PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
DRAFT ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1 - PROJECT OVERVIEW
CHAPTER 4 - PROJECT ALTERNATIVES

CONTENTS

1 INTRODUCTION

This chapter discusses the various alternatives to the Project Sea Dragon Stage 1 Legune Grow-out Facility (the Project or Project Area), or components of the Project that were considered during the Project planning and design. Alternatives considered include:

- not proceeding with the Project
- the location of the Project
- the location and design of various Project components including:
  - seawater intake
  - seawater channel and settlement pond
  - grow-out farms
  - freshwater sources
  - freshwater distribution
  - outfall
  - central services road
  - central facilities and accommodation village
  - transport
  - energy sources and power generation
- operational processes.

2 NOT PROCEEDING WITH THE PROJECT

The Project has the potential to provide significant short and long term economic and social benefits to the Northern Territory (NT). Not proceeding with the Project would result in a loss of:

- prawn production valued at an average of $195 million per year
- capital expenditure during the construction of the Project of approximately $411 million
- recurrent operating expenditure of approximately $125 million at full production
- business opportunities, particularly for local suppliers, to supply goods and services to the Project
- 444 Full Time Equivalent (FTE) construction jobs and 334 FTE operations jobs
- royalties over the life of the Project to the Commonwealth and NT governments.

The economic and social benefits of the Project are discussed in more detail in Volume 3, Chapter 1.

3 PROJECT LOCATION

The proponent spent considerable time studying suitable sites for the Stage 1 Legune Grow-out Facility across northern Australia. To determine the optimal location for the Project, a formal multi-criteria analysis was applied across the northern Australian coast using site suitability criteria based on initial investigations by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and further developed by the proponent.

Biophysical, environmental, economic, commercial and socio-political attributes were used to define the criteria used in the analysis. Site selection considered, *inter alia*, land tenure, land area, topography, temperature, rainfall, evaporation, biosecurity risk, land use, availability of fresh-water and marine water, assimilative capacity of the receiving environment, feasible logistics and workforce, location away from industrial processes and contamination and relative proximity to a port. In terms of avoidance of environmental and cultural values it specifically considered avoidance of sites with significant populations of threatened species, sites of archaeological, heritage or Aboriginal significance, Ramsar wetlands, breeding colonies, known critical habitat, mangroves, intertidal zones, acid sulfate soils, vegetation clearance and Great Barrier Reef and inshore reefs.

Based on this analysis, Legune Station was the number-one ranked site. While a number of other sites met some of the criteria, none offered:

- the future business growth potential of Legune Station
- a large existing source of freshwater (i.e. Forsyth Creek Dam)
- a central floodplain (otherwise referred to as the estuarine-deltaic plain) which is largely free-draining and has sufficient separation from the wetlands environment
- pasture habitat in the area of the proposed grow-out farms, thus is already highly modified, minimizing the destruction of native woody vegetation.

In CSIRO's opinion, "…*Legune Station has one of the highest levels of economic and environmental attributes required for the sustainable development of large-scale land-based marine aquaculture in northern Australia*" (Volume 5, Appendix 17).

4 PROJECT DESIGN

Protecting biological diversity, and maintaining essential ecological processes, has also been a core focus of the engineering and operational design of the Project. For example, design has focused on: minimising the extent of the Project footprint; minimising earthworks movement; avoiding dredging; avoidance of Acid Sulfate Soils and Potential Acid Sulfate Soils; stormwater, erosion and sedimentation control; avoidance of the use of toxicants and antibiotics; hydrocarbon management; dust management; noise minimisation; traffic management; maximisation of water re-use/recirculation; use of settlement ponds, channels and environmental protection zones to treat effluent; use of outfall controls and optimisation of timing of discharge; breeding efficiency (i.e. the genetic improvements from the domestication program mean that prawns grow faster and require less feed over time); best practice for feed formulation (minimising marine ingredients - fish meal, fish oil); and incorporation of renewable energy component into the power generation demand.

As part of the philosophy of minimisation and avoidance, a number of alternatives were considered in the siting and/or design of various Project components including, the seawater intake, seawater channel and the settlement ponds, grow-out farms, freshwater sources, freshwater distribution, outfall, central facilities and accommodation village, transportation, central services road and power generation.

4.1 SEAWATER INTAKE

A number of locations were considered for the seawater intake including sites along Alligator Creek, Victoria River and Forsyth Creek. None of the sites were considered ideal as they all carry a high sediment load; however, Alligator Creek did not offer sufficient reliability or water quality (i.e. low salinity in the wet season, higher turbidity on the spring tides), and the Victoria River was too far from the farms and construction of the delivery channel would have necessitated crossing a large expanse of the coastal plain and several waterways.

Forsyth Creek was the preferred option for the location of the seawater intake for a number of reasons including:

- its proximity to the grow-out farms
- it required the shortest distance across the coastal plain for the construction of seawater channel thus minimising the extent of earthworks required for this Project element
- largest available depth of water for the pumps to operate without drawing silty water from near the bottom of the waterway, minimising the amount of marine sediments entering the settlement ponds, which in turn reduces the required size of the settlement ponds, thus minimising the size of the footprint for this Project element.

4.2 SEAWATER CHANNEL AND SETTLEMENT POND

Options investigated for seawater delivery from the seawater intake to the settlement pond included an open channel or pipeline. The open channel was the preferred option as the construction of a pipeline would have been more expensive, had a larger footprint and would have been more problematical to maintain owing to the marine fouling. Marine fouling of the pipeline would have resulted in regular chlorination and higher downtime for mechanical cleaning.

While the construction of the seawater channel on the coastal plain cannot be avoided, the settlement pond has been sited up on the estuarine-deltaic plain. This increases the distance that the seawater needs to be pumped initially; however, the water levels can be set such that water is lifted only once to the intake channel, then gravity fed to the main feeder channel and grow-out farms thereafter, hence pumping, and power requirements, are minimised.

4.3 GROW-OUT FARMS

The ponds and channels for the grow-out farms are proposed to be constructed entirely of the naturally occurring surface clay soils on the estuarine-deltaic plain. Consequently, the location and the shape of the grow-out farms have been determined by the soil strata and the extent of the estuarine deltaic plain.

However, a number of options were considered in the design of the grow-out farms, including:

- the pond size and shape
- the number of ponds within each grow-out farm
- the configuration of ponds within each grow-out farm.

Different pond sizes and shapes were considered with reference to successful trends overseas. Square shapes require least power to circulate the water within the pond.

Project economics lead to larger sized ponds (8 to 10 ha) being the preferred option over smaller sized ponds (1 to 1.5 ha) which are used at Seafarm's Queensland operations and in older farming practices. Ten hectare square ponds are considered to be the most energy efficient.

Also critical to the selection of larger sized ponds for the Project was the prawn species being stocked, the stocking density, manpower efficiency, feed distribution, biomass control, and aeration/circulation.

The number of ponds within each grow-out farm was also considered in the Project design. Grow-out farms with 36 to 40 ponds were the preferred option as there are manpower efficiencies associated with a larger number of ponds per grow-out farm. Greater than 40 ponds per farm however, was considered to be a risk owing to the amount of water required to be managed across the farms and length of channels required to distribute the water.

Different configurations of the ponds within each grow-out farm were also considered. Long, rectangular shaped grow-farms result in long channels which increases the depth of excavation in order to achieve the required slope to drain water from the channels. The maximum rectangularity for the grow-out farms that still resulted in acceptable depth of excavation was determined to be a configuration of 9 x 4 ponds.

4.4 FRESHWATER SOURCES

Options considered for freshwater supply for the grow-out farms included:

- the existing Forsyth Creek Dam
- flood lifting from Alligator Creek and Forsyth Creek above the salt incursion zones
- construction of additional dams on the property and
- freshwater supply from the Ord Irrigation Areas, in particular Ord Stage 3.

These options were studied at a concept engineering level only as there is confidence that the existing Forsyth Creek Dam has sufficient capacity for the Project (see Volume 1, Chapter 5). The Forsyth Creek Dam was one of the key reasons Legune Station was ranked as the number one site based on the multi-criteria analysis described earlier in Section 3.

Flood lifting from Alligator and Forsyth Creeks was dismissed owing to the potential impact on avifauna.

4.5 FRESHWATER DISTRIBUTION

Options investigated for delivery of the freshwater from Forsyth Creek Dam to the grow-out farms included an open channel or pipeline. Both options were considered to be equal in terms of potential for environmental impacts. The open channel option involves less capital and operating costs, and was adopted as it also minimises the disruption of overland water flow by following the natural boundary of Alligator and Forsyth Creek catchments.

4.6 OUTFALL

A number of considerations were made in respect of the alternatives for the outfall location and design. These included:

- Separate outfall locations for each of the grow-out farms versus a single outfall location.
- Siting the outfall on the bank of Alligator Creek versus Victoria River or Forsyth Creek.

Separate outfall locations for each of the grow-out farms would allow the discharge water to be widely distributed into the receiving environment. This would, however, involve larger capital costs and a large Project footprint. Furthermore, upon consideration of the environmental pros and cons of a multi-discharge approach, it was considered preferable to contain the potential impacts of the discharge to one location only, but to look for a location that provided for comparatively superior flushing capabilities. Therefore, the preferred option was for a single outfall location into a large receiving body of water with a large tidal prism.

As Forsyth Creek was the preferred location for the seawater intake site (Section 4.1), the outfall was required to be sited away from this area on a tributary of the Keep River to avoid potential for re-uptake and recirculation of the discharge water. The preferred site for the location of the outfall point was Alligator Creek.

To establish the appropriateness of the outfall location at Alligator Creek, an alternative outfall location on Bob's Creek, to the north of the farm area, was identified. An assessment of the impacts on the coastal environment and water quality as a result of effluent discharges from this alternative location has been completed.

The assessment concluded that the main issues associated with the alternative outfall location were primarily related to the lower assimilative capacity of the waterway and the lower elevation of the intertidal floodplain adjacent to Bob's Creek.

The tidal prism of Bob's Creek was roughly 25% of that of Alligator Creek, and as such the discharge of effluent into the creek had increased potential to impact water levels, tidal prism and currents within Bob's Creek. Increases in current speeds could also lead to increased bed scour and channel morphology.

The smaller tidal prism also resulted in much higher concentrations of effluent within Bob's Creek as dilution and dispersion was lower. The mixing zone extended a number of kilometres along the channel. In addition to higher effluent concentrations within the channel, the lower intertidal topography and hence intertidal inundation frequency results in increased effluent concentrations across these areas.

Alligator Creek was therefore identified as the preferred option for the outfall location.

Having chosen Alligator Creek for the outfall location, the options considered for the design of the outfall included:

1. A discharge channel running directly southwards of the main discharge channel to intercept Alligator Creek at its nearest point.
2. A longer discharge channel to the south-west, intercepting Alligator Creek some 2 km closer to the Keep River.

The longer discharge channel option was chosen because:

- The location intercepts Alligator Creek at an area with a greater tidal prism than Option 1.
- It allows for the development of a larger environmental protection zone before the outfall point.
- It follows a long thin area of estuarine-deltaic plain, thereby avoiding the construction of a long channel on the coastal plain.
- The discharge point is devoid of mangroves and other potentially sensitive habitat.

4.7 CENTRAL FACILITIES AND ACCOMODATION VILLAGE

A number of locations were considered for the central facilities and accommodation village, including:

- close to the grow-out farms, on the estuarine-deltaic plain
- rebuilding the area currently occupied by the Legune Station homestead
- an area off-site of Legune Station, where it could be incorporated into a future open town
- off the estuarine-deltaic plain on the higher ground adjacent to the Legune Access Road.

The siting of the central facilities was made in consultation with the Traditional Owners of Legune Station, having in mind their wishes and the obligation of the Project to protect and avoid sites of heritage and cultural significance.

The siting the central facilities at the grow-out farms would require extra earthworks to raise the area for flood immunity, and would increase the daily travel for many of the workforce, being separated from the proposed site of the accommodation village by 10 km.

The site of the current homestead does not provide sufficient flat land and it is not central to the transport corridor between the grow-out farms, the accommodation village and the Legune Access Road.

Considerations for a future town off the property was not supported in any dialogue with the NT Government.

The location for the central facilities was chosen because:

- It is off the estuarine-deltaic plain, and thereby immune from flooding and considered likely to be less prone to biting insects by virtue of the separation of this site from the marine environment.
- It is on the transport alignment between the farms and the Legune Access Road.
- It satisfied the Traditional Owners.
- It is close to the preferred accommodation village site.

- It utilises part of a gravel quarry which minimises the amount of vegetation required to be cleared.

4.8 ACCOMODATION VILLAGE

The options considered for the accommodation village were very similar to those considered for the central facilities and the preferred site was also chosen for similar reasons.

4.9 TRANSPORT

Two transportation options were considered for the Project:

1. Barging between Legune Station and Darwin.
2. Road transportation. This would involve the upgrade of the Cave Springs Road between the boundary of Legune Station and the West Australian border to allow all weather access to the Project area.

The option of barging between Legune Station and Darwin was rejected based on:

- Navigation risks associated with the waterways surrounding Legune Station, including the highly dynamic nature of the channels, high velocity currents and large tidal variations (see Volume 5, Appendix 8).
- Costs associated with the development of port infrastructure on Legune Station and dredging that would be required to keep the waterways navigable.

Consequently the preferred option is for road transport. The NT Government supports the idea of the road transport option and has indicated it will take the lead in its funding and development, because it will have greater long term multi-user benefits.

4.10 CENTRAL SERVICES ROAD

The Central Service Road must cross Alligator Creek and an associated wetland area. A number of different routes were investigated.

Each route was studied for the 1 in 100 year average recurrence interval (ARI) flood event across the floodplain, with a road design level to avoid saturating the sealed pavement for long periods of time. The existing station tracks also cross this wetland in several locations, with high flows overtopping these roads. For the Central Service Road a similar design concept was followed, whereby low flows would be able to pass under with culverts, and high flows designed to overtop at selected control places, so as to maintain the current water retention and hence minimise impacts to the environmental values of Alligator Creek.

Alignment A would cross furthest upstream and head east to high ground, then join the freshwater channel. Alignment B would follow the same crossing, but keep to slightly high ground to the west of Alignment A. These two options were discounted in favour of Alignment C because:

- Alignments A and B were considered too close to a sensitive sacred site. This matter was raised by the Traditional Owners.
- Alignment C would be no worse than the existing roads in terms of passing the floods and hence not causing any significant changes to the existing hydrology of Alligator Creek.
- Alignment C is 4.7 km shorter than Alignment B, and 9.8 km shorter than Alignment A, resulting in approximately the same capital costs, taking into account the differences in earthworks foundation and

culverting to pass the floods, but significantly lower operating and maintenance costs when considering the life-of-project transport impacts (fuel, tyres, and greenhouse gases).

4.11 ENERGY SOURCES AND POWER GENERATION OPTIONS

The operation of the Project requires a sustainable, economic, reliable energy source to maintain production. A number of energy sources were investigated for the Project including renewable energy sources (i.e. solar, wind, geothermal and tidal) and fossil fuels (i.e. diesel, trucked liquefied natural gas, trucked compressed natural gas and piped gas).

Wind power was not considered a feasible option, owing to the cyclone exposure and unreliability.

Tidal power was subject to a desktop review. Tidal Power Australia Pty Ltd provided some costing data, based on a study for tidal generation at the lower reaches of the Ord River. The high capital cost for this option to generate and transmit to Legune Station, and the high line losses because of the transmission distance made this uneconomic. Tidal Power Australia also considered a two pond scheme for the Victoria River but did not venture with this concept further, principally for environmental impact concerns.

Geothermal data indicated that potential sources of geothermal energy were too remote from Legune Station to be of further interest.

Solar energy generation was of keen interest to the Project and studies for maximising the solar penetration have been undertaken. Battery systems for solar energy are improving worldwide at a rapid rate, but at this stage of the Project they remain under study. An initial conservative position has been taken to maximise the solar penetration, without battery support. The design of the hybrid power generation plant is such that batteries could be added as soon as the economics dictates.

Without batteries, thermal cycle engines will be required for the night-time loads and for standby when cloud cover causes the photovoltaic (PV) power to drop. The Danvest technology will permit maximum PV penetration, by having no-load diesel engines on standby for near-instantaneous back-up. Diesel engines are proposed for this back-up function, owing to the technology constraints.

Dual-fueled engines have, however, been selected for the thermal cycle for the bulk of the night-time load. This decision was made before the current crash of energy pricing, wherein the modelling done for the Project showed a clear economic advantage of gas over diesel. A further benefit of this economic case was the reduced traffic in road tankers between Legune and Wyndham, or Darwin.

The decision to keep the dual-fueled engines in the design was taken to maintain flexibility and hedge against the market, in the event that gas will once again show a clear economical margin over diesel.

4.12 POWER STATION SITING OPTIONS

Consideration was made between siting the power station close to the centroid of the farms versus close to the Central facilities, or even off the property to the south.

The centroid of the power load is close to the centroid of the farms, and to site the power station and switchyard there would result in less line losses overall. However, this would mean a critical piece of infrastructure would be sited on the floodplain and at increased risk of flooding. This could be overcome by earthworks, to build up a pad to achieve flood immunity. Power would be transmitted by 132kV overhead line to farms, pump station, village and central facilities, resulting in slightly less lightning strike exposure for the farms and pump station, by virtue of reduced distance.

Siting the power station close to the central facilities provides greater flood security without the earthworks, and centralises that small part of the workforce close to the village, workshops and transport. It also minimises the volume of fossil fuel being trucked out onto the floodplain, and thereby minimises the risk of fuel spill near the wetlands.

One consideration was the possible future ownership of the power station, and whether or not there would be a benefit in it being off the property for possible ownership by a third party or Government agency or Corporation needing land tenure security. The Ord Stage 3 project was a possible opportunity. Discussions with NT Government have shown that such options are not of sufficient certainty for the basis of the Project.

Whilst each of these options have advantages and disadvantages, the compelling case for the Project, and thereby the basis of this submission, is a compromise solution of:

- Thermal power generation and fuel facilities at the central facilities, off the floodplain, on a portion of land that could be excised from the lease in future, if necessary.
- Solar PV pods distributed over six or seven locations, to minimise the cloud risk.
- A transmission line from the power station to substations at each farm and major load, backed up by distributed standby generators at critical locations.

5 OPERATIONAL PROCESSES

Numerical modelling was used to quantify the impact of effluent discharged into Alligator Creek on the creek and the wider coastal environment. For the assessment two alternative effluent discharge rates were considered; a constant discharge rate, and a variable discharge rate (See Volume 2, Chapter 2 for the full description).

5.1 CONSTANT DISCHARGE RATE

The results of the constant discharge rate modelling indicated that the effluent was rapidly mixed in the large waterbodies around Legune Station and very low levels of effluent are expected to be present outside Alligator Creek. The effluent concentrations quickly reached steady state levels within Alligator Creek and a pattern of increasing and decreasing concentrations within the creek was observed with the spring-neap tidal cycle progression. The peak concentrations would occur at the outfall site and the effluent accumulates upstream of the outfall before reaching equilibrium conditions in the upper reaches of the creek system. Downstream of the outfall, the effluent rapidly dilutes.

Additional nitrogen concentrations in Alligator Creek resulting from a constant discharge rate will be between 0.05 and 0.25 mg/L. The interim site specific water quality trigger values based on measured data is 0.31 mg/L total nitrogen and thus little buffer is available for natural variation in nitrogen before this level is exceeded. The combination of median values of additional nitrogen and ambient background conditions results in a mixing zone within Alligator Creek extending approximately 1 km downstream from the outlet and upstream to the tidal limit.

The level of chlorophyll-a in the effluent when compared with background conditions is high and the modelling predicted that under the constant discharge scenario a concentration of chlorophyll-a over 2 µg/L will occur relatively frequently within Alligator Creek. The combination of median values of additional chlorophyll-a and ambient background conditions result in exceedance of the interim site specific water quality trigger value of 3.2 µg/L for the same mixing zone extent as for nitrogen.

5.2 VARIABLE DISCHARGE RATE

The purpose of the variable discharge rate conditions for the effluent is to maximise the potential dilution of the effluent as a result of flow conditions in Alligator Creek. Sensitivity testing identified that discharging the effluent across the ebb tide only, as opposed to a constant rate, significantly improved mixing conditions and reduced concentrations within the waterways. The result is that the effluent mixing zone, defined as the zone within which the interim site specific water quality trigger values are exceeded, is significantly reduced within Alligator Creek, when compared to the constant discharge scenario. The variable discharge rate condition is therefore an appropriate mitigation option for managing elevated nutrient concentrations in Alligator Creek as a result of the discharge.

The ebb tide discharge modelling results showed the following outcomes:

Additional nitrogen concentrations in Alligator Creek as a result of the ebb tide discharge regime are below 0.1 mg/L. The combined concentration of the effluent and the ambient conditions is 0.2 mg/L and therefore the interim site specific water quality trigger value of 0.31 mg/L is not exceeded. No mixing zone therefore applies to nitrogen.

The level of phosphorus within the effluent is low and levels of additional phosphorus predicted to occur within the receiving waters are also low. The additional concentrations of phosphorus within Alligator Creek under the ebb tide discharge scenario are less than 0.01 mg/L, well below the interim site specific water quality trigger value of 0.20 mg/L. Therefore, no mixing zone applies to this parameter.

The level of chlorophyll-a in the effluent when compared with background conditions is high. However, the modelling predicts that under the ebb tide discharge scenario a concentration of chlorophyll-a over 2 µg/L will only occur within 200 m of the outfall. The combination of this median value of additional chlorophyll-a and the ambient background condition results in exceedance of the interim site specific water quality trigger value of 3.2 µg/L for an area approximately 200 m upstream and downstream of the outfall. This is therefore the mixing zone.

Discharging effluent only under ebb tide conditions was found to successfully mitigate issues related to elevated nutrients and chlorophyll a in Alligator Creek as a result of the effluent discharge. The concentration of nutrients outside of Alligator Creek was not increased as a result of only discharging under ebb tide conditions.