4. ENVIRONMENTAL EFFECTS, ASSESSMENT AND MANAGEMENT

4.1 SYNTHESIS OF EFFECTS

The lease area is relatively undisturbed, with its main habitats in good condition. The area is relatively free of weed infestations and feral animals are present in low numbers. Only occasional recreational use of the lease area is made by members of the public. A synthesis of anticipated effects from construction and operation of the proposed aquaculture development is provided below.

Construction of the development will alter some components of the biophysical environment within the lease area. Significant surface soil disturbance will occur during construction of the production ponds, exchange water treatment ponds, saltwater channels and freshwater dams. Approximately 200 ha of vegetation will be cleared during Stage 1 construction works, with an additional 290 ha requiring clearing for Stage 2. No endangered plant species or plant communities of conservation significance have been recorded in the lease area. One species found within the lease area is listed as rare, however it is anticipated that the aquaculture development will have a minor effect on the overall population of this species. The development will result in minimal direct disturbance of mangrove populations.

There is likely to be a reduction in the frequency and intensity of fires within the lease area as a result of the proposed development and the fire management strategies employed.

Clearing works will result in loss of habitat for fauna within the lease area. It is unlikely that the lease area provides habitat for any endangered or 'specially protected' species. One mammal and two bird species identified in survey works are listed as 'low risk, near threatened' and five reptile species are classified as 'insufficiently known'. However, no significant breeding, roosting or feeding sites were recorded and the habitats present are well represented in the region. The development will not have a significant impact upon the Darwin Harbour barramundi population. There will be no impediment to barramundi movements and no loss of barramundi breeding grounds. The development is likely to result in an increase in the available breeding grounds for mosquitoes. Infrastructure design and management strategies will be employed to reduce this impact.

Areas within the freshwater dam, production ponds and exchange water treatment ponds will be inundated, replacing vegetation communities with marine and aquatic habitats. Currently there is no body of freshwater within the lease area. Construction of the freshwater dam will provide fauna with a permanent supply of fresh water and is likely to be colonised by a number of wildlife species.

The presence of the freshwater dam, and the walls of the production/treatment ponds will alter the surface water hydrology of the area. These changes may affect some of the vegetation communities and associated fauna within the lease area. Construction activities will result in minor alterations to tidal water flow. Alteration to the existing natural drainage characteristics of the lease area and the redirecting of rainfall runoff may lead to increased erosion which, if not managed, would increase the suspended solids content of runoff water released into the receiving environment. Management strategies will be adopted to prevent the occurrence of erosion and reduce sedimentation.

The exchange water treatment ponds will be designed to reduce suspended solids and nutrients generated during the production process. This will minimise the potential for impacts on the receiving environment, including vegetation and fauna communities, from release of the discharge water. Monitoring of discharge water quality will be undertaken on a regular basis.

Construction activities will not disturb significant deposits of ASS, and so no detrimental effect to downstream flora and fauna communities from acid runoff is expected.

Each of the six archaeological sites and many of the 60 isolated artefacts identified within the lease area will be destroyed as a result of construction activities. The archaeological significance of the archaeological sites was assessed to be low and Ministerial consent to disturb the sites will be sought.

Recreational access to the Blackmore River, other off-site waterways and the Middle Arm boat ramp will not be effected by the development. However, the public will not be permitted to access the lease area. This will limit the activities of off-road motorcycle riders who currently utilise the area on an occasional basis. Areas adjacent to the lease will still be available for motorcycle riding and the restriction is not expected to have a significant impact. Visual amenity as a result of vegetation clearing and construction activities is not expected to be significantly compromised.

A summary of potential impacts and environmental management and monitoring methods associated with the project is provided in **Table 19** and an outline of an Environmental Management Plan (EMP) for the development is included in **Section 5**.

Table 19

Environmental Effects and Management Register

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
BIOLOGICAL				
Vegetation clearing Refer Section 3.9 and 4.2	Extensive Eucalypt woodlands dominate the hinterland vegetation with open woodlands fringing a narrow riparian corridor along the seasonal drainage lines. Mangrove communities of the Blackmore River and its tributary creeks fringe the upland woodlands of the lease area. Narrow grasslands occur in the transitional area between the hinterland and the mangrove margin. No endangered plant species or special vegetation communities have been recorded in the lease area. However, several populations of Grevillea longicuspis, an endemic species of restricted distribution occurs in Open Woodland habitat within and adjacent to the lease area. The proposed production ponds will be located entirely within upland woodland habitat.	Loss during construction will result in clearing of: ~200 ha during Stage 1 ~290 ha during Stage 2	Farm layout designed to minimise loss of vegetation. Construction adjacent to mangrove areas will aim to protect intertidal areas from negative impacts including siltation and changes in drainage. Clearing within the freshwater dam will be selective and limited to those communities that will be permanently flooded to a level considered lethal to the trees. Trees fringing the upper levels of the dam will be retained to reduce disturbance and loss of habitat. Restriction of construction activities to specified areas. Movement of construction vehicles will be managed to ensure that tree loss is minimised. Should areas of the development be decommissioned appropriate vegetation will be reestablished.	Total loss due to clearing through to Stage 2 development: ~420 ha of eucalypt woodland; ~61 ha of drainage line communities; ~8 ha of grassland community; and ~1 ha of mangroves. The communities to be cleared are well represented elsewhere within the lease area and surrounding region. No significant adverse ecological impacts are anticipated.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Inundation of vegetation Refer Section 3.9 and 4.2	The proposed production and exchange water treatment ponds will be located within upland vegetation communities. Stage 1 freshwater dam will inundate riverine open woodland and associated drainage line communities and some Eucalyptus woodlands. Stage 2 freshwater dam will inundate riverine open woodland and associated drainage line communities and some mixed species woodlands. The Stage 2 dam will inundate Eucalyptus dominated open woodland, including limited areas with Grevillea longicuspis, a Darwin region endemic currently listed as rare. Tracts of similar habitat are present outside the southern boundary of the lease area.	Approximately 200 ha of vegetation will be effected by dams. Some areas of woodland not cleared prior to dam construction may be permanently or seasonally inundated.	Clearing for freshwater dam construction will be kept to the minimum necessary and fringing vegetation in the upper levels of the proposed dam will be retained. Similarly, clearing along the dam spillway will be selective and minimised to prevent erosion and habitat loss. Regular surveys of freshwater dams will be undertaken to control the introduction and spread of aquatic weeds. The staged approach to the development will enable an assessment of Stage 1 of development to be conducted prior to clearing and inundation of the Stage 2 freshwater dam.	If the development proceeds to Stage 2 approximately 200 ha of vegetation will be effected by seasonal and permanent inundation to 14 m AHD. Increased diversity of aquatic, semi-aquatic and fringing wetland plant species, including Melaleuca spp. and Lophostemon spp.
Indirect vegetation changes Refer Section 3.9 and 4.2	Mangrove communities fringe the estuarine creeks adjoining the lease area.	Changes to the pattern of drainage, seepage and sedimentation may lead to the loss of some trees within the mangrove fringe in the vicinity of the exchange water treatment dams and saltwater supply channel. Gradual shifts in species composition may also occur over time.	The saltwater supply channel and the wall of the exchange water treatment dams are designed to minimise impacts on natural hydrological and sedimentary regimes, especially within adjacent mangroves.	The transitional grassland communities will be most asffected (8 ha cleared). The hinterland margin of the mangroves may be effected by changes in drainage, but this community is well represented elsewhere within the surrounding region. No significant ecological impacts are anticipated.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Colonising native vegetation Refer Section 3.9 and 4.2	Mangrove communities occur between the Blackmore River and the hinterland along the alignment of the saltwater supply channel.	Mangrove seedlings can be expected to colonise the bund walls and mangrove growth may be encouraged downstream of the dam spillway. Increased waterlogging and possibly raised groundwater levels in the vicinity of the freshwater dams may encourage the expansion of paperbark and Lophostemon communities in this area. Native reeds such as Eleaocharis spp. may proliferate in the swampy areas created along the margins of the freshwater dams.	Growth of native species will be encouraged, except where this may exacerbate biting insect problems.	Minor, regionally insignificant, colonisation of parts of the lease area by native vegetation can be expected.
Weeds Refer Section 3.9 and 4.2	The lease area is free from large weed infestations. Four introduced species recorded, three of which are declared noxious weeds (Class B).	Clearing of native vegetation and terrain disturbance may create conditions favourable for the proliferation of weed species. The new and extensive freshwater aquatic habitats created by the freshwater dams may provide conditions suitable for the proliferation of aquatic and semi-aquatic weed species.	Weed management and prevention measures will include: • earthmoving equipment washed-down prior to entering the lease area during construction works to prevent spread of seeds; • rapid draw-down of water in the freshwater dam early in the Dry Season to discourage formation of semi-aquatic reed swamps along the dam margin; • selection of native species for the pasture production area and for landscaping around farm buildings; • weed removal from areas around farm buildings; • during the operational phase, off site vehicles will not be permitted to enter the site other than to park at designated parking bays outside the prawn farm; • slashing of fire breaks; and • annual weed surveys.	Management of weed issues will result in low risk of occurrence spread of weeds.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Fire regime Refer Section 3.9.5 and 4.9	Frequent, extensive burning of lease area and surrounds.	Reduction in frequency, timing and spread of fires.	A fire management plan will be developed, which will include: • fire break alignment and construction; • reduction of flammable fuel loads around farm infrastructure; • protection of fire-sensitive species and communities; and • promotion of habitat heterogeneity.	A shift in vegetation species composition may occur towards a more dense mid-stratum layer, possibly including fire-sensitive monsoon forest species. Frequency, timing and spread of fires will be reduced due to site access restrictions and construction of fire breaks. Habitat heterogeneity may increase due to protection of fire-sensitive vegetation.
Terrestrial fauna Refer Section 3.10 and 4.3	One mammal and two bird species listed as 'low risk, near threatened' and five reptile species classified as 'insufficiently known' were identified within the lease area. However, the lease area is not considered to contain significant sites for these species. No significant breeding, roosting or feeding sites have been recorded. Feral animals are present in low number in the lease area.	Removal of terrestrial fauna habitat. .	Feral animals will be managed on an 'as required' basis. Bird nets will be installed on the production ponds if water birds cause significant stock losses.	Vegetation clearing will reduce available terrestrial fauna habitats within the lease area. The freshwater dam may increase the extent of habitats favoured by fauna such as wading birds and frogs. Increased habitat heterogeneity through improved fire management practices may improve wildlife habitat quality. Loss of ~1 ha of mangrove habitat is likely to be insignificant to mangrove fauna, given the extensive area of similar habitat in the immediate vicinity.
Fisheries resources Refer Section 3.11 and 4.3	No supralittoral swamps (potential barramundi nursery habitat) have been identified within the lease area.	Minor disturbance to intertidal salt flats and mangrove creek banks during construction of the saltwater supply channel and exchange water discharge channel. Low potential for increases in nutrient levels or depletion in dissolved oxygen levels in Middle Creek due to exchange water discharge. Low potential for infection of wild prawn stocks by disease outbreaks.	Restriction of construction activities to the minimum required for construction of the channels. Treatment of exchange water to minimise nutrient loads and to return dissolved oxygen to background levels prior to discharge. Disease control management measures will be implemented to minimise the potential for significant impacts upon stocks of wild prawns and mud crabs.	No significant adverse impacts to fisheries resources are anticipated.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Biting insects Refer Section 3.12, 4.10 and 5.4.4	Significant numbers of mosquitoes and biting midges have been recorded. Areas where mangroves border brackish supralittoral swamps can become major mosquito breeding habitats during the late Dry and early Wet Seasons.	Mosquito breeding habitat may: increase along the shallow margins of the freshwater dam if growth of aquatic vegetation is enhanced; and/or decrease on the tidal flats to the west and south-west of the dam wall due to reduced seasonal fresh water flow The production ponds and exchange water treatment ponds are unlikely to provide suitable breeding habitats for biting insects.	Management of biting insect problems will include: • drainage designed to prevent ponding of water in low-lying areas; • native fish populations will be maintained in the freshwater dams to assist in control of larval mosquito numbers; • farm buildings positioned away from low-lying areas; • regular clearing of vegetation in vicinity of buildings; • clothing, repellants and antiseptic creams will be available to all personnel on site; • screening of staff facilities; and • staff induction.	Staff will receive adequate protection against biting insects.
PHYSICAL				
Soil erosion Refer Section 4.8.2	The existing hydrology of the site includes ongoing natural erosion and deposition processes.	Increased erosion associated with altering natural hydrological patterns.	The following measures will be adopted to minimise erosion: • all development will be undertaken in the Dry Season; • minor access roads will be formed so as not to impede or divert sheet flow drainage or channel drainage; • roads will be drained with side gutters and runoff drains; • embankments will be compacted and have a cover of lateritic gravel; and • channels will be lined with rock rip-rap.	Erosion will be minimised by the implementation of management measures. Some localised erosion may be expected as the natural hydrological patterns are reestablished. Current dynamic erosion patterns will continue.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Hydrological regime Refer Section 3.7 and 4.5	The existing hydrology of the site includes ongoing natural erosion and deposition processes.	Increased erosion associated with altering natural hydrological patterns	The following measures will be adopted to minimise hydrological changes: • scouring will be prevented through implementation of erosion control measures; • farm alignment/design will avoid interruption to tidal movement; • drainage channels will be constructed around buildings and stormwater will be directed towards natural drainage lines; • overflow from the freshwater dam spillway will be directed back into the natural channel; and • main farm infrastructure will be constructed above the 1 in 100 year peak combined sea level prediction for the area.	The freshwater dams will significantly alter the natural hydrological processes. There will be a limited impact on the natural hydrological processes by the construction of the remaining structures.
POLLUTION MANAGEMENT				
Dust generation Refer Section 4.8.4	The existing Middle Arm Boat Ramp Road generates significant dust during the Dry Season.	Farm traffic will increase dust generation along the Middle creek Boat Ramp Road and the site access roads.	Management procedures will be put in place to minimise the volumes of traffic generated from the aquaculture farm.	Minimal increase in dust generation from Stage 1 development. Moderate increase in dust generation from Stage 2 development.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Discharge water quality Refer Section 3.8, 4.6 and 5.4.1	No discharge waters are currently released into the environment at the site.	Water quality (nutrients, recreational)	Management procedures will be put in place to minimise the nutrient load of waste discharge water. Discharge water will be passively treated in pond(s) prior to release. Active treatment of discharge water will, if required, be implemented. Discharge water will be released on outgoing tides to maximise dilution. Stocking levels, water exchange, feed and aeration times will be determined with reference to water quality parameters. Accidental or unauthorised release of discharge water will be prevented by use of valve locks. Water quality monitoring of discharge water will be regularly undertaken.	Minimal impact on water quality of the Blackmore River system.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Waste disposal Refer Section 4.7	No waste is presently generated at the site.	The following general wastes will be produced on site: • sludge from the production ponds; • vehicle washdown water; • disinfectants and detergents from cooking and packing factory; • domestic sewage effluent; • diseased prawns; • used parts, sump oil, etc from farm machinery; and • domestic waste; Potential impacts include localised on-site contamination.	Sewage and domestic discharge water will be treated by septic systems designed in accordance with Territory Health guidelines. General waste material will be either buried onsite or disposed off-site. Sludge will not be transferred from the desalination bays to the pasture area until in-situ conductivity measurements indicate a sufficient reduction in salinity levels. A bund wall will be constructed to contain runoff from the pasture area. Tail water drains will be constructed to collect excess stormwater from the pasture area for diversion into the exchange water treatment ponds. A TIT will be installed to remove potentially oily discharge water from vehicle/plant wash-down Waste oil will be disposed off-site by a licenced waste management contractor.	No reduction in water quality from the domestic sewage effluent disposal systems. Minimal adverse effects on the ecosystem from the on-site operations and waste disposal.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
Disease control and quarantine Refer Section 4.4	Present level of prawn related disease within wild stocks unknown.	Introduced diseases could cause total loss of crop. Movement of introduced diseases could damage wild prawn stocks.	Quarantine facilities will be utilised for new stock. Broodstock will be certified as 'disease-free' prior to transfer to growing ponds. Dead and diseased stock will be collected and buried with a heavy application of lime to increase decomposition. Stock escape will be prevented by pond design measures.	No adverse impact to wild stocks is anticipated.
SOCIAL ENVIRONMENT				
Sacred sites Refer Section 3.13 and 4.12	There are no identified sacred sites within the lease boundaries.	No impact.	No management required.	No adverse outcome
Heritage sites Refer Section 3.13 and 4.12	There are 6 archaeological sites that have been identified at the site. Sixty isolate artefacts were identified on the lease area.	All 6 archaeological sites will be destroyed as a result of the development, either through physical destruction or inundation. Isolated artefacts are likely to be destroyed/inundated.	Ministerial consent to destroy the 6 archaeological sites will be sought prior to construction activities. No management measures required.	Destruction of the 6 archaeological sites on the lease area. Each of the sites is considered to be of low archaeological significance.
Public access Refer Section 3.14 and 4.13	The lease area is currently accessed on an occasional basis by off-road motorcycle riders.	Loss of access	Boundary fencing will prevent public access to the lease area for recreational purposes.	Public access to the site for off-road motorcycle riding will be prevented. Areas adjacent to the property will remain available to motorcycle riders. The impact of access restrictions to recreational users is limited. The development will have no effect on access to the adjacent waterways by recreational fishers.

Table 19 (continued)

Environmental Factor	Existing Environment	Potential Impact	Environmental Management	Predicted Outcome
DECOMMISSIONING				
Site rehabilitation Refer Section 4.15	The site is currently relatively undisturbed.	The site is abandoned or partly decommissioned and not subsequently rehabilitated.	The rehabilitation program will include: • leveling of earthen structures; • removal of miscellaneous construction items; • revegetation of cleared areas, where practical; • feasibility study on potential to convert freshwater dam into a conservation area; • removal of buildings; and • regeneration of access roads.	If the site is abandoned or partly decommissioned project infrastructure will be cleared and disturbed areas revegetated.

4.2 FLORA

Of the 155 plant species recorded during the field vegetation survey, one species (*Grevillea longicuspis)* is listed as rare and of restricted distribution (Leach et al, 1992). This species is however, no longer considered by botanists of the NT Herbarium to warrant rare status, being locally common and well represented in several nature reