suggest extremely low aquifer permeability and hence water movement in the aquifer is expected to be slow;
- Numerical modelling of the groundwater system with particle tracking calculations suggests that movement of water in the aquifer beneath the ponds is expected to be extremely slow. Particle velocities of less than 0.5 m/year have been estimated. From this result it is clear that nutrient-enriched salt water leaking through the pond liners and into groundwater is unlikely to migrate off site in 100 years of pond operation; and
- The existing shallow groundwater at the site is saline and as such cannot be used for domestic, stock water or irrigation water supply.

On the basis of the findings summarised above it is concluded that there will be no significant impact associated with leakage of water through the pond liners and into the underlying groundwater. The low permeability of shallow sediments present at the site will result in poorly conductive pond liners that will inhibit leakage into the underlying groundwater. Once the saline water enters the aquifer its migration will be further inhibited by the poorly conductive aquifer present beneath the site. The pre-existing salinity of the groundwater at the site renders it unsuitable as a source of domestic, stock or irrigation water and as such there are no nearby groundwater users that could be adversely impacted by the migration of solutes from the ponds.

7.2 Impacts of Prawn Farm Discharges to Abbot Bay

The nature of the discharge from the prawn farm to Abbot Bay is determined generally by the feed inputs into the farm. The predicted Total Nitrogen (TN), Total Phosphorus (TP), and Total Suspended Solids (TSS) concentrations for the discharge from the ponds after treatment are discussed below.

These predicted concentrations were used in the water quality dispersion model for the prawn farm discharges into Abbot Bay undertaken by the CRC for Reef Research. Other inputs to the model were tides, bathymetry and the Australian Eastern current at Abbot Bay and wind records for the area.

Impact zones of nutrient and TSS concentrations for sensitive species e.g. seagrass were determined based upon the modelling outputs. In particular, the effects of TSS and nutrients on seagrass growth and growth of epiphytes on seagrass are discussed.

A risk assessment based upon ESD principles was completed to establish impacts on the ecology of Abbot Bay and the World Heritage Values of the Great Barrier Reef.

The outcomes of this approach indicated that an area less than 5 % of the total seagrass area in Abbot Bay may potentially be disturbed by the prawn farm discharge. The impacts, if any, on seagrass would be localised when compared to the total habitat area. These levels would be considered acceptable given the percentage of area affected, the types of impacts occurring and the recovery capacity of the habitat.

7.2.1 Disposal Arrangements

7.2.1.1 On Farm Treatment

Discharge waters from the grow-out ponds will drain to water treatment systems, with each production area being serviced by an independent treatment area. The treatment system consists of two main elements:

- Primary sedimentation areas; and
- Settlement ponds.

The primary treatment area is designed to allow sedimentation of the coarse fraction of suspended solids. A Hydraulic Retention Time (HRT) of approximately 8 hours will be provided. Each primary sedimentation area will have two ponds. At regular intervals, one sediment pond will be drained and the material in the pond collected and taken to another pond where drying can be completed.

Water will discharge from the sedimentation area into settlement ponds, where further sedimentation and biological treatment will occur. Settlement ponds have been sized to provide a minimum of 48 hours HRT under peak discharge conditions.

As discussed above, it will be possible to raise the water level to 5.0m AHD to provide additional treatment to accommodate periods when water quality issues occur on the farm. Settlement Ponds will be clay lined and will incorporate rip-rap protection on inside batters.

7.2.2 Location of Outfall Pipe and Effect on Mixing and Dispersion

The outfall pipe is located in Abbot Bay some 500 m offshore. The diffuser in the discharge pipe will be approximately 100 m long and water will be discharged at a rate of approximately 3m/sec at peak discharge. The discharge water may be denser and warmer than the surrounding oceanic water which may affect the dispersion of the discharge. It is likely that this effect will be minor as any small changes in density between discharge waters and oceanic waters should be negated by the relative depth of the discharge point (3 to 5m) and the velocity of the discharge waters. The diffuser ports will be pointed at an angle of 60 degrees to the surface which also will improve mixing. The water will therefore be mixed throughout the water column.

The design of the discharge diffuser and ports is considered to be the best practicable from of discharge for the volumes of water to be discharged.

The high efficiency of mixing and dispersion of the proposed outfall can be seen in the modelling results presented below and in Appendix D. The outfall in Abbot Bay also eliminates any environmental impact in the Elliot River.

7.2.2.1 On–Farm Reuse

The volumes of water and re-circulation rates that will be undertaken will be heavily dependent upon climatic conditions. In November, when the likelihood of rain is low and evaporation is high, salinity is predicted to increase from 39 ppt to 45 ppt based upon the predicted exchange rates at this time of year, whilst in April with higher daily exchange rates, the salinity is predicted to increase from 39 ppt to 43 ppt when there is no rain. Rainfall events will reduce the salinities in the ponds and assist in pond management. Rainfall should occur during the summer months of December through to March, however even in some of these months, evaporation losses are greater than average rainfall, thus increasing the potential for salinity increases. Where feasible, recirculation will be undertaken at Guthalungra to minimise discharge volumes.

Recirculation will be considered when salinities in the ponds are diluted by rainwater. A possible trigger would be 36 ppt and lower in individual ponds. At these salinities, recirculation would be undertaken. However, when salinities reach 40 ppt in individual ponds, recirculation would be discounted and regular pumping would be recommenced as required.

7.2.3 Discharge Flow Rates

One of the key determinates of the prawn farm operation is discharge. The good quality of Abbot Bay water allows the predicted water exchange use to be approximately 2.7% over the growing season. This figure is about half of the industry standard. The discharge flow rates expected for the farm in full production for a typical year are shown in Figure 7-1.

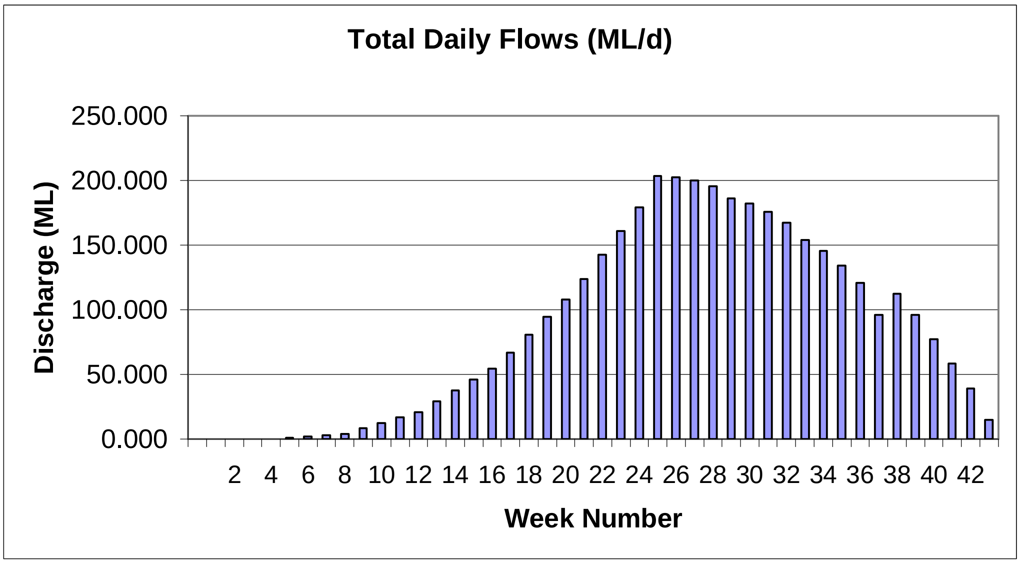


Figure 7-1
Daily total discharge rates each week indicating peaks in discharge volume (September to June).

The discharge flow rates are will be from October to December. Eighty-four percent (84 %) of discharges will occur from January to June. Peak discharges will occur during the months of February and March.

7.2.4 Nutrients Sources and Discharge Water Quality

7.2.4.1 Nutrient Mass Balance based on Feed Inputs

The predicted annual total feed for the project is 2987 tonnes, based upon a Feed Conversion Ratio (FCR) of 1:1.8. The total nitrogen contribution to the ponds will be 187 tonnes based upon a nitrogen component in the feed of 6.25% (pers. comm, Ridley Feeds). Briggs and Funge-Smith (1994) and Jackson *et al*. (2002) estimated that the total nitrogen exported from prawn ponds without treatment during a grow out season as a percentage of the total input was between 35% to 57%. That is, between 43% and 65% of the Total Nitrogen stayed within the ponds, was lost by volatization, or was taken out by prawn biomass.

Assuming 35% of the total nitrogen input is exported from the ponds at Guthalungra, this would be the equivalent of 65 tonnes based upon the given feeding rates for the project. The use of treatment systems will reduce this load. The proposed treatment system is predicted to remove 30% (Jones *et.al.,* 2000) of the initial 65 tonnes in the sedimentation ponds i.e. 20 tonnes thus reducing the load to 45 tonnes. A further 20% reduction in the settlement ponds would remove another 9 tonnes. A residual load of 36 tonnes would be discharged. This load would correspond to a daily loading rate during the discharge period (287 days) of 0.48 kg/ha/d. The discharge period will be from the first week in September thorough to the second week in June.

Alternatively, if it is assumed that 57% of the total nitrogen input is exported from the ponds at the proposed site, this would be the equivalent of 107 tonnes based upon the given feeding rates. The treatment system is predicted to remove 30% in the sedimentation ponds i.e. 31 tonnes reducing the load to 76 tonnes. A further 20% reduction in the settlement ponds would remove an additional 15 tonnes. A residual of 61 tonnes would be discharged. This load would correspond to a daily loading rate during the discharge period (287 days) of 0.82 kg/ha/d. These calculations are tabulated in Table 7-1.

Table 7-1
Nitrogen Mass Balance based on Feed Inputs and Treatment Streams

Total Nitrogen Load at FCR of 1:1.8 (tonnes) in to the Grow Out Ponds	Percentage Nitrogen Exported from Pond Systems without treatment (%) (tonnes exported from ponds in brackets)	Treatment Stream Reduction – Sedimentation ponds (% capture) (tonnes remaining in discharge stream in brackets)	Treatment Stream Reduction – Settlement ponds (% capture) (tonnes remaining in discharge stream in brackets)	Daily discharge rate over the discharge period (287 days) (kg/ha/d)
187	35 (65)	30 (45)	20 (36)	0.48
187	57 (107)	30 (76)	20 (61)	0.82
187	45 (84)	30 (59)	20 (47)	0.63

7.2.4.2 Nutrient Composition

Total nitrogen and total phosphorus are typically found in low concentrations in prawn farm discharges when compared with other forms of discharge e.g. sewage or feedlot effluent. The bio-available form of nitrogen in the prawn farm discharge is ammonia, which will be in the order of 25% of the bio-available fraction of the total nitrogen component Jackson *et al*. (2002).

Ammonia concentrations in the discharge should range between 0.10 to 0.50 mg/L. Significantly, the conceptual modelling developed by the Western Australia EPA (1992) for seagrass and nutrient interactions focuses only on additional dissolved nutrients and not total nitrogen and phosphorus because of the question of the bio-availability of the inorganic component.

The dissolved organic nitrogen (DON) fraction of the prawn farm discharge is refractory and will break down after a period of about 7 or so days (Burford and Pearson, 1998). These DON concentrations should range also between 0.10 to 0.50 mg/L. Essentially much of this material will have left the area and be highly diluted before there should be any biological break down and uptake of this material. The algal material in the discharge is likely to be a source of fish food for fish larvae within the region.

Total phosphorus is also likely to be predominately in the organic form as a component of total suspended solids.

Even though the organic component of the discharge is likely to be high and not readily bio-available; the water quality dispersion modelling undertaken by the CRC for Reef Research used conservative Total Nitrogen and Total Phosphorus concentration described below.

7.2.5 Abbot Bay Water Quality - Receiving Water Quality Values

Water quality collected in Abbot Bay was highly variable with Total Suspended Solid concentrations were generally between 1 and 10 mg/L. These concentration values generally matched those found at the mouth of the Elliot River and upstream of Nobbies Creek in the Elliot River. Most TSS concentrations (over 80 % of values) were less than 5 mg/L (refer to Section 6.4).

Total nitrogen concentrations were generally less than or equal to 250 µg/L. These concentrations again generally matched those found at the mouth of the Elliot River and upstream of Nobbies Creek in the Elliot River. The trigger ANZECC level for near shore tropical marine systems is 100 µg/L for Total Nitrogen. Many of the concentrations found in Abbot Bay were slightly above the trigger level (~ 120 µg/L) with several values between 200 and 250 µg/L.

Total phosphorus concentrations were generally less than or equal to 50 µg/L. These concentrations generally matched those found at the mouth of the Elliot River and upstream of Nobbies Creek in the Elliot River. The trigger ANZECC Level for near shore tropical marine systems is 15 µg/L of Total Phosphorus. Many of the concentrations found in Abbot Bay were of this order with several values as high as 50 µg/L.

Turbidity levels recorded in Abbot Bay reflect the low total suspended solid concentrations found in Bay. Most turbidity values were between 1 and 5 NTU's.

Chlorophyll a concentrations were generally less than or equal to 1 µg/L. These concentrations again generally matched those found at the mouth of the Elliot River and upstream of Nobbies Creek in the Elliot River. The trigger ANZECC Level for near shore tropical marine systems is 1.0 µg/L. Most of the Chlorophyll a concentrations found in Abbot Bay were of this order.

Salinity concentrations were generally between 38 to 39 ppt.

The nutrient concentrations of collected samples were highly variable, ranging between the ANZECC (2000) default trigger levels and values several times higher than the default values. For the purposes of dispersion modelling and impact assessment, conservative background water quality values have been adopted for Abbot Bay, being the default ANZECC trigger levels.

7.2.6 ANZECC Guidelines and the Great Barrier Reef Action Plan

The most appropriate ecosystem condition for Abbot Bay based upon the ANZECC Water Quality Guidelines (2000) is described below:

> *"Slightly to moderately disturbed systems - ecosystem in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typical freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities.*
>
> *A level of protection is a level of quality desired by stakeholders and implied by the selected management goals and water quality objectives for the water resource. The water quality objectives may have been derived from default guideline values recommended for the particular ecosystem condition; or they may represent an acceptable level of change from a defined reference condition; it can be formalised as a critical effect size. Where appropriate the reference conditions should be defined from as many reference sites as practicable using pre-impact data where appropriate".*

During the community consultation process with shack owners at the Elliot River and with the Bowen town community, a number of environmental values were identified. These values were:

- Access to the beach and Abbot Bay should remain;
- The aesthetics of the Elliot River and Abbot Bay to be maintained; and
- Fishing and other recreational activities in the Elliot River and Abbot Bay were a key lifestyle issue.

The beneficial uses to be managed are:

- The protection of aquatic ecosystems and in particular seagrass meadows which are important grazing grounds for dugongs and turtles;
- Maintenance of recreational values; and
- Maintenance of aesthetic values.

The recently published Great Barrier Reef Action Plan was completed to further improve water quality in the Great Barrier Reef. In the plan, the area defined as the Don River under the Action Plan includes the Elliott River. The Don River area is one of 26 catchments included in the Reef Water Quality Protection Plan.

In the plan, the catchment is described as being 93% cleared, primarily for grazing with a small amount of intensive horticulture. The catchment is only 16% gauged so that the following data has a Data Confidence Level of 1. The water quality targets for the Don River catchments in which the Elliott River is a sub–area suggest a 2011 target of 544 tonnes, a reduction from 812 tonnes.

The stated current discharges from the Don Catchment, the estimated discharges for year 1850 and the target reductions are set out below:

Table 7-2
Current Discharges from the Don Catchment

	1850 T/yr	Current T/yr	2011 % Red'n	2011 T/yr Target
Sediment Export	46,000	509,528	33	341,384
Total N Export	183	812	50	544
Total P Export	9	178	33	89

(T = Tonnes)

The Action Plan states that some reform of Queensland legislation or the manner in which is it administered may be necessary.

The Examples of actions that could be implemented to achieve water quality targets are identified in the Action Plan. These are:

- "Reforms to ensure that in the catchments adjacent to the Reef, all environmentally significant activities (including significant new agricultural activities or the significant intensification of existing activities) are subject to proper environmental impact assessment and approval processes. Environmental assessments should address potential impacts on water quality. Appropriate conditions should be attached to ensure that activities are carried out in a manner that protects and, as necessary, improves water quality;
- Constraint mapping for current and future agricultural development in the Great Barrier Reef Catchment should be promoted;
- Catchment areas at risk such as freshwater wetlands and riparian vegetation should be protected and rehabilitated;
- Standards for sewage, wastewater and stormwater discharge from coastal developments to watercourses should be established and enforced;
- Environmental management plans should be promoted for agricultural activities.

These plans should promote farming practices that minimise downstream impacts, such as:

- Minimising erosion through conservation cropping techniques and pasture management;
- Minimising nutrient loss by aligning fertiliser amount, type and application methodology to the physiological requirements of the crop and;
- Implementing the integrated pest management techniques;
- Promote full compliance with Industry Codes of Practice; and

- Initiate public and catchment specific education programs about the connectivity between land use and the impacts on the Reef."

These examples of actions have been considered in the design and operation of the prawn farm.

7.2.7 Water Quality Model - CRC Reef Research

The Marine Modelling Unit, School of Engineering, James Cook University; Townsville undertook the outfall dispersion modelling for this project as part of the CRC for Reef Research (Appendix Q).

A 3D hydrodynamic model and a particle tracking model was used to investigate the dispersal of prawn farm discharge into Abbot Bay. Two six-month simulations, for the years 1900 and 1998 were undertaken using a constant discharge of 200 ML/d. Each simulation used the hydrodynamic forcing produced by the wind and tide and Eastern Australian Current. Constant concentrations of total nitrogen, total phosphorus and chlorophyll a for the discharge and the receiving water concentrations in Abbot Bay were adopted for inputs in to the model (see Table 7-3).

The years 1990 and 1998 were selected based upon a review of thirteen years of wind data gathered at Cape Cleveland, 60 km north of Guthalungra. The year 1990 was considered to be the poorest year for wind speed and 1998, an average year in terms of wind speed. The month of February, which represents the month of maximum discharge in to Abbot Bay, was used to determine the dispersion of prawn farm discharge in the poorest (1990) and average year (1998) in terms of wind speed.

A number of field tidal measurements were taken to calibrate the model. Overall, the results of model comparisons with field measurements indicate that the model is capable of producing realistic current speeds and direction in the study area.

7.2.7.1 Receiving Water Quality and Discharge Concentrations used in the Water Quality Dispersion Model

Background water quality concentrations for the modelling were based on the default triggers from Table 3.34 in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) for Tropical Australia marine in-shore waters (see Table 7-3)

Discharge concentrations were based on extensive literature search, discussion with prawn farmers and CSIRO scientists. These concentrations are described in more detail in Section 4.5

Table 7-3
Input Variables to the Water Quality Model for Abbot Bay

Parameter	Water Quality Background - ANZECC Trigger Values for Tropical Australia (mg/L)	Discharge water quality from the prawn farm ponds (mg/L)
Total Nitrogen	100	2000
Total phosphorus	15	150
Chlorophyll a	1	30
Flows	-	200 ML/day

7.2.7.2 Water Quality Impacts on Sensitive Environments in Abbot Bay

GBRMPA has proposed the following ambient concentrations for sensitive environments e.g. reefs and seagrass communities (Table 7-4 - QEPA, May 2000).

Table 7-4
Proposed GBRMPA Ambient Concentrations for Sensitive Environments

Parameter	Inshore Coral Reefs	Seagrass communities	Marine Inshore* (ANZECC Trigger for Tropical Australia values)
Chlorophyll a (µg/L)	0.5	1.0	0.7-1.4
Total Phosphorus (µg/L)	12	24	15
Total Nitrogen (µg/L)	100	150	100

*lower values typical of clear coral dominated waters (GBR), higher values typical of macrotidal systems (NW shelf of WA).

These values were used as the boundary limits for the impact zone for the two six monthly and the two February average modelled concentrations for Total Nitrogen and Total Phosphorus. Chlorophyll a was considered a surrogate for Total Suspended Solids as TSS was not listed by GBRMPA as an appropriate parameter to determine impacts for sensitive reefs and seagrass communities.

7.2.7.3 Modelled Discharge Flows and Total Nitrogen Loads from January to June

Modelling of discharges from the prawn farm to Abbot Bay in 1990 and 1998 was undertaken for six months of the discharge period – January to June. The total flows over this period are 22,190 ML or 84% of the total discharge flows from October through to June. The average discharges during the period of modelling (January to June) were predicted to be 138 ML/d. By comparison, the average discharge over the total discharge period from September to June is 96 ML/d (see Table 7-5).

Because of the large computational time required, it was decided to run discharges for the January to June period at the maximum discharge rate of 200 ML rather than at the varying weekly rates equating to an average of 138 ML/d. This discharge rate of 200 ML/d is highly conservative being 49% more than the predicted discharge over the same period (see Table 7-5).

The total nitrogen loadings for the period January to June (34 tonnes) are 95% of the total nitrogen loadings predicted for the entire discharge period of October through to June (35 tonnes). The modelled outputs based upon flows of 200 ML increase the total nitrogen loadings by 88% to 66 tonnes or nearly double the total nitrogen load predicted to be discharged from October to June.

In conclusion:

- The modelling period (January to June) represents 84% of flows and 95% of the Total Nitrogen for the discharge period (October to June); and
- The modelling outputs (January to June) represent 149% of total discharges and 188% of the Total Nitrogen for the discharge period (October to June).

Thus, the modelled results will be very conservative with nutrient loadings nearly double to that predicted.

Table 7-5
Predicted Percentage Total Flows and Total Nitrogen Loads from October to June and January to June

Period of Predicted Discharge Flows	Flows (ML)	Percentage of Total Flows (%)	Kg of Total Nitrogen	Percentage of Total Nitrogen (%)
October to June	26,306	100	35,198	100
January to June (Discharge Modelled period)	22,190	84	33,400	95
January to June @ 200 ML/d (23 weeks) (Discharge flows modelled)	33,200	149	66,400	188

Following the completion of the initial modelling, additional modelling results for a discharge rate of 100 ML/d was undertaken. The 100 ML/d represents the average concentrations of the discharge flows over the season.

This means that the discharge mass flux of the initial nutrients will be half that simulated in the previous modelling producing significant reductions in discharge concentrations in the receiving waters.

The average concentrations for the 100 ML/d discharge rate for six-month periods in 1990 and 1998 for February of the same years are plotted in Appendix Q. As expected, the extent of the background plus 10% and the threshold contours for all the average concentration plots, have been significantly reduced compared to the 200 ML/d discharge rate case. For the background plus 10% concentration the area enclosed by the contours are in the range of 25 to 50 % of the area enclosed by the corresponding contours for the 200ML/d case.

In the case of the *threshold* contours the reduction in area is much greater, the six-month average concentrations for nitrogen, the area bound by the *threshold* contour is now limited to small area in the vicinity of the outfall. The average concentrations for nitrogen during February again show a significant reduction in the area bounded by the *threshold* contours. The area bounded by this contour is approximately 10% of the area originally bounded in the 200 ML/d discharge scenario. For phosphorus and chlorophyll a, the area bound by the *threshold* contour was small in the original scenario and cannot be detected for the present flow rate.

In summary, the concentration patterns remain the same but are at a significantly reduced level.

7.2.8 Model Outputs of Discharge Concentrations in Abbot Bay

The sensitive environments selected by GBRMPA are inshore coral reefs and seagrass communities. The survey of Abbot Bay indicates that inshore coral reefs are associated with Camp Island. There are documented large areas of seagrass beds in Abbot Bay. Subsequently, seagrass has been adopted as the principal indicator of ecological impact as discharge concentrations impact are likely to impact on these areas.

A detailed report of the modelling outcomes is in Appendix Q.

7.2.8.1 1990 and 1998 Six Month Average Concentrations of Total Nitrogen, Total Phosphorus, Chlorophyll a and Total Suspended Solids in Abbot Bay

The impact zone is considered to be an area where:

- Modelled Total Nitrogen concentrations are greater than 150 µg/L; or
- Modelled Total Phosphorus concentrations are greater than 24 µg/L; or
- Modelled Chlorophyll a concentrations are greater than 2 µg/L.

The impact zone criteria are based upon the GBRMPA values for sensitive environments.

The distances required for full assimilation of individual parameters are discussed in Appendix Q.

a) Total Nitrogen

Over a period of six months the modelling results were averaged to determine the impact zone for sensitive environments (eg seagrass) in which Total Nitrogen was reduced from 2000 µg/L (at the outlet) to 150 µg/L. Based on the GBRMPA criteria, seagrasses within this area could be impacted if exposed to prolonged periods of nitrogen. The impact zones for 1990 and 1998 did not vary between the years (18 ha total). Refer to Figure 7-2 and Figure 7-3.

The estimated area of seagrass in Abbot Bay is 4465 ha (see Section 6.5). Percentage values for areas of seagrass impacted by the discharge compared with the total estimated area of seagrass in Abbot Bay were calculated (refer to Table 7-6). For example, the impact zone for the average six monthly TN concentrations represents 0.4% of seagrass estimated to occur in Abbot Bay (Figure 7-2 and 7-3).

b) Chlorophyll a

The calculated area of the impact zone is between 0.6 and 0.7 % of the estimated seagrass area in Abbot Bay for an average six monthly Chlorophyll a concentration of 30 µg/L in pond discharge water, a background concentration of 1 µg/L, and an impact zone criterion of 2 µg/L for seagrass (refer to Table 7-6 and Figures 7-4 and 7-5).

c) Total Suspended Solids

Chlorophyll a also can be used as a surrogate for Total Suspended Solids since the bulk of the suspended solids will be algae. For example, a discharge of 30 mg/L of Total Suspended Solids is assumed to have the same distribution and dilution pattern as Chlorophyll a. Therefore the impact zone for a discharge concentration of 30 mg/L of TSS, with a background concentration of 1 mg/L and an impact zone criterion of 2 mg/L for seagrass, is between 0.6 and 0.7 % of the estimated seagrass area in Abbot Bay. Refer to Figures 7-4 and 7-5.

7.2.8.2 1990 and 1998 February Average Concentrations of Total Nitrogen, Total Phosphorus, Chlorophyll a and Total Suspended Solids

The impact zones calculated for the maximum discharge concentrations of TN, TP and Chlorophyll a in February 1990 and 1998, were between 0.5 and 1.0 % of the total estimated seagrass area in Abbot Bay with one exception. In February 1990, the impact zone for Total Nitrogen was calculated to be 1.8 % of the total area of seagrass estimated to be present in Abbot Bay. Refer to Figures 7-6, 7-7, 7-8, 7-9, 7-10, and 7-11.

The importance of the percentage areas of the impact zones is expanded below in the section on National ESD Reporting Framework for Fisheries - The How To Guide for Wild Fisheries, 2002.

Table 7-6
Impacted seagrass area as a % of total estimated seagrass area in Abbot Bay (area in brackets (ha))

Year	1990		1998	
Period	**December to June**	**February**	**December to June**	**February**
Parameter				
TN	0.4 (18)	1.8 (80)	0.4 (18)	0.8 (36)
TP	0.5 (22)	0.6 (27)	0.5 (22)	0.5 (22)
Chl a	0.7 (31)	1.0 (44)	0.6 (27)	0.8 (36)

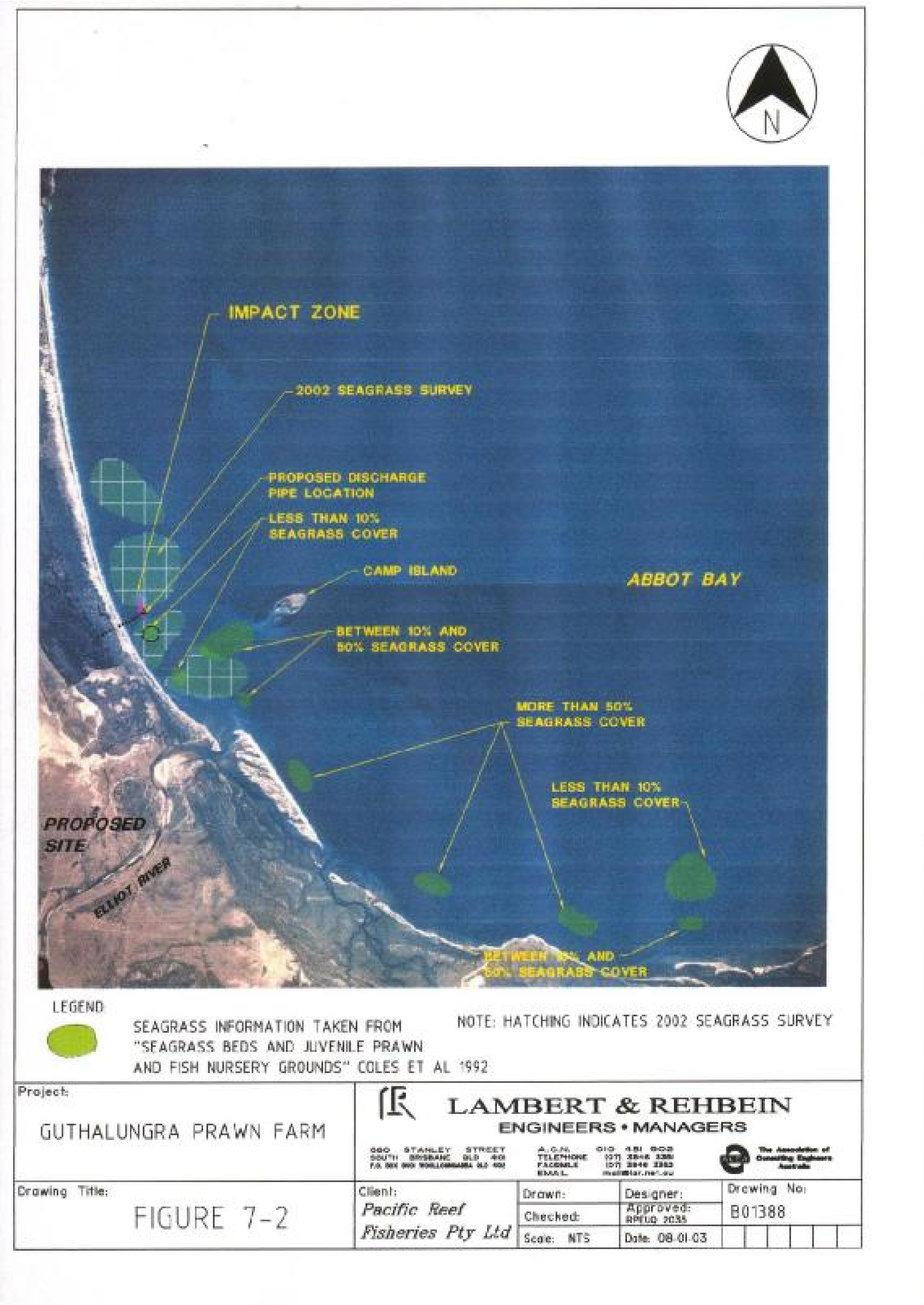


Figure 7-2
Impact Zone
Total Nitrogen Discharge Concentration (2000 µg/L) 1990 (January to June)

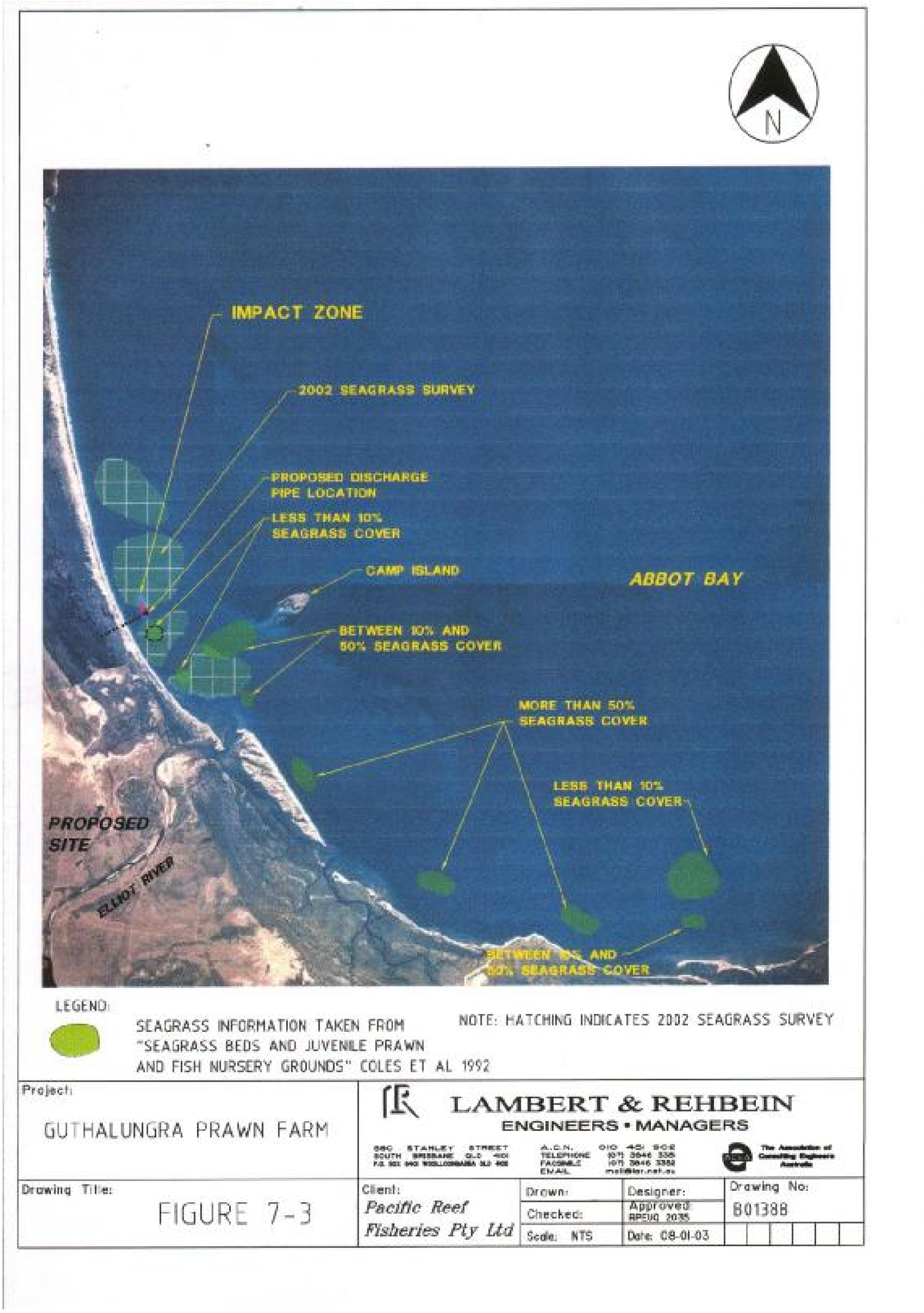


Figure 7-3
Impact Zone
Total Nitrogen Discharge Concentration (2000 µg/L) 1998 (January to June)

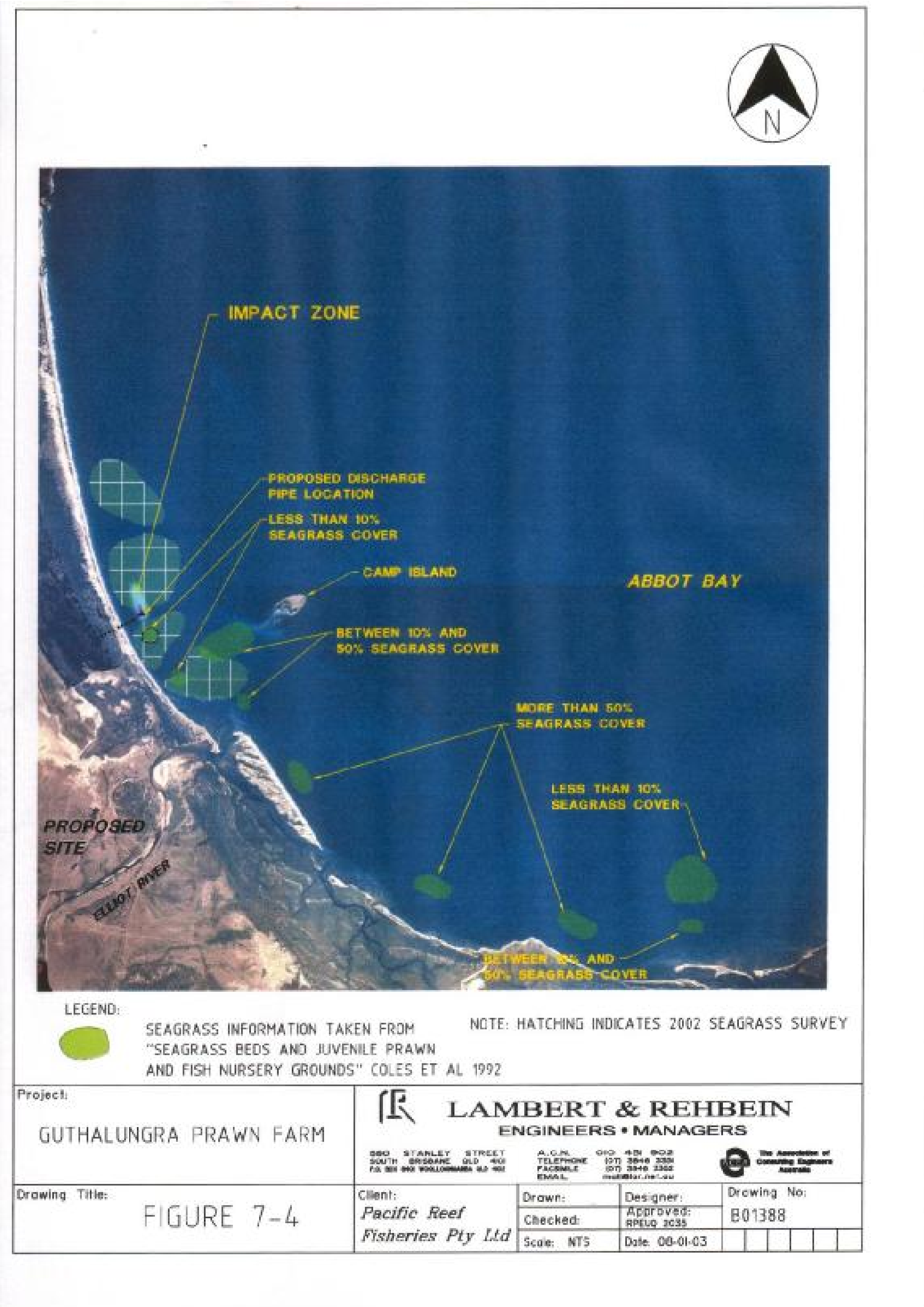


Figure 7-4
Impact Zone
Chlorophyll a Discharge Concentration (30 µg/L) 1990 (January to June)

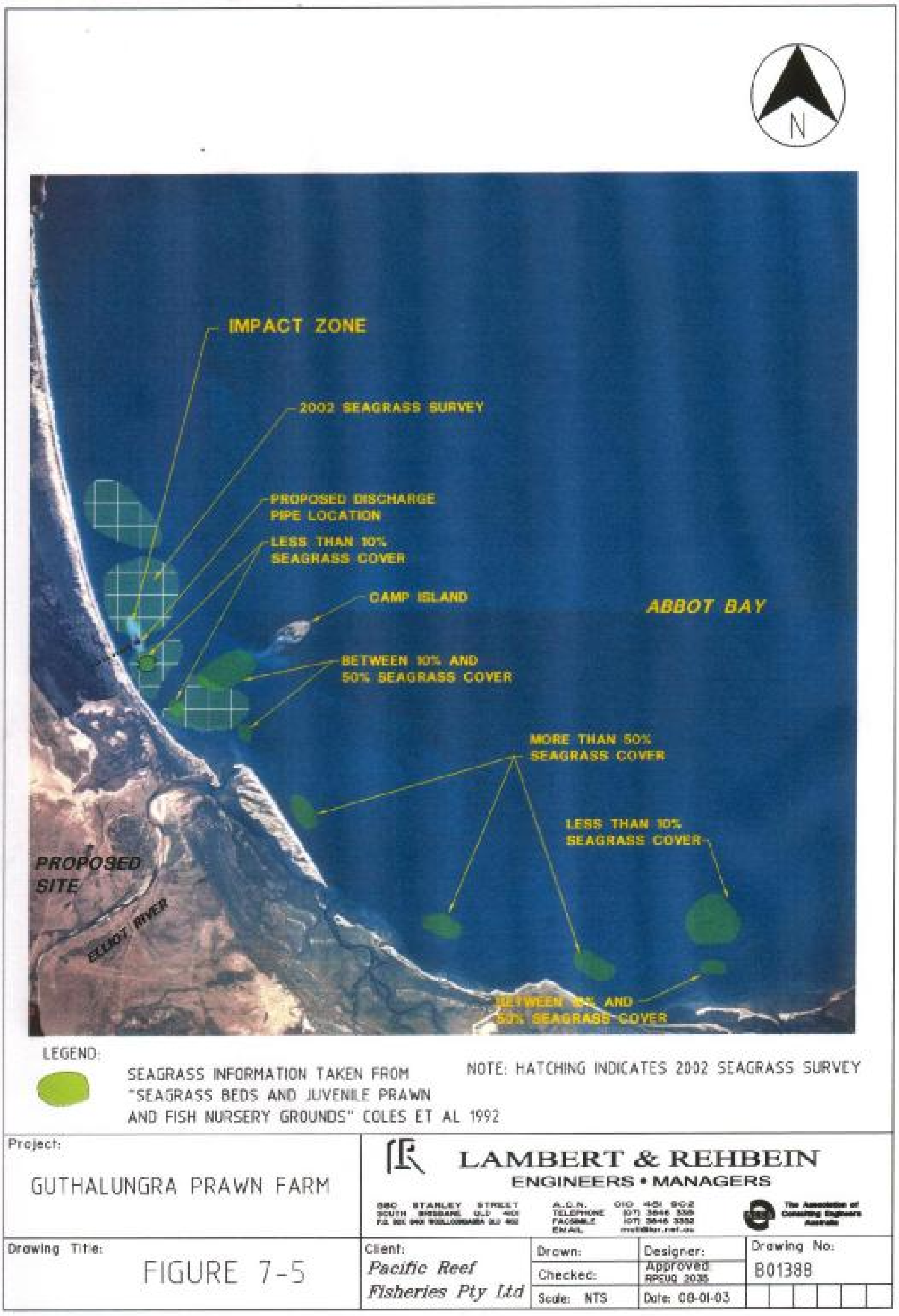


Figure 7-5
Impact Zone
Chlorophyll a Discharge Concentration (30 µg/L) 1998 (January to June)

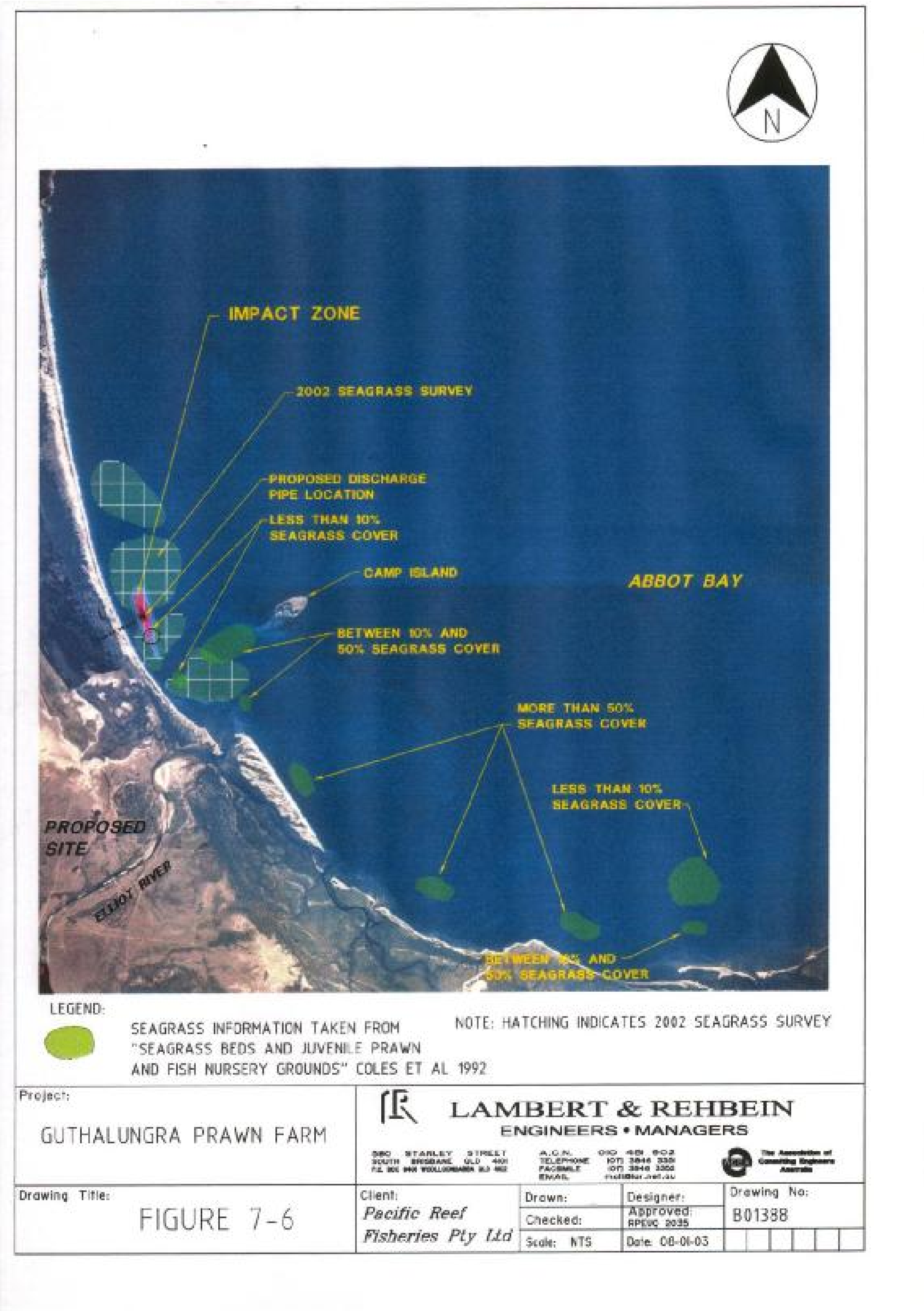


Figure 7-6
Impact Zone
Total Nitrogen Discharge Concentration (2000 µg/L) 1990 (February)

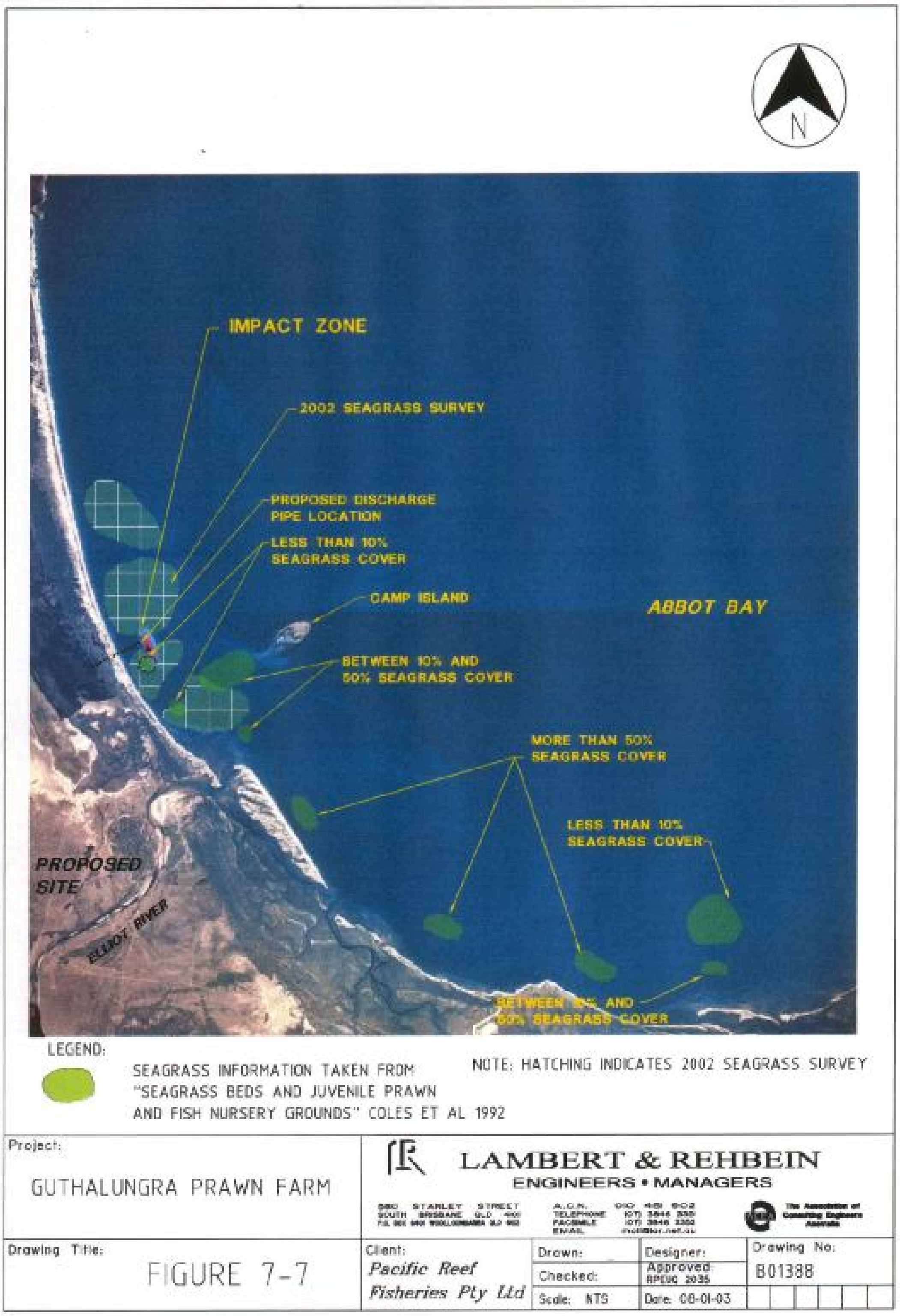


Figure 7-7
Impact Zone
Total Nitrogen Discharge Concentration (2000 µg/L) 1998 (February)

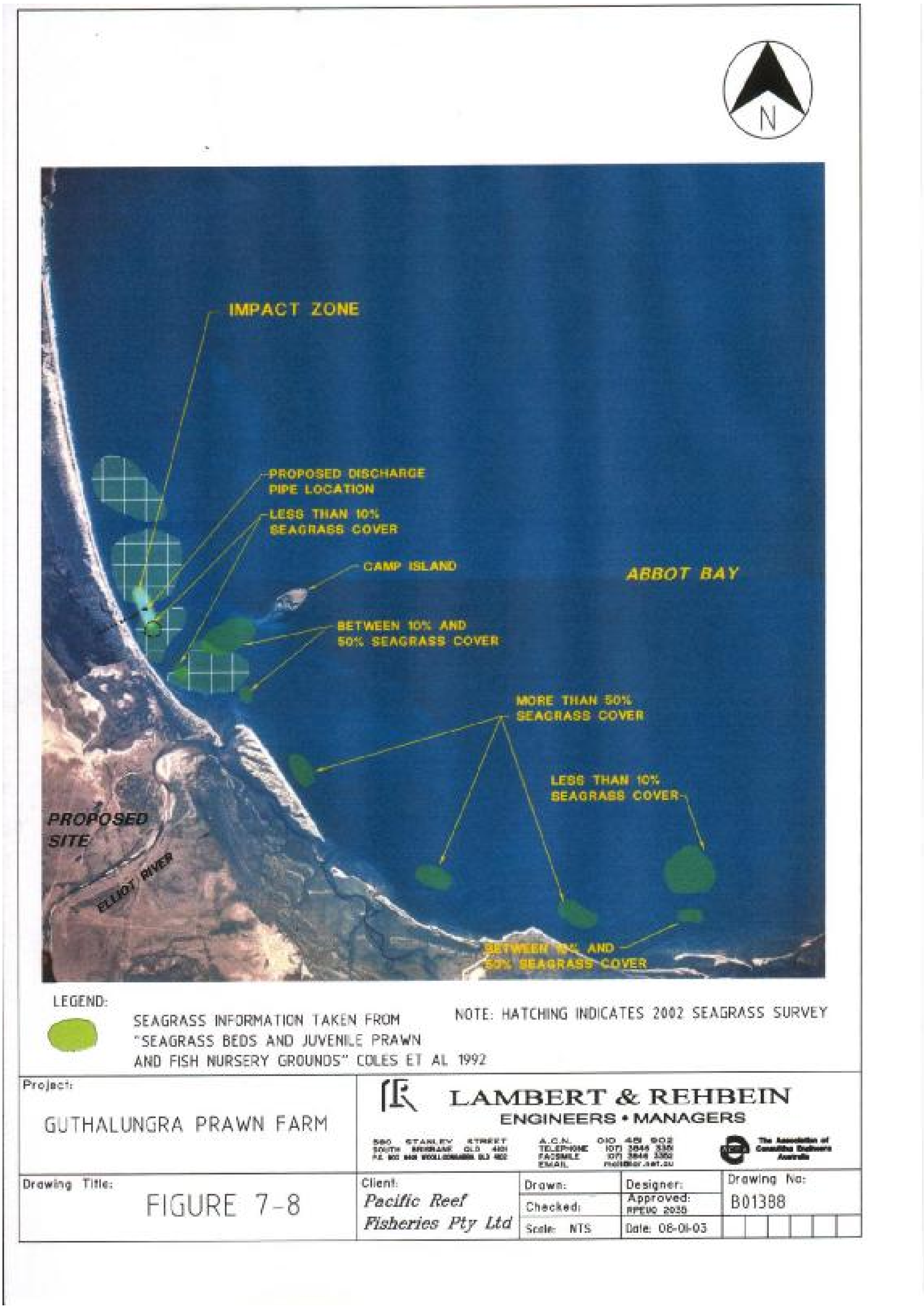


Figure 7-8
Impact Zone
Total Phosphorus Discharge Concentration (150 µg/L) 1990 (February)

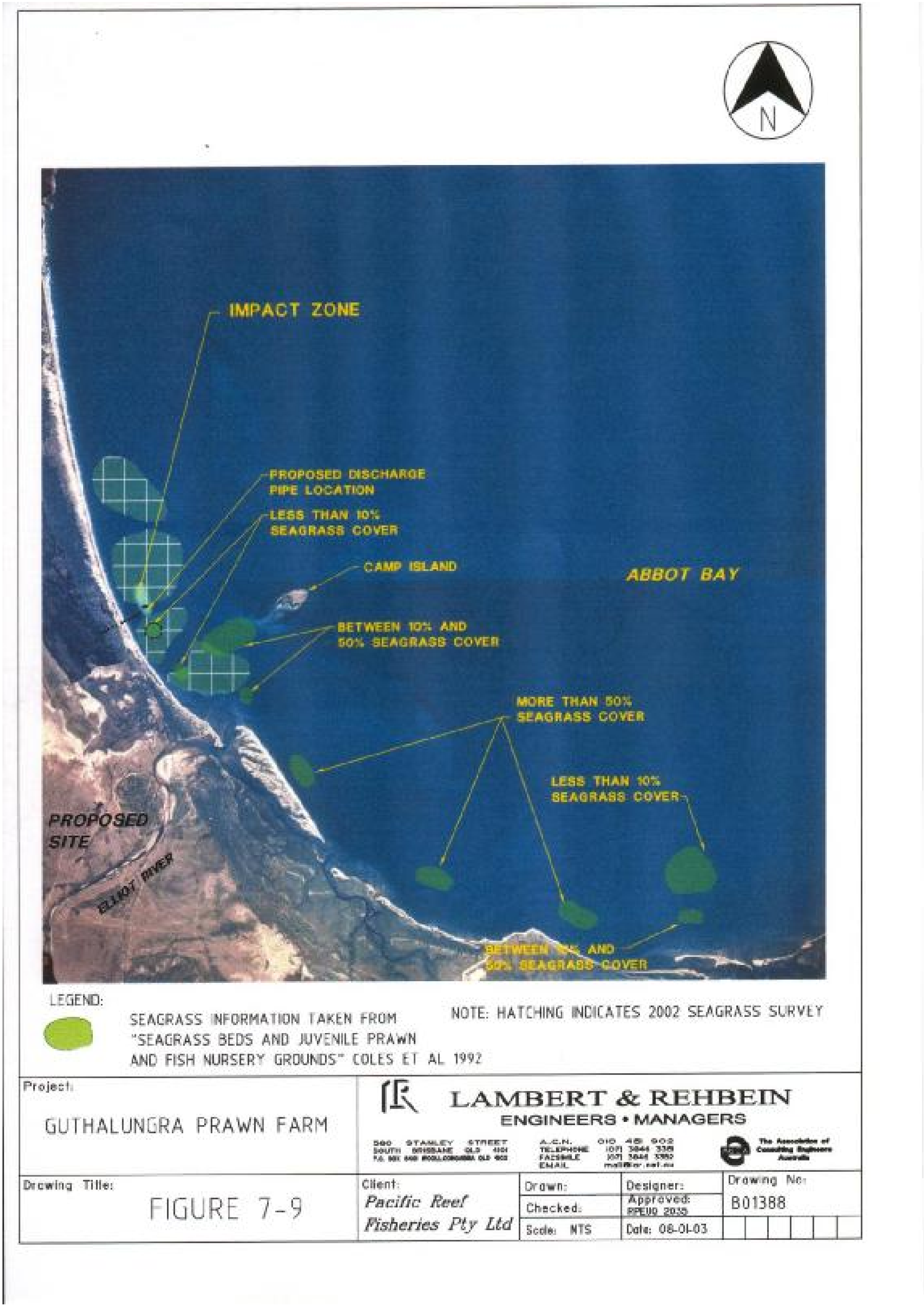


Figure 7-9
Impact Zone
Total Phosphorus Discharge Concentration (150 µg/L) 1998 (February)

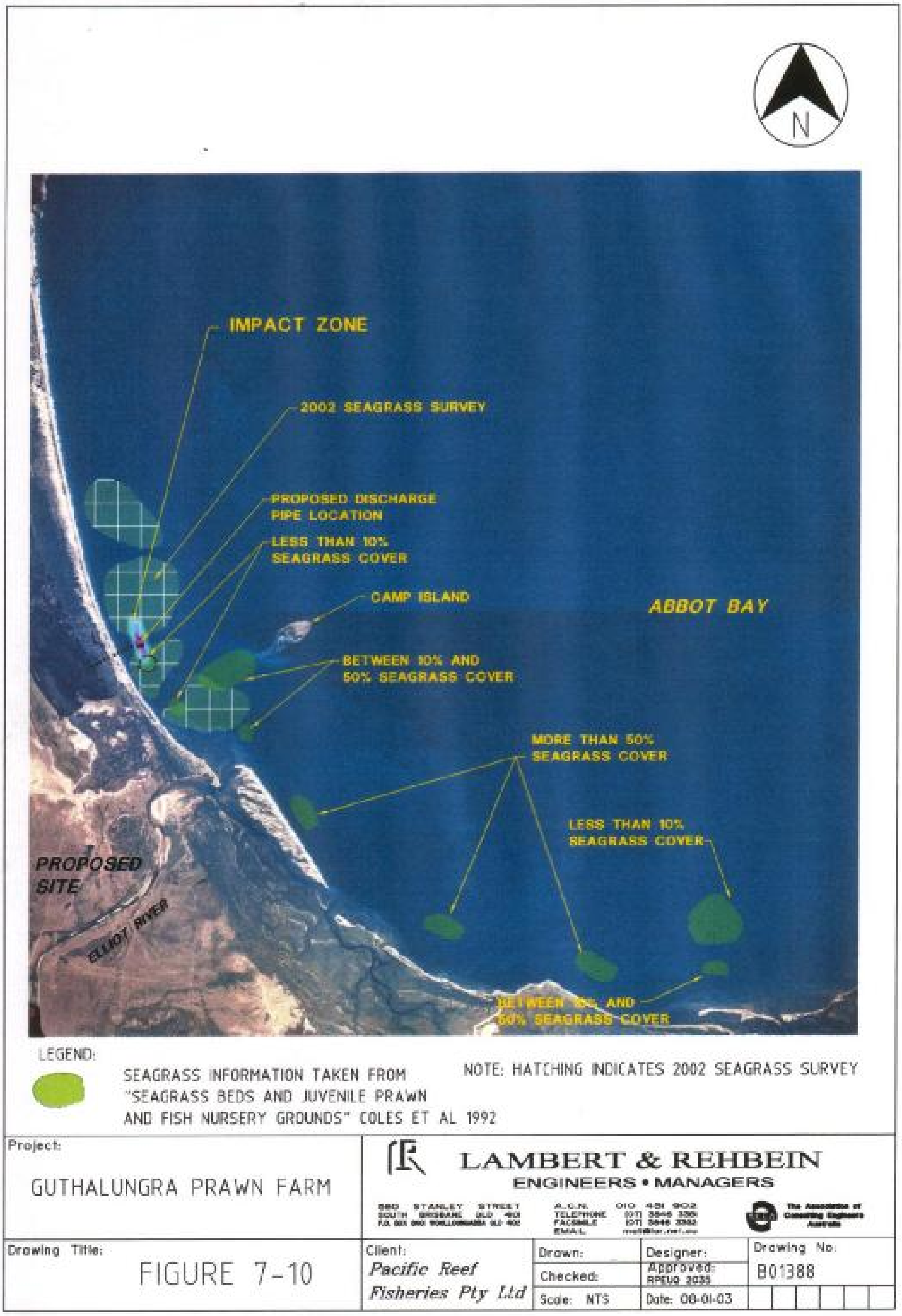


Figure 7-10
Impact Zone
Chlorophyll <u>a</u> Discharge Concentration (30 µg/L) 1990 (February)

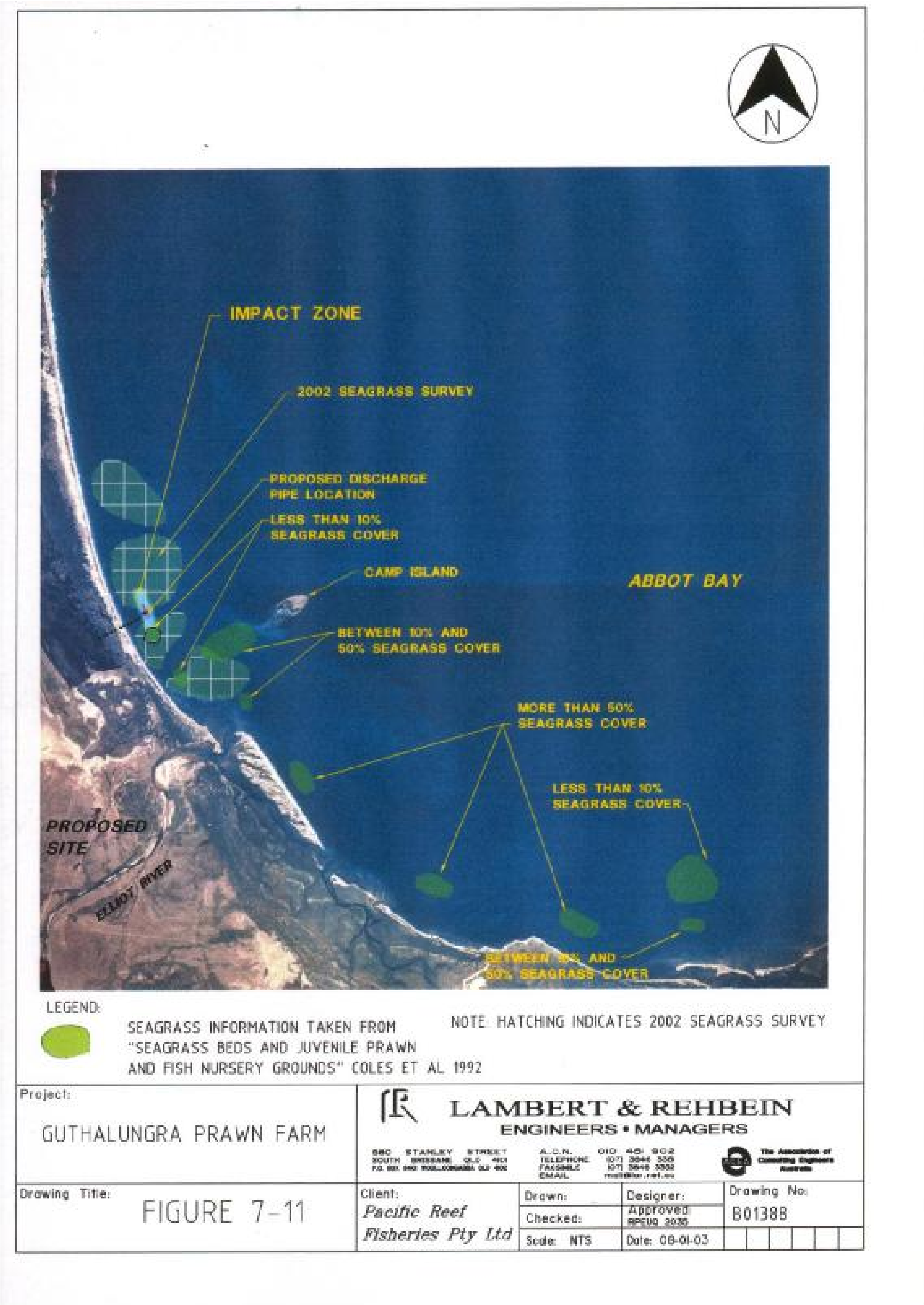


Figure 7-11
Impact Zone
Chlorophyll <u>a</u> Discharge Concentration (30 µg/L) 1998 (February)

7.2.9 Concentration Time Series

Concentration time series are shown at the two points marked in Figures 7-12 and 7-13 for total nitrogen in order to illustrate typical temporal variability in concentration at a point in space. Figures 7-12 (1990) and 7-13 (1998) have three plots. Time series (a) is the concentration of nitrogen at the point 500 m north of the outfall and (b) is the same for a point 500 m to the south. Time series (c) is of a much shorter time period for both north and south locations indicated by the vertical lines through (a) and (b).

As discussed previously, that the two simulation time periods were chosen to represent periods of weaker winds (1990) and average winds (1998). Notice that Figures 7-12 and 7-13 all show concentrations that are always above 100 µg/L since that is the assumed background level for nitrogen. All of these time series are punctuated by sharp changes in concentration. These high frequency changes are caused by the ebb (to the north), and flood (to the south) of the tide. For example the north point receives a pulse of discharge during ebb tide, but concentrations will drop sharply during flood tide. Of course the opposite occurs for the south point.

The clusters of higher concentrations near the end of March 1998 (Figure 7-12) are caused during periods of weaker winds in which the discharge is not as rapidly advected from the study area. During stronger winds the concentration levels decline to approach background levels. The expanded time series in Figures 7-12 and 7-13 show that what appears as concentrations that are persistently at high levels in (a) and (b) are actually closely group spikes of concentration separated by reduced levels.

These concentrations have been measured at the 500m contour. At 1000m these concentrations will be considerably more diluted with nutrients at much lower concentrations and close to background concentrations. Refer to Figures 7-14 and 7-15.

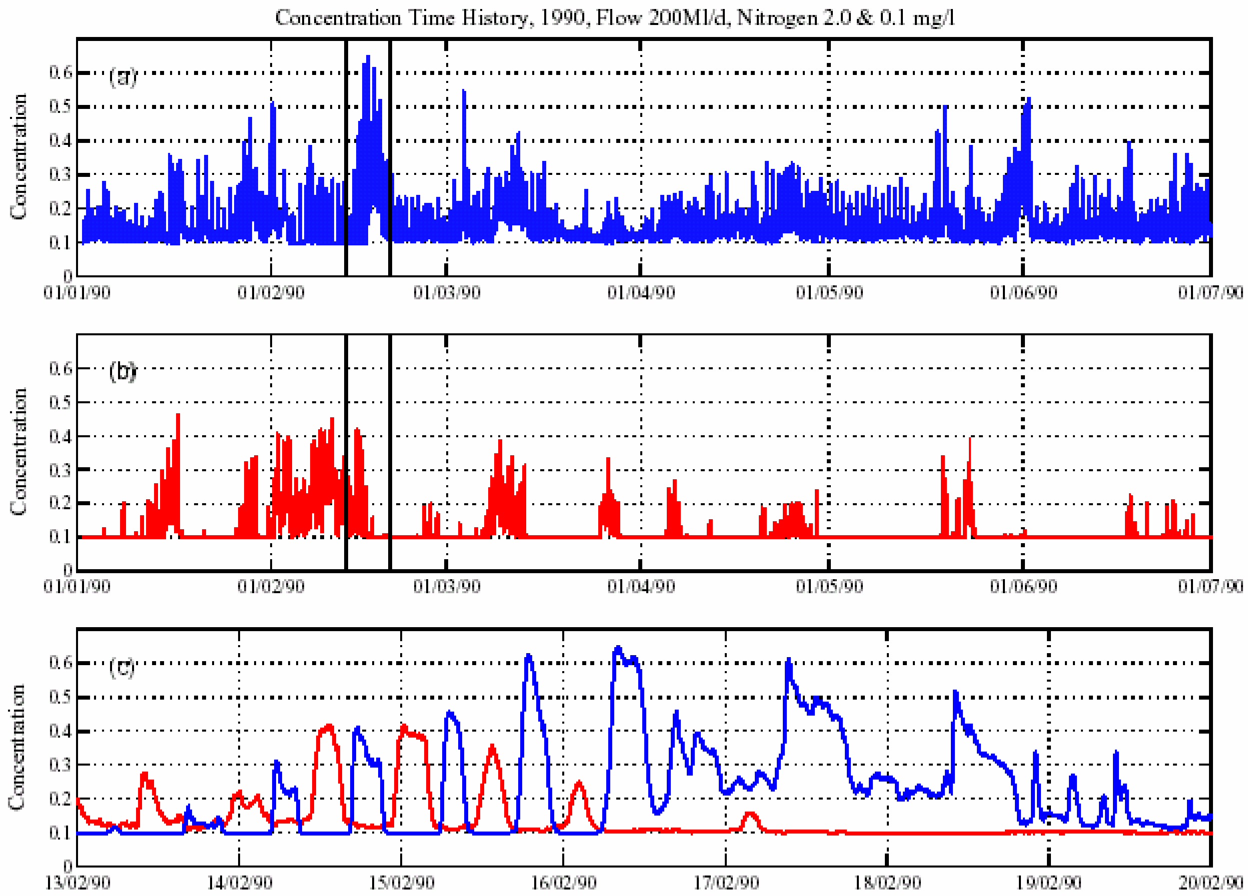


Figure 7-12

Concentration time history for Nitrogen during year 1990; (a) blue, point 500 m north of outfall; (b) red, point 500 m south of outfall; (c) shorter time window indicated by vertical lines in (a) and (b). Assumes a discharge of 200 Ml/d, Discharge concentration 2.0 mg/l, Background concentration 0.1 mg/l. Concentric circles at 500, 1000 and 2000 m

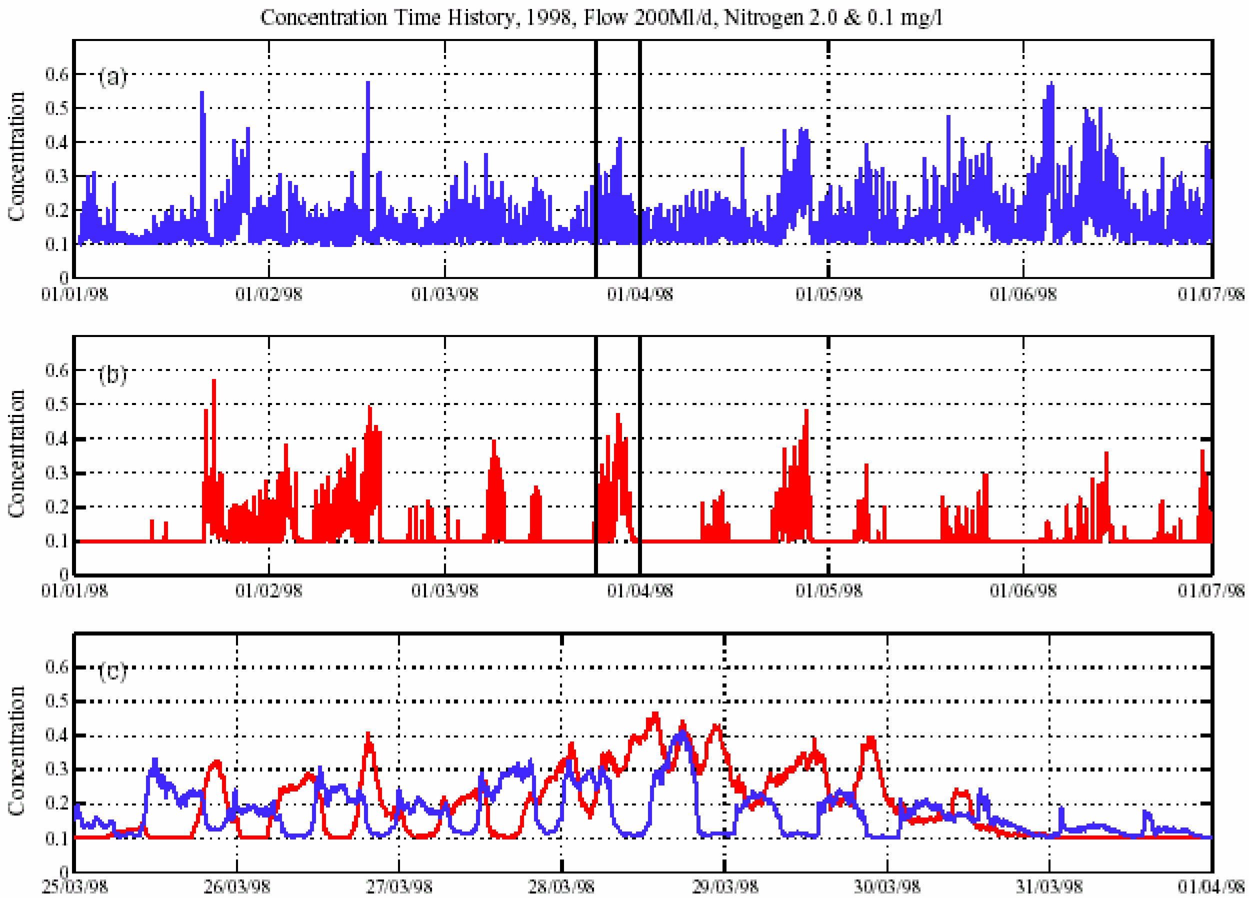


Figure 7-13

Concentration time history for Nitrogen during year 1998; (a) blue, point 500 m north of outfall; (b) red, point 500 m south of outfall; (c) shorter time window indicated by vertical lines in (a) and (b). Assumes a discharge of 200 Ml/d, Discharge concentration 2.0 mg/l, Background concentration 0.1 mg/l. Concentric circles at 500, 1000 and 2000 m radii.

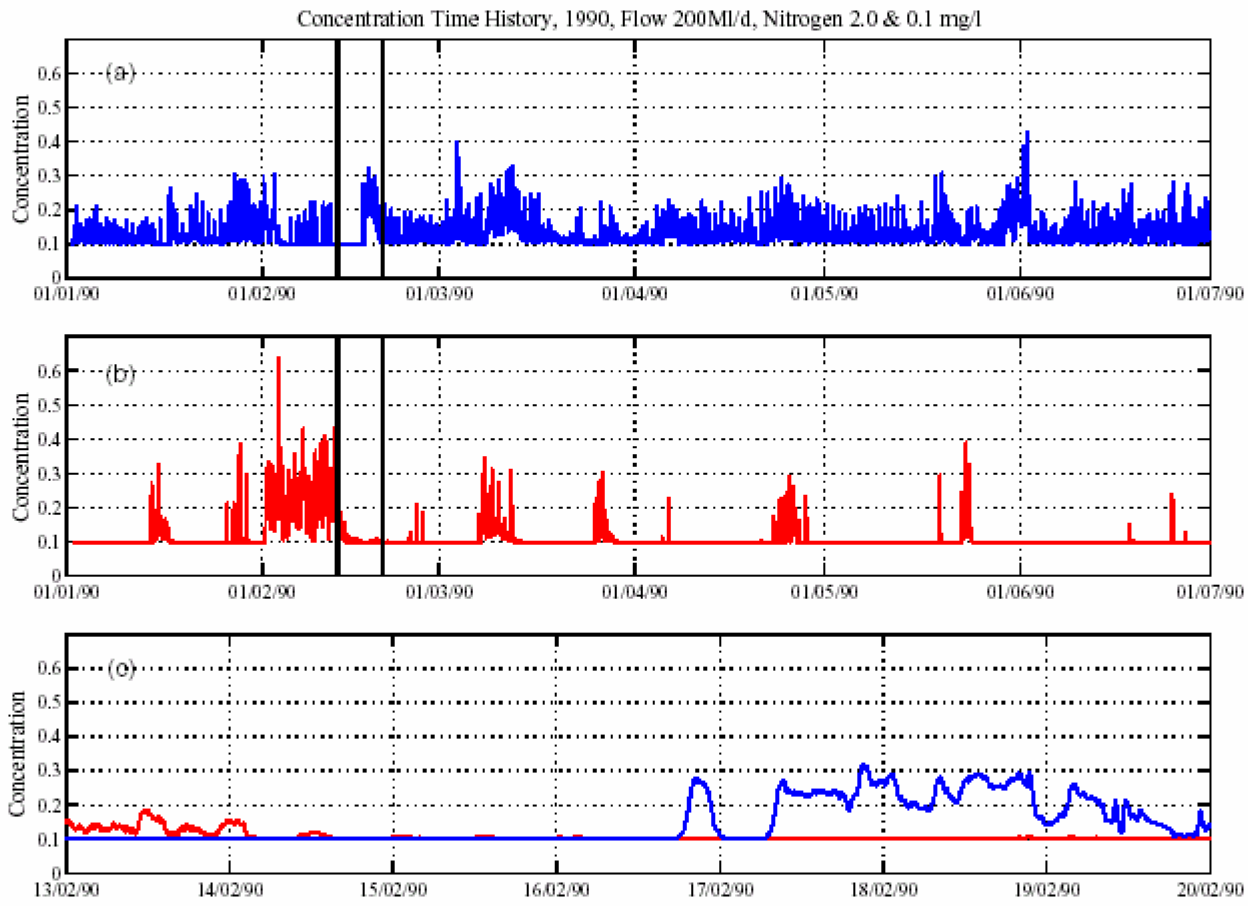


Figure 7-14

Concentration time history for Nitrogen during year 1990; (a) blue, point 1000 m north of outfall; (b) red, point 1000 m south of outfall; (c) shorter time window indicated by vertical lines in (a) and (b). Assumes a discharge of 200 Ml/d, Discharge concentration 2.0 mg/l, Background concentration 0.1 mg/l. Concentric circles at 500, 1000 and 2000 m radii.

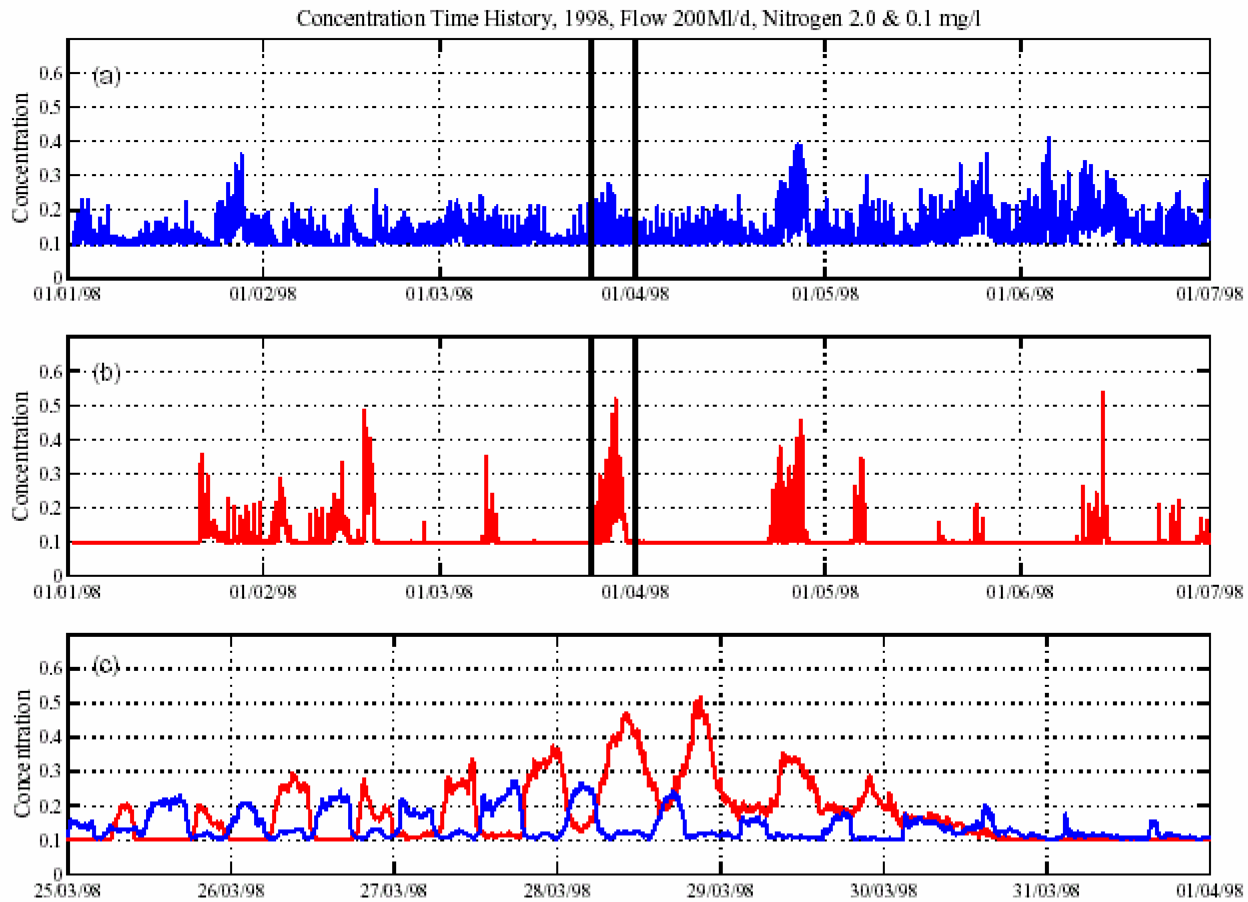
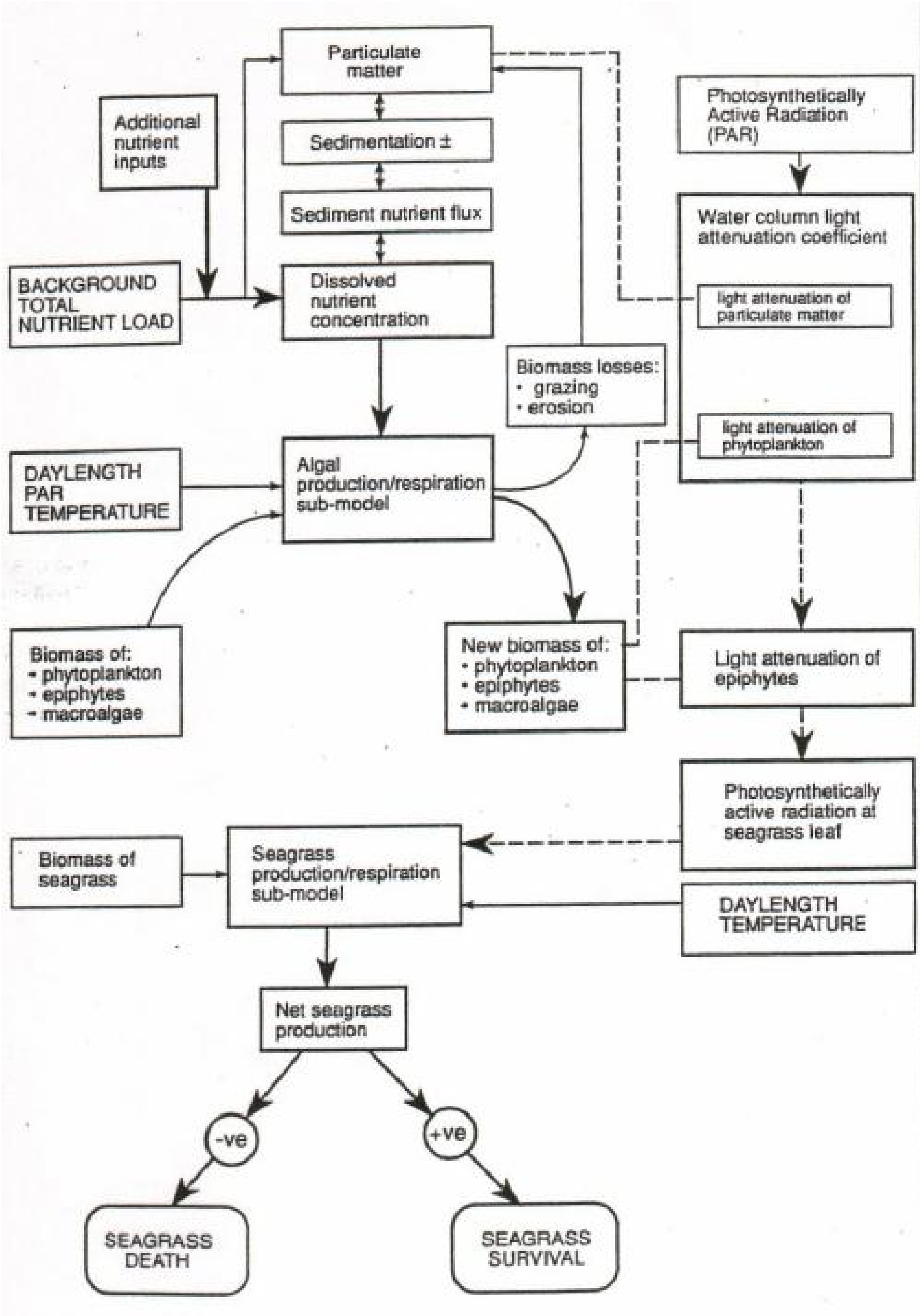


Figure 7-15

Concentration time history for Nitrogen during year 1998; (a) blue, point 1000 m north of outfall; (b) red, point 1000 m south of outfall; (c) shorter time window indicated by vertical lines in (a) and (b). Assumes a discharge of 200 Ml/d, Discharge concentration 2.0 mg/l, Background concentration 0.1 mg/l. Concentric circles at 500, 1000 and 2000 m radii.

7.2.10 Potential Environmental Impacts

The ecological process which may lead to either a seagrass increase or seagrass loss is described in Figure 7-16.



Western Australia EPA, 1992

Figure 7-16
An ecological model for a seagrass dominated system

A simple conceptual model as per the Australian Water Guidelines (2000) shows seagrass growth and survival is controlled by:

- Dissolved Nutrient concentrations (TN);
- Flow conditions;
- Light climate (TSS); and
- Possibly other variables e.g. substrate.

The risk assessment undertaken is described in Tables 7-7 to 7-10 in the following text. These risks are based upon the stressors shown in the conceptual model and the risk based decision tree (see Figures 7-17 and 7-18). This risk-based approach has been used to assess the impacts of the prawn farm discharge on the receiving environment in Abbot Bay. A decision tree "risk assessment" method has been used to evaluate potential impacts on seagrass communities and hence the world heritage values of the Great Barrier Reef.

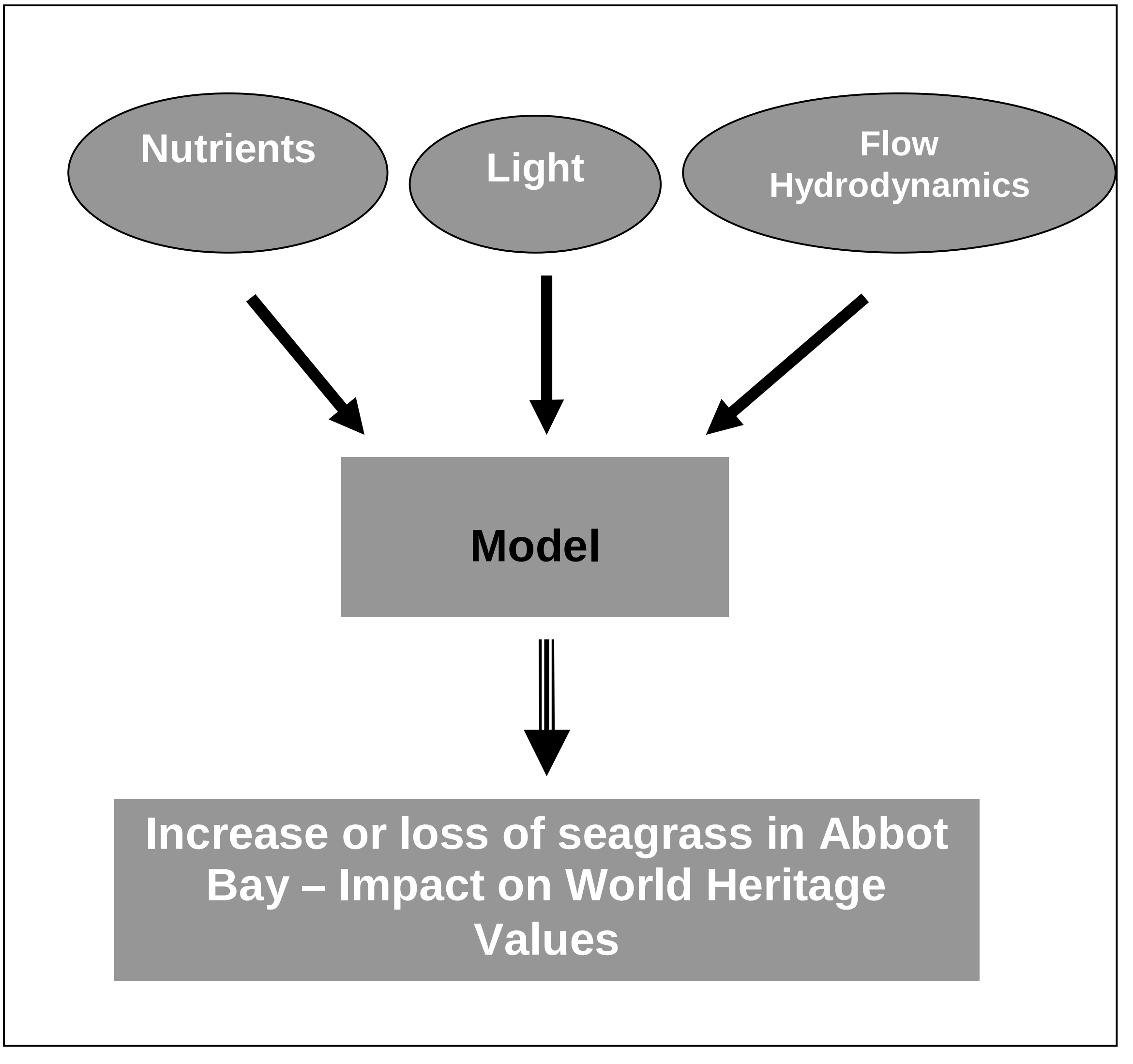


Figure 7-17
Conceptual Model of Impacts on Seagrass

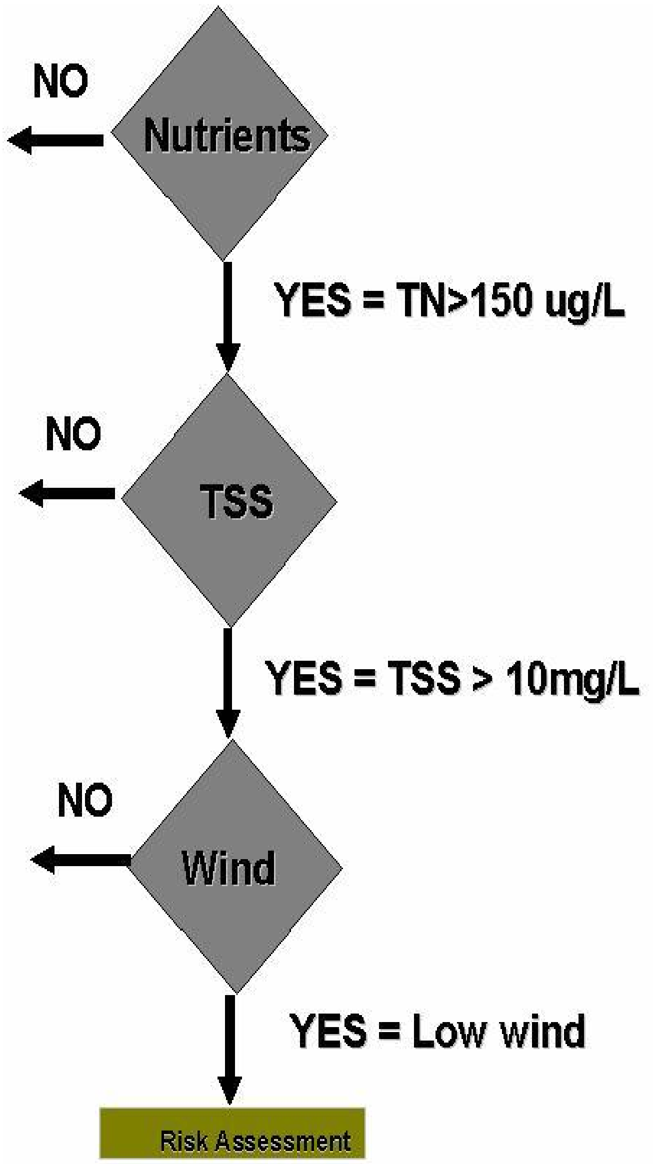


Figure 7-18
Decision tree for the potential increase or loss of seagrass in Abbot Bay as a result of prawn farm discharges

7.2.11 Conclusions

A combination of the following discharge criteria and off shore mechanisms may potentially impact on seagrasses:

i) Total nitrogen concentrations greater than 150 µg/L;
ii) Total Suspended Solids concentrations greater than 10 mg/L; and
iii) Low wind events.

However, as discussed below, these mechanisms are species and environment dependent.

7.2.12 Impacts on Seagrass

A summary of the species and some of their attributes found in Abbot Bay as part of the detailed 2002 survey (Scientific Marine study – Appendix L) are listed below.

Halodule uninervis leaves emerge from an erect shoot, not directly from the stem. The plant grows towards the low tide mark with other seagrasses. It tolerates intertidal and shallow subtidal zones on sand to soft mud. It penetrates estuaries often and is quick to return to areas after disturbance. The plant grows in northern Australia from Shark Bay WA to northern NSW, the Indo- West Pacific from South Africa to Japan and Tonga.

Halophila ovalis is common in the intertidal zone, tolerates salinity changes, exposure and varied substrates. This is a major food for dugongs and green turtles. The species occurs Australia wide; Indo - West Pacific from South Africa to Japan and Samoa.

Halophila spinulosa is widespread but only occurs below spring low-tide level; grows as sparse sprigs along steep edges of channels as it needs less light than other species. Found in Northern Australia from Shark Bay, WA to Moreton Bay; north through Indonesia and Malaysia to Philippines.

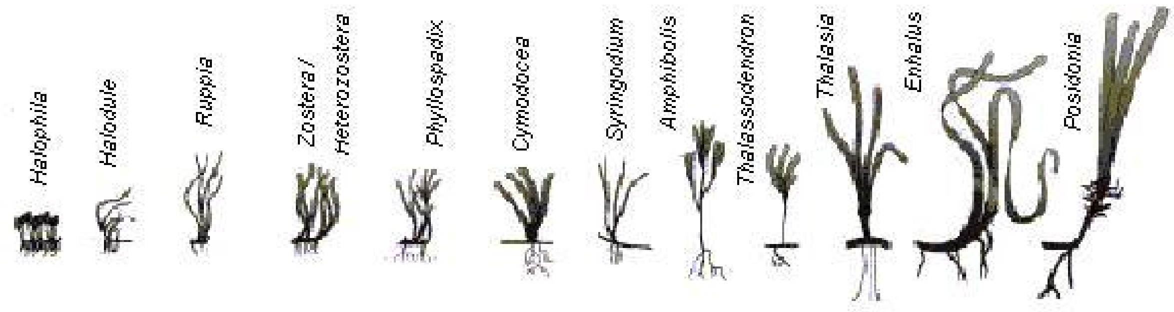
A review of the knowledge of seagrass in Australia is summarized in "Seagrass in Australia – Strategic review and Development of an R and D Plan" (1999) by Butter and Jernakoff. The authors conclude that in spite of the large research efforts in Australia, the diversity of seagrasses as well as the habitats they provide has frustrated efforts to synthesize and integrate results. In addition, most seagrass studies have concentrated on a few temperate species, especially *Zostera marina* and *Posidonia oceania* with some on tropical species of the Caribbean e.g.; *Thallassia testudinum*. The extrapolation of these overseas results to other seagrasses, especially the diverse Indo-Pacific flora present in Australia is inappropriate. The Australian species differ in morphology and have different life histories, so models based on overseas paradigms cannot be applied directly. Our limited knowledge of Australian seagrasses restricts our ability to formulate general models of seagrass ecophysiology, ecology and ecological interactions.

Butter and Jernakoff (1999) found that in Northern Australia, seagrass species possess tropical affinities e.g. *Thalassia* and *Cymodocea*. Tropical beds can be highly diverse, but generally possess lower biomasses than temperate zones. While large areas of seagrasses occupy embayments such as Hervey Bay, Queensland, tropical seagrasses are generally confined to intertidal environments or to deep water. The genera *Halophila* and *Halodule* extend beyond the Tropics in to cooler waters. Tropical seagrasses meadows directly support (*Dugong dugon*) and green sea turtles (*Chelonia mydas*).

One useful method of categorizing seagrasses is on the basis of their growth forms, which range from with thin leaves (e.g. *Halophila* and *Halodule*) to large plants with thick leaves (e.g. *Thalassia, Enhalus,* and *Posidonia*). As a general trend there is rapid rhizome turn over in the smaller genera and slower turnover of persistent turnover in the larger seagrasses. This difference may also affect the way large and small seagrass interact with higher trophic levels, because they are linked through turnover rates.

The hypothesized gradient from small to large genera is the following: *Halophila* < *Halodule* < *Ruppia* < *Zostera* < *Heterozostera* < *Phyllospadix* < *Cymodocea* < *Syringodium* < *Amphibolis* < *Thalassodendron* < *Thalassia* < *Enhalus* < *Posidonia* (see Figure 7-19). The two smallest seagrass genera *Halophila* and *Halodule* are the preferred food source for dugongs and green turtles for grazing.

These two genera have relatively high species diversities with more than 10 species per genera. This high diversity is probably related to length of time since the genera evolved, the rapidity of the life cycle, and frequency of disturbance.



Tropical Tropical Temperate Temperate Temperate Tropical Tropical Temperate Tropical Tropical Tropical Temperate

> 10 spp/genus | **> 3 spp / genus** | **1 - 2 spp / genus** | **1 spp/genus**

Broad Seed banks/ rapid reseeding Ephemeral	**Distribution** • Distributional ranges • Reproduction • Temporal variability	Restricted Vegetative regeneration/ slow recolonisation Persistent
Rapid turnover Open Rapid	**Ecophysiology** • Regrowth dynamics • Nutrient cycling • Responsiveness to perturbation	Slow turnover Closed Slow
High Low Low Low	**Ecological Interactions** • Direct grazing • Detritus production • Epiphyte production • Leaf canopy baffling	Low High High High

Source: Walker *et al.* (1999)

Figure 7-19
Seagrass Functional Form Model

Butter and Jernakoff (1999) report that disturbance from repeated grazing of *Halophila* and *Halodule* could lead to more speciation in these genera. Smaller seagrasses tend to have small rhizomes, which persist for weeks to months, while larger seagrasses tend to have larger, more persistent rhizomes, which exist for months or years. Similarly rates of leaf turnover of smaller seagrasses are more rapid than turnover rates in larger species. The potential epiphyte load on seagrass leaves is correspondingly low on fast turnover species compared with epiphyte loads on slow turnover species.

This turnover capacity means that potentially smaller seagrasses found in Abbot Bay are less likely to be reduced in number as a result of epiphyte load and light reduction as a result of nutrient enrichment when compared with larger temperate seagrass species.

According to Butter and Jernakoff (1999), smaller seagrasses tend to be more responsive to environmental conditions with faster and more significant responses than larger seagrasses. Small seagrass recover rapidly from disturbance via seed banks but larger seagrass can be very slow to recover.

This rapid recovery should enhance decolonisation of the area where seagrasses may be removed during pipeline construction.

Butter and Jernakoff (1999) report that the production of large banks of small seeds in smaller seagrasses contrast with the production of larger seeds that germinate readily in larger species. This is of significance to dispersal and recruitment of seagrasses, but available data are rare. Growth responses to nutrient additions are higher for small seagrass (*Hadodule*) than for larger species like *Zostera* and *Cymodocea* or *Posidonia*. The worldwide debate over whether seagrasses are N, P or Fe limited has not been resolved in Australia and recent studies by Udy (1997) have implicated N rather than P limitation in a variety of locations.

For example, *Halodule uninervis* was considered to be exclusively N limited in eastern Moreton Bay (Udy, 1997). The distribution and biomass of seagrasses (*Thalassia hemprichii* and *Halodule univervis*) around Green Island (adjacent to Cairns) has increased during the 50 years, possibly due to local and regional increases in nutrient availability.

Udy (1997) hypothesises that the source of nutrient may have been fluvially derived by rivers to the Cairns region of the GBR lagoon over the past 50 years. Alternatively, the observed N limitation of seagrasses at Green Island may not be due to anthropogenic impacts and may represent a typical Australian phenomenon. This is supported by the PO_4^{3-} concentrations in the GBR “lagoon” (0.16 to 0. 21 µM) being much higher than in reefal environments, such as Caribbean (0.03 µM) where P limitation of seagrass growth has been demonstrated. Nitrogen fixation requires large inputs of fixed carbon for energy and is inhibited by the presence of available N in the environment. Hence high N_2 fixation rates suggest high N demand in a low N environment. Vegetated marine sediments in Australia have N_2 fixation rates 10 - 1000 times. Udy (1997) suggests that nutrient limitation of seagrass growth is probably wide spread on the GBR and may explain the absence of seagrass meadows from the cays of the southern GBR.

Additional small amounts of nitrogen may assist seagrass growth in Abbot Bay.

Seagrass declines have been well documented both around Australia and elsewhere in the world. A variety of mechanisms can cause seagrass loss, the most ubiquitous and pervasive cause of decline is the reduction of light availability. Seagrasses have high minimum light requirements for survival compared with other plants. This requirement for 10 - 30% incident light is thought to be related to the significant proportion of seagrass biomass that can be located in anoxic sediments. Three major factors can cause a reduction in light availability:

- Chronic increases in dissolved nutrients leading to a proliferation of light absorbing algae, with phytoplankton, macroalgae or algal epiphytes on seagrass leaves and stems;

- Chronic increases in suspended sediments leading to increased turbidity; and
- Pulsed increases in suspended sediments and/or phytoplankton that cause a dramatic reduction of light penetration for a limited time.

A high correlation was obtained between TSS and seagrass depth range in Moreton Bay by Abal and Dennison (1996). They found that where median annual total suspended solids concentrations were in excess of 10 mg/L, there was a complete loss of seagrass. In effect, Abal and Dennison (1996) suggest that half of the TSS values recorded over the year were above 10 mg/L. This compares favourably with a similar study conducted in Chesapeake Bay in which 15 mg/L was established as a minimum habitat requirement (Dennison and Abal, 1999).

Modelling of TSS concentrations in Abbot Bay suggest an area of seagrass less than 1-2% of the total seagrass area in Abbot Bay will receive TSS concentrations of greater than 2mg/L. Light limitation of seagrass by TSS from the prawn farm discharge appears to have a low probability.

An area of seagrass may be lost from Abbot Bay as result of the prawn farm discharge in to the Bay notwithstanding that:

- The smaller seagrasses species found in Abbot Bay tend to be more responsive to environmental conditions with faster and more significant responses than larger seagrasses. Smaller seagrasses recover rapidly from disturbance via seed banks but larger seagrass can be very slow to recover;
- Udy's (1997) hypothesises that nutrient limitation of seagrass growth is probably wide spread on the GBR and his recent studies have implicated N rather than P limitation in a variety of locations; and
- Rates of leaf turnover of smaller seagrasses are more rapid than turnover rates in larger species. The potential epiphyte load on seagrass leaves is correspondingly low on fast turnover species compared with epiphyte loads on slow turnover species. This suggests that the potential for a high epiphyte load on the seagrasses in Abbot Bay is unlikely, reducing the likelihood of any impact of any light limitation upon the growth and survival of these species.

An assessment has been undertaken to determine the risk of seagrass loss and its effect on ecosystem function and world heritage values. Details of this risk assessment approach are described in detail below.

To assist decision-makers and proponents assess environmental damage as part of the ESD process for Wild Fisheries, the first National ESD Reporting Framework for Fisheries - The How To Guide for Wild Fisheries was developed. Many of the principles of The "How To Guide" for Wild Fisheries have been incorporated into the yet unfinished ESD "How to Guide" for Aquaculture. These principles espoused in The "How To Guide" for Wild Fisheries can be utilized to assess the risk of environmental damage as a result of the development impacts on receiving waters.

A key element in this assessment is the risk management approach utilised by "The How to Guide for Wild Fisheries" which is described below.

7.2.12.1 Risk Assessment

The formal evaluation and management of risk via Risk Analysis is generally accepted as one of the basic instruments of good management practice. Risk Analysis involves:

- Identifying the hazards/components e.g. impacts of discharge on the receiving environment ;
- Analyzing those that pose a risk; epiphytic algal growth, light limitation;
- Determining appropriate management options; reduce discharge, improve mixing;
- Implementing the best of these options; and
- Reviewing their effectiveness e.g. monitoring program.

Table 7-7 suggests a range of consequence levels as a measure of ecological impacts based upon fishery activity. Using the same framework for aquaculture development provides some direction in assessing the impacts upon the receiving environment in Abbot Bay. For example, a minor level (1) of impact is predicted to occur based upon the possible loss of seagrass and coral in Abbot Bay. That is, there is measurable impact on habitat (s) but these are very localized compared to total seagrass habitat area – these impacts are predicted to be <5% of the original area of seagrass habitat.

Table 7-7
Suggested consequence levels for the impacts of a fishery on habitats

Level	Ecological (Habitat)
Negligible (0)	Insignificant impacts to habitat or populations of species – probably not measurable levels of impacts. Activity only occurs in very small areas of the habitat, or if the larger area is used, the impact on the habitats from the activity is unlikely to be measurable against background variability. (*Suggestion – these could be activities that affect <1% of original area of habitat or if operating on a larger area, have virtually no direct impact*).
Minor (1)	Measurable impact on habitat (s) but these are very localized compared to total habitat area. (*Suggestion – these impacts could be <5% of the original area of habitat*).
Moderate (2)	These are likely to be more widespread impacts on the habitat but the levels are still considered acceptable given the % of area affected, the types of impact occurring and the recovery capacity of the habitat. (*Suggestion – for impact on non-fragile habitats this may be up to 50% [similar to population dynamics theory] – but for more fragile habitat, to stay in this category the percentage area affected may need to be smaller e.g. 20 %*)

Level	Ecological (Habitat)
Severe (3)	The level of impact on habitats may be larger than is sensible to ensure that the habitat will not be able to recover adequately, or it will cause strong downstream effects from loss of function (*Suggestion – Where the activity makes a significant impact in the area affected >20—50% [based on recovery rates] of habitat is being removed*).
Major (4)	Substantially too much of the habitat is being affected which may endanger its long term survival and result in severe changes to ecosystem function (*Suggestion this may equate to 70-90% of the habitat being affected or removed by this activity*).
Catastrophic (5)	Effectively the entire habitat is in danger of being affected in a major way/removed. (*Suggestion: this is likely to be in the range of >90% of the original habitat being affected*).

Note: Scale of habitat assessment (attached species – e.g. seagrass/coral) assessed at the regional habitat level, defined as the entire habit equivalent to that occupied by the exploited stock. The real extent against which impacts should be judged is not the current distribution, but what is considered the best estimate of the original extent of the habitat.

From National ESD Reporting Framework for Fisheries - The How To Guide for Wild Fisheries, 2002

The likelihood of seagrass being lost from a small area in Abbot Bay can be ranked in a Likelihood Table (see Table 7-8). It is suggested that < 5 % of the seagrass estimated to be in Abbot Bay may be lost as a result of the development. However, it must be remembered that there is also the possibility there may be an increase in seagrass growth within the impact zone of the discharge, because seagrass growth is likely to be nitrogen limited. A small amount of nitrogen may increase the growth of seagrass within this area. If a conservative approach is taken, it could be assumed that the likelihood of seagrass loss over the impact zone is high i.e. Likely (6).

Table 7-8
Likelihood Table

Level	Descriptor
Likely (6)	It is expected to occur
Occasional (5)	May occur
Possible (4)	Some evidence to suggest this is possible here
Unlikely (3)	Uncommon, but has been known to occur elsewhere
Rare (2)	May occur in exceptional circumstances
Remote (1)	Never heard of, but not impossible

To complete the risk-based matrix, a combination of the values of likelihood multiplied by the value of consequence is completed. Based upon a Consequence of 1 – Minor Impact and a Likelihood of 6, a value of 6 is calculated. Refer to Table 7-9 below for the risk matrix.

Table 7-9
Risk Matrix
(Numbers in cells indicate risk value, the shades indicate risk rankings)

		Consequence					
		Negligible	**Minor**	**Moderate**	**Severe**	**Major**	**Catastrophic**
Likelihood		0	1	2	3	4	5
Remote	1	0	1	2	3	4	5
Rare	2	0	2	4	6	8	10
Unlikely	3	0	3	6	9	12	15
Possible	4	0	4	8	12	16	20
Occasionally	5	0	5	10	15	20	25
Likely	6	0	**6**	12	18	24	30

7.2.12.2 Output from Risk Assessment Matrix

An output of 6 (six) from the risk matrix represents a minor overall risk (see Table 7-10) below. For the negligible and minor risk issues, whilst full performance reports are not needed, a necessary element of the ESD Reporting framework is to document the rationale for classifying issues in these categories. These should form part of the ESD report so that stakeholders can see why these issues were awarded these ratings. The rationale for these issues has been discussed above.

It should be noted that if a full performance report is not needed, this by definition means that there are no specific management actions being taken.

Table 7-10
Risk Rankings and Outcomes

Risk Rankings	Risk Values	Likely Management Response	Likely reporting Requirements
Negligible	0	Nil	Short Justification Only
Minor	1-6	None Specific	Full Justification needed
Moderate	7-12	Specific Management needed	Full Performance needed
High	13-18	Possible increase to management activities	Full Performance needed
Extreme	>19	Likely additional management activities	Full Performance Report

In conclusion, a risk management approach adopted for this aquaculture venture was based upon the ESD for Wild Fisheries. This approach is used to assist decision makers and proponents assess environmental impact as part of the ESD process. This proposal represents a minor risk for the receiving water environment and seagrass habitat.

A monitoring program will be instigated to monitor impacts on the receiving environment so that the minor risk profile is maintained.

7.2.13 Cumulative Impacts within Abbot Bay

An existing aquaculture farm is established on Abbot Bay and has license to produce fish fingerlings. Negotiations are ongoing with the regulatory agencies to produce prawns and barramundi on site.

The Abbot Bay catchment also supports cattle grazing and vegetable production. Vegetable production is unlikely to increase, as the area is water limited. A longer term plan of importing water from the Burdekin River system has been mooted. This scheme would enhance the area to grow vegetables should it come to fruition. A major coal terminal also operates in Abbot Bay, but is not responsible for any nutrient discharge.

The cumulative impacts on Abbot Bay appear to be sustainable based upon the risk assessment and modelling undertaken.

7.3 Flora and Fauna

This section summarises Thomas's (2002) conclusions regarding potential impacts on flora and fauna, and areas of ecological significance (Appendix M).

7.3.1 Extent and Effect of Clearing

During construction, clearing of the site will be undertaken with the construction of 260 ha of grow out ponds, approximately 50 ha of sedimentation and settlement ponds and ancillary services such as offices and a processing plant (Figure 4-1). The site has been cleared over the last 50 years for cattle grazing. Therefore the vegetation onsite is sparse and is not in original condition. Consequently its fauna habitat value is relatively low and clearing should have little impact on native fauna associated with the site and surrounding area.

a) Impacts on Regional Ecosystems and the effects of the Vegetation Management Act

The extent of clearing of native vegetation on the site and the effect of the (Queensland) *Vegetation Management Act 1999* on the project has been assessed. The Code for the Clearing of Vegetation (State Policy for Vegetation Management for Freehold Land - September 2000) has also been considered.

Extent of Clearing

Figure 7-20 details the extent and Vegetation Management Act (VMA) status of regional ecosystems within and immediately adjacent to the study area.

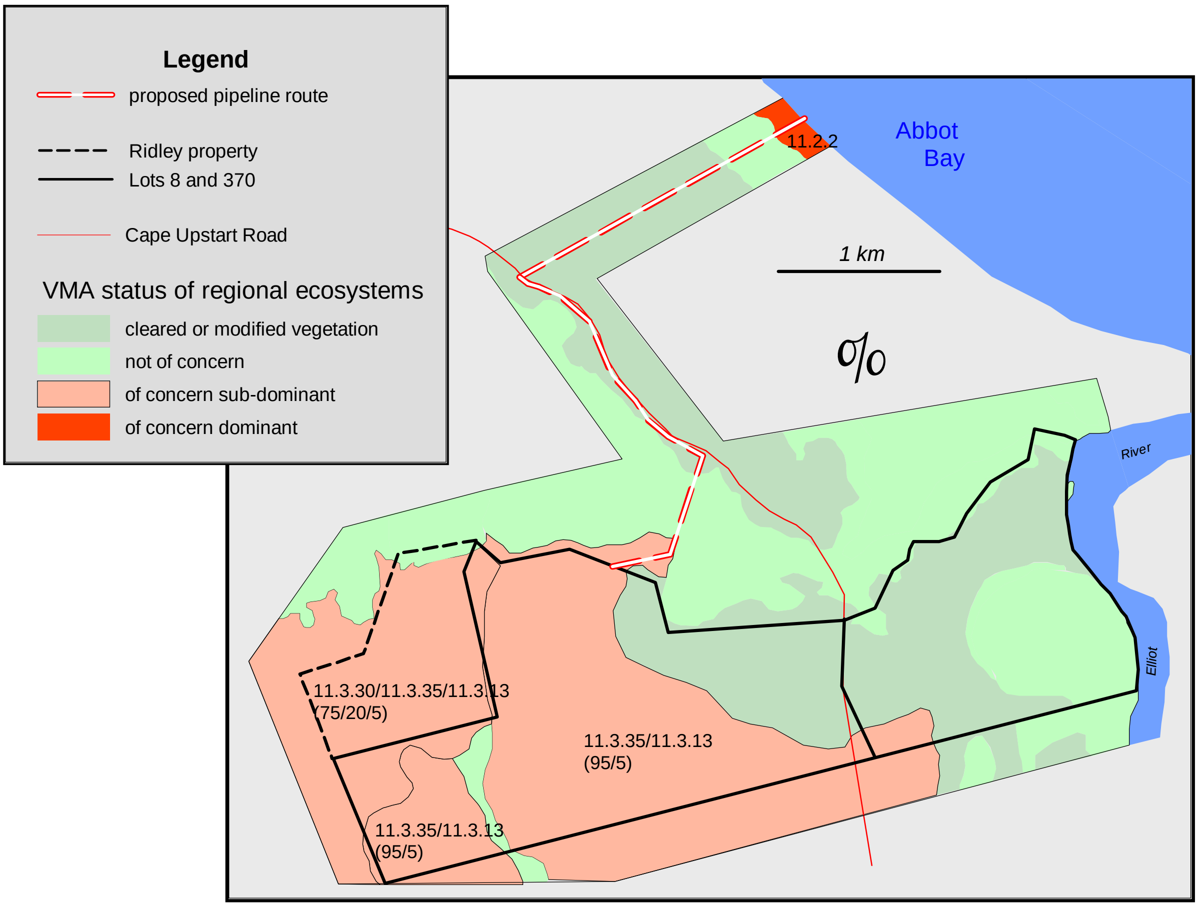


Figure 7-20
VMA status of Regional Ecosystems within and adjacent to the main development area and proposed pipeline (Thomas, 2002).

Table 7-11 summarises the pre-clear and remnant area information (Accad *et al.,* 2001) for the two Of Concern Regional ecosystems occurring within the study area.

Table 7-11
Pre-clear and remnant areas within the Townsville Plains Province of the two *of concern* Regional Ecosystems occurring within the study area.

		Area (ha)		
RE	Tenure	Pre-clear	Remnant 1997	Remnant 1999
11.2.2	Freehold	693	597	596
	Leasehold	648	526	526
	National Park	696	583	583
	Reserves (other)	263	195	195
	Total ha	2300	1901	1900
	% of pre-clear	100%	82.7%	82.6%
11.3.13	Freehold	2201	399	339
	Leasehold	694	344	341
	National Park	4	4	4
	Reserves (other)	437	368	368
	Total ha	3336	1115	1052
	% of pre-clear	100%	33.4%	31.5%

Table 7-12 summarises the estimated effect that the development is likely to have on the remnant extent of the *of concern* RE's, based on Remnant 1999 data. The area of each RE to be directly disturbed by the proposal has been estimated as follows:

- ***RE 11.2.2*** - A 50m wide access corridor through the dunal system will be required for pipeline trenching (see Section 4.3). Sand from the beach will be used to replace the dune which will be then stabilized and re-vegetated. The length of pipeline corridor traversing RE 11.2.2 is in the order of 70 metres. Estimated area of RE 11.2.2 to be disturbed would be approximately 0.3 ha.

- ***RE 11.3.13*** - This RE occurs as small patches within eucalypt woodland vegetation on Lots 8 and 370. The EES survey and EPA RE mapping suggest that RE 11.3.13 occupies an estimated 5% of three polygons covering approximately 586 ha of the main development area. Estimated area of RE 11.313 to be disturbed is 5% of 586, which equals 29ha.

Table 7-12
Estimated areas of disturbance of the two *Of Concern* RE's due to the proposed development, and resulting overall remnant areas for each RE within the Townsville Plains Province

Regional Ecosystem	Pre-clear area (ha)	Estimated area to be disturbed		Resulting remnant area *	
RE	hectares	Hectares	% of pre-clear	hectares	% of pre-clear
11.2.2	2300	0.3	<0.5	1899	82.5 %
11.3.13	3336	29	0.9	1023	30.6%

* based on Remnant 1999 data

Disturbance of RE 11.2.2 [*Ipomoea pes-caprae* and *Spinifex sericeus* grassland +/- *Casuarina equisetifolia*] resulting from the proposed development will reduce the overall remnant area of the RE from 82.6% to 82.3% of the pre-cleared area. This reduction represents a small proportion of the pre-clear area of the RE, and will not significantly reduce the remnant area of the Regional Ecosystem.

Disturbance of RE 11.3.13 [*Grevillea striata* open woodland] resulting from the proposed development will reduce the remnant area of the RE from 31.5% to 30.6% of the pre-clear area. This is a relatively small reduction that will not significantly progress the remnant area of the RE towards the 10% threshold of an endangered Regional Ecosystem.
State Policy for Vegetation Management for Freehold Land - September 2000.

The purposes of the code are:

- The protection of remnant endangered regional ecosystems;
- The protection of vegetation in areas of high nature conservation value;
- The maintenance of biodiversity;
- The maintenance of ecological processes;
- The prevention of land degradation; and
- The maintenance of the sustainable productive potential and use of agricultural land.

Purpose 1 (the protection of remnant endangered regional ecosystems) is achieved by not clearing in any remnant endangered regional ecosystem except where the chief executive is satisfied that:

- The clearing is necessary to protect the remnant endangered regional ecosystem from a threatening process;
- The clearing is essential for establishing a necessary fence, road or other built infrastructure and no suitable alternative site exists; and
- The vegetation is not part of a remnant endangered regional ecosystem.

Purpose 2 (the protection of vegetation in areas of high nature conservation value) is achieved by not clearing in any declared area of high nature conservation value except where the chief executive is satisfied that:

- The clearing is necessary to protect the declared area or its conservation values from a threatening process; and
- The clearing is essential for establishing a necessary fence, road or other built infrastructure and no suitable alternative site exists.

Purpose 3 (the maintenance of biodiversity) is achieved by:

- Not clearing in any remnant regional ecosystem to the extent of causing a change to its conservation status, except where the chief executive is satisfied that:

  - The clearing is necessary to protect the remnant vegetation or regional ecosystem from a threatening process;
  - The clearing is necessary for establishing a necessary fence, road or other built infrastructure and no suitable alternative site exists; and
  - The vegetation is not remnant vegetation.

- Not reducing the total extent of remnant vegetation in a bioregion to less than 30% of its pre-clearing extent except where the chief executive is satisfied that:

  - The clearing is necessary to protect the remnant vegetation or regional ecosystem from a threatening process;
  - The clearing is essential for establishing a necessary fence, road or other built infrastructure and no suitable alternative site exists; and
  - The vegetation in not remnant vegetation.

- Meeting the performance requirements PR1 and PR2 in Table 7-13.

Purpose 4 (the maintenance of ecological processes) can be achieved by meeting the performance requirements PR1 and PR6 in Table 7-13.

Purpose 5 (the prevention of land degradation) is achieved by:

- Not clearing vegetation in declared areas venerable to land degradation except where the chief executive is satisfied that:

  - The clearing is required for the management of the degradation;
  - The clearing is necessary to protect the declared area from a threatening process; and
  - The clearing is essential for establishing a necessary fence, road or other built infrastructure and no suitable alternative site exists.

- Meeting performance requirements PR3 and PR 6 in Table 7-13.

Purpose 6 (the maintenance of the sustainable productive potential and use of agricultural land) is achieved by meeting performance requirements PR7 in Table 7-13.

Performance Requirements and Acceptable Solutions

Table 7-13 details performance requirements with acceptable solutions. In determining whether a performance requirement will be met the precautionary principle will be applied.

An acceptable solution represents one way in which the relevant performance requirement may be met. Applicants who do not adopt the acceptable solution must show how they will meet the performance requirement.

Local Tree Clearing Guidelines developed under Part 6 of the *Land Act 1994*, formerly applying to the area of the State in which the land subject to the application is located, will be key factors in deciding whether a performance requirement is met where the requirements of the guidelines exceed the standards set out as acceptable solutions.

Explanatory Notes provide additional details on, and should be read as part of, performance requirements and acceptable solutions.

Table 7-13
Performance requirements and acceptable solutions

Performance Requirement	Acceptable Solutions
PR1 Nature conservation values and water quality of significant natural wetlands, lakes and springs are maintained.	AS1 Vegetation is retained: In wetlands, lakes and springs Within at least 50m of wetlands, lakes or springs.
PR2 Viable networks of wildlife habitat are maintained	AS2 On properties that are greater that 100 ha, vegetation is retained: In clumps greater than 10 ha with a perimeter (m) to area (ha) ratio of no more than 200:1 In corridors connecting remnant vegetation at least 200m wide On properties that are less than 100 ha, the configuration of retained vegetation will optimize the viability and connectivity of the retained vegetation.
PR3 Watercourses and adjacent habitat are protected by: Maintaining bank stability by protecting against erosion and slumping Maintaining water quality by filtering sediments, nutrients and other pollutants Maintaining aquatic habitat Maintaining wildlife habitat	AS3 In areas listed as Coastal Areas in the Explanatory Notes, vegetation is retained along each side of a watercourse within at least: 50m of each high bank of a river 25m of each bank of a creek or waterway In all other areas vegetation is retained along each side of a watercourse within a t least: 200m of each high bank of a river 100m of each bank of a creek 50m of each bank of a waterway.
PR4 The soil resource is protected against the loss of chemical and physical fertility through erosion or mass movement.	AS4 Vegetation is retained: in areas identified as vulnerable to mass movement on slopes
PR5 The landscape is protected against increased salinity or water logging.	AS5 Vegetation is retained: in existing or identified potential discharge area in at least 30% of the contributing catchment area above an existing or identified potential discharge area, with priority given to identified recharge areas in areas subject to increased water logging
PR6 No adverse effects on the environment caused by the release of acid and metal contaminants from the disturbance of acid sulphate soils.	AS6 Vegetation clearing in areas identified as containing acid sulphate soils does not cause soil disturbance or alterations in ground water levels that would result in the aeration of horizons containing iron sulfides.

Performance Requirement	Acceptable Solutions
PR7 Land proposed to be cleared is capable of sustainable use (where the proposed use is for primary production or forest plantation purposes)	AS7 Clearing occurs only on land that has been classified as suitable for the proposed agricultural, pastoral or forest plantation purpose: - in a Land Management Manual - in a land resource assessment survey - where such information is unavailable, in a written report prepared by a land resource surveyor.

Acceptable Solutions

AS 1

There are no significant natural wetland lakes or springs on Lot 8 SB294 or Lot 370 K124843. The proposed pipeline route situated to the north of the main development area will run through the Southern Upstart Bay wetland. This wetland is listed on the directory of important wetlands in Australia (Environment Australia, 2002a). A series of bunds have been constructed to the south of The Cape homestead, increasing the areas of freshwater available and isolating the lower lying areas from saltwater incursion.

The intake pump station will be on the back of the primary dune situated in a depression between the primary and secondary dune. The footprint of the pump station will be in the order of 500 m^2 (20 m x 25 m) and will have minimal impact on the natural conservation values of the adjoining natural wetlands. The pump station will be at ground level set in a concrete apron (approx. 20 m x 25 m). There will be negligible noise emissions and no air emissions from the pump station as the pumps are below water level and are electrically driven (see Section 7.4). A 3m high security fence will ring the concrete apron. There will be no external lighting at the pump station.

Road construction from the ponds to the pump station across the salt pan and wetland is described in Section 4.3. Construction will occur in the dry season over a period of six to eight weeks. More details of these impacts are provided in Section 7.3.

These measures described above and detailed further in Section 9 – Environmental Safeguards and Mitigation Measures will maintain the natural conservation values of these significant natural wetlands.

AS 2

There are no clumps of vegetation greater than 10 ha or in corridors connecting remnant vegetation at least 200m wide on the site.

AS 3

The Townsville Plains and Bogie River Hills Province of the Brigalow Belt Bioregion is classified as a coastal area. Vegetation will be retained within at least 50 metres of each high bank of the Elliott River. There are no waterways or creeks on Lots 8 SB294 and Lot 370 K124843.

AS 4

The site is relatively flat (typical gradient 2%). There are no areas with potential soil creep, earth flow, and slumping, landslide or rock avalanche.

AS 5

There is no potential for increased salinity or water logging as result of clearing vegetation on the site. This is because there is little remnant vegetation on site and the geohydrology study (Appendix O) has found significant amounts of salty groundwater across the site.

AS 6

Acid sulphate soils will be treated as appropriate according to QASSIT guidelines.

AS 7

The land to be cleared is capable of sustainable use.

7.3.2 Construction of the Supply and Discharge Pipelines

The discharge and intake pipeline route, hereon known as “the pipeline route”, will cross several different vegetation and geomorphic features from the prawn farm to the discharge and intake points in Abbot Bay. A description of the construction methods is in Section 4.3, and longitudinal sections are shown in Appendix B.

The route will run west to east from the prawn farm through sparsely vegetated hypersaline flats (salt pans), along an unsealed Council road (Coventry Road), through a coastal wetland system, then through a secondary and primary dune system, before crossing a sandy beach, and finishing several hundred metres into the Great Barrier Reef Marine Park. As such there are three distinct types of pipeline construction, each with specific environmental management requirements:

- The land-based sections of pipeline inland from the intake pump station, which will generally involve conventional construction techniques;
- The near-shore sections of pipeline between the intake pump station and the low water mark in Abbot Bay, which will involve deep excavation through sandy conditions with high water tables;
- Ocean pipeline construction.

a) *Land-based Pipeline Construction*

- The land–based pipeline route will be approximately 5.1 km long. The pipeline will be buried, typically in a trench 1.5m deep, providing approximately 0.5m cover, and have a base width of 3m. Two pipelines (both 1000 mm in diameter) will be laid side by side within the trench. Where poor ground conditions are encountered, it will be necessary to batter back the sides of the trench to ensure stability of the earthworks. In such areas the width of the trench opening could increase to up to 10m;
- The pipeline will be laid in the winter months during the dry season. Construction on land will occur over a six to eight week period. The area disturbed during the construction of the pipeline will have a footprint approximately 15 - 20m wide. Trucks and excavators will use this area for movement during trenching and laying of the pipeline.

The pipeline from the prawn farm to Coventry Road (approximately 500m) will traverse a salt pan. To minimise construction risks due to poor sub-grade material, the trench depth in this section will be reduced to 1.3m, providing 300mm cover over the pipes.

Isolated individuals or patches of salt couch and samphire occur in the salt pan. Therefore a DPI Marine Plants Permit will be required before construction. The excavated material from the salt pan will be treated for any acid sulphate soils as required before placement and re-profiling back over the buried pipeline. If the excavated material is too wet for use as backfill around pipes, clay will be imported and used for backfill up to the top of the pipes. The top 300 mm layer will be backfilled with *in situ* material. Any excess spoil material will be removed from the route.

Ground levels along the route in the salt pan will be restored so flows are consistent with those flows prior to construction. Natural re-vegetation of the area should occur when the area is flooded by occasional tidal inundation and as a result of dispersion of seeds from surrounding marine plants.

- The pipeline will pass under Coventry Road and run north-west alongside (east of) the road for approximately 1870 m. The road crossing and exact location of the pipeline in the road reserve will be determined during detailed design in consultation with Bowen Shire Council;

- At approximately Ch 2933 the pipeline route diverts from Coventry Road and follows an unmade Council road reserve to the coast. Along this 2100 m length the route passes through the Southern Upstart Bay wetland. During construction, materials will be laid aside and backfilled as quickly as possible within the excavation. The excavated material from the wetland will be treated for any acid sulphate soils as required before placement and re-profiling back over the buried pipeline. If the acidity is considered too high, this material will be removed, treated and disposed of off-site in accordance with the Acid Sulphate Soil Management Plan. Clean imported fill will be used where this material has been removed;

- It is expected that backfilling will occur within the same day as trench excavation and backfill will be re-profiled to ground level. Backfill will be compacted and seeded with local provenance vegetation as required;

- The impacts on fauna should be minimal. The majority of migratory birds will not be impacted by construction works as they do not arrive in Australia until later in the wetter part of the season during the autumn and summer months. The small footprint of disturbance (15 - 20m wide during construction) and the relatively large surrounding natural area should provide suitable habitat for any migratory birds that are present during construction;

- Rehabilitation will be based on the principal of collecting seed from species endemic to the area. The seed will be stored. Soils will be replaced as they are removed i.e. the soil will be placed back in the layers in the same order as they were removed. The soils will be returned to area to be rehabilitated as quickly as possible i.e. within three days to retain the microbial structure within the soil. Seeds of the local plants will be placed in small depressions and then covered with soil to assist in germination. An active weed management plan will remove any weeds that establish in the rehabilitated area;

- The wetland is a modified system with permanent bunds built at both the southern and northern ends of the wetland. The bunding has in effect significantly changed the hydrology of the wetland. Before the bunding, tidal exchange would have been the dominate mechanism of water exchange, this now has been effectively stopped. As a consequence, the vegetation appears to have changed from a dominate saline based terrestrial floristic component to that of a mosaic of both saline and freshwater terrestrial flora. The saline nature of the soils still supports saline tolerant flora except where freshwater accumulates in depressions allowing freshwater sedges to become established;

- The present floristic characteristics of the wetland and thus its habitat values will be retained by maintaining the flow of any surface waters under and though the proposed road which will cross the wetland. The wetland area now essentially acts as a large sponge since surface connections to the tidal creeks have now been stopped by the two permanent bunds. Rainfall saturates the area and fills depressions. It is also likely groundwater connections are still active with the tidal creeks.

The effect on the habitats of any small mammals or marsupials found in the wetland area should also be minimal as impacts are limited by the length of construction time and the small foot print of construction activities.

As part of pipeline construction an access track will be constructed, as described in Section 4.3. This track will be retained for future use to provide access to the intake pump station. Through lower parts of the route, this track will be low-level and constructed with a rock base to ensure trafficability. The rock base will allow any groundwater to flow laterally beneath the road. Over time, the rock base will also accumulate organic matter, which will support the establishment of local plant species. Access to this track will be via a locked gate at Coventry Road so that traffic is restricted only to Pacific Reef Fisheries personnel.

Across the secondary dune, the pipeline trench will be maintained at a depth of 1.5m with a 0.5m cover. A hydraulic excavator will be used for trench excavation. The trench opening width will be of the order of 10 m in this section, due to the sandy conditions. This will mean the area of disturbance will be approximately 20m. Excavated material will be temporarily placed to the side of the trench and be replaced after laying of the pipe. The dune will then be re-profiled before stabilisation and rehabilitation.

b) Near-shore Pipeline Construction

The pump well site will be situated approximately 60m behind the seaward toe of the primary dune (Figure 4-2). The proposed construction sequences for the sections of the pipelines through the primary dune and beach have been described in Section 4.3.

The area of disturbance between the intake pump station and the shore line will be approximately 50m wide, allowing for battering of earthworks, and to provide working area alongside the pipe trench.

After the pipes have been laid, the primary dune will be re-profiled and stabilized with mulch made on site from cleared vegetation or imported mulch, before replanting with local provenance species.

De-watering of the pipeline trench will be required. This water will be pumped onto the beach and allowed to filter through the sand before returning to the ocean. The amount of de watering required will be reduced by staged trench excavation and backfill.

c) Ocean Pipeline Construction

Beyond the low water mark, the pipelines will diverge and sea based excavation techniques will be used (see Figure 4-2). Excavation below the low water mark will be undertaken using a cutter - suction dredge. Installation of a screen on the intake pipelines will also be undertaken.

The pipeline construction sequence will involve excavation of a trench to varying depths along the full pipeline routes. The trench will be slightly over excavated to allow some incidental filling during the construction period. The length of the trenches will be 300m for the intake pipes and 500m for the discharge pipe, and the depth of excavation will vary from 3m at the shore to approximately 1m along the final 100m of the discharge pipeline.

The trench is expected to be about 30m wide. Approximately 1 ha of the approximately 4600 hectares of seagrass may be directly lost during construction. A marine plants permit will be required, as some seagrass will be removed during this process. A management plan to minimize the transport of sediment and any additional loss of seagrass outside the excavated area will be implemented. A key feature of this plan will be the use of silt curtains to stop and capture any released sediment plumes, which may occur as excavation occurs.

Dredge water will be pumped onto a bunded area of the beach of the beach to minimise dispersion of sediments.

It is expected the sea based construction activities will take approximately two months to complete.

Dredging is also an Environmentally Relevant Activity under the EPA 1994, and an Environmental Authority (EA) issued by the Environmental Protection Agency is required to carry out this activity. The EA will contain a number of conditions in relation to environmental management of the dredging activity. A Dredge Management Plan will be developed for the dredging process including:

- Monitoring of suspended sediment levels and appropriate triggers for corrective action; and
- Biological monitoring of impacts on adjacent seagrass beds;
- After the pipe has been laid it will be covered naturally by sand. *Halodule uninervis* is known to quickly return to an area after disturbance therefore it is expected that re-colonization should occur after a period of time.

The intake screen will installed after the intake pipelines have been constructed. The works will be undertaken from a barge, and will involve placement of anchor blocks and the screen structure. The screen will be designed to ensure intake velocities are <0.2 to minimise the risk of small fish and marine life being drawn in to the intake system. Any fish that are drawn into the system will be screened out from the ponds by intake screening on farm.

d) Intake Pump Station

The intake pump station will consist of an 8.5m diameter concrete wet well, with a floor level of approximately – 5.3m AHD, or 8.7m deep.

The wet well structure will be constructed prior to commencement of the intake pipeline installation. It will be a caisson type construction and it is expected that approximately six "lifts" will be required to reach the design depth.

As discussed previously, the footprint of the pump station will be in the order of 500 m^2 (20 m x 25 m). As such it will have minimal impact on the natural conservation values of the adjoining natural wetlands. During construction, there will be a small area set aside for lay down of materials, all of which will occur within the 50m area of disturbance discussed above. Rehabilitation of all disturbed areas will be undertaken as discussed above.

The top of the pump station caisson will be at ground level surrounded by concrete apron (20 m x 25 m). There will be negligible noise and no air emissions from the pump station as the pumps are below water level and are electrically driven (See Section 7.3). A 3m high security fence will ring the concrete apron. There will be no external lighting at the pump station.

Post construction, daily inspections will be undertaken of the pump station and generally for several weeks each year during annual maintenance. Impacts will be minimal during these inspections.

7.3.3 Extreme Weather Risks during Construction

The site is located in the dry tropics and, as such, is subjected to strong wet season / dry season annual climate variability. The wet season generally runs from about November to March, although it is not unusual for the onset of the wet season to be delayed until early January. The incidence of cyclones is greatest during wet season months (although cyclones have been known to occur outside these times). Extreme run-off events are most usually associated with cyclonic activity.

The dry season usually extends from about April to October. During this seven month period, humidity levels are lower, and extended periods of no rainfall are common.

In relation to the risks of extreme weather conditions during construction, the main risks can be categorised as:

- Heavy rainfall causing local or regional (Elliott River) flooding, resulting in high levels of sediment transport from the site, and / or inundation of works (particularly earthworks);
- Extreme wave conditions during cyclonic events causing disruption to the installation of the ocean pipes, or damage to partially installed pipe infrastructure; and
- Extreme wind conditions during cyclone events damaging partially complete building infrastructure (sheets, freezers, processing facilities).

The main strategy for minimising these risks will be to undertake the bulk of the works during the Dry Season. Appendix B details the proposed construction schedule. All major earthworks will only be constructed during Dry Season months. This has necessitated (in part) construction over a number of years. Earthworks will proceed in accordance with Environmental Management Plans for construction that will include:

- Construction sequencing to minimise the extent of exposed earthworks at any one time;
- Installation of bunds to direct stormwater flows around the work site in a controlled manner; and
- Containment of local run-off within the open work area and detention of run-off for settling prior to discharge from the site.

Flood modelling indicates that the risk of flooding from the Elliot River is greatest east of Coventry Road. Works in this area will be sequenced so that perimeter banks associated with the Settlement Ponds are constructed first, thereby limiting the potential for Elliot River floodwater to enter the work site. Where practical, a similar approach will be used for other areas of Settlement Pond construction.

It is expected that the construction period for the marine and inter-tidal zone works will be up to 3 months, all of which will occur in the first year of construction. These works will be timed to start in early June, to minimise any risk of extreme weather conditions. During this period, the highest risk will occur when the pipelines are being fabricated on shore, and towed out to see for sinking. It is expected this will only occupy a two week period.

A Cyclone Response Plan will also be prepared by the contractor that will include:

- Monitoring for extreme weather conditions;
- Procedures for securing the site in the event of a cyclone to minimise potential for damage to pipes or infrastructure; and
- Relocation of machinery or vessels to safe areas / anchorages.

The risks of damage partially constructed land-based infrastructure due to high winds during cyclones will also be managed by the development of a Cyclone Response Plan. This will include provisions for securing or removing from site plant, equipment or materials that could be damaged or cause an environmental hazard during extreme weather conditions.

7.3.4 Protection from Pipeline Failure

The discharge and intake pipelines will traverse areas of freshwater marsh between Coventry Road and the Intake Pump Station.

The pipeline route will be inspected weekly using all-terrain vehicles and the access track adjacent to the pipelines. The pipes will be buried to a relatively shallow depth and any leakage or failure will be readily detectable.

In addition, both pipelines will be fitted with water pressure sensors that will detect any significant loss of pressure (for example by pipeline failure) and automatically shut down the pumps.

Such protection and control arrangements are common on pumping systems, to protect from pump damage in such situations. Therefore there will be only very minor discharges in the event of a break in the pipeline. The discharge contains only salt water and small amounts of nutrients and algae.

7.3.5 Impacts on Native Flora and Fauna Habitats

a) Rare or Threatened Terrestrial Flora

Assessment of the potential impacts on significant flora resulting from the development is provided in Table 7-14. No rare or threatened flora are definitely known to occur in the study area; however, three species are at least moderately likely to occur. No rare or threatened flora are anticipated to be significantly effected by the proposal. This is because only very small areas of potential habitat for the species will be disturbed by the development, and extensive areas of similar habitat occur locally and regionally.

The wetland is a modified system with bunding of the wetland occurring at both the southern and northern ends. The bunding has in effect significantly changed the hydrology of the wetland. Before the bunding, tidal exchange would have been the dominate mechanism of water exchange, this now has been effectively stopped. As a consequence, the vegetation appears to have changed from a dominated saline based terrestrial flora to that of a mosaic of both saline and freshwater flora. The saline nature of the soils still supports saline tolerant flora except where freshwater accumulates in depressions allowing freshwater sedges to become established.

The floristic characteristics of the wetland and thus its habitat values will be retained by maintaining the flow of water under and though the proposed road which will cross the wetland. The wetland area now essentially acts as a large sponge since surface connections to the tidal creeks have now been stopped by the northern and southern bunds. Rainfall saturates the area and fills depressions.

The road will constructed with a number of culverts which will allow any surface waters to flow beneath the road thus maintaining the hydraulic connectivity within the wetland. These culverts will be positioned in low lying surveyed areas where water ponds thus maintaining flow between both sides of the road.

Groundwater flows across the wetland will still be maintained because of the surface flow connectivity which is in direct contrast to the permanent bunds at either end go the wetland.

Table 7-14 summarises the potential impacts on rare or threatened terrestrial flora that may occur within the study area.

Table 7-14
Potential impacts on threatened flora with a moderate or high likelihood of occurrence within the study area.

	Potential Impact		
Species	**Main site**	**Pipeline**	**Adjacent areas**
Aponogeton queenslandicus V *Hydrocharis dubia* V	The main potential ephemeral wetland habitats for this species occur on the central section of Lot 370. These potential habitat areas will not be affected by the development. Should the farm layout change to include these areas, they represent only a small area of potential habitat and it is unlikely that the regional or local population (if any) will be significantly affected.	The large ephemeral wetland traversed by the pipeline route represents potential habitat for the species; however, only a very small area of this habitat will be disturbed during construction. Provided that appropriate measures are taken to control erosion and sedimentation during construction, significant impacts on the species (if present) are not anticipated.	The development is unlikely to have any adverse effects on potential habitat areas on adjacent areas.
Grewia graniticola R [Tiliaceae]	unlikely to be present	A narrow corridor (approximately 20m wide) of potential dunal woodland habitat is traversed by the pipeline route. Any plants present within this corridor will be disturbed during construction; however, the dunal woodland habitat extends for 7km to the north and 2km south.	Potential impacts on the species in adjacent areas (if present) will be negligible as the ecological footprint of disturbance is small. Above ground installation methods may create significant water and wind erosion impacts adjacent to the pipeline in which case a small area of potential habitat may be disturbed. However, impacts on the local population of the species (if present) are anticipated to be minimal.

b) Rare or Threatened Fauna

None of the rare or threatened terrestrial fauna species known or likely to occur in the study area are anticipated to be significantly effected by the proposal since:

- For the majority of the species, potential habitat immediately adjacent to the main development area and proposed pipeline will not be effected; and
- In instances where potential habitat will be disturbed, only relatively small areas of habitat will be involved, and extensive areas of similar habitat occur locally and regionally.

The local impact on the Bare-rumped sheath-tail bat (*Saccolaimus saccolaimus*) (if present) may be significant, as a result of the removal of scattered poplar gums (*Eucalyptus platyphylla*) that occur over the majority of Lot 8. This tree is favoured as a roosting site by the species. However, the EPA RE mapping shows that RE's containing poplar gum (RE 11.3.9 and 11.3.35) are widely distributed in the surrounding area and the viability of the regional population of the species is unlikely to be significantly effected.

Table 7-15 summarises the potential impacts on rare or threatened terrestrial fauna and rare, threatened or migratory fauna that may occur within the study area. Species are listed according to their highest conservation status in Table 7-15.

Table 7-15
Potential impacts on rare or threatened fauna with a moderate or high likelihood of occurrence within the study area.

Common Name	Potential Impact Main site	 Pipeline	 Adjacent areas
Endangered			
Birds			
Little tern	unlikely to be present	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Some short term impacts on wetland habitat quality adjacent the pipeline corridor may occur during construction but no significant effect on this species is anticipated
Vulnerable			
Birds			
Beach Stone-curlew	unlikely to be present	Installation of the pipeline across the beach habitat of this species is unlikely to significantly effect foraging or movement of the species If pipeline construction occurs during the July-February breeding season of the species, a pre-construction survey is recommended to ensure that nest sites will not be affected. Significant impacts are not anticipated.	The Elliot River estuarine habitats will not be directly disturbed by the project so direct impacts on the species are not anticipated.
Squatter pigeon and Black-throated finch	The eastern portion of Lot 370 may provide suitable habitat conditions for these species; however, similar habitats are widespread locally and regionally, and the main development area is not anticipated to represent an especially significant area for the species. The proposed current farm layout suggests that this potential habitat area will not be disturbed.	unlikely to be present	Potential habitat in adjacent areas will not be affected by the project.
Reptiles			
Estuarine crocodile	unlikely to be present	unlikely to be present	The Elliot River estuarine habitats will not be directly disturbed by the project so direct impacts on the species are not anticipated.

Rare			
Birds			
Black-necked stork	Some of the artificial and seasonal wetlands on Lot 370 may be disturbed during construction. Loss of these small areas of habitat is not anticipated to significantly affect the species, and some of the sedimentation and water storage ponds to be constructed may provide foraging habitat.	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Some short term impacts on wetland habitat quality adjacent the pipeline corridor may occur during construction but no significant affect on this species is anticipated.
Black-chinned honeyeater	The woodland habitats on Lot 8 will be removed during construction. The more diverse woodland habitats on the eastern section of Lot 370 are unlikely to be disturbed and provide better habitat opportunities. Some reduction in woodland habitat will occur but it is not anticipated to significantly affect the species.	A narrow corridor (approximately 20m wide) of potential dunal woodland habitat is traversed by the pipeline route. This habitat is unlikely to be disturbed if directional boring is used to install the pipeline. If more disruptive installation methods are used, significant impacts on the species are not anticipated since extensive areas of similar habitat exist to the north and south.	Potential habitat in adjacent areas will not be affected by the project.
Cotton pygmy-goose	The dam adjacent to the main track in Lot 370 provides limited suitable habitat for the species. Removal of the dam during construction may be necessary but is not anticipated to produce significant effects on the species.	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Some short term impacts on wetland habitat quality adjacent to the pipeline corridor may occur during construction but a significant effect on this species is not anticipated. Potential farm dam habitat in adjacent areas will not be affected by the project.
Eastern curlew	unlikely to be present	unlikely to be present	The Elliot River estuarine habitats will not be directly disturbed by the project so direct impacts on the species are not anticipated.
Lewin's Rail and Painted snipe	unlikely to be present	Some short term impacts on marsh habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Some short term impacts on marsh habitat quality adjacent to the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.

Mammals			
Bare-rumped sheathtail bat	Poplar gum woodland is a key habitat of this species. While true poplar gum woodland does not occur in the main development area, poplar gums are widely scattered across approximately 70% of Lot 8 as co-dominant trees. Loss of these trees will comprise loss of habitat for the species; however, the EPA RE mapping shows that RE's containing poplar gum (11.3.9 and 11.3.35) are widely distributed in the surrounding area. Removal of these trees may have an impact on the local population of the species, but the viability of the regional population of the species is unlikely to be significantly effected.	unlikely to be present	Potential habitat in adjacent areas will not be affected by the project.

c) Marine Mammals and Reptiles

Table 7-16 lists the ten marine fauna species listed by provisions of the EPBC Act 1999 that have a moderate or high likelihood of occurring in the adjacent marine environment (refer to Section 6.5 for further details). Table 7-16 also lists the potential impacts to the species as a result of the prawn farm development.

Table 7-16
Potential impacts on marine fauna listed in the EPBC Act 1999 with a moderate or high likelihood of occurrence within the study area.

Scientific Name	Common Name	Status	Potential Impact
Dugong dugon	Dugong	V	Degradation of habitat as a result of prawn farm discharge. An increase in nutrients and algal flocs may affect seagrass distribution and abundance in Abbot Bay. It is predicted that <5 % of seagrass may be impacted. Therefore some minor changes to dugong feeding regimes in Abbot Bay may occur as a result of the project.
Crocodylus porosus	Estuarine Crocodile	V	No impact likely. Prawn farm discharge and stormwater will not be directed into the Elliot River.
Chelonia mydas	Green Turtle	V	Degradation of habitat as a result of prawn farm discharge. An increase in nutrients and algal flocs may affect seagrass distribution and abundance in Abbot Bay. It is predicted that <5 % of seagrass may be impacted. Therefore some minor changes to green turtle feeding regimes in Abbot Bay may occur as a result of the project.
Natator depressus	Flatback Turtle	V	No impact likely. The pump station near the beach will have no external lights.
Aipysurus eydouxii	Spine-tailed Seasnake	M	No impact likely.
Astrotia stokesii	Stokes' Seasnake	M	No impact likely.
Enhydrina schistosa	Beaked Seasnake	M	No impact likely.
Hydrophis elegans	Elegant Seasnake	M	No impact likely.
Hydrophis mcdowelli	A seasnake	M	No impact likely.
Hydrophis ornatus	A seasnake	M	No impact likely.
Lapemis hardwickii	Spine-bellied Seasnake	m	No impact likely.

Key to Status:

V Vulnerable
m Listed under migratory provisions of EPBC

d) *Marine and Estuarine Fishes*

The Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes (Pogonoski *et al.,* 2002) was referred to in this section. Based on this publication, seventeen (17) species of fish (either threatened, near threatened or data deficient) are likely to occur in the marine environment adjacent to the proposed site. Table 7-17 below lists these fish species and potential impacts as a result of the project.

The loss of habitat for several of the near shore animals may occur. A loss of seagrass (<5 % of the seagrass recorded in Abbot Bay) may occur, (refer to Section 7.2). The impact on these animals is expected to be minor.

Table 7-17
Potential impacts on threatened or near threatened fishes with a likelihood of occurring in the adjacent marine environment

Scientific Name	Common Name	IUCN	Potential Impact
Brachaelurus colchoughi	Colclough's shark	VU	No Impacts likely.
Carcharhinus limbatus	Common blacktip shark	DD	No impacts likely.
Carcharhinus obscurus	Dusky shark	LR (nt)	No impacts likely.
Carcharhinus plumbeus	Sandbar shark	LR (nt)	No impacts likely.
Epinephelus coioides	Estuary rockcod	LR (lc)	No impacts likely.
Epinephelus fuscoguttatus	Flowery cod	LR (lc)	No impacts likely.
Epinephelus lanceolatus	Queensland grouper	LR (cd)	No impacts likely.
Epinephelus malabaricus	Malabar grouper	LR (lc)	No impacts likely.
Himantura chaophraya	Freshwater whipray	VU	No impacts likely.
Hippocampus dahli	Low-crown seahorse	LR (nt)	Limited inshore habitat degradation as a result of the prawn farm discharge.
Hippocampus hendriki	Eastern spiny seahorse	DD	No impacts likely.
Hippocampus taeniopterus	Common seahorse	DD	No impacts likely.
Pristis clavata	Dwarf sawfish	EN	No impacts likely.
Pristis miscrodon	Freshwater sawfish	CR	Limited inshore habitat degradation as a result of the prawn farm discharge.
Pristis zijsron	Green sawfish	EN	No impacts likely.
Syngnathoides biaculeatus	Alligator pipefish	DD	No impacts likely.
Urogymnus asperrimus	Porcupine ray	LR (nt)	Limited inshore habitat degradation as a result of the prawn farm discharge.

Key to Status (in order of importance):

CR Critically Endangered
EN Endangered
VU Vulnerable
LR (cd) Lower Risk (conservation dependent)
LR (nt) Lower Risk (near threatened)
DD Data Deficient
LR (lc) Lower Risk (least concern)

e) *Migratory and Wetland Fauna*

The conservation of migratory waterbirds is closely linked to the management of wetlands (Asia-Pacific Migratory Waterbird Conservation Committee, 2001). The key elements of the *Asia-Pacific Migratory Waterbird Conservation Strategy: 2001-2005* is for the conservation of migratory waterbirds and their habitats. The following elements of the strategy apply to this prawn farm development:

- A network of sites that are internationally important for migratory waterbirds are required to be effectively managed; and

- There is a requirement for the raised awareness of the presence of waterbirds and their link to wetland values and functions throughout the region and at all levels.

These elements have been considered as part of the design of the prawn farm and pipeline. Since migratory birds have been identified to occur within and adjacent to the development, construction time of the pipeline will be occur when migratory birds numbers are lowest, construction time will be limited to 12-16 weeks, the ecological footprint is small and rehabilitation of any disturbance will be undertaken.

A total of five (5) migratory, wetland or marine terrestrial fauna species listed under the EPBC Act are known to utilise the study area. An additional twenty-three (23) species are at least moderately likely to occur in the study area. Twelve (12) of these species are listed on both the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA), another three (3) are JAMBA only listed, and an extra seven (7) are CAMBA only listed.

None of these species are anticipated to be significantly affected by the proposal since:

- For the majority of the species, potential habitat immediately adjacent to the main development area and proposed pipeline route will not be effected;
- In instances where potential habitat will be disturbed, only relatively small areas of habitat will be disturbed by the development, and extensive areas of similar habitat occur locally and regionally; and
- The pipeline will be laid in the winter months during the dry season. Construction will only occur over a 12 - 16 week period. Migratory birds will not be impacted by construction works as they do not arrive in Australia until the wet season. The pipeline route through the wetland areas will be rehabilitated post construction.

Table 7-18 summarises the potential impacts on migratory and wetland fauna with a moderate or high likelihood of occurrence within the study area.

Table 7-18
Potential impacts on migratory and wetland fauna with a moderate or high likelihood of occurrence within the study area.

Common Name	JAMBA CAMBA	Potential Impact Main site	Pipeline	Adjacent areas
Common sandpiper Bar-tailed godwit Whimbrel	J, C J, C J, C	Unlikely to be present	unlikely to be present	The Elliot River estuarine habitats will not be directly disturbed by the project so direct impacts on the species are not anticipated.
Cattle egret	J, C	Grassy plain habitats will be lost but these habitats are extensively available in adjacent areas locally and regionally. Significant effects on this species are not anticipated.	unlikely to be present	Potential habitat in adjacent areas will not be affected by the project.

Common Name	JAMBA CAMBA	Main site	Potential Impact Pipeline	Adjacent areas
Pectoral sandpiper	J	unlikely to be present	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Unlikely to be present
Lesser sand plover	J, C	Only a very small area of saltflat habitat occurs along the northern periphery of the main site.	Some short term impacts on wetland and saltflat habitat quality within the pipeline corridor may occur during construction but this is not anticipated to significantly affect the species.	Some short term impacts on small areas of wetland and saltpan habitat quality adjacent the pipeline corridor may occur during construction but a significant effect on this species is not anticipated. The Elliot River estuarine habitats will not be directly disturbed by the project so direct impacts on the species are not anticipated.
Oriental plover Black-tailed godwit Pacific golden plover Red-necked stint Curlew sandpiper Sharp-tailed sandpiper	- J, C - J, C J, C J, C	unlikely to be present	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on these species is not anticipated.	Some short term impacts on wetland habitat quality adjacent the pipeline corridor may occur during construction but no significant effect on this species is anticipated.
White-bellied sea eagle	C	Likely to utilise perches adjacent to the Elliot River. Fringing vegetation will be retained in these areas so significant impacts are not anticipated.	Only small areas of wetland, dune woodland and beach habitats, will be disturbed by the development. Given the abundance of these habitats adjacent to the pipeline, significant impacts are not anticipated.	Some short term impacts on wetland habitat quality adjacent the pipeline corridor may occur during construction but no significant effect on this species is anticipated
White-throated needletail	C	This species forages high above the ground surface. The anticipated levels of disturbance to ground habitats is not anticipated to significantly affect the species ability to forage above the study area.	This species forages high above the ground surface. The anticipated levels of disturbance to ground habitats is not anticipated to significantly affect the species ability to forage above the study area.	This species forages high above the ground surface. The anticipated levels of disturbance to ground habitats is not anticipated to significantly affect the species ability to forage above the study area.
Barn swallow	J	The terrestrial habitats of the area are unlikely to be of special significance for this species and extensive potential habitat occurs locally and regionally. Significant effects on this species are not anticipated.	The terrestrial habitats of the area are unlikely to be of special significance for this species and extensive potential habitat occurs locally and regionally. Significant effects on this species are not anticipated.	Potential habitat in adjacent areas will not be affected by the project.

Common Name	JAMBA CAMBA	Main site	Potential Impact Pipeline	Adjacent areas
Black-faced monarch Spectacled monarch Satin flycatcher	- - -	These species may utilise the woodland areas on the eastern section of Lot 370. These areas are unlikely to be disturbed by the development; however if they are disturbed, extensive areas of similar habitat occur locally and regionally, and significant impacts are not anticipated.	A corridor (approximately 20m wide) of potential dunal woodland habitat is traversed by the pipeline route. This habitat is unlikely to be disturbed if directional boring is used to install the pipeline. If more disruptive installation methods are used, significant impacts on the species are not anticipated since extensive areas of similar habitat exist to the north and south.	Potential habitat in adjacent areas will not be affected by the project.
Little curlew Glossy ibis Oriental pratincole Latham's snipe	C C J, C C	Grassy plain habitats will be lost but these habitats are extensively available in adjacent areas locally and regionally. Significant effects on these species are not anticipated.	Some short term impacts on marsh and wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on these species is not anticipated.	Some short term impacts on marsh and wetland habitat quality adjacent to the pipeline corridor may occur during construction but no significant effects on these species are anticipated
Common greenshank Marsh sandpiper Caspian tern White-winged black tern Whiskered tern Great egret	J C C J, C - J, C	Species likely to utilise large dam on Lot 370. Loss of this artificial habitat area is not anticipated to have a significant effect on the species	Some short term impacts on wetland habitat quality within the pipeline corridor may occur during construction but a significant effect on this species is not anticipated.	Some short term impacts on wetland habitat quality adjacent the pipeline corridor may occur during construction but no significant effect on this species is anticipated

f) Endemic Species

The pygopod lizard *Delma labialis*, listed as Vulnerable on the Commonwealth EPBC Act 1999 and the Queensland NCWR 1994, is endemic to the Townsville region and could potentially occur in coastal dune thickets in the vicinity. Thomas (2002) in the EES flora and fauna survey of the site indicated that the likelihood of its presence is low based on the absence of suitable habitat.

The coastal dune structure will be temporarily modified along the pipeline route (refer to Section 7.2 for detail) however rehabilitation of the dunal system will occur immediately. Any impacts on the species are likely to be minimal and the pipeline route is not likely to obstruct the movement of the species.

g) Taxa representing World Heritage Values of the Great Barrier Reef

Dugong

The following factors have been identified as posing a real or potential risk to populations of dugong (GBRMPA, 1994):

- Commercial gill netting;
- Boat traffic;
- Pollution;
- Coastal development;
- International over-exploitation;
- Traditional hunting;
- Shark netting operations;
- Habitat degradation;
- Commercial trawling;
- Illegal take;
- Terrestrial practices and run-off; and
- Natural impacts including tropical cyclones, floods, storms and predators.

Habitat degradation, resulting from changes in seagrass beds, may occur as a result of this project through prawn farm discharges into Abbot Bay. Most seagrass losses, both natural and anthropogenic, are attributed to reduced light intensity due to sedimentation and/or increased epiphytism from nutrient enrichment (eutrophication) (Kirkman, 1997). Therefore changes in seagrass species and abundance as a result of prawn farm discharge may affect Dugong presence in Abbot Bay.

Marsh and Penrose (2002) in their report of the seasonal distribution of dugongs in the Southern Great Barrier Reef Marine Park indicate that dugong numbers in Upstart Bay (Dugong Protection Area Zone A) and Edgecumbe Bay (Dugong Protection Area Zone B) are far greater in these two bays than in Abbot Bay. Numbers of over 200 dugongs have been recorded in Upstart Bay and Edgecumbe Bay. Based upon this data, large numbers are likely to exist in Abbot Bay as:

- Dugongs will swim between these two dugong protection zones; and
- Dugong feeding trails have been identified in Abbot Bay (see Appendix L).

In these dugong protection areas, gill or net fishing are prohibited or greatly restricted in these areas. Marsh *et al.* (1996) suggests that the reported decline of dugongs are complex and could include habitat loss and change, incidental drowning in both commercial and illegal gill nets and shark nets set for bather protection and traditional hunting.

Changes to important dugong habitats such as seagrass beds may occur as a result of prawn farm discharges into Abbot Bay. It is predicted there may be a loss of < 5 % of seagrass, which is likely to have a minor impact on dugong habitat.

Marine Turtles

The main threats to marine turtles in the Great Barrier Reef include (Environment Australia, 2002c):

- Pollution and changes to important turtle habitats, especially coral reefs, seagrass beds, mangrove forests and nesting beaches;
- Accidental drowning in fishing gear;
- Over-harvesting of turtles and eggs; and
- Predation of eggs and hatchlings by foxes, feral pigs, dogs and goannas.

Changes to important turtle habitats such as seagrass beds may occur as a result of prawn farm discharges into Abbot Bay. The issues as reported in detail for dugongs apply to turtles. Accordingly, it is predicted there may be a loss of < 5 % of seagrass, which is likely to have a minor impact on the marine turtle habitat.

Cetaceans

The Whale and Dolphin Conservation Policy (GBRMPA, 2000) states the following types of impacts of human activities on whales and dolphins can threaten their survival:

- Deliberate or reckless killing and injuring;
- Harassment;
- Ship and boat strikes;
- Accidental entanglement in fishing gear and marine debris;
- Ingestion of marine debris;
- Noise;
- Explosions;
- Pollution;
- Disease;
- Live capture;
- Physical habitat degradation or destruction;
- Prey depletion; and
- Physical displacement.

None of these processes that may threaten cetaceans would occur as a result of this prawn farm development and operation.

7.3.6 Impacts on Wetlands and Waterways

Impacts on the Southern Upstart Bay wetland are discussed below - Potential Impacts on Conservation Values, part (d).

There will be no impacts on the Elliot River as no waters will be pumped from or discharged into the river, and no clearing of riparian vegetation will be undertaken.

7.3.7 Potential Impacts on Conservation Values

a) Conservation values of the Great Barrier Reef World Heritage Area and the Marine Park

Impacts may occur to the conservation values of the Great Barrier Reef World Heritage Area as a result of this project. Prawn farm discharge will be released into the WHA and Marine Park potentially affecting seagrass distribution and abundance, and in turn, may affect dugong and green turtles within Abbot Bay. Refer to Section 7.2 - Impacts on Native Flora and Fauna and Habitats, part (f) for further details.

b) Fish Habitat Areas

The Burdekin Fish Habitat Bay receives a small proportion of its land-based runoff from the proposed development area and catchment areas upstream of the site.

Minor changes in floodplain hydrology will occur where the proposed prawn farm will be developed. Flood waters, which would previously sheet flow across the proposed project area, will be channelled around the project's perimeter post construction. These channelised waters will be allowed to dissipate as sheet flow from the northern boundary of the development. This will reduce the erosion potential from a point source discharge, and secondly, will mimic more naturally the sheet flow which originally came from the site. These flows will still be directed into the adjoining property adjacent to the Burdekin Fish Habitat Area.

Subsequently there is expected to be no net discernable change in the amount and quality of stormwater entering the Burdekin Fish Habitat Area.

c) National Parks

No impacts will occur to nearby National Parks (Abbot Bay Resources Reserve and Cape Upstart National Park) as a result of this project.

d) Wetlands of National and International Importance

The project will have a minor impact on the Southern Upstart Bay wetland listed on the directory of important wetlands in Australia. The proposed pipeline route situated to the north of the main development area will run through this wetland area within a designated Crown road reserve. Refer to Section 7.2, for detail on construction methodology and proposed mitigation measures of the Pipeline Route.

Where the pipeline has been constructed in the wetland a permanent track will run adjacent to the pipeline route to provide maintenance access for the pipeline and pump station. This track will be only used daily for routine monitoring. This will usually be via a 4WD motorbike. Once per year for several weeks the track will be sued to provide access for light vehicles and tracks, as part of regular maintenance activity. With this level of use the track will remain well vegetated and maintain the habitat values of the wetland.

e) Places listed on the Register of the National Estate

The project will have a minor impact on the Cape Upstart Lowlands National Estate listed on the Register of the National Estate. This area overlaps the Southern Upstart Bay wetland as discussed above. Refer to the above section for impacts to this area.

7.3.8 Impacts on Ecologically Significant Areas

No ecologically significant areas occur on the main development site. However the eastern section of the pipeline route traverses two ecologically significant areas:

- Freshwater wetlands established on marine deposits which provide extensive foraging habitat for migratory waders; and
- The band of habitat types occurring on the dune complex fringing Abbot Bay.

Temporary effects as a result of construction will occur to both areas however the entire length of the pipeline will be rehabilitated.

7.3.9 Impacts on Marine Habitat

There will be impact on a small area of marine plants on the saltpan during construction of the pipeline. Further details are in Section 7.2 – Construction of the Pipeline Route.

Some seagrass may be lost as a result of the construction of the intake and discharge pipelines. Further details are in Section 7.2 – Construction of the Pipeline Route.

7.3.10 Potential Impacts on Fisheries Stocks

The fishing activity in the vicinity of Abbot Bay is described in more detail in Section 6.7 – Social and Economic Environment. The fisheries data was obtained from the Queensland Department of Primary Industries – Queensland Fisheries Service (QFS) for the waters of Abbott Bay and adjacent areas. Local commercial fisheries catch data can be accessed via the interactive Coastal Habitat Resources Information System (CHRIS).

QFS commercial fisheries catch is reported by thirty-minute grids, the relevant grid for Abbot Bay is L22 shown in Figure 6-34 (Section 6.7 - Existing Industry Profile). The area covered by L22 is around 3000 km^2 and encompasses most of Abbot Bay and Upstart Bay, to a point north of the mouth of the Burdekin River. Table 7-19 below provides a summary of the catches recorded for L22 in 2000. The information provides an indication of the species caught in the region. It is not intended as an indication of catch rates; the species listed are consistently recorded for the region however quantities vary considerably from year to year. Evidence of this is shown in Figure 6-36 (Section 6.7 Existing Industry Profile) which shows the historical commercial catches of tiger and banana prawns from CHRIS Grid – L22 from 1988 through to 2001.

Table 7-19
Commercial Fisheries Catches from CHRIS Grid – L22 (2000)

Species	Kg
Crab – Mud	47331
Barramundi	12655
Fish - unspecified	805
Flathead - unspecified	401
Mullet - unspecified	2302
Shark - unspecified	54233
Threadfin - Blue	2967
Threadfin - King	359

Species	Kg
Bugs – Whole	7765
Prawns - Banana	15735
Prawns – Coral	1518
Prawns - Endeavour	2116
Prawns – King	5966
Prawns – Tiger	21248
Squid - unspecified	85

It can be assumed that there is limited potential for direct or indirect impacts of the Guthalungra Prawn farm proposal on wild fishery stocks.
Interactions with wild fishery stocks may occur through:

- The escape or loss of farmed stock;
- The release of water borne disease vectors;
- Activities associated with the farming operation;
- Activities associated with design, construction or location of elements of the farm; or
- Hatchery requirements for additional broodstock.

The escape or loss of farmed stock

Farm stock interactions with wild fishery stocks may occur through a failure in the escape prevention procedures (see Section 7.3 – Strategies for escape prevention).

Issues to be considered should stock escape occur include:

- The potential introduction of non-endemic stock to the region:

  Guthalungra post larvae (P/Ls) will be sourced from local (Queensland) hatcheries. All species farmed at Guthalungra will be native to Australia and the region. Therefore negative impacts from non-endemic farmed stock are not envisaged.

- The introduction of endemic stock with genetic modifications:

  Currently, the life cycle of tiger prawns is not closed. Gravid wild females are required to provide juveniles for the industry. There are research projects underway both in Australia and overseas to 'close' the lifecycle of the tiger prawn. Until a reliable process for producing tiger prawns from cultured stock has been established, hatcheries will continue to source egg bearing females from the wild fishery. It is envisaged that this will continue for at least 5 years. In this time the juveniles used to stock the farm will be sourced from wild caught broodstock.

  Once the lifecycle of the tiger prawn is closed, policies and procedures will need to be established by the prawn farming industry and the State Government to ensure that the integrity of the wild stocks are maintained. There are many examples of aquaculture product being used in restocking programs where genetic diversity is maintained.

There may be limited production of banana prawns at Guthalungra. Unlike tiger prawns, banana prawns can be farm reared to produce viable eggs and larvae in captivity.

- Disease transfer from escaped farmed stock or prawn carcases or processing waste:

  The diseases of farmed prawns are outlined in Section 4.4 - Species Farming Details and Section 7.3 – Disease Outbreaks. The availability of information regarding the contamination of wild prawn stocks with disease from farm stock is limited. However an extensive assessment of the potential for the introduction of exotic diseases into existing wild prawn stocks has been undertaken to support the Prawn and Prawn Products Import Risk Analysis currently being undertaken by Biosecurity Australia.

  Animal Biosecurity (Biosecurity Australia) develops policies which allow for the safe importation of animals, their genetic material and other products. Major policy changes are based on an Import Risk Analysis (IRA) process that is conducted according to Government policy and in a manner consistent with the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

  A number of relevant reports are available and can be found at the Animal Biosecurity website:

A risk assessment of the introduction of an exotic prawn virus (WSSV) to Australian wild and farmed prawn stocks considered a number of events and assigned a probability of occurrence (Baldock, 1999).

The report indicated that the risk of outbreak occurrence in farmed pawns, wild prawns and non prawn crustacean according to WSSV infection source was "very low" to "low to moderate" depending upon the event. Table 7-20 summarises the risk analysis for this virus.

Table 7-20
Risk Analysis for Introduction of the Exotic Prawn Virus in Australia

Event	Probability	Comments
Spread of infection from farmed to local wild populations	Low to moderate	Based on: High probability of farm outbreak reporting compliance and stamping out policy implementation on farms; High level of competition for infected tissue from non-susceptible scavengers compared with pond populations; Evidence of minimal spread of infection in Texas and probably South Carolina

Event	Probability	Comments
Spread of infection to local wild (non-prawn) crustacean populations	Low to moderate	Based on: High probability of farm outbreak reporting compliance and stamping out policy implementation on farms High level of competition for infected tissue from non-susceptible scavengers compared with pond populations; Evidence of minimal spread of infection in Texas
Spread to other areas from initial focus in local wild prawns with subsequent disease outbreaks	Low	Based on: Wild prawn population densities are low relative to farms; Prawns may avoid stress by migrating elsewhere Low-moderate environmental stress levels combined with moderate dilution of infectious material under high rainfall conditions; Moderate stress levels combined with high levels of dilution of infectious material under high rainfall; No convincing evidence of overseas disease occurrence
Spread to other areas from initial focus in local, wild (non-prawn) crustaceans with subsequent disease outbreaks	Low	Based on: Evidence suggests virus is more pathogenic to prawns than to other crustaceans; Wild prawn population densities are low relative to farms; Relatively sessile crustaceans populations may not be ale to avoid stress by migrating elsewhere; Low-moderate environmental stress levels combined with moderate dilution of infectious material under high rainfall conditions; Moderate stress levels combined with high levels of dilution of infectious material under high rainfall; No convincing evidence of overseas disease occurrence
Re-introduction into local prawn farms by infected crabs or other wild crustaceans	Moderate	Based on: Anecdotal evidence from Thailand, if not excluded by piscicides, fences.

Source: Baldock, 1999

The table is reproduced here for reference and highlights the probability of a series of events. It should be noted that prawn farms have been screened for exotic prawn diseases and none have been identified on any farms in Australia.

Release of water borne disease vectors (Refer: Section 7.2 – Disease Outbreaks)

The diseases identified to date on Queensland prawns farms are endemic to wild stocks in Queensland waters. One disease in particular is of concern to the Queensland prawn farming sector and has caused considerable economic loss to farms. Gill-associated virus (GAV) (also known as Lymphoid organ virus (LOV) in its covert form) is known to be present in natural populations of *Penaeus monodon*. There is comprehensive reporting and management requirements for farms that have an outbreak of GAV see Section 9 – Environmental Safeguards and Mitigation.

The mechanism for the transfer of GAV is reported in Walker (2000), and is discussed in Section 4.4 Species Farming Details. The virus can be transferred horizontally i.e. through the water column. For this reason, the Guthalungra farm has the facility to quarantine individual ponds or sections of the farm to prevent the release of potentially contaminated water.

It should be noted that GAV outbreaks have occurred on prawn farms in Australia in the past, and while wild stocks of tiger prawns have been identified as carrying the covert form, healthy prawns in their natural environment do not appear to be subject to the stressors that initiate the overt form.

Activities associated with the farming activity

Release of discharge and its impact on fish stocks and important fisheries habitats:

The impacts of discharge from the proposal are discussed in detail in Section 7.1. In particular the loss of seagrass may have an adverse impact on fish stocks due to the removal of important habitat for juvenile life stages of a variety of species.

- Impact on Seagrass in Abbot Bay

  The elevated nutrient levels in the discharge are likely to have some impact on seagrass in the vicinity of the discharge pipe (Refer to Section 7.2). Given the low concentration of discharge (relative to other anthropomorphic influences or natural seasonal events) and the high level of dilution, it is possible that seagrass growth may be encouraged. The results of the water quality modelling in Abbott bay and the seagrass survey, suggests that less than <5% of seagrass found in Abbott Bay will be exposed to elevated nitrogen levels that may either cause the growth of epiphytic algae and therefore some loss of seagrass or result in enhanced seagrass growth.

  In the event that seagrass growth in Abbott bay is enhanced then it may be assumed that there will be an increase in resources to support fisheries stocks. In the even that seagrass growth is adversely impacted it has been estimated that less than <5% of seagrass cover in the bay may be affected.

- Release of Algae

  Around 50% of the nitrogen in the discharge water is incorporated in particulate matter, primarily algae. The elevated concentration of algae in the immediate vicinity of the discharge diffusers may attract planktonic feeding fish and in particular juveniles stages of various marine species.

- Waste Disposal

  The transfer of prawn waste and discharge water from the processing facility will be tightly controlled through treatment processes outlined in Section 7.6 - Waste Management/Minimisation. No adverse impact is anticipated from this activity.

Activities Associated with design, construction or location of elements of the farm

- Surface Flood and Tidal Flows
  The natural surface water flows across the site and adjacent properties have been maintained to allow drainage into important fisheries habitat including the Cape Upstart Fish Habitat Area, which is in close proximity to the farm.
- Access to Fishing Areas
  Trawling in the vicinity of the discharge structures will have to be avoided. Trawl nets and lines could damage diffuser ports on the discharge line and intake structures attached to the intake lines, conversely the structures could damage the trawls. For this reason the intake and discharge lines should be marker on maritime charts and buoyed as appropriate to mark their location. Interference to fishing activities as a result of the offshore structures will be minimal.

Hatchery requirements for additional broodstock

The Guthalungra prawn faming operation will require in the vicinity of 100 million (post larvae) P/Ls at full production. Female broodstock produce from 0.2 to 1.0 million eggs. Given the fecundity of the broodstock and the proposed stocking density on the farm it may be assumed that around wild 200 broodstock will be required per annum. This will not place undue pressure on the wild fishery, and there is capacity in the existing hatchery sector to produce this amount of P/Ls. Nevertheless Pacific Reef is investigating the establishment of a hatchery nearby and considers the hatchery production of Post Larvaes to be an important future development for the company.

7.3.11 Potential for Disease Outbreaks on the Farm and risks to Wild Stock

7.3.11.1 Potential diseases encountered on Australian prawn farms

The following is taken from the Scientific Review of Prawn Diseases report to AQIS by Ausvet Animal Health Services 1997 (Ausvet, 1997). The diseases listed below have been identified in Australian wild or farmed stocks and have been shown to cause mortalities in farmed or wild stocks. It is possible that some of the listed diseases will be encountered at the Guthalungra site however it should be noted that farm management practice and site selection to ensure optimal culture conditions will reduce the likelihood of outbreak.

It should be noted that a variety of viral diseases have been identified in Australian animals. These are not necessarily pathogenic to farmed or wild stocks however if animals are stressed mortalities may occur.

Bacterial Disease

a) Vibrios

Vibriosis is ubiquitous through out the world and all marine crustaceans including prawns are susceptible. Epizootics occur in all life stages, but are more common in hatcheries. Vibrio species are part of the natural micro flora of wild and cultured prawns and become opportunistic pathogens when natural defence mechanisms are suppressed. They are usually associated with multiple etiological agents.

Most *Vibrio spp.* associated with vibriosis exist in Australia, although few major epidemics have been reported. Mortalities due to vibriosis occur when prawns are stressed by factors such as poor water quality, crowding, high water temperature and low water exchange.

Transmission:

Vibrio species exist in the water used in prawn culture facilities. Bacteria enter prawns via wounds or cracks in the cuticle and are ingested with food.
Treatment:

Vibriosis is controlled by rigorous water management and sanitation to prevent the introduction of vibriosis to the culture water and to reduce stress on prawns. Good site selection, pond design and pond preparation are also important. An increase in daily water exchange and a reduction in pond biomass by partial harvesting are recommended by Queensland State Government veterinary staff to reduce mortalities caused by vibriosis. Draining, drying and administering lime to ponds following harvest is also recommended.

b) Aeromonas species and Pseudomonas species

Both are part of the normal micro flora of wild and cultured crustaceans and are opportunistic pathogens. They are associated with mortality less frequently than *vibrio spp.* and are not considered primary pathogens. *Aeromonas spp*. and *Pseudomonas spp*. and usually occur in mixed infections with other bacteria, particularly *Vibrio spp*. viruses and/or fungi. All species and life stages of penaeids are susceptible to infection by these bacteria.

Transmission:

Opportunistic bacteria invade through wounds and cracks in the cuticle and are ingested with food.

Treatment:

Bacterial necrosis and septicaemias are controlled primarily by maintaining good husbandry practices, such as ensuring adequate water exchange and adequate, high quality feeds in odder to reduce stress on prawns.

Parasites

c) Microsporidean

In Northern Australia *Agmasoma spp*. infects a variety of wild juvenile and adolescent prawns species. Microsporidiosis is primarily a problem in wild prawns in Australia. It is thought that finfish may act as an intermediate host and prawns may be infected by feeding on the faeces of certain fish. This is not considered a major disease of cultured prawns.

Viral Transmission

d) Monodon Baculovirus (MBV)

Largely restricted to hatcheries. Mortalities occur primarily among post larvae in the hatchery and therefore not considered to be a problem at Guthalungra *e) Gill Associated Virus (GAV) and Limphoid Organ Virus (LOV)*

The most significant cause of economic loss from disease in the Queensland prawn industry is from GAV. The following is taken from Walker et al. (2000):

Experiments have shown that GAV and LOV are different forms of infection by the same virus. LOV is a covert infection that occurs naturally in healthy prawns. GAV is an overt form of infection by the same virus that causes mass mortalities in prawn ponds.

The process by which GAV causes disease is not yet understood. Disease appears to occur when prawns are not able to control the covert form of infection. It is clear that no genetic change (i.e. mutation in the virus) is required for LOV to cause mortalities. The trigger for disease appears to be an external factor such as environmental stress (i.e. poor water quality) or a second, complicating infection.

In healthy prawns, the virus is primarily contained within partitioned areas of lymphoid organ tissue called spheroids. The virus is also present in some other tissues including spermatophores. But generally, it is at very low levels and appears to multiply very slowly. In diseased prawns, there is an explosion of multiplication in the lymphoid organ and the virus rapidly invades many prawn tissues including the gills. The prawns are unable to contain the infection, they become sick and death usually follows.

There are two ways in which GAV can be transmitted – vertically and horizontally.

In healthy prawns covertly infected with GAV (ie. LOV), the virus is transmitted vertically to each successive generation, normally without causing disease. This appears to occur in wild prawns as the natural route of transmission. The virus is present in the spermatophores of male broodstock but appears to be restricted to the seminal fluid and surrounding connective tissue rather than in the sperm cells. The virus is also present in ovaries at lower levels, and in fertilized eggs. As a result, almost all post-larvae produced from infected broodstock carry the virus.

It has been discovered that *P. monodon* can transmit the virus horizontally to other adult prawns. In a disease outbreak, GAV transmission can occur by feeding on moribund prawns or dead carcasses, or by immersion in infected water. All healthy *P. monodon* are susceptible to disease by horizontal transmission, even if they already carry LOV.

It has been shown that healthy *P. monodon* infected covertly with LOV can transmit the virus to other prawns through infected water, or if they are cannibalised. Transmission is not restricted to other *P. monodon.* LOV can also be transmitted horizontally to *P. esculentus*, and likely to other species if they are cultured in the same pond.

P. monodon appears to be the only natural host of GAV in eastern Australia. In sampling conducted to date, CSIRO have found no evidence of natural infection in any other farmed or wild prawns. This includes Kuruma prawns (*P. japonicus*), brown tiger prawns (*P. esculentus*), banana prawns (*P. merguiensis*), grooved tiger prawns (*P. semisulcatis*) and greasyback or bay prawns (*M. bennettae*). Researchers also screened glass shrimp (*Acetes sp*) and freshwater prawns (*Macrobrachium sp*) and found no evidence of infection with the virus.

Virtually all *P. monodon* post-larvae presently available in eastern Australia are covertly infected with GAV. Any prawn infected with this virus is potentially at risk of disease. The precise conditions that cause an outbreak on farms are still being investigated. However, as for many other covert infections, stress is likely to be a crucial factor. The risk of disease should be minimized by maintaining high water quality and moderate stocking densities.

It is also important to recognize that GAV is not the cause of all disease. However, as a general precaution, dead or moribund prawns appearing in the pond should be removed and destroyed. This will limit the opportunity for horizontal transmission of infection, particularly to other ponds on the farm.

If a suspected GAV outbreak does occur, it must be confirmed, contained and eradicated.

Operational Response Procedures for GAV Outbreaks

The following course of action is required under the Fisheries Act 1994:

Immediately notify Queensland Fisheries Service (QFS).
Under the direction of QFS:

- Restrict access to diseased ponds;
- Do not release untreated water from the diseased ponds without the approval of the Environmental Protection Agency (EPA);
- Restrict movement from the property of prawns, persons, machinery, clothing, equipment and vehicles until suitable decontamination;
- Disinfect any farm equipment or clothing that may have been contaminated through contact with water or prawns from diseased ponds;
- QFS will arrange urgent testing of diseased prawns by State (or private) laboratories to confirm GAV as the cause of disease;
- If GAV disease is confirmed by isH, QFS may recommend an emergency harvest by a method that will allow treatment of the pond water;
- Drain the pond and chlorinate the water in a closed effluent canal; or
- Use a seine net and then chlorinate the water in the pond;
- Prawns deemed by QFS as suitable for sale may be cooked on site. No uncooked prawns will be permitted to leave the property;
- Disposal of diseased prawns unsuitable for sale will be conducted under the guidance of EPA;
- Decontaminate any equipment used for harvesting or handling the diseased prawns;
- Dry out the pond until restocking next season.

7.3.11.2 Potential for Disease at Guthalungra

The approach taken by Pacific Reef Fisheries to minimise the incidence of disease at Guthalungra will be the same as that undertaken at the existing farm at Ayr:

- Maintain appropriate stocking densities;
- Closely monitor stock health;
- Purchase quality P/Ls that have been disease tested;
- Maintain good water quality (adequate aeration, exchange as required);
- Purchase quality feed, cap the feed to a pond;

- Reduce potential stress to the animals;
- Rigorous escape prevention measures;
- Capacity to quarantine production ponds and areas of the farm.

The availability of information regarding the contamination of wild prawn stocks with disease from farm stock is limited. However an extensive assessment of the potential for the introduction of exotic diseases into existing wild prawn stocks has been undertaken to support the Prawn and Prawn Products Import Risk Analysis currently being undertaken by Biosecurity Australia.

7.3.11.3 Risks to Wild Stocks

Animal Biosecurity (Biosecurity Australia) develops policies which allow for the safe importation of animals, their genetic material and other products. Major policy changes are based on an Import Risk Analysis (IRA) process that is conducted according to Government policy and in a manner consistent with the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

An IRA has been undertaken for imported prawns and a number of relevant reports are available which can be found at the Animal Biosecurity website: http://www.affa.gov.au/corporate_docs/publications/pdf/market_access/biosecurity/animal

It should be noted that Australian prawn farms have been screened for exotic prawn diseases and none have been identified on any farms in Australia.

Like exotic diseases, the risk of transfer of endemic disease from outbreaks on prawn farms to wild stocks can be considered low. The risk analysis outlined in Table 7.18 is applicable to endemic disease. However the risks may be further moderated as individuals in the wild stocks may be already carrying the disease.

7.3.12 Escape Prevention Strategies

The following measures will be put in place to prevent stock escape from the facility (also refer to Section 4.4)

a) Screens

The outlet structures on the ponds will be fitted with screens to prevent direct escape from the ponds during normal operation. Screens vary in mesh size from 2 to 9 mm depending on the size of the prawns in the ponds.

Also, screens of similar specifications will be placed on the intake and discharge points of the treatment system including both the sedimentation and settlement ponds.

b) Drains

There is a relatively long network of discharge channels on the farm. Inevitably during the growing season fish and a variety of animals inhabit the drains. Often fish and crabs etc gain access to the drains during early water exchanges through the farm and may spend up to 10 months in the drains before they are dried out between crops. During this time they will predate on any escaped prawns. Noticeably, it is often the drains rather than the ponds that attract birds to the farm due to variety of potential prey and the shallow depth of water. Prawns that escape from the ponds therefore are very likely to perish in the drainage channels before or during dry-out.

c) Drain-Down and Dry Out

Farming tiger prawns in the dry tropics necessitates that the ponds and settlement systems be drained at the end of the growing season. In this way any disease vectors are destroyed and any escaped prawns or residual fish or marine fauna are killed.

d) Pumping

All of the water released from the Guthalungra prawn farm will be pumped through around 4.5 km of pipeline and into the ocean through a diffuser. Mechanical damage during pumping and discharge via the pipeline is expected to kill most of the animals that do find there way into the discharge system. The survival rates of any prawns and other animals leaving the farm though discharge waters will be minimal.

e) Predation

It is anticipated that the discharge point for the farm will attract a variety of scavenging carnivorous and omnivorous aquatic species, largely fish due to the nature of the discharge. It is anticipated that the remains of any animals that are discharged through the diffusers with be quickly consumed by fish close to the discharge point.

7.3.13 The Effect of Lighting on Turtles

Dr Colin Limpus (pers. comm., 2002) from the Queensland Parks and Wildlife Service was contacted on the 15th August 2002, in regards to turtle nesting in the Abbot Bay area. Dr Limpus advised that this stretch of coastline has been poorly surveyed and the last surveys were conducted in 1971 and were not extensive in nature. However every sandy beach in this general area has at least low density Flatback turtle (*Natator depressus*) nesting.

The pump station nestled behind the primary dune will not be lit. If repairs are needed, temporary lighting will be used for a short period of time while repairs are completed.

There will be a small number of security lights around the prawn farm on a 3 m high external fence. This lighting will be set up to meet the Australian Standard 4282 – "Control of Obstructive Effects of Outside Lighting". The farm will be some 4 km from the ocean. The foredunes and secondary dunes will also act as a significant line of sight barrier for the turtles for any external lighting on the site as well.

7.3.14 Bird Attraction

The following bird species are likely to be attracted to this prawn farm development:

- Terns;
- Cormorants;
- Pelicans;
- Black-necked Storks;
- Herons;
- Egrets; and
- Ibis.

A number of these bird species are primarily fish feeders and will be likely to feed in the pond discharge channels where they capture fish. Shags in particular will dive into the ponds for the prawns. As these bird species are fish-eating birds they are not known to impact on horticulture. Therefore they are not considered to be a threat to adjoining properties.

The impact of the prawn farm on the natural population profiles of these bird species is not likely to be significant as bird preventative measures will be used regularly. A combination of preventative measures to discourage birds from the site will be introduced alternatively. These include:

- The use of scarecrows, scare guns, selective culling and netting where appropriate. However the use of scare guns and selective culling will be used as a last resort to ensure minimal disruption to wader birds on the adjacent wetland;
- Keeping the farm tidy by ensuring that no prawn bodies will be left after harvest and any processing wastes will be disposed of appropriately;
- Disposing of major mortalities on-site by burying in a dry pit and liming and covering with soil;
- Draining all ponds and drainage lines at the end of each harvesting season resulting in fish deaths, depriving the birds of a food source. This is likely to disrupt the feeding regimes of birds attracted to the prawn farm therefore discouraging overall bird attraction.

7.3.15 Mosquito Breeding

Mosquitos are known to inhabit the site however population numbers will not increase as a result of this project.

The larval cycle of breeding mosquitos will be controlled at the prawn farm by the following design and housekeeping considerations:

- The combination of steep sides of the ponds and constant water level will mean that the available surface area for breeding is limited; this is particularly important for the settlement ponds;
- The control of vegetation on pond walls which provides a habitat for the adult mosquito;
- The surface aerators will maintain relatively turbulent conditions which are not attractive to mosquitos;
- The prawns can be expected to eat mosquito larvae; and
- General housekeeping should ensure that containers are not left lying around to collect water and allow mosquitos to breed.

7.4 Noise Management

Information relating to typical activities being undertaken throughout the farming process was obtained via personal communication with Pacific Reef Fisheries (PRF, 2002). The proposed prawn farming operation would involve progressively filling the ponds from mid August through to the end of October and harvesting from January through to June. At the end of the crop, the ponds are cleaned out over an approximate 2 month period and prepared for the commencement of the next seasons farming.

Biomass in the ponds requires air input and feed, with demand for each increasing throughout the growth period. Pelletised feed is delivered to the ponds via a hopper on the back of a tray top truck. A petrol pump blows feed into the ponds at a controlled rate. Feeding typically commences at 4 times per day during the beginning of the growth season, increasing to 5 times per day prior to harvest. The first feed commences at 6 am and the last feed finishes at 10 pm.

Aeration of the ponds is achieved through the use of paddle wheel aerators. Initially, each pond would typically require 4 paddlewheel aerators, potentially operating 24 hours per day. This could increase to around 6 paddlewheel aerators and 4 air injectors (which drive air below the surface of the ponds) towards the end of the crop growth period.

The paddlewheel aerators are driven by submersible electric motors, with the only noise contributions being splashing sounds from the paddles. The air injectors also have submersible motors, which suck air through a surface intake and bubble it out near the bottom of the water column.

Sea water will also be circulated through the ponds via a series of inlet pipelines and channels. An intake pump facility would be constructed within the beach dunes to the north of the site. The concept design for the intake pump is based on a multi-pump wet well system, involving submersible pumps. A similar pump station will be located on the farm to pump excess exchange and release water to Abbot Bay. A number of re-lift and re-use pumps would also be installed on-site, at ground level.

Routine maintenance, involving oxygen testing of the water, feed status and the like, would be undertaken using 4WD motorbikes. A maximum of approximately 30 bikes would be required for the whole farm, not all of which will be operating at once. A grader and excavator would also be used as part of routine maintenance on the drains and banks throughout the year.

Harvesting of the crop is undertaken between 6 am – 4 pm during the months from January to May. Harvesting typically involves the use of 4 wheel drive motor bikes or utes travelling back and forth between the processing area and the ponds. The prawns are captured by draining the ponds with a net over the outlet and are transported immediately to the processing area. Some prawns are transported fresh from the site and others are cooked, frozen and packaged prior to transport. Transport of product from the site is restricted to a few hours per day, during the middle of the day, and would be via refrigerated trucks.

The processing area operates between the hours of around 6 am – 10 pm, however refrigeration and freezing plant is maintained 24 hours per day. Site operations during night-time hours would be restricted to the use of surface aerators and the associated water reticulation system. No processing, maintenance or feeding would be scheduled during night-time hours.

Other activities on-site include offices, machinery sheds, food storages and transfer stations for receiving feed deliveries and the like. These operations would not occur during night-time hours. Emergency backup diesel generators will also be required on-site, to maintain pond aeration in the event of mains power failure. These generators would operate fortnightly, as part of routine maintenance, for a period of approximately 3/4 hours during the daytime.

Following cropping and drainage of the ponds, the ponds are cleaned during July and August. Uneaten food, dead animals and debris is cleaned from the bottom of the ponds using loaders and trucks. Some of this material may be used to repair internal walls of the ponds. At any one time 4 trucks and 2 loaders would typically be used on-site for this purpose.

7.4.1 Noise Legislation and Guidelines

The assessment of noise is complex and subjective and the assessment procedure should not be considered in isolation from other social and economic aspects of a development. The following sections refer to relevant Queensland legislation and guidelines for protecting against adverse noise impacts as a result of development. Reasonable project specific noise limits, as determined for the Proposed Guthalungra Prawn Farm, are summarised below.

Environmental Protection Act (1994)

The acoustic environment in Queensland is protected under the *Environmental Protection Act 1994* (EP Act), the objective of which is to allow development that improves the total quality of life using the principles of “Ecologically Sustainable Development”. The object of the EP Act is implemented through the *Environmental Protection (Noise) Policy 1997* (EPP Noise), which provides a framework for managing and assessing noise emissions from development proposals and aims to protect and enhance environmental values, namely the wellbeing of the community and individuals.

Environmental Protection (Noise) Policy 1997

The Noise EPP specifies an “acoustic quality objective” of achieving an ambient LAeq (24 hour) level of 55 dB(A) or less for the majority of Queensland's residential population. The Policy lists issues that the administering authority must consider when making a decision with regard to development applications and setting project specific noise limits.

These issues include:

- The characteristics of the noise from the noise-relevant activity;
- Other noises ordinarily present at or near the relevant place; and
- Any other information or other matter concerning the effect of the noise-relevant activity on the acoustic environment.

The User’s Guide for the *Environmental Protection (Noise) Policy 1997* adds that the administering authority should also consider the:

- Background level;
- Ambient level;
- Number of noise events emerging above the background;
- Maximum sound pressure level of the events;
- Characteristics of the noise emissions; and
- Receiving environment.

Development Noise

The Noise EPP does not specify any absolute or relative sound pressure level criteria for developments and it is not correct to interpret the LAeq (24 hour) 55 dB(A) level as a contributed noise criteria for specific activities or developments. Environmental authority limits have historically been set based on an incremental level above the prevailing background noise level. Noise levels from the operation of a proposed facility are generally considered reasonable at the noise sensitive receiver locations if the LAMAXadj, T does not exceed the background noise level by more than:

- Background + 5 dB(A): 7 am - 10 pm; and
- Background + 3 dB(A): 10 pm - 7 am.

There are no existing contributions from industrial sources in the area adjacent to the proposed development and, as outlined in above, is dominated by natural and domestic sources. The addition of industrial sources associated with the prawn farm operation may result in a perceived increase in noise levels by the community even though there may not be any detectable increase in actual noise levels.

Using these guidelines, and the conservative estimate of existing background noise levels within the area are 35 dB(A) during the day and evening and 30 dB(A) during the night, the following prawn farm operational noise levels, when measured at nearest sensitive receivers to the site, are considered reasonable:

- LAMAXadj, T : 40 dB(A), between 7 am - 10 pm; and
- LAMAXadj, T : 33 dB(A), between 10 pm - 7 am.

Road Traffic Noise

Schedule 1 of the Noise EPP sets planning levels for noise. The planning levels for road traffic noise at sensitive locations are:

- 68 dB(A) for state controlled roads assessed as the LA10 (18 hour) level;
- 63 dB(A) for another public road assessed as the LA10 (18 hour) level;
- 60 dB(A) assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10.00 p.m. and 6.00 a.m.; and
- 80 dB(A) assessed as a single event maximum sound pressure level.

The LA10 indicator is an arithmetic average of 18 hourly LA10 levels determined over the consecutive hours between 6 am and midnight on the same day. This indicator is widely used to represent road traffic noise exposure.

Such levels apply for the design and construction associated with new or upgraded road corridors. For this project, an estimate of the potential impacts from road traffic noise can be gauged by the relative increase in traffic noise compared to the existing situation.

Construction Noise

The EPP (Noise) does not outline specific construction noise level guidelines. The Queensland Nuisance Laws, outlined in Section 6 of the *Environmental Protection Regulation 1998* (EPR, 1998), provide time restrictions for construction, maintenance and building works having the potential to affect residential premises. Table 7-21 provides a summary of the noise level and time restrictions from these activities.

Table 7-21
Limits to Construction Works affecting Residential Premises

Day of Week	Working Hours	Noise Level Restriction
Monday to Saturday	6:30 am-6:30 pm	Noise Permitted
All Days	6:30pm – 6:30 am	No audible noise permitted
Sundays, public holidays	All hours	No audible noise permitted

The nuisance laws are complaint driven, meaning a complaint must be made before a problem will be investigated. Following receipt of a valid complaint, authorised officers have the ability to issue abatement notices, infringement notices or undertake a prosecution for causing unlawful environmental nuisance.

Noise Criteria Applicable to this Project

Table 7-22 summarises proposed noise level limits for the construction and operation of the proposed development, as determined in accordance with relevant EPA Guidelines and Policies.

Table 7-22
Project Specific Operational Noise Criteria

Goal	Project Specific Goal	Time period
Operational Noise	$L_{AMAXadj, T}$ = 40 dB(A)	7 am-10 pm
	$L_{AMAXadj, T}$ = 33 dB(A)	10 pm – 7 am
Construction Noise	No audible noise at sensitive receiver locations	6:30 pm-6:30 am: Monday to Saturday, all hours: Sundays and Public Holidays

Implementation of these limits will protect the acoustic quality of the environment within the adjacent area to the proposed development and minimise potential impacts resulting from the proposed prawn farm operations.

7.4.2 Impacts on Noise

The main noise issues associated with operations at the proposed site are likely to be the operation of construction equipment during site preparation and pond construction activities, and the operation of water pumps, aeration systems and site activities during times when ambient noise levels are low. The potential issues are discussed in the following sections.

Construction Phase Impacts

Construction of the proposed ponds and associated drainage infrastructure will be staged, with works being undertaken during the dry season months from approximately April to September over 4 successive years. Construction during the first stage would mainly be centred on the eastern area of the site, including ponds, the water treatment and sedimentation area, the site office, amenity and processing facilities. Construction of the main water supply and discharge pipelines would also occur during the first stage, allowing the operation of the first part of the farm from completion of the first stage of works. During each successive year, additional ponds and drains would be constructed and brought on-line, expanding the size of the operating farm.

In accordance with the EPR (1998) construction works undertaken during each stage would be restricted to the hours of 6:30 am-6:30 pm, Monday to Saturday.

Construction activities would typically include:

- Bulldozer and chain to clear and stockpile vegetation on-site. Topsoil would also be removed and stockpiled to the north-east of the proposed processing area and sedimentation area 1, for use in rehabilitation of the finished earthworks areas;
- Bulk earthmoving, during excavation of the ponds and drainage channels, would be undertaken using scrapers, dozers, excavators, rollers etc. Water trucks would also be used to control dust and to supply water during the compaction of pond bases; and
- Concrete trucks would also be required intermittently throughout the construction period for the construction of pipe culverts, pump stations and miscellaneous concrete works. However no major 24 hour concrete pours will be required as part of the works.

The construction equipment used on the site, and the subsequent level of noise emission, would vary, depending on the stage of the works. A discussion of the likely construction traffic noise impacts is provided below.

A detailed construction plan was not available at the time of preparation of this report. Discussions with design engineers determined that a selection of typical items of earthmoving equipment would operate simultaneously at the proposed site during the excavation and bulk earthmoving stage of the works. It has been assumed that a number of items will be operating simultaneously in the proposed processing area and adjacent sedimentation area, while also stockpiling fill within the area to the north-east of this, as works being undertaken in these areas have the greatest potential for noise impacts at adjacent receivers.

Sound Power levels for typical activities associated with the construction works have been sourced from AS2436-1981 Guide to Noise Control on Construction, Demolition and Maintenance Sites and our own in house database. The sound power levels used to calculate indicative construction noise levels at nearest sensitive receivers to the east of the proposed site include:

- Excavator 116 dB(A);
- Front End Loader 117 dB(A);
- Grader 117 dB(A);
- Dozer 118 dB(A);
- Haul Truck 118 dB(A);
- 10 t Product Truck 105 dB(A);
- Concrete Mixer Truck 118 dB(A);
- Concrete Pump 102 dB(A);
- Vibratory roller 119 dB(A).

Noise attenuation calculations, based on the CONCAWE algorithms, were used to calculate LAMAXadj, T construction noise levels at nearest noise sensitive receivers to the proposed site during the earthworks phase. The results of these calculations are outlined in the following section.

7.4.2.1 Construction Noise Level Predictions and Impacts

The assessment of construction phase noise impacts is based on a selection of typical items of equipment operating simultaneously. The results of construction noise calculations at distances indicative of the closest sensitive receiver location are shown in Table 7-23.

Table 7-23
Calculated Construction Noise Levels

	Approx Distance from Works (m)		**L_{A10} Noise Level (dB(A))**
Receiver Location	Stockpiling Area[1]	Processing Area and Ponds[2]	Resultant $L_{AMAXadj,T}$ noise level (dB(A))
Guthalungra Beach Community	800	2000	35
Isolated Residence (SE)	800	450	45

1 Sources include: Excavator, loader, grader, dozer, Water Truck
2 Sources include: Haul Truck, concrete mixer truck, concrete pump, 2 dozers, 2 graders, excavator, loader, vibratory roller

The calculations presented in Table 7-23 incorporate the effects of air absorption, divergence and distance attenuation between the source and receiver over flat, moderately absorptive ground.

The indicative construction noise calculations presented in Table 7-23 show that while stockpiling works are being undertaken within a distance of approximately 800 m of the nearest residences, and excavation and earthmoving works are being undertaken at the processing area, construction noise calculations of around 45 dB(A) may be expected at the nearest receiver to the site while some discrete activities occur. During these times, the resultant noise level is approximately 10 dB(A) above the assumed (conservative) background daytime noise level of 35 dB(A). Given the approximate 6 month construction period, construction noise levels of this order are considered acceptable, provided works are restricted to the hours of 6:30 am – 6:30 pm when they are audible at the receiver location.

It should be noted that construction noise levels will vary throughout the construction period, depending on the level of activity on-site and the type of activity being undertaken, however significant noise impacts are not expected to result from these activities.

7.4.2.2 Construction Traffic Level Predictions and Impacts

The peak traffic generation during construction is expected to occur immediately either side of the construction shift, from 7 am – 3 pm. The Traffic Impact Report (Section 7.3) indicates that approximately 30 workers will travel to the site between 6:30-7:30am and leave the site between 2:30-3:30pm. Access would be along Coventry Road, via the Bruce Highway, which is speed limited to 60 km/hr.

Heavy construction equipment will be transported to the site at the commencement of the construction period and will remain on-site for the duration of the works. Intermittent vehicle movements are likely to occur throughout the daytime hours, however, the majority of movements will occur during the AM and PM peaks. Peak hourly construction traffic forecasts are approximately 47 vehicles per hour, 10 of which are heavy vehicles.

The nearest residence to the propose construction site is located approximately 400 m from the access route. Given the relatively short duration of the construction period, the restriction to daytime working hours, and the relatively low construction traffic flows indicated in the traffic assessment, noise impacts from construction traffic are not expected to be significant at nearby receivers adjacent to the Bruce Highway and Coventry Road.

7.4.2.3 Operational Phase Impacts

Operations at the site would vary throughout the year. The potential noise impacts from the proposed prawn farming operations have been assessed for two operating scenarios, which are considered to have the greatest potential for noise impacts:

- Scenario 1 – Farming Activities
  - The operation of surface paddle wheel aerators;
  - Drain maintenance equipment (including a grader and excavator);
  - Site delivery truck;
  - Operation of relift pumps and re-use pumps; and
  - Feed and surveillance vehicles.
- Scenario 2 – Post Harvest Pond Maintenance Operations
  - 3 excavators;
  - 3 graders;
  - One truck; and
  - One 4WD vehicle

7.4.2.4 Environmental Noise Model

In order to assist in the qualification of potential noise impacts from the operation of the proposed prawn farm, the Environmental Noise Model was used to predict noise levels for two scenarios. The operational LAeq noise levels, at distances representative of the nearest noise sensitive receivers to the site, were calculated and compared with appropriate noise emission limits.

Estimates of the sound power levels for the surface aerators, above ground pump drives and earthmoving machinery were made with reference to the SKM Sound Power Level database, or adjustment made to similar plant items. The octave band sound power levels for relevant items are outlined in Table 7-24.

Table 7-24
Indicative Sound Power Levels – Farming Operations

Source	Assumed No. Units	Lin	Swl dB (A)	31.5	63	125	250	500	1k	2k	4k	8k
Farming Activities												
Feed / Surveillance vehicle	1	101	101	-	81	84	90	92	90	92	96	96
Paddle wheel aerator[1]	84 ponds	86	76	75	79	74	73	76	80	78	76	73
Grader	1	117	111	103	109	111	112	108	106	101	96	83
Excavator	1	119	113	110	112	114	111	111	107	104	96	90
Delivery truck (10t)	1	105	105	60	76	85	96	98	99	101	93	85
Pump motors[2]	7	98	96	85	86	87	89	89	92	89	85	79
Post Harvest Maintenance Activities												
Surveillance vehicle	1	101	101	-	81	84	90	92	90	92	96	96
Grader	3	117	111	103	109	111	112	108	106	101	96	83
Excavator	3	119	113	110	112	114	111	111	107	104	96	90
Delivery truck (10t)	1	105	105	60	76	85	96	98	99	101	93	85

1 Based on modified STP surface aerator spectrum, assuming a minimum of 4 aerators per pond.
2 Assumed 160 kW drive, nominal spectral distribution.

Operation of the main water supply and disposal pumps was not considered as part of the modelling. The proposed pumps will be located below ground level, within an enclosed concrete tank. Noise impacts from the operation of these potential sources are therefore not considered to be significant.

Predictions made on the data listed in Table 7-24 result in the determination of the LAMAXadj, T index and assume that the process units are fully and simultaneously operational and under typical load conditions during the operation. The modelling incorporated the conservative conditions of:

- 3^{o}/100 m temperature inversion; and
- 3 m/s wind blowing in the general direction from source to receiver.

The acoustic model run under these conditions, including indicative early morning temperature and relative humidity information for the site, is considered to represent the worst case potential impact at the nearest sensitive receivers to the proposed farming operation.

The results of noise modelling for the two main operating scenarios are provided in Appendix N.

7.4.2.5 General Impacts

The predicted noise levels at the isolated residence to the south-east of the processing area were approximately 32 dB(A) during farming activities, even under adverse meteorological conditions. The predicted noise levels at the Guthalungra beach community were less than 22 dB(A) during farming activities. The operation of the proposed prawn farming activities were predicted to comply with the night-time project specific noise level objective of 33 dB(A). Given that the existing background daytime and night-time noise levels were assumed to be 35 dB(A) and 30 dB(A) respectively, operational noise levels during farming are not expected to give rise to the loss of acoustical amenity and not likely to generate significant impacts at the nearest receiver and are not likely to be audible for much of the time at the Guthalungra beach community.

During post harvest pond cleaning and maintenance activities the predicted noise levels at the nearest residence were predicted to be 35 dB(A) and less than 27 dB(A) at the Guthalungra beach hut community under adverse meteorological conditions. At other times noise levels at the nearest residence were predicted to be less than 32 dB(A). Given that the maintenance activities would only be undertaken during the daytime hours for a period of approximately 2 months of the year, noise impacts from the proposed maintenance activities are not expected to be significant.

The noise levels presented above include consideration of temperature inversion conditions and winds blowing in the direction from the source to the receiver. In reality, these conditions are not likely to occur for a significant period of the time throughout the year. The results are therefore considered conservative.

Potential contributions from the operation of the water intake pump have not been incorporated into the modelling. The proposed intake pump will be located below ground level, within a concrete well structure. Given this, and the remote location of the proposed intake pump, noise impacts from the operation of this pump are not considered to be significant.

Emergency Generator Noise

Emergency backup diesel generators may also be required periodically, during mains power failure and routine maintenance. Information from Pacific Reef Fisheries indicates that one generator would service aerators for approximately 16 ponds. Due to the fact that these generators would operate fortnightly, as part of routine maintenance, for a period of approximately 3 - 4 hours during the daytime, the likely noise impacts from such a scenario have also been considered.

Table 7-25 provides indicative sound power level data for the operation of various generator sets, mounted on the ground, without any enclosures. The sound power level data has been sourced from information provided by the likely suppliers of these units.

Table 7-25
Indicative Sound Power Levels – Emergency Generators

Source	Assumed No. Units	Lin	Swl dB (A)	63	125	250	500	1k	2k	4k	8k
Emergency Generators[1]											
F182	5	113	112	102	95	98	108	107	106	102	100
F172	5	106	106	94	91	91	98	101	101	96	91
F173	5	98	96	92	89	87	88	91	90	88	84

1 Cummins Performance Specifications for typical generator sets to be installed on-site.

Given the fact that the requirement for emergency backup power is not predictable, aside from the routine maintenance that would occur during daytime hours, the modelling of potential impacts has been undertaken for daytime hours only.

The predicted noise levels at the isolated residence to the south-east of the processing area were approximately 29 dB(A). When considering the contribution of noise from general farming activities (above) with the emergency generators, a resultant noise level of less than 32 dB(A) would be expected during daytime hours under non-enhancing meteorological conditions. The combined contribution from emergency diesel generators and prawn farming activities at the Guthalungra beach community was predicted to result in noise levels of less than 25 dB(A) during farming activities.

The routine maintenance operations of the emergency diesel generators are therefore not expected to generate nuisance noise impacts at nearest sensitive receiver locations. However, noise from the operation of the emergency generators, in conjunction with the pond aerators may be audible at times at the nearest isolated residence, under adverse meteorological conditions, during night-time hours. It is therefore recommended that no routine maintenance activities be undertake during night-time hours. Consideration should be given to the appropriate siting of generator units adjacent to the processing area to maximise shielding to nearest residences.

No consideration of emergency generators in conjunction with post harvest pond cleaning and maintenance activities has been undertaken, due to the fact that the majority of ponds will not be under aeration during this time.

Impacts on Migratory Birds

A review of relevant research papers prepared on how wildlife reacts to noise from compressor and motor-type noise suggests that whilst some impacts do occur within very close proximity to the noise source, the effects will depend on the intensity of the noise, the species of bird and the proximity to the source. Some birds exhibit avoidance of high noise areas, while other species, with seemingly higher tolerance levels, tend to take advantage of the reduced competition within these areas and increase their habitation. The overall conclusions in literature indicate that impacts are typically of short radius and are temporal, with animals tending to adapt to the change in their environment with time.

7.4.2.6 Operational Traffic and Impacts

The proposed prawn farm will result in an increase in traffic travelling to the site, along Coventry Road from the Bruce Highway.

The peak traffic generation during operation of the proposal was identified by Lambert and Rehbein (2002) as the AM peak (6:30-7:30 am) and PM peak (2:30-3:30 pm) periods, with staff travelling to and from the site, deliveries to the site and transport of produce from the site. The development is expected to generate 24 additional vehicles along Coventry Road during the AM peak hour flow, 7 of which would be heavy vehicles. Additional workers would be required during the processing and harvesting period, extending the working hours to around 10pm.

An increase of 212 vehicles per day is expected as a result of the proposal, which averages to less than 15 vehicles per hour between the hours of 6:30 am 10:30 pm. Compared with the existing traffic flows on the Bruce Highway, an increase of this order is likely to generate an increase in the long term road traffic noise level of less than 0.3 dB(A). Along Coventry road, the lower background flows will necessarily result in a larger increase in road traffic noise compared to the existing situation. However, given the low flows involved, and the fact that the majority of vehicles will be travelling to and from the site during the daytime, the potential road traffic noise impacts resulting from the proposal are not likely to be significant.

In conclusion, the predictions showed that construction works are not likely to generate significant acoustic impacts at nearby sensitive receiver locations, providing the recommended daytime working hours are adhered to. Construction works, may however, be audible for part of the works.

A noise model for the operation of the proposed Guthalungra Prawn farm was established to estimate the likely noise levels during general farming activities and during the post-harvest maintenance activities. The predicted noise levels showed that operation of the proposed facility is not likely to generate noticeable noise levels at the nearest sensitive receiver, located approximately 2000 m east of the proposed processing area and the nearest pond.

The project is expected to comply with the day and evening operational noise level objective of 40 dB(A) and the night-time noise level objective of 33 dB(A) at the nearest sensitive receiver, located approximately 2000 m to the east of the proposed processing area of the site.

7.5 Air

7.5.1 Disposal of Cleared Vegetation

Some clearing of vegetation is required prior to construction of ponds and ancillary features. The cleared vegetation would normally be burnt in piles where the wood has been collected or windrowed.

The commercial value of the timber will be investigated and if economically acceptable be removed as felled timber. The economics of mulching timber on site will be also investigated. It is unlikely that there will be a large need on site for a mulched product, though again an outside entity may have a need for such a mulched product.

If either of these two avenues, or any other approaches are not available, the vegetation will be burnt.

7.5.2 Impacts on Air Quality

a) Construction Phase

Use of above ground installation methods such as trenching to install the pipeline in the coastal dune area at the easternmost extent of the pipeline could lead to water and/or wind erosion of the dune structure.

During construction of the production ponds some short term dust generation may occur during removal of the top soil, which will be minimised by use of water trucks. Deeper soils are anticipated to be reasonably moist and should not generate as much dust as the top soil.

There is no respective regulatory criteria for dust generation during the construction phase of projects, however as a guide visible dust clouds should be avoided wherever possible.

The combination of distance and management of dust generation will reduce the potential for impacts to air quality. Impacts to air quality at sensitive locations are not considered to be significant during the construction phase.

There will be little or no air emissions from the site other than dust and normal vehicle emissions during construction.

b) Operational Phase

Ergon Energy will supply mains power and back up generators will also be installed on site. Subsequently no air emissions or noise will be generated on site from this source except on the occasions the generators are required.

Production ponds would be drained at the end of each crop for maintenance and preparation purposes. While a pond is empty the accumulated sediment in the bottom of the pond is allowed to dry and is then removed and placed in the sediment storage area. The odour generated by pond culture, including ponds that are drained for the purposes of drying sediments, is indistinct to that associated with inter-tidal areas.

The processing facility will involve the processing (sorting, cooking, refrigerating and freezing), of prawns. The processing facility including cold room will be enclosed during processing. The prawns are initially sorted then cooked. There is little odour associated with these activities; particularly as the prawns are cooked whole and there is little waste generation. The time taken from harvesting to processing is only 15 minutes, so maximum freshness, texture and flavour in maintained.

There will be no discernable odours associated with discharge waters.

7.5.3 Emission Control Measures

Based on the distance to sensitive locations and methods of operation it is unlikely that odour or dust would be a potential cause of annoyance to nearby residents during operation of the prawn farm and hence is unlikely to become an unreasonable release as defined in the *Environment Protection (Air) Policy 1997*.

7.5.4 Greenhouse Gases

Vehicle use on site will be restricted to all terrain vehicles, and cars driven by staff to the farm. There will no methane generated from the ponds, as they remain well aerated. To reduce the energy usage and the production of greenhouse gases, the most energy efficiency aerators used in the prawn farm industry will be installed. Both wind and solar energy generation have been considered. A wind energy power generation company has been commissioned to investigate the use of wind turbines to generate energy on site.

7.6 Waste Management/Minimisation

The *Environment Protection (Waste) Policy 1997* provides a strategic framework for managing waste in Queensland. The Regulations provides the requirements for handling of specific waste items. The policy outlines the preferred waste management hierarchy and principles for achieving good waste management.

The Waste EPP is based on principals of:

- Polluter pays: all costs associated with waste management should be borne by the waste generator;
- User pays; all costs associated with the use of a resource should be include in the price of the goods and services developed from that resource; and
- Product stewardship the producer or importer of a product should take all reasonable steps to minimise the environmental harm from the production use and disposal of the product.

The prawns will be harvested from the ponds and transported by motorized transport to the processing facility. The prawns are sorted by size mechanically, then either cooked in salty brine or frozen immediately as “green prawns”. The cooked prawns are collected and allowed to drain over the cooking area then packaged in polystyrene boxes. Green prawns will also be packed in polystyrene boxes. All boxes will then be frozen in the cold room.

As market demands boxes of prawns will be road transported to Townsville then air freighted to southern markets.

The prawn farm will produce little solid waste that would need to be disposed to landfill. Solid waste from packaging used during processing will be disposed of by a solid waste contractor. During processing over a period of 6 months, it is expected that 15 m^3 month of solid waste material will require disposal. Of this material, 5 kg will be prawn waste; i.e. remnant small bits of prawn damaged in transport and processing.

The prawn waste will be collected daily and held in sealed plastic bags in cold storage. A solid waste contractor will arrive weekly to collect this material for disposal to the local Bowen landfill. Other solid waste material from process packaging will be stored in large collection bins supplied by the solid waste contractor.

Prawn feed will be brought in bulk. Solid waste of 5 m^3 per month is generated from the farm. This may include machinery parts, paper, plastics, cardboard and other unwanted solid waste from the farm. This material will be stored in large collection bins supplied by the solid waste contractor. Small amounts of oil from farm machinery will be produced.

The farm will be serviced by a regular pick up service by the solid waste contractor who will dispose of this material to the local Bowen landfill.

Sludge volumes up to 250 tonnes (dry weight) during the growing season from the sedimentation ponds will be allowed to dry then collected by bobcat. This material will be placed in a drying pond and allowed to further oxidize and decompose. At the end of the season this material will be ploughed into the basin of this pond and other ponds as required. Sludge that accumulates in the settlement ponds will be allowed to dry at the end of the season and will be ploughed into the basin and sides of the ponds.

Pigging (the use of a plug to run through the pipe and remove material) of both the discharge and intake lines will be undertaken at the end of growing season. Rates of bio-accumulation within the pipeline are not known however, it is estimated that up to 100 m^3 of material could be removed from the pipes during pigging operations assuming 5mm thick accumulation each year. The material will be primarily barnacles and some organic material. There will be only small quantities of seaweed and macro-algae, as the light climate within the pipes will limit plant growth. Most of this waste will be collected on farm and allowed to decompose in dried out pond and the material will be disturbed among dried out ponds. About 10% of this material will be expelled to Abbot Bay as a result of the pigging of the ocean pipelines.

This amount, in the order of 10 m^3 is likely to consist of barnacle shells and some organic matter. Most of this material will be dispersed quickly by ocean currents with the remainder heavier shell material depositing at the end of the pipe from where it will be moved over the course of the year. The area of deposition is likely to be in the order of 10 m x 10 m.

Waste oil and grease from the workshop will be minimal. This material will be collected in empty 200 L containers or containers provided by the licensed waste removal contractor. This material will be removed regularly from site by a licensed waste collector.

All work areas will be roofed, minimising the risk of contamination of stormwater.

A summary of the waste management strategies proposed for the project are shown in Table 7-26.

Table 7-26
Summary of Waste Management Strategies

Item	By- Product	Discussion
Grow out ponds - water	An average of 96 ML of water will be discharged over of period of approximately 270 days. The maximum daily discharge is 200ML, which includes 40 ML of harvest water. The flux on nutrients exported in the discharge waters is expected to be 36 tonnes of Total Nitrogen and 3.6 tonnes of Total Phosphorus. More than 50 % of the discharge will be as suspended planktonic material. Approximately 25% will be as dissolved organic nitrogen and 25 % as ammonia.	A mixing zone of approximately 1 km long by 500 m wide will be required based upon an 6 monthly average total nitrogen threshold concentration for seagrass of 150 ug/L. Seagrass in this area may be impacted by increased epiphytic algal growth or reduced light penetration. The area of seagrass impact is less than 5 % of the seagrass in Abbot Bay as recorded by Coles *et. al* (1992), and Scientific Marine. There is also the possibility that the increased nutrient content of the discharge waters will support seagrass growth and survival.
Grow out ponds - sludge	Up to 250 tonnes/annum of sediment will be captured in the sedimentation ponds.	Sludge rapidly oxidizes to a useful soil conditioner. A sludge drying and containment area has been set aside.

Item	By- Product	Discussion
Processing Plant	On site processing is limited to cooking, processing and freezing product. No other processing is required.	Wastewaters will be chlorinated prior to discharge to the settlement ponds. These chlorinated wastewaters will be discharged to a small aerated pond so that the chorine is reduced prior to discharge to the settlement ponds. Solid waste will be collected, bagged and placed in the cold room for odour control. These wastes will be disposed of by a waste management contractor to a controlled landfill.
Workshops	Waste oil and greases from maintenance of farm machinery will occur.	These wastes will be collected in appropriate containers and removed by a licensed waste disposal contractor.
Sewage	Primary sewage treatment will be provided at source point. Septic tank overflow will be recirculated to a central sand bed filter. Filtered water will be used for irrigation of ornamental trees on the farm. The system will be designed to accommodate approximately 110 people during peak times of operation.	Solid wastes will be collected periodically by a licensed waste collector and disposed of in the appropriate manner.
Solid waste	All unusable solid waste e.g. paper, plastics and tins will be placed in appropriate bins. Organic waste will be placed in separate bins.	These wastes will be collected in appropriate containers and removed by a licensed waste disposal contractor.
Pigging Wastes	Pigging of both the discharge and intake lines will be undertaken at the end of growing season. It is estimated that up to 100 m^3 of material will be removed from the pipes during pigging operations. The material will be primarily barnacles and some organic material. There will be only small quantities of seaweed and macro-algae, as the light climate within the pipes will limit plant growth.	The amount of biofouling within the pipes is difficult to predict. The pigging will be arranged so that most of the material after pigging will be deposited in the seawater storage on the farm. Approximately 10% of pigged material could be deposited in Abbot Bay as a result of pigging of ocean pipelines.

7.7 Traffic and Transportation

The proposed site at Guthalungra is currently grazing land. The development is situated north of the township of Guthalungra and access to the site is gained from the Bruce Highway via Coventry Road which is currently an unsealed dirt road. The Bruce Highway is currently a two (2) lane undivided road with localised intersection widening and painted medians at the intersection of Coventry Road / Nevada Road to allow for turning traffic to use the Service Station and Rest Area. Coventry Road and Nevada Road are under Give Way control. The surrounding areas are generally vacant rural land. The Bruce Highway is a 100kph speed zone.

7.7.1 Existing Traffic Volumes

The existing AADT, obtained from the Department of Main Roads - Northern District (DMR), shows approximately 2136 daily vehicles (two way) passing by the intersection of the Bruce Highway / Coventry Road / Nevada Road. Approximately 19.8% of the total traffic are heavy vehicles. The existing volumes can be seen below in Table 7-27. The vehicle classifications used are based on the 12 AUSTROADS Vehicle Classes.

Table 7-27
AADT Traffic Count

Type	1	2	3	4	5	6	7	8	9	10	11	12	Total
Count	1530	183	104	42	6	6	23	29	174	40	0	0	2136

No intersection count was available for Coventry Road / Nevada Road. Turning movements were derived for the intersection based on the site visit. This allowed analysis of the intersection from a capacity standpoint.

The existing turning movements (derived) at the intersection of the Bruce Highway/ Coventry Road / Nevada Road are shown on the SIDRA output included in Appendix R

7.7.2 Existing Intersection Geometry

The intersection currently has a Type A left turn and a Type C right turn from the south. The right turn pocket is approximately 165m long. The northern approach has a Type B left turn and a Type C right turn. The right turn pocket is approximately 75m long and the left turn is approximately 150m long. The northern approach has a split in the painted median, to allow vehicles from the rest area to head north, approximately 75m from the intersection.

AUSTROADS Part 5 - Intersections at Grade indicate that for a 100kph speed limit a Stopping Site Distance of 170m and a Safe Intersection Site Distance of 250m is required for the highway. The intersection has adequate Sight Distances in all directions. The terrain is also flat and there are no obstructions that would hinder the drivers' view from any of the intersection approaches.

7.7.3 Existing Equivalent Standard Axles

Based on the count data obtained from DMR, Equivalent Standard Axles (ESA) pavement calculations were undertaken for the existing volumes. The ESA calculations were done using methodology and factors from the Queensland Transport – Pavement Design Manual. The results of the ESA calculations (for 365 days) can be seen below in Table 7-28.

Table 7-28
Existing Equivalent Standard Axles

Type	1	2	3	4	5	6	7	8	9	10	11	12	Total
Count	1530	183	104	42	6	6	23	29	174	40	0	0	2136
Daily Factor	0	0	0.6	1.2	1.5	1.5	1.5	3.1	2.5	3.1	3.1	3.1	-
Total	0	0	22680	18413	3368	3368	12350	32485	159059	45248	0	0	296972

7.7.4 Traffic Generation

Investigation of the NSW RTA Guide to Traffic Generating Developments and other recognised trip generation documents shows there are no generation guidelines associated with prawn farms. As such, generation rates were based on employment numbers and the total production of prawns for the year.

7.7.4.1 Construction Phase

It is believed that during the construction phase of the development approximately 30 workers (4 contractors, 20 machine operators and 6 labourers) will be on site at any one time. During the construction phase (6 – 8 months), it is understood that all the associated heavy equipment will remain on site until the construction work is completed. Construction is normally during daylight hours only, unless delays require additional works to be undertaken to meet schedules. During the construction phase the majority of staff are expected to arrive on site before 7 am and leave after 3 pm. Construction is likely to be undertaken between March and October.

7.7.4.2 Operational Phase

Indicative staffing numbers, indicating the numbers and operating hours have been supplied by Pacific Reef Fisheries. It is understood there will be 80 fulltime staff to oversee the day to day farm operations (August – June). An additional 25 staff will be employed during the processing phase (December – June). It is intended that staff working hours will be staggered with the majority on operational staff beginning work at 7 am. During the processing operations an additional 15 staff will begin work at 8 am. It has been assumed that all workers will arrive separately.

Along with the on site workers, there will be a number of heavy vehicle movements associated with the transportation of the produce to Townsville. It is understood that the produce will be transported using refrigerated 6 axle articulated vehicles with a carrying capacity of 20 tonnes per vehicle. An estimate of the expected transport cycle of the produce is also given in Appendix R. It is expected that the produce will be transported off site 2 days per week. The heaviest period of transportation off site is expected to be between October and December.

Feed for the prawns will be transported onto the site also using 6 axle articulated vehicles with a carrying capacity of 20 tonnes per vehicle. It is understood that deliveries will take place on a weekly basis. An indicative level of feed required for the farm is shown in Section 4.4.5.

The peak generation for staff is likely to occur between 6:30 – 7:30 am and around 2:30 – 3:30 pm during normal operation. The worst case scenario is for the heavy vehicles carrying produce and feed products to arrive at the same time. We have assumed that the heavy vehicles will arrive and depart during the hour, again the worst case scenario.

- Vehicle Trips – Staff
  - am Peak – 27 In, 0 Out;
  - pm Peak – 9 In, 27 Out.

- Heavy Vehicle Trips – Produce
  - am Peak – 2 In, 2 Out;
  - pm Peak – 2 In, 2 Out.

- Heavy Vehicle Trips – Feed
  - am Peak – 7 In, 7 Out;
  - pm Peak – 7 In, 7 Out.

7.7.5 Traffic Volumes

Traffic volumes were derived from the Department of Main Roads – Northern District (DMR) AADT count; the site visit; and engineering judgment. These volumes were used in the analysis of the intersection of the Bruce Highway and Coventry Road to assess capacity of the intersection.

It has been assumed that the private vehicles are likely to come from all the neighbouring towns. We have assumed that the directional distribution split is 40/60 between north and south based on the distances to Ayr and Bowen respectively. All the heavy vehicles are destined for Townsville to the north of the proposed development.

During construction, the machine operators and the labourers begin at 7 am and finish at 3 pm, the likely peaks are 6:00 – 7:00 AM and 3:00 – 4:00 PM. The 4 contract workers begin and end their workday outside these times.

- Vehicle Trips – Construction Workers
  - am Peak – 26 In, 0 Out;
  - pm Peak – 0 In, 26 Out.

The associated construction phase traffic flows at the intersection of the Bruce Highway / Coventry Road / Nevada Road are shown on the SIDRA output included in Appendix R.

The analysis for the construction phase has assumed that approval would allow for work to begin in March 2004 and be completed by October 2004.

7.7.6 Future Traffic Volumes Without Farm

A background growth rate was supplied by DMR for the corresponding section of the Bruce Highway. This rate (1.26% p.a.) was applied to the historical volumes to predict future traffic volumes (2012 design year) without the prawn farm.

The future year 2012 (without development) traffic flows at the intersection of the Bruce Highway / Coventry Road / Nevada Road are shown on the SIDRA output included in Appendix R.

7.7.7 Future Traffic Volumes with Farm

Future traffic volumes, with the prawn farm fully developed (2012 design year), were derived by adding the traffic associated with the prawn farm to the future 2012 traffic volumes derived above.

The future year 2012 (with development) traffic flows at the intersection of the Bruce Highway / Coventry Road / Nevada Road are shown on the SIDRA output included in Appendix R.

Equivalent Standard Axles calculations were undertaken on both the future year without development and with development scenarios. As stated before calculations were done using methodology and factors from the Queensland Transport – Pavement Design Manual for a period 365 days. The future year 2012 without development scenario ESA calculations are tabled below in Table 7-29.

Table 7-29
Future Year 2012 without Farm ESA

Type	1	2	3	4	5	6	7	8	9	10	11	12	Total
Count	1734	207	117	48	7	7	26	33	198	45	0	0	2421
Factor	0	0	0.6	1.2	1.5	1.5	1.5	3.1	2.5	3.1	3.1	3.1	-
Total	0	0	25705	20870	3818	3818	13998	36819	180276	51283	0	0	336585

Based on the proposed levels of staffing, production cycle and feed deliveries the AADT increase in heavy vehicles is less than one (1) per day, in each direction, over the whole year. The future year 2012 with development scenario ESA calculations are tabled below (Table 7-30).

Table 7-30
Future Year 2012 with Farm ESA

Type	1	2	3	4	5	6	7	8	9	10	11	12	Total
Count	1944	207	117	48	7	7	26	33	200	45	0	0	2633
Factor	0	0	0.6	1.2	1.5	1.5	1.5	3.1	2.5	3.1	3.1	3.1	-
Total	0	0	25705	20870	3818	3818	13998	36819	182101	51283	0	0	338410

7.7.8 Intersection Requirements

The Guthalungra township is a rural environment and the intersection of the Bruce Highway / Coventry Road / Nevada Road will be required to meet the auxiliary turn lane warrants as prescribed in AUSTROADS Part 5 - Intersections at Grade. Based on the predicted turning volumes with the development in place, the right turn into Coventry Road would require Type C treatment while the left turn would require a Type B treatment.

Current Intersection Geometry:

- Northern Approach - Type C Right Turn (57m) and Type B Left Turn (150m);
- Southern Approach - Type C Right Turn (165m) and Type A Left Turn.

Based on Table 5.6 of AUSTROADS Part 5 - Intersections at Grade - Length of Deceleration Lanes, a right turn pocket of 170m must be provided for a vehicle to come to a complete stop prior to turning. As indicated above the existing right turn lane for vehicles entering Coventry Road (proposed site access) is approximately 165m. This measurement was taken during the site visit, and while not 170m it is considered adequate.

For a Type B left turn a deceleration lane a minimum length of 50 m is required. To decelerate from 100kph to 30kph to negotiate the left turn, 154m of lane must be provided. As discussed previously the existing geometry at the site includes a left turn lane of approximately 150m. On this basis the left turn is considered adequate to satisfy the turning lane requirements. Clearly the left and right turn treatments into Coventry Road meet all of the requirements as identified in AUSTROADS Part 5.

The treatment of turns into Nevada Road are not impacted on by the proposed development and have not been assessed in detail. These turns are not relevant to the subject development.

Based on the current and projected turning volumes and AUSTROADS Part 5 – Guide to Traffic Engineering Practice – Intersections at Grade, the intersection will not need any remedial works associated with the proposed development. The intersection has already been designed for the surrounding land uses and 100kph speed limit.

7.7.9 Pavement Requirements

From the calculations mentioned above, the increase in ESA's in the future from the proposed aquaculture project is less than 1%. Based on the Department of Main Roads – "Guidelines for Assessment of Road Impacts of Development Proposals" Section 5 – Pavement Impact Assessment, no pavement works are required as the increase in ESA's from proposed project will be less than 5%.

Currently Coventry Road is paved for approximately 100m from the Bruce Highway to the end of the Rest Area. The remaining section into the subject site is a formed gravel road. Based on the predicted traffic flows for the subject development it is considered that a well maintained fully formed gravel road be constructed as part of this approval. The costs associated with the provision of a sealed road in any form is not justified on the basis of traffic activity. To ensure that the road is well maintained it is desirable to have a maintenance schedule for the section of road between the highway and the proposed site.

7.7.10 Operational Assessment

While the intersection requirements have been based on turning traffic due to the rural environment, the assessment of the operation of the proposed access intersection of Coventry Road / Nevada Road was also undertaken. The impact of the development on the adjacent road network was assessed using standard "gap acceptance" parameters as described in AUSTROADS Part 5 - Intersections at Grade. This assessment included an analysis of the intersection of the Bruce Highway / Coventry Road / Nevada Road using SIDRA 1.0 and the standard gap acceptance parameters described above.

The analysis of the existing conditions indicates that the intersection operates with significant spare capacity as expected. The results from the analysis are listed in Table 7-31.

Table 7-31
Existing Intersection Operation

Movement Approach	Turning Flow (veh/hr)	Deg Sat'n (%)	Delay (secs)	Queue (m)
Peak				
Bruce Highway LT	1	0.067	9.7	0
Bruce Highway Thru	107	0.066	9.7	0
Bruce Highway RT	12	0.009	11.4	0
Coventry Road LT	12	0.030	11.5	1
Coventry Road Thru	1	0.030	11.5	1
Coventry Road RT	12	0.030	11.5	1
Bruce Highway LT	12	0.008	15.6	0
Bruce Highway Thru	107	0.065	9.6	0
Bruce Highway RT	1	0.000	10.1	0
Nevada Road LT	1	0.003	9.3	0

Movement Approach	Turning Flow (veh/hr)	Deg Sat'n (%)	Delay (secs)	Queue (m)
Nevada Road Thru	1	0.003	9.3	0
Nevada Road RT	1	0.003	9.3	0

The results in the table above clearly demonstrate that the intersection operates with significant spare capacity in its current form. The intersection degree of saturation is 0.067 in the Peak. The intersection is operating at Level of Service B.

The analysis for the construction phase has assumed that approval would allow for work to begin in March 2003. Analysis results are shown in Table 7-32 below. As indicated in the construction is expected to continue to October 2004. The operational assessment below is based on 2003 background traffic.

Table 7-32
Intersection Operation During Construction

Movement Approach	Turning Flow (veh/hr)	Deg Sat'n (%)	Delay (secs)	Queue (m)
Peak				
Bruce Highway LT	1	0.067	9.7	0
Bruce Highway Thru	108	0.066	9.7	0
Bruce Highway RT	31	0.024	11.4	1
Coventry Road LT	31	0.070	12.0	3
Coventry Road Thru	1	0.070	12.0	3
Coventry Road RT	25	0.070	12.0	3
Bruce Highway LT	25	0.016	16.0	0
Bruce Highway Thru	108	0.066	9.6	0
Bruce Highway RT	1	0.000	10.1	0
Nevada Road LT	1	0.003	9.5	0
Nevada Road Thru	1	0.003	9.5	0
Nevada Road RT	1	0.003	9.5	0

The results in the table above clearly demonstrate that the intersection operates with significant spare capacity in its current form. The intersection degree of saturation is 0.070 in the Peak. The intersection is operating at Level of Service B.

The analysis of the future conditions (without the prawn farm) indicates that the intersection still operates with significant spare capacity. The results from the analysis are listed in Table 7-33.

Table 7-33
Future Intersection Operation (Without Prawn Farm)

Movement Approach	Turning flow (veh/hr)	Deg Sat'n (%)	Delay (secs)	Queue (m)
Peak				
Bruce Highway LT	2	0.074	9.7	0
Bruce Highway Thru	121	0.075	9.7	0
Bruce Highway RT	15	0.012	11.8	0
Coventry Road LT	15	0.041	11.8	2
Coventry Road Thru	2	0.041	11.8	2
Coventry Road RT	15	0.041	11.8	2
Bruce Highway LT	15	0.010	16.0	0
Bruce Highway Thru	121	0.074	9.7	0
Bruce Highway RT	2	0.001	10.1	0
Nevada Road LT	2	0.007	9.6	0
Nevada Road Thru	2	0.007	9.6	0
Nevada Road RT	2	0.007	9.6	0

The results in the table above clearly demonstrate that the intersection operates with significant spare capacity in its current form. The intersection degree of saturation is 0.074 in the Peak. The intersection is operating at Level of Service B.

The analysis of the future conditions (with prawn farm) indicates that the intersection still operates with significant spare capacity. The results from the analysis are listed in Table 7-34.

Table 7-34
Future Intersection Operation (With Prawn Farm)

Movement Approach	Turning flow (veh/hr)	Deg Sat'n (%)	Delay (secs)	Queue (m)
Peak				
Bruce Highway LT	2	0.074	9.7	0
Bruce Highway Thru	121	0.075	9.7	0
Bruce Highway RT	31	0.023	11.0	1
Coventry Road LT	26	0.080	12.5	3
Coventry Road Thru	2	0.080	12.5	3
Coventry Road RT	30	0.080	12.5	3
Bruce Highway LT	34	0.024	17.5	0
Bruce Highway Thru	121	0.074	9.7	0
Bruce Highway RT	2	0.001	10.1	0
Nevada Road LT	2	0.007	9.7	0
Nevada Road Thru	2	0.007	9.7	0
Nevada Road RT	2	0.007	9.7	0

The results in the table above clearly demonstrate that the intersection operates with significant spare capacity in its current form. The intersection degree of saturation is 0.080 in the Peak. The intersection is operating at Level of Service B.

In conclusion, the traffic impacts of the proposed development on the State Controlled Road Network are negligible. The intersection will not require remedial works as it has already been designed in accordance with Austroads Part 5 – Intersections at Grade with right turn pockets and deceleration lanes. The intersection would operate with significant spare capacity in the future. The intersection has adequate sight distances and safety should not be an issue. No pavement works will be required based upon the Equivalent Standard Axles calculations detailed above.

7.8 Cultural Heritage

This material is discussed in detail in the Cultural Heritage Report which is a confidential document.

7.9 Impacts on Amenity

7.9.1 Aesthetics

The land to be developed, sited adjacent to the Elliot River, is relatively flat with a gradual fall from the southwest to the northeast. The mouth of the Elliot River is approximately 2km to the east of the main growout area. The levels across the site range from 2 m AHD to 8.5 m AHD. There are isolated areas of lower than 2m AHD where the land adjoins saltpans or tidal creeks. Vegetation across most of the lots is sparse. The majority of the land has previously been used for grazing cattle

There are several line of sight aspects to Cape Upstart. The first is from the Bruce Highway at Guthalungra. Another is from Coventry Road which is seldom used. The third line of sight to Cape Upstart is from Abbot Bay.

The pond banks will up to 6 m AHD. The main on farm seawater storage will have banks at 7m AHD. The ponds will be screened from both Coventry Road and the Bruce Highway by a grove of trees. The ponds are 1 - 2 km from the Bruce Highway and 2-3 km from Abbot Bay and will not be visible from either. A house is situated at the base of Cape Upstart. From this house, some ponds should be visible.

A small number of buildings including an administrative building, residential housing and processing plant will be constructed on the eastern side of Coventry Road. These buildings will be also be screened from Coventry Road by a grove of trees.

A 3m high fence will be constructed around the ponds. This fence will be also be screened from Coventry Road by planted trees.

The pipeline will be buried. The pump station is at ground level and is situated between the primary and secondary dunes and will not be visible. Several navigation aids will be constructed in Abbot Bay to protect the pipeline from being pulled up by trawlers. These aids will need to meet statutory requirements for navigational aids.

A community of shack owners lives on the southern banks of the Elliott River. They will not be able to see the prawn farm as the ponds are 1-2 km from the Elliot River and at least 3 m above the height of the Elliot Rive and the huts. The mangroves which line Nobbies Creek and are opposite the shacks on the Elliott River will remain undisturbed. Most of the remaining trees on the grazing property will be removed to build the ponds.

The area of the ox-box lake will remain untouched and is relatively well vegetated. The ox-box lake is the main area viewed by the shack owners also the Elliot River and continues the visual buffer along Nobbies Creek, the Elliot River and the ox-bow lake.

The impact of aesthetics on the surrounding area by the development should be minimal.

7.9.2 Signage and Lighting

There will be minimal signage and lighting onsite. A sign will be erected at Guthalungra on the Bruce Highway advertising the location of the prawn farm. Another Pacific Reef Fisheries sign will be erected on the security fence to the entrance of the farm. All regulatory signs will be erected in the appropriate manner e.g. HAZCHEM.

Lighting will be erected according to the Australian Standard - AS/NZS 1158.1.1:1997: *Road lighting - Vehicular traffic (Category V) lighting - Performance and installation design requirements*.

7.9.3 Visual Elements

a) Grow Out Ponds and Administration Precinct

The site is flat and is divided into two by the unsealed Coventry Road (see Figure 4-2). Ponds are to be built on the western side of the road while the processing plant and administration building will be situated on the eastern side of the road. The site is 1 - 2 km from the main highway and is not visible from the highway.

The majority of the area is low lying and is not visible from Abbot Bay. The pond area to be developed is approximately 3 km from Abbot Bay with a primary and secondary dune screening the site from Abbot Bay. The community on the southern side of the mouth of the Elliot River is between 1 – 2 km from the pond development area. The shack hut community is on the lower side of the Elliot River which restricts their line of vision to the development site.

The administration precinct and the growout pond area will also be screened with local plant species.

A 3m steel galvanized fence will enclose the development.

b) Landscaping Plan

Areas of the prawn farm to be landscaped include the frontage along Coventry Road; the administration precinct; and the sides of the individual prawn farm ponds.

Poplar Gum (*Eucalyptus platyphylla*) and Moreton Bay Ash (*Corymbia tessellaris*) will be planted alternatively along Coventry Road to partially screen the ponds.

Within the administration facilities area gardens will be planted using a range of local indigenous species at a density of 20:40:40 (understorey/shrubs/trees). The aim is to reflect the original vegetation type of the area.

Species to be planted within the garden beds include (Table 7-35):

Table 7-35
Species to be planted in garden beds

Layer	Species
Trees	Moreton Bay Ash (*Corymbia tessellaris*); Poplar Gum (*Eucalyptus platyphylla*); Dallachy's Gum (*C. dallachiana*)
Shrubs	Sally Wattle (*Acacia salicina*); Whitewood (*Atalaya hemiglauca*); Broad-leafed Paperbark (*Melaleuca viridiflora*)
Understorey	Barbed Wire Grass (*Cymbopogon refractus*); Bluegrass (*Dicanthium sericeum*)

One dwelling will have an outlook over the proposed development. The dwelling is located on higher ground near Cape Upstart over 5 km metres north of the proposed site. A farmhouse of a neighbour is approximately 2 km away.

The proposed development will have some visual impact on aircraft passengers in the vicinity, considering that the site plan incorporates approximately 250 hectares of grow out ponds.

The outlook from the administration area will be to Cape Upstart which is the dominate feature of the surrounding area. Saltpans will be visible from the pond areas.

c) Pipeline

Visual impacts associated with the pipeline will mostly be incurred during construction. The pipeline will cross a saltpan, a wetland, secondary and primary dune and beach. The general geology of the area is low coastal plain, with beach ridges occurring to the east with a large interdunal ephemeral freshwater swamp to the west.

The current land use of the area comprises extensive cattle grazing, and salt evaporators. Some very limited tourism has also occurred in the area.

Pipeline construction works will be visible from Coventry Road during construction for a period of six to eight weeks. Ocean pipelines will be buried and will not be visible after construction. The pipelines in Abbot Bay will be buried.

Construction of the in take pump station will be behind the primary dune and will therefore be partially hidden from Abbot Bay. The pump station will be essentially below ground and will therefore have minimised visual impact on the local environment.

7.9.4 Structures in the GBRMPA

To protect the pipeline from unwarranted damage, two buoys will be placed on the end of each pipeline. In particular, these aids are to restrict prawn trawlers from trawling across the pipeline.

7.9.5 Transportation

The volume of traffic will increase. This flow of traffic will occur in peak times of change in shifts. Trucks delivering feed and transporting prawns to market will the major traffic users. The neighbouring farmhouse will see this increased traffic. Dust control for the road will be undertaken as required.

7.10 Social and Economic

7.10.1 Positive and Negative Impacts

7.10.1.1 Economic Impact of the Project

a) Background - Queensland Aquaculture

A study undertaken by the Queensland State Government Office of Economic and Statistical Research OESR (Queensland Treasury 2001) found that in 1998/99, from a production value of $58m, the aquaculture industry contributed $37.5m both directly and indirectly to the Queensland economy in terms of gross state product. Gross state product is defined as output less the value of goods and services consumed in the production process, other than depreciation of fixed assets.

The study showed that industries that share significant linkages with aquaculture include finance, property and business services, wholesale and retail trade, and food manufacturing. Furthermore, the study also showed that the intensity of labour for the aquaculture industry as a whole is 12.4 FTE (Full Time Equivalent) jobs for every $1m of sales in 1996/97.

During 1998/99, the Queensland aquaculture industry directly employed 608 FTE persons with a further 205 full-time equivalent persons employed as a result of flow-on activity. The combined direct and indirect impact of aquaculture on Queensland household income during 1998/99 totalled $17.6m (OESR Queensland Treasury, 2001).

The aquaculture industry in Queensland is made up of a number of sectors. These sectors vary considerably in terms of size and structure. The OESR study was undertaken on the entire Queensland aquaculture industry. At that time, the prawn industry was responsible for 75% of the value of the industry. Given that the majority of aquaculture production in Queensland is from the farmed prawn sector it might have been assumed that the data generated would be a reasonable reflection of the prawn sector. However this may not be the case; the 25% of non-prawn production appears to have distorted the results of the study, particularly in terms of the employment levels.

The inefficiencies of the smaller aquaculture sectors appear to have skewed the employment levels. For example the data used in the report shows that 12 FTE were employed for every one million dollars of sales in the aquaculture industry, prawn farming in 1996-97 employed around 8 FTE for every one million dollars of production, and Pacific Reef Fisheries will be striving to achieve production with 6 FTE for every one million dollars of sales.

Never the less the figures from the report are provided here to give an indication of the flow on effects from aquaculture to the Queensland economy. Also, the data from the output model has been used to estimate the potential flow-on impacts from the Guthalungra project.

Table 7-36
The economic impact of aquaculture in Queensland, 1998/99

Sector	Value Added/Gross State Product*		Employment (Fte)		H'hold income	
	$m	%*	Jobs	%	$m	%
Aquaculture	25.3	67%	608	75%	11.3	64%
Finance, Property and Business Services	3.5	9%	51	6%	1.9	11%
Trade	2.1	6%	56	7%	1.5	9%
Food Manufacturing	1.7	5%	24	3%	0.9	5%
Government Admin					0.3	2%
Electricity Supply	0.9	2%				
Road Transport			10	1%		
Other Industries	4.0	11%	64	8%	1.8	10%
Total	37.5	100	813	100	17.6	100
Total /Direct	1.49		1.34		1.57	

Source OESR, Queensland Treasury, 2001

The ratio of flow-on to direct jobs indicates the number of flow-on jobs (FTE) that is generated for every direct job (FTE) in the Queensland economy. The ratio of 0.4 for the aquaculture industry suggests that on average for every direct job in the aquaculture industry, 0.4 of a job (FTE) is supported as flow-on in other industries (which can include aquaculture) in the Queensland economy. When compared with the poultry and pig industry it was shown that all three industries had relatively low ratios of direct to indirect employment in 1996-97 with poultry recording 1.1 and pigs 0.4 (OESR, Queensland Treasury, 2001).

b) The Economic Impact of Tuna Farming in South Australia

A socio-economic impact assessment of aquaculture has been undertaken by Primary Industries South Australia on an annual basis since 1998 (EconSearch, 2002). The South Australian Aquaculture industry is similar to the Queensland industry in that a single sector dominates production.

The South Australian study provided an assessment of economic impact in terms of Output as well as the Value Added or Gross State Product method of presentation adopted by Queensland Treasury. The assessment of the tuna industry in South Australia is given below as it provides a useful indication of the potential economic impacts of an aquaculture sector that is regionally focussed in one geographic area and has reached a significant critical mass. It is anticipated that the Guthalungra project will stimulate further aquaculture development in the dry tropics region and a locus of aquaculture related industries will develop. The economic benefits to the region would increase significantly and the economic impact may then be comparable with aquaculture in the lower Eyre Peninsula:

c) The economic impact of tuna farming in South Australia 2000/01

Table 7-37
The economic impact of tuna farming in South Australia 2000/01

Sector	Output		Value Added		Employment		H'hold income	
	$m	%	$m	%	Jobs	%	$m	%
Tuna Farming Direct	263.8	59	151.2	58	720	45	21.6	37
Fishing	62.1	14	51.5	20	226	14	10.3	18
Property and Business Services	22.4	5	14.4	6	68	4	3	5
Processing	37.6	8	10.1	4	135	8	6.2	11
Trade	13.9	3	6.7	3	154	10	4.3	7
Other Manufacturing	10.1	2	5.6	2	56	3	2.3	4
Transport	6.5	1	3.3	1	33	2	1.7	3
Finance	7.9	2	5.4	2	48	3	2.7	5
Other sectors	22.6	5	13.0	5	176	11	6.4	11
Total	446.9	100	261.2	100	1615	100	58.4	100
Total /Direct	1.69		1.73		2.24		2.71	

Source: EconSearch, 2002.

There are substantial economic impacts from the tuna farming industry in South Australia. Direct business turnover (output) generated in South Australia by tuna farms summed to almost $264 million in 2000/01. Flow-ons to other sectors added another $183 million in business income. The sectors most affected were the fishing, manufacturing, trade, business, and property services, and finance sectors.

For business turnover, the ratio of 1.69 indicates that for each dollar of sales generated by the tuna farming industry there is a total of $1.69 of business income earned by businesses throughout the state, $1 in the tuna farming industry and $0.69 in other sectors of the economy.

The net contribution to regional growth by the tuna farming industry was $151 million in 2000/01. Associated with this was flow-on value added in other sectors of the State economy of almost $110 million.

The tuna farms were responsible for the direct employment of approximately 720 people in 2000/01. Flow-on business activity was estimated to generate a further 895 jobs to give a total employment of approximately 1,615 jobs in the state. For each job generated directly in tuna farming there are an additional 1.24 jobs (2.24 jobs total) in the rest of the state.

It was estimated that personal income of $21.6 million was earned in the tuna farming industry in 2000/01, comprising both wages by employees and drawing by owner/operators. Wage and salary earners in other sectors of the state economy earned a further $24.2 million. For each $1.00 of household income generated directly by the tuna farms in 2000/01 there was an additional $1.71 ($2.71 total) generated in other sectors of the state economy.

The ratio of Jobs created per single industry job is much greater for aquaculture (2.5) in the Eyre region and Port Lincoln) compared to both grains and (2) and sheep industries (1.5). This implies that each extra job in aquaculture will have greater flow-on employment than will extra jobs in the traditional agricultural industries.

d) Employment Considerations

The South Australian tuna farming industry is centred around the fishing port of Port Lincoln on the Eyre Peninsula. EconSearch (1998) further reports that the South Australian aquaculture industry generates around 11 jobs (directly and indirectly) per million dollars of sales. This is similar to the grains industry but less than the sheep industry. The sheep figures are misleading because of the low price of sheep meat and wool.

e) Contribution of the Guthalungra Prawn Farm to the Gross State Product

The anticipated annual revenue of the Guthalungra operation is estimated at $29 million at full production in 2007/08. Table 7-38 below provides an indication of the economic impact of the operation.

Table 7-38
Estimated Economic Impact of the Guthalungra Prawn Farm Development on the Queensland Economy

Sector	Value Added/Gross State Product [a]		Employment (Fte)[b]		H'hold income[c]	
	$m	%	Jobs	%	$m	%
Guthalungra Prawn Farm Direct	11.00	67%	88	75%	2.80	64%
Finance, Property $ Business Services	1.52	9%	7	6%	0.47	11%
Trade	0.70	6%	8	7%	0.70	9%
Food Manufacturing	0.50	5%	4	3%	0.50	5%
Government Admin						2%
Electricity Supply	0.30	2%			0.30	
Road Transport			1	1%		
Other Industries	1.30	11%	9	8%	1.30	10%
Total	16.34	100	118	100	4.39	100
Total /Direct	1.49		1.34		1.57	

[a] Output less the value of goods and services consumed in the production process, other than depreciation of fixed assets. Percentages taken from OESR Queensland Treasury 2001. Direct prawn farm values from Guthalungra Prawn Farm Business Plan 2003.

[b] and [c] Percentages taken from OESR Queensland Treasury 2001. Direct prawn farm values from Guthalungra Prawn Farm Business Plan 2003.

The direct business turnover (output) generated by the Guthalungra is estimated at $29 million. Flow-ons to other sectors may add another $14.3 million to regional business income (total $43.3 million). The sectors most likely to be affected include manufacturing, trade, business and property services and finance sectors. It is anticipated that for each dollar of sales generated by the Guthalungra prawn farm there will be a total of $1.50 of business income earned by businesses throughout the state; $1.0 by Pacific Reef Fisheries and $0.5 in other sectors of the economy.

Gross state product or direct value added generated by the Guthalungra is expected to be around $11 million. Associated with this will be a flow on value added in other sectors of the economy of almost $5.3 million. Again, for each $1.00 of gross state product directly generated by the Guthalungra farm is likely to result in $0.5 ($1.5 total) in gross state product generated in other sectors of the State economy.

The Guthalungra prawn farm will be responsible for the direct employment of around 88 people (FTE'S). Flow on business activity from the operation (at full operation) may generate a further 30 jobs to give a total of around 118. For each job directly generated at the Guthalungra prawn farm there may an additional 0.34 jobs (1.34 jobs total) created.

It has been estimated that personal income of $2.8 million will be earned by Guthalungra employees and a further $1.6 million by wage and salary earners in other sectors or aquaculture businesses. For each $1.00 of household income generated directly by the Pacific Reef Fisheries Guthalungra prawn farm, an additional $0.6 (1.6 total) will be generated in other sectors of the State economy.

f) Guthalungra Impact on the Regional Economy

EconSearch (1998) indicated that the impact of a growing industry can be measured by the quality of the employment (skills required, career path opportunities etc) as well as the absolute number of jobs generated. Employment quality is reflected partly by income earned and this is shown to be relatively high in the aquaculture industry. Data for the aquaculture industry in the Eyre Peninsula in South Australia indicates a relatively high income earned by those working in aquaculture compared to the traditional agricultural industries.

Like many regional economies including the Bowen Shire, small rural towns are characterised by a heavy reliance on one or a small number of major industries, combined with a set of other fundamental activities that provide basic services and infrastructure to those industries. They lack the diversity and complexity of larger economic units.

The aquaculture industry has the potential to develop rapidly. Through its relatively large requirement of labour and material input, the industry has shown the potential to increase the complexity and diversity of local economies. The demand for local labour, goods and services has helped to offset the contraction of other local industry and has helped avoid the range of economic and social pressures associated with declining regional economies. In a similar way, Guthalungra has the potential to contribute significantly to the economy of Bowen Shire, and may provide a catalyst for further investment in aquaculture leading to the establishment of a substantial aquaculture industry in the area.

It has been found that the presence of a large industry or set of enterprises has considerable effects on the character of a local rural economy in which it is embedded. In the case of aquaculture development, the enterprise to support its own activities makes purchases of juvenile stock, feedstuffs other material inputs labour energy and services. Much of the expenditure from aquaculture businesses goes to persons and companies located in the region.

In summary, it is likely that the Guthalungra prawn farm will help to improve the economic base and the social stability of the shire. Prawn farming will remain a labour hungry, high-tech rural activity that depends on local goods and services for successful operation.

7.10.1.2 Construction Impacts

The following table (Table 7-39) gives an indication of the costs involved in the construction of the Guthalungra prawn farm. The source of contactors or services is highlighted to show that a high proportion of goods and services may be sourced locally.

Table 7-39
Capital Cost Estimates and Source of Goods or Services

Construction Costs		
Growout Ponds:	**Total Cost Estimate $M**	**Source of Goods or Services**
Earthworks		Local/Regional
Electrical		Local/Regional
Inlet		Local/Regional
Outlet		Local/Regional
Channels		Local/Regional
Drains		Local/Regional
Aeration		Regional/State
Bank reinforcement		Local/Regional
Gravel for roads		Local/Regional
Other		Local/Regional
Sub Total	13.5	
Water Supply:		
Main Supply Pumps and Pipe		Regional/State
On-farm Storages		Local/Regional
Lift Pumps		Regional/State
Sub Total	6.5	
Wastewater Treatment/disposal:		
Sedimentation Basins		Local/Regional
Sedimentation Aeration)		Regional/State
Wetland Treatment		Local/Regional
Re-use Pumps		Regional/State
Ocean Outfall Pump and Pipe:		Regional/State

Construction Costs		
Sub Total	7.0	
Ancillary Facilities:		
Processing Facilities		Local/Regional
Freezer Storage		Local/Regional
Feed storage/handling		Local/Regional
Machinery/workshops		Local/Regional
Office Accom		Local/Regional
Housing Facilities		Local/Regional
Power Supply		Local/Regional
Security Fencing		Local/Regional
Entrance Road Upgrade		Local/Regional
Plant and Equipment		Regional/State
Standby Power Generation		Regional/State
Potable Water Supply and Sewage Treatment		Local/Regional
Staff Training		Local/Regional
EIS/Approvals		Regional/State
Design/survey		Regional/State
Construction Management		Local/Regional
Sub Total	9.0	
Total	36	

7.10.1.3 Demographic Impacts

a) Population

There will not be a marked increase in the population of the Bowen Shire Council resulting from the establishment of the Guthalungra prawn farm. It has been estimated that over 75% of the staff could be employed locally from the local workforce given the comprehensive training program that Pacific Reef Fisheries is currently establishing.

It is likely that some of the managerial and technical staff will be employed from either interstate or overseas. For the purposes of estimating impacts, it is realistic to assume that around 50% (55) of staff members may be employed from outside of the Shire, moving to take up residence in the Shire. Assuming they are members of a household with an average household number (2.6 State Average, Census 2001), and move to the Shire, then the resident population of Bowen Shire may increase by around 140 individuals as a result direct employment at Guthalungra. In reality it will be less than this as these figures include casual staff.

Indirect employment may account for a further 40 jobs in the State, the majority of these will be based in the region. Again it may be assumed that 50% will move into the Shire from elsewhere resulting in an increase in the population of Bowen by 52. Therefore, based on the assumptions outlined the regional population may increase by up to 200 in total over a period six years.

An increase in the population of this magnitude is unlikely to put undue pressure on the infrastructure and services of Bowen Shire. However it will positively contribute to a reduction in the ongoing decline of the Shire population.

b) Age and Gender Structure

The ongoing changes to age and gender structure in Bowen Shire reflect the state and national trend for older populations with an increasing number of women making up the population. Again the population of Bowen is typical of rural regions in which the populations are aging at a quicker rate than urban centres.

The Guthalungra prawn farm may help to slow the trend towards an older overall population in Bowen however the impacts will be slight and transient as this is an overriding global trend.

c) People of Aboriginal and Torres Strait Origin

Pacific Reef Fisheries is currently negotiating a Memorandum of Understanding and Cultural Heritage Management Plan with the Traditional Owners of the area in which the prawn farm is to be located. It is envisaged that a proportion of the Pacific Reef Fisheries workforce will consist of people of aboriginal origin and these may include existing residents and individuals currently located outside the Shire. It is unlikely that Guthalungra will have any significant impact on the number of People of Aboriginal and Torres Strait origin living in the region.

d) Household Structure

Bowen Shire currently has a lower number of households with families with children than the State average and a higher number of families without children, or lone person households. Guthalungra may redress the balance with a number of young families with children moving to, or staying in, the region. However there is an overriding trend towards an older population in which there will be more lone parent families and families in which the children have left home.

e) Education Status

It will be essential for the senior staff at Guthalungra to be suitably qualified. For this reason it is likely that the number residents with graduate and post graduate qualifications will increase in the Shire. Pacific Reef Fisheries is implementing a training program at its existing prawn operation at Ayr in preparation for the establishment of Guthalungra. The training is linked to the National Seafood Industry Training Package and staff members will obtain vocational qualifications to diploma level. Therefore is may be assumed that the number of residents in the Bowen Shire with vocational qualifications will increase.

7.10.1.4 Social and Cultural Impacts

a) Regional Impacts

The establishment of a successful aquaculture enterprise in the region is likely to help to redress some of the community concerns regarding the economic future of the region (see below). Guthalungra is likely to contribute to a more positive economic outlook for the region. The establishment of a successful enterprise that fully integrates with the local community and is seen as part of the community will assist and relieve some of the negative attitude toward the economic future of Bowen currently harboured by some residents of the community, particularly those involved in cattle production and the fishing industry.

b) Community Concerns

Key themes of community concern identified from literature reviews and recent consultations include:

- A perception, based on recent experiences that major projects do not come to fruition;
- Need to protect the natural assets of the region and maintain the recreational lifestyle that utilises these resources;
- Environmental impacts must be managed;
- Suspicion of investment schemes (the demise of Seafood Online has soured some community members perception of aquaculture);
- Access to important cultural, environmental and recreational areas must be maintained;
- Mistrust of Government information; and
- Concerns over the pressures on traditional agricultural activity from declining commodity prices and tightening environmental regulation.

c) Environment

Community consultation highlighted concerns about the need to protect the local environment and appropriately manage natural resources. In particular, residents of the Shire and the region are keen to maintain the existing level of resource access that will enable long established recreational activities such as fishing and boating to continue.

The establishment of Guthalungra will not interfere with the land use, resource, lifestyle or recreational values considered important by the local population. There will not be any interference with existing access to coastal resources, nor visual amenity. The environmental impacts of the proposal are discussed extensively elsewhere in the EIS however, given the importance placed on the maintenance of the social and economic fabric of the community, it is expected that the local community will continue to be supportive of the proposal provided the management and mitigation measures seek to minimise any environmental impacts.

d) Community Confidence

The region is experiencing considerable change, particularly with respect to population movements and the restructuring of the agricultural and fishing sectors. This situation is putting demands on the community and the testing ability of individuals to adapt and respond to the social and economic changes taking place. Some individuals expressed a lack of confidence in the future economy of the Shire.

There have been several proposals for new businesses or large infrastructure projects in the area that have not materialised. In particular the State Government and Bowen Shire Council have been actively attempting to promote aquaculture development. Despite the identification of Bowen Shire as having considerable potential for aquaculture development, there has been very little investment. The public demise of Seafood Online, has shaken local confidence in aquaculture. Constant disappointment about major projects, which were expected to lift the economy of the region, may have contributed to a negative perception about future economic opportunities in the area.

Also, the neighbouring shires of Whitsunday, Mackay and further north, Townsville are experiencing substantial economic growth. This too is impacting on local sentiment.

e) Impacts on Leisure and Recreation

No negative impact on leisure or recreational activities in the region is foreseen.

7.10.2 Impacts on Current Land Use, Human Service Delivery and Potential Conflicts

7.10.2.1 Impacts on Current Land Use

The Guthalungra development site has been extensively cleared and used for grazing for over 100 years. The property is freehold and was purchased from an immediate neighbour for the purpose of prawn farming. It is not envisaged that there will be any negative environmental impacts that will effect neighbouring freehold or leasehold properties or effect for the purpose they are currently used i.e. cattle grazing economic or social impact on the. There will be no impact on amenity or quality of life for those living adjacent to the development site.

The potential impacts on current land use in the near vicinity of the development site are considered in detail in the sections outlined below:

- Noise
  - Refer Section 7.4;
  - Noise levels will adversely impact on adjacent land holders.
- Amenity
  - Refer Section 7.9;
  - The roads and access to the site will be upgraded to accommodate the additional traffic;
  - Trees will be planted extensively around the site, they will provide a barrier between Coventry Road and the operation;
  - The external perimeter of the property will be fenced and the boundary between the fence and operations planted to reduce external vision to the operation. Also, the elevated (approx 2m) water channels surround the ponds will mean that very little is seen of the operation.
- Odour
  - Refer Section 7.5;
  - Odour will not be detectable from the operation.
- GQAL
  - Refer Section 6.8;
  - Despite the area not having been designated a GQAL area, the development conforms to the State policy 1/98 and the objectives and intent of the Bowen Shire Council Planning Scheme.

- Ground Water
  - Refer Section 7.1;
  - The soil types, design and current ground water configuration are such that the will be no impact on ground water supplies to adjacent properties.
- Birds
  - Refer Section 7.3;
  - The profile of birds that may be attracted to prawn farms are not going to adversely affect the adjoining properties agricultural activities.
- Surface Water Flows
  - Refer Section 7.1;
  - The development has been designed to maintain surface water flows regardless of the flood event; therefore there will be no adverse impact.

7.10.2.2 Human Service Delivery

The increases in population in the Bowen Shire resulting from the prawn farming operation are not expected to put Government services under additional pressure.

7.10.2.3 Conflicting Uses of Land and Sea

Land

The Guthalungra prawn farm development is consistent with the objectives and intent of the Bowen Shire Planning Scheme as outlined in Section 6.8.

The cultural heritage issues raised by Traditional Owners during EIS have been discussed in detail in the Cultural Heritage Report (Confidential Report).

The possible areas of conflict over land use identified in this study include those related to:

a) Access to the Development Site by Third Parties:

The development site is located on freehold land and access to the operational areas will be restricted and the production area fenced. This is not considered unreasonable given the value of the product farmed and the need to maintain security. However provision will be made for access by Traditional Owners to areas of cultural importance. Also, discussions have been undertaken with neighbours regarding the movement of cattle over various parts of the property. Where practical requests from neighbours to transfer cattle through the development property will be accommodated.

b) Access through the Site by Third Parties:

Coventry Road runs north between Lot 8 and lot 370 toward Cape Upstart. This is a gazetted road that is used by the Cape Upstart Station for access to their property. The road also provides access to the Cape Upstart National Park. Pacific Reef Fisheries will not restrict access along Coventry Road.

c) Buried Intake/Discharge Pipeline Route:

The proposed pipeline route crosses two adjacent properties. After leaving the development site it will cross land over which a special lease held by Cheethams Salt. Cheethams Salt is a subsidiary of Ridley Corporation. Pacific Reef Fisheries representatives are in the process of negotiating the terms of an easement across a section of the adjacent salt pan for the pipeline route.

It is proposed that the pipeline will be buried beneath Coventry Road adjacent to a neighbouring property for around 2 km, it then follows another road reserve to the beach across the adjacent freehold property which is part of the Cape Upstart Station. The pipes will be buried below the road reserves from the boundary of the Cheethams Salt lease to the pump station. Qualified support has been obtained from the Bowen Shire Council for the placement of the pipes below the road reserves.

Pacific Reef Fisheries will require access along the road reserves on an ongoing basis. Application will be made for the construction of a low impact access track across the road reserve that lies perpendicular to Coventry Road.

The pump station will be located at a position between the primary and secondary dune in the road reserve. Application will be made to the Department of Natural Resources and Mines for a permit to occupy. Details of this facility are given in Section 4.

The owners of the Cape Upstart Station have placed on record through a response to the public notification of the EIS Terms of Reference that the use of road reserves for the laying of pipelines is an unacceptable use of road reserve. The matters raised by the Station owners have been addressed through the EIS and the ability for council to authorise the construction of pipes below a road reserve is addressed in the Local Government Act 1993 Chapter 13 Part 2, Division 1; 902 (1).

Pacific Reef Fisheries representatives have made numerous attempts to engage the owners of the Cape Upstart Station. The early concerns of the owners have been addressed as part of this study and it is proposed that that there will be no lasting adverse environmental impacts of either the buried pipeline or the track after the initial disturbances during construction. It is proposed that the pipeline route will be fully rehabilitated within 12 months of construction.

d) Environmental Values

The potential for conflict over the land use of adjacent properties with recognised environmental value is addressed throughout Section 7.

Water

Conflict with recreational or commercial users of the Elliot River or Abbot Bay is unlikely to occur. There will be no access restrictions placed on users of the waterways as a result of the establishment of the prawn farm. It is envisaged that a marker buoys will be placed at the intake and discharge points of the pipeline in Abbot Bay and the structures marked on charts as appropriate however neither the buoys nor the pipelines are expected to create conflict with waterway users.

Conflict is not envisaged with the Traditional Owners or the Native Title claimants regarding the proposal.

7.10.3 Use of Australian Goods and Services

Pacific Reef Fisheries has adopted an internal purchasing policy which relates to the use of goods and services supplied by local suppliers:

Pacific Reef Fisheries will preferentially purchase from local (and regional) suppliers provided the price and quality of the goods or services supplied are comparable with those available elsewhere.

7.10.4 Industry Opportunities

Prawn farming is reliant on a range of goods and services, from equipment supplies, and financial services through to construction and transportation. Inevitably there will be many opportunities for local businesses to be involved in the Guthalungra development. A more detailed discussion of the flow-on effects of the development is provided in Section 7.10.1.

7.10.5 Revenue Value

Refer to Table 7-40 Pacific Reef Fisheries Value of Sales.

Table 7-40
Pacific Reef Fisheries Value of Sales

	02/03 ($m)	03/04 ($m)	04/05 ($m)	05/06 ($m)	06/07 ($m)	07/08 ($m)	08/09 ($m)	09/10 ($m)	10/11 ($m)	11/12 ($m)
Alva Beach	7	9	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
Guthalungra	-	-	5.7	12.5	18.9	25.7	29.2	29.2	29.2	29.2
Total Production	7	9	16	22.8	29.2	36	39.5	39.5	39.5	39.5

7.10.6 Impacts on the Livelihood of Other Industries, Operators and Users

The following outlines the likely impact on of the Guthalungra operation on the livelihood of other industries Operators and Users.

7.10.6.1 Impact on local agricultural crops due to the attraction of birds and other native species

Land use in the near vicinity of the proposal is rural grazing. Gumlu, the nearest concentration of horticultural activity, is approximately 15km away. A discussion of the potential impacts from bird activity is given in Section 7.2. The species of birds attracted to prawn farms is limited to saltwater species that are predominantly fish feeders. Farm management practices will ensure that waste from processing and farming is adequately removed therefore the incidence of scavenging birds is likely to be minimal.

Additionally, a combination of measures will be put in place to deter bird activity on the production site. Therefore it is envisaged that there will be no adverse impacts on neighbouring cattle or horticultural activities, and consequently no impact on the livelihood of adjacent land users from birds attracted to the Guthalungra site.

It is unlikely that other native species attracted to the site will be considered a pest to either the prawn farm or adjacent landholders.

7.10.6.2 Dust on Adjacent Crops

The management procedures to minimise dust during the construction of the operation is detailed in Section 4. During construction water will be sprayed where required to minimise dust movement. Coventry road will be upgraded and resurfaced with crushed rock to improve durability and reduce dust. Pond banks will be lined with rock and external banks and canal walls will be revegetated. Trials may be undertaken with salt resistant grass. Extensive landscaping and planting will reduce dust movement across the development site.

7.10.6.3 Impact on the livelihood of commercial operators

It is not envisaged that the establishment of Guthalungra operation will compromise any operator in any industry. A number of local and regional businesses will benefit considerably from the establishment of the prawn farm at Guthalungra. For example, it is likely that the increase in traffic entering and leaving Coventry Road will substantially increase the number of customers at the roadhouse/service station at Guthalungra.

The Guthalungra prawn farm will not adversely impact on the local fishing industry see Section 7.3, nor the tourist industry in the region. Further details regarding the impacts of the development on visual amenity are outlined in Section 7.9 - Aesthetics.

The likelihood of any impact from equipment failure, pipeline break, storm damage, or pond seepage on the livelihood of adjacent operators is not envisaged (Refer to Sections 7.1 and 7.2)

The operation will be constructed taking account of the 1/100 flood event and the subsequent impacts that this may have on elements of the operation see Section 7.1.

7.10.6.4 Aboriginal and Torres Straight Islander traditional and contemporary uses of the land and sea

The region has been identified as having significant cultural values to the traditional owners. The potential impacts of the construction and operation of the Guthalungra prawn farm development have been thoroughly investigated with the Traditional Owners. Discussions with the Gudjuda Reference Group were initiated in September 2001 and have resulted in the preparation of a Cultural Heritage Report that includes a range of recommendations. At the Traditional Owners request the Cultural Heritage Report is not included for public comment.

The Traditional Owners and Pacific Reef Fisheries are drafting a Memorandum of Understanding that will establish traditional owner involvement in the operation. It is envisaged that the agreement will enhance the Traditional Owners level of access and usage of the region beyond their current level.

7.10.6.5 Recreational users of land and sea including tourism

There will be no adverse impacts on the livelihood of recreational users of the area or on the local tourist industry.

The mouth of the Elliott River is an area of relatively high recreational use, particularly by the inhabitants of the residential huts located in the vicinity. The huts are located on the southern bank of the River. The Guthalungra prawn farm development located some distance to the north of the opposite river bank and will not impinge on the activities, access, of visual amenity of the recreational users of the Elliott River, the National Park or the beaches of Abbott Bay.

The prawn production ponds on Lot 8 are a considerable distance from the Elliott River (approx 1.5 km) and there are dense areas of vegetation in between. A small section of Lot 370 will be developed for settlement ponds however the majority of the Lot will remain intact and there is no intention to develop the land. An area of remnant vegetation will be maintained in the vicinity of the ox bow lake, and the rehabilitation of the land adjacent to Nobbies Creek and the Elliot River will be undertaken.

Access to the Cape Upstart Station and beyond to Cape Upstart National park will not be impeded. The raised external water distribution canals and water storage areas around the periphery of the ponds at the northern end of Lot 8 will ensure that the ponds will not be visible from Coventry Road. Visual amenity is fully discussed in Section 7.9.

7.10.6.6 Local and State Fisheries

There will be no adverse impacts on the livelihood of local or state fishers either in terms of employment or economic value of their operations.

The data presented in the Australian Prawn Market Analysis undertaken for the Australian Prawn Farmers Association by Ruello and Associates 2002 show that there is considerable scope for domestic farmed prawn production to replace imports from overseas. Australian aquaculture product has not adversely impacted on the price of local wild caught prawns to date. Experience of other aquaculture industries would suggest that farmed production tends to have the effect of bolstering rather than reducing the price of comparable wild caught products. As the farmed product becomes more and more commonplace and the wild caught product more scarce (in relative terms) a higher price is likely to be paid for the wild caught product.

Generally, Australian wild caught prawns are becoming less commonplace in the market with lower catches and a higher proportion going to export. As a result domestic wild product is commanding higher prices as supply declines. This trend is likely to continue.

There is no evidence to indicate that prawn farms operating in Australia have had any detrimental impact on fisheries resources. The diseases encountered on Australian prawn farms to date are naturally occurring in wild populations. The diseases encountered on prawn farms have been transferred from wild to farmed stocks rather than visa versa.

The tiger prawns currently grown on Australian prawn farms have not been genetically modified and until broodstock domestication becomes established virtually all the tiger prawns produced will be the offspring of wild caught broodstock. Once the life cycle is closed measures will be put in place to ensure the genetic diversity of farmed stock.

The broodstock caught each year for the Australian prawn farm industry represents a fraction of the total harvest of the fishery harvested for human consumption. Fishermen are issued special permits to harvest broodstock for prawn hatcheries during the annual northern trawl fishery closure (15 Dec to 1 March). The requirement of the Guthalungra development for additional broodstock is not considered to pose any threat to the wild fishery stocks.

It should be noted that wild catches of a number of species of prawn along the east coast of Queensland are highly variable and heavily influenced by seasonal weather patterns see Section 7.6.7.

The discharge and intake pipe structures will be located around 400 m offshore. It will be necessary to mark the structures to ensure that vessels do not trawl across the pipes or structures and cause damage. The small area that will be removed from trawling is not considered an unacceptable burden on the potential activity of the trawl sector.

7.10.6.7 Impacts on adjacent industries reliant on groundwater extraction

This topic is discussed in some detail in Sections 7.1. There will be no adverse impact on underground water supplies resulting from the establishment of the prawn farm and therefore no impact on water supplies to adjoining properties or livelihoods as a result of the development.

7.10.7 Number and Source of Workforce

7.10.7.1 Workforce Numbers

The following table (Table 7-41) is taken from the Guthalungra Prawn Farm Business Plan and provides an indication of the total numbers of staff (by occupation) that will be employed each year by Pacific Reef Fisheries to assist with the construction and to undertake the operation of the farm. The table does not include staff employed by contractors or flow on employment.

Table 7-41
Total farm number of staff employed in the construction and operation of Guthalungra.

Position	Stage 1 2004	Stage 2 2005	Stage 3 2006	Stage 4 2007*
General Manager	1	1	1	1
Production Manager	1	1	1	1
Production				
Farm Manager	1	1	1	1
Husbandry Manager	2	3	4	5
Pond Manager	4	6	8	10
Environmental Technician	2	3	4	5
Pond Technician	4	6	8	10
Farm hand	8	12	16	20
Casual Pond Staff	8	12	16	20
Maintenance				
Manager	1	1	1	1
Mechanics	1	2	2	2
Electricians		1	1	1
Offsiders	2	2	3	5
Administration				
Accounting	1	1	1	1
Gen Admin	1	1	2	3
Marketing				
Manager	1	1	1	1

Position	Stage 1 2004	Stage 2 2005	Stage 3 2006	Stage 4 2007*
Marketing Support			1	1
Processing				
Processing Manager	1	1	1	1
Senior Hand	1	1	1	1
Casual Process Staff	10	10	15	20
Total Staff	50	66	88	110
Total Perm Staff	32	44	57	70
Total casual Staff	18	22	31	40

* Ongoing

A significant number of new staff will be required each year. The following table (Table 7-42) is taken from the Guthalungra Prawn Farm Business Plan and provides an indication of the new or additional positions that will be required each year for both Alva Beach (the existing Pacific Reef Fisheries farm located at Ayr) and Guthalungra. Many of the positions will require training. The Alva Beach operation will reach its full complement of staff in 2004.

Table 7-42
Additional staff required each year for Alva Beach and Guthalungra

Position	2003	2004	2005	2006	2007	2008	Total
Production Manager		1					1
Farm Manager		1					1
Husbandry Manager	1	2	1	1	1	1	7
Pond Manager	1	4	2	2	2		11
Environmental Technician	1	2	1	1	1		6
Pond Technician	1	4	2	2	2		11
Farm Hand	2	8	4	4	4		22
Casual Pond staff	2	8	4	4	4		22
Maintenance Manager		1					1
Mechanic		1	1				2
Electrician			1				1
Offsiders	1	2		1	2		6
Accounts Officer	1	1					2
General Admin		1		1	1		3
Marketing Manager	1						1

Position	2003	2004	2005	2006	2007	2008	Total
Marketing assistant	1			1			2
Processing Manager		1					1
Processing senior Hand	1	1					2
Casual Processing staff	15	10		5	5		35

The most critical time for the development of the Pacific Reef Fisheries business in terms of sourcing and employing new staff will be in 2004 in preparation to commission and operate the first stage of the Guthalungra site. Senior staff may be employed in the year prior to the commencement of production (2003) to assist with construction, training and overall farm preparation.

7.10.7.2 Staff Availability and Source

The proposed development will employ around 110 people when completed; around 70 of these will be full time positions. Of these around 12 will be senior management positions requiring specialist qualifications and considerable experience. Given the strong technical and managerial base of the resident (regional) population, it is highly likely that some of these positions will be filled locally. Around 65 staff will be required for jobs for which training and experience will not be a prerequisite of employment. These staff may be employed locally.

Around 25 staff positions will require some specialist training and experience prior to undertaking the role. These staff may be sourced locally, nationally or internationally.

The initial development of the farm (2003/04 intake) will require that specialist staff will be employed from various parts of Australia and the world. However a significant proportion of untrained and inexperienced staff will be required, it is anticipated that the majority of these positions will be filled locally. The proportion of local staff employed will increase as the farm becomes established. The temporary pond, processing and construction staff will be sourced locally.

Given the size of the Guthalungra prawn farm proposal, the number of jobs created and the ongoing population decline in Bowen it is envisaged that there will be some stabilisation of the local workforce resulting from the proposal.

Historically, there has been a higher incidence of staff with qualifications working in aquaculture operations than traditional agricultural activities, and this has tended to result in a higher average rate of pay for aquaculture workers (Econsearch, 2002).

7.10.8 Training Needs and Skill Development

Construction

Skilled and experienced subcontractors will undertake the construction of the farm. The majority of components of a prawn farm utilise well-established construction techniques and there are a number of well qualified, regionally based, companies capable of undertaking the tasks required. Specialist construction and engineering services will be required for some components of the operation. Again, the subcontractors will provide qualified personnel to undertake these tasks.

Pacific Reef Fisheries staff will be required to oversee construction and there are a number of elements of the construction that will be undertaken by farm staff. Casual staff may be employed to assist with these tasks.

Appropriate induction training will be given to those casual staff employed in construction tasks however it is envisaged that those employed will have the necessary skills and experience to carry out the job required.

Operation

The training and skills development needs of the organisation is detailed in the Guthalungra Prawn Farm Business Plan, in summary, an extensive training program has been established for the existing prawn operation at Alva Beach in association with state based training providers utilising the National seafood Industry Training Package.

The National Seafood Training Package comprises a series of units or competencies that can be gathered to form qualifications ranging from Certificate I (farm hand - school leaver/industry entrant) to Diploma or Higher Diploma (manager/owner).

The program will be used to train staff employed at the Guthalungra farm. In brief, a suite of units has been chosen from the Seafood Training Package at each qualification level. On-the-job training and skills recognition programs will be put in place to enable staff to achieve competency in each unit and ultimately obtain the relevant qualification. Staff performance appraisals and remuneration will be linked to the training program.

Tables 7-43 to 7-46 list the units in which staff will be expected to achieve competency during employment at Guthalungra. Each position on the farm has a program of units in which they will be expected to achieve competency. Staff will undertake a combination of on-the-job and external training to achieve these competencies. Where possible, local training providers will be used.

Table 7-43
Staff Training – Farm Hand Level 1

SITP Certificate II Qualification	
Farm Hand Level 1	
Common Industry Core Units	
SFICORE101A	Apply basic food handling safety practices
SFICORE102A	Carry out work effectively in the seafood industry
SFICORE103A	Communicate in the seafood industry
SFICORE104A	Meet workplace health and safety requirements
Aquaculture Core Units	
SFIAQUA202A	Control pests, predators and diseases
SFIAQUA206A	Handle stock
SFIAQUA207A	Harvest stock
SFIAQUA208A	Maintain stock culture and other aquaculture operations structures
SFIAQUA209A	Manipulate stock culture environment
SFIAQUA101A	Carry out basic aquaculture operations

SITP Certificate II Qualification	
RUHHRT212A	Apply chemicals and biological agents
Aquaculture Elective Units	
SFIAQUA205A	Feed stock
SFIAQUA210A	Operate and maintain plant and equipment
SFIAQUA213A	Monitor stock and environmental conditions
SFIAQUA308A	Maintain water quality and environmental monitoring
SFIAQUA204A	Carry out on-farm post-harvest handling
Other Elective Units	
RUAAG2133EMA	Perform routine maintenance
TDTA1097A	Operate a forklift
THHBHO2A	Clean premises and equipment
RUAAG2100EOA	Operate ride-on farm vehicles

Table 7-44
Staff Training – Farm Hand Level 2 and Technician Level 1

SITP Certificate III Qualification	
Farm Hand Level 2 and Technician Level 1	
Common Industry Core Units (May have already been completed in earlier course)	
SFICORE101A	Apply basic food handling safety practices
SFICORE102A	Carry out work effectively in the seafood industry
SFICORE103A	Communicate in the seafood industry
SFICORE104A	Meet workplace health and safety requirements
Aquaculture Core Units	
SFIAQUA206A	Handle stock
SFIAQUA208A	Maintain stock culture and other aquaculture operations structures
SFIAQUA209A	Manipulate stock culture environment
SFIAQUA101A	Carry out basic aquaculture operations
RUHHRT212A	Apply chemicals and biological agents
SFIAQUA213A	Monitor stock and environmental conditions
SFIAQUA301A	Oversee and undertake effluent and waste treatment and disposal
SFIAQUA303A	Coordinate stock handling activities
SFIAQUA304A	Oversee the control of predators, pests and diseases
SFIAQUA305A	Optimise feed uptake
SFIAQUA308A	Maintain water quality and environmental monitoring
SFIAQUA310A	Oversee emergency procedures in an aquaculture enterprise
SFIOHS301A	Implement OHandS Policies and Guidelines

SITP Certificate III Qualification	
Aquaculture Elective Units	
SFIAQUA306A	Oversee production and maintain algal and live-feed cultures
SFIAQUA307A	Select and supervise the use of chemicals and biological agents in an aquaculture operation
SFIAQUA309A	Oversee harvest and post-harvest activities
Other Elective Units	
BSFXMI301A	Manage personal work priorities and professional development
BSFXMI305A	Manage operations to achieve planned outcomes
BSFXMI304A	Participate in, lead and facilitate workplace teams

Table 7-45
Staff Training – Technician Level 3 and Pond Manager Level 2

Stage 1 Management Training	
(also qualifies for SITP Certificate IV Qualification)	
Technician Level 3, Pond Manager Level 2	
Common Industry Core Units (May have already been completed in earlier course)	
SFICORE101A	Apply basic food handling safety practices
SFICORE102A	Carry out work effectively in the seafood industry
SFICORE103A	Communicate in the seafood industry
SFICORE104A	Meet workplace health and safety requirements
Aquaculture Core Units	
SFIAQUA401A	Supervise a stock health program
SFIAQUA402A	Coordinate construction/installation of stock culture and farm structures
SFIAQUA403A	Supervise stock production
SFIAQUA405A	Develop emergency procedures for an aquaculture enterprise
SFIAQUA407A	Coordinate sustainable aquaculture practices
SFIAQUA305A	Optimise feed uptake
SFIAQUA309A	Oversee harvest and post-harvest activities
SFIOHS301A	Implement OHandS Policies and Guidelines
RUHHRT331A	Maintain an office
RUAAG4205BMA	Budget for farm production
RUHHRT426A	Develop teamwork
Aquaculture Elective Units	
SFIAQUA408A	Supervise harvest and post-harvest activities
RUAAG4206BMA	Maintain effective working relationships
THHGLE06A	Monitor staff performance

Other Elective Units	
RUHHRT418A	Supervise staff
RUAAG3202BMA	Organise human resources
THHGLE05A	Roster staff

Table 7-46
Staff Training –Pond Manager Level 3 and Husbandry Manager Level 1

Pond Manager Level 3, Husbandry Manager Level 1	
(also qualifies for SITP Diploma Qualification)	
Must have completed Stage 1 Management Training	
Common Industry Core Units	
(already completed in earlier course)	
Aquaculture Core Units	
SFIAQUA501A	Develop a stock nutrition program
SFIAQUA502A	Develop and implement an aquaculture breeding strategy
SFIAQUA503A	Establish an aquaculture enterprise
SFIAQUA504A	Plan ecologically sustainable aquacultural practices
SFIAQUA505A	Plan stock health management
SFIAQUA506A	Develop a stock production plan
SFIAQUA507A	Plan and design water supply and disposal systems
SFIAQUA508A	Plan and design stock culture systems and structures
SFIOHS501A	Establish and Maintain the Enterprise OHandS Program
RUHHRT513A	Manage business operations
RUHHRT602A	Develop a business plan
RUAAG6206BMA	Manage human interaction
RUAAG5201BMA	Market products
Aquaculture Elective Units	
RUAAG5203BMA	Rural business planning
RUHHRT604A	Manage human resources
Other Elective Units	
THHGLE07A	Recruit and select staff
RUHHRT422A	Operate within a budget framework
THHGLE20A	Develop and update the legal knowledge required for business compliance
BSFXMI501A	Manage personal work priorities and professional development
BSFXMI502A	Provide leadership in the workplace
BSFXMI503A	Establish and manage effective workplace relationships
BSFXMI504A	Participate in, lead and facilitate workplace teams
BSFXMI505A	Manage operations to achieve planned outcomes

7.10.9 Accommodation Requirements

It is intended to construct three family sized houses on site at Guthalungra. The houses will be located near to each other in the vicinity of the Administration block (refer to Section 4 for a further description of the houses).

These houses will be for the use of the families of the Maintenance Manager, the Production Manager and the Processing manager. There will be no other accommodation on site during the operation of the farm. There may be limited temporary accommodation on-site during construction (refer to Section 4)

Staff employed at Guthalungra will be expected to make their own accommodation arrangements. It is likely that the majority of staff will choose to locate in or around Bowen where they will find a large range of temporary accommodation, a full spectrum of rental accommodation and real estate.

The demands for additional accommodation by staff of the prawn farm will not put undue pressure on the rental or real estate market in the region. Bowen is well serviced with temporary accommodation (see section 6.7) largely as a result of the high use of itinerant workers in the horticultural sector, and the seasonal nature of the tourist industry. The majority of casual staff will be required at Guthalungra at a time that coincides with a drop in tourist numbers.

It is possible that at full production (2007/08), around half of the casual staff are permanently resident in the region and up to 50 of the 70 permanent positions will have been filled by local residents. Under this scenario around 20 permanent staff would have moved to the shire and around 20 casual staff, which may be transient, could be seeking local temporary seasonal accommodation. This possible influx of personnel will not unduly affect the Bowen Shire property market.

It should be noted that the number of casual staff used by the operation will reduce over time.

7.10.10 Social and Economic implications of Natural Hazards

The Guthalungra facility has been designed taking into account the impact of a cyclone on the area. It is anticipated that a level of superficial damage to the operation will occur during a cyclone however cyclones pose not threat to the ongoing viability of the project. It may be assumed that the consequential implications of natural hazards in terms of stock loss, irreparable damage and possible job loss are remote.

7.11 Impacts on World Heritage Values

The development site is located adjacent to, and will discharge into, the Great Barrier Reef World Heritage Area (GBRWHA). The Great Barrier Reef World Heritage Area is the largest World Heritage Area in the world and one of just a few that meet all four natural World Heritage criteria:

Criterion (i)	An example of a major stage in the earth's evolutionary history
Criterion (ii)	An outstanding example of geological processes, biological evolution and people's interaction with their natural environment.
Criterion (iii)	A place with unique, rare and superlative natural phenomena.
Criterion (iv)	A place that provides habitats for rare and endangered species of plants and animals.

Within the Great Barrier Reef World Heritage Area (GBRWHA) particular emphasis is placed on the conservation of threatened species such as dugong, marine turtles, dolphins and whales. About 98% of the World Heritage Property is within the Great Barrier Reef Marine Park, the remainder being Queensland waters and islands. The Great Barrier Reef Marine Park was declared in 1975 with the purpose of preserving the area's outstanding biodiversity whilst providing for its reasonable use.

The prawn farm site and the adjacent area meets Criterion (ii), (iii), and (iv) as identified in Table 7-47 below.

Table 7-47
World Heritage Values of the proposed site

Criterion	World Heritage Values
Criterion (ii)	The diversity of fauna and flora including: Marine reptiles; Marine mammals; Terrestrial vertebrate fauna; and Feeding grounds for international migratory seabirds and sea turtles.
Criterion (iii)	Superlative natural phenomena including: Migrating whales, dolphins, dugong, whales sharks, sea turtles, seabirds and concentrations of large fish.
Criterion (iv)	Habitats for species of conservation significance including: Seagrass beds; Mangroves; and Species of plants and animals of conservation significance.

Even though Abbot Bay meets these criteria and contains high conservation value, other areas in the Great Barrier Reef World Heritage Area (eg. Upstart Bay), have greater significance in relation to the World Heritage criteria. In particular, Upstart Bay has significant populations of Dugong and extensive seagrass meadows as it is protected from major climatic events by Cape Upstart, whereas Abbot Bay is coastal and highly dynamic and provides less protection for seagrass habitat.

The major risk to these values is the loss of seagrass and the associated ecological impact eg loss of grazing grounds for dugongs and turtles. The loss of seagrass is predicted to be less than 5 % of the estimated seagrass area within Abbot Bay. The loss of this seagrass is not expected to impact significantly on the grazing patterns of dugongs and turtles.

The impacts and risk analysis of the World Heritage Values of the Great Barrier Reef are described in detail in Sections 7.2 and 7.3. Monitoring and mitigation are discussed in Section 9 – Environmental Safeguards and Mitigation Measures. This review has been based upon the World Heritage Values as outlined in the Table 7-45 below.

Great Barrier Reef World Heritage Values

The Great Barrier Reef was inscribed on the World Heritage List in 1981. The World Heritage criteria against which the Great Barrier Reef was listed remain the formal criteria for this property. These criteria have been included in the Values Table below (Table 7-48). The World Heritage criteria are periodically revised and the criteria against which the property was listed in 1981 are not necessarily identical with the current criteria.

Examples of the World Heritage values for which the Great Barrier Reef was listed are included in the Values Table for each criterion. These examples are illustrative of the World Heritage values of the property, and they do not necessarily constitute a comprehensive list of these values. Other sources including the nomination document and references listed below the Values Table are available and could be consulted for a more detailed understanding of the World Heritage values of the Great Barrier Reef.

Table 7-48

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981 (Great Barrier Reef Marine Park Authority 1981, *Nomination of The Great Barrier Reef by the Commonwealth of Australia for inclusion in the World Heritage List*, GBRMPA, Townsville).

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
Criterion (i) an outstanding example representing a major stage of the earth's evolutionary history.	The Great Barrier Reef is by far the largest single collection of coral reefs in the world. The World Heritage values of the property include: • 2904 coral reefs covering approximately 20 055km^2; • 300 coral cays and 600 continental islands; • reef morphologies reflecting historical and on-going geomorphic and oceanographic processes; • processes of geological evolution linking islands, cays, reefs and changing sea levels, together with sand barriers, deltaic and associated sand dunes; • record of sea level changes and the complete history of the reef's evolution are recorded in the reef structure; • record of climate history, environmental conditions and processes extending back over several hundred years within old massive corals; • formations such as serpentine rocks of South Percy island, intact and active dune systems, undisturbed tidal sediments and "blue holes"; and • record of sea level changes reflected in distribution of continental island flora and fauna.
Criterion (ii) an outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment.	Biologically the Great Barrier Reef supports the most diverse ecosystem known to man and its enormous diversity is thought to reflect the maturity of an ecosystem, which has evolved over millions of years on the northeast Continental Shelf of Australia. The World Heritage values include: • the heterogeneity and interconnectivity of the reef assemblage; • size and morphological diversity (elevation ranging from the sea bed to 1142m at Mt. Bowen and a large cross-shelf extent encompass the fullest possible representation of marine environmental processes); • on going processes of accretion and erosion of coral reefs, sand banks and coral cays, erosion and deposition processes along the coastline, river deltas and estuaries and continental islands; • extensive *Halimeda* beds representing active calcification and sediment accretion for over 10 000 years; • evidence of the dispersion and evolution of hard corals and associated flora and fauna from the "Indo-West Pacific centre of diversity" along the north-south extent of the reef; • inter-connections with the Wet Tropics via the coastal interface and Lord Howe Island via the East Australia current; • indigenous temperate species derived from tropical species; • living coral colonies (including some of the world's oldest); • inshore coral communities of southern reefs; • five floristic regions identified for continental islands and two for coral cays; • the diversity of flora and fauna, including: – Macroalgae (estimated 400-500 species); – Porifera (estimated 1500 species, some endemic, mostly undescribed);

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
	– Cnidaria: Corals - part of the global centre of coral diversity and including: – hexacorals (70 genera and 350 species, including 10 endemic species); – octocorals (80 genera, number of species not yet estimated); – Tunicata: Ascidians (at least 330 species); – Bryozoa (an estimated 300-500 species, many undescribed); – Crustacea (at least 1330 species from 3 subclasses); – Worms: *Polychaetes* (estimated 500 species); *Platyhelminthes:* include free-living Tubelleria (number of species not yet estimated), polyclad Tubelleria (up to 300 species) and parasitic helminthes (estimated 1000's of species, most undescribed); – Phytoplankton (a diverse group existing in two broad communities); – Mollusca (between 5000-8000 species); – Echinodermata (estimated 800 extant species, including many rare taxa and type specimens); – fishes (between 1200 and 2000 species from 130 families, with high species diversity and heterogeneity; includes the Whale Shark *Rhynchodon typus*); – seabirds (between 1.4 and 1.7 million seabirds breeding on islands); – marine reptiles (including 6 sea turtle species, 17 sea snake species, and 1 species of crocodile); – marine mammals (including 1 species of dugong (*Dugong dugon*), and 26 species of whales and dolphins); – terrestrial flora: see “Habitats: Islands” and; – terrestrial fauna, including: *nvertebrates* (pseudoscorpions, mites, ticks, spiders, centipedes, isopods, phalangids, millipedes, collembolans and 109 families of insects from 20 orders, and large over-wintering aggregations of butterflies); and *vertebrates* (including seabirds (see above), reptiles: crocodiles and turtles, 9 snakes and 31 lizards, mammals); • the integrity of the inter-connections between reef and island networks in terms of dispersion, recruitment, and the subsequent gene flow of many taxa; • processes of dispersal, colonisation and establishment of plant communities within the context of island biogeography (e.g. dispersal of seeds by air, sea and vectors such as birds are examples of dispersion, colonisation and succession); • the isolation of certain island populations (e.g. recent speciation evident in two subspecies of the butterfly *Tirumala hamata* and the evolution of distinct races of the bird *Zosterops spp);* • remnant vegetation types (hoop pines) and relic species (sponges) on islands. • evidence of morphological and genetic changes in mangrove and seagrass flora across regional scales; and • feeding and/or breeding grounds for international migratory seabirds, cetaceans and sea turtles.
Criterion (iv) contain unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty.	The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The World Heritage values include: • the vast extent of the reef and island systems which produces an unparalleled aerial vista; • islands ranging from towering forested continental islands complete with freshwater streams, to small coral cays with rainforest and unvegetated sand cays; • coastal and adjacent islands with mangrove systems of exceptional beauty; • the rich variety of landscapes and seascapes including rugged mountains with dense and diverse vegetation and adjacent fringing reefs;

Natural criteria against which the Great Barrier Reef was inscribed on the World Heritage List in 1981.	Examples of World Heritage values of the Great Barrier Reef for which the property was inscribed on the World Heritage List in 1981.
	• the abundance and diversity of shape, size and colour of marine fauna and flora in the coral reefs; • spectacular breeding colonies of seabirds and great aggregations of over-wintering butterflies; and • migrating whales, dolphins, dugong, whale sharks, sea turtles, seabirds and concentrations of large fish.
Criterion (iv) provide habitats where populations of rare and endangered species of plants and animals still survive.	The Great Barrier Reef contains many outstanding examples of important and significant natural habitats for *in situ* conservation of species of conservation significance, particularly resulting from the latitudinal and cross-shelf completeness of the region. The World Heritage values include: • habitats for species of conservation significance within the 77 broadscale bioregional associations that have been identified for the property and which include: – over 2900 coral reefs (covering 20 055km^2) which are structurally and ecologically complex; – large numbers of islands, including: 600 continental islands supporting 2195 plant species in 5 distinct floristic regions; 300 coral cays and sand cays; seabird and sea turtle rookeries, including breeding populations of green sea turtles and Hawksbill turtles; and – coral cays with 300-350 plant species in 2 distinct floristic regions; – seagrass beds (over 5000km^2) comprising 15 species, 2 endemic; – mangroves (over 2070km^2) including 37 species; – *Halimeda* banks in the northern region and the unique deep water bed in the central region; and – large areas of ecologically complex inter-reefal and lagoonal benthos; and • species of plants and animals of conservation significance.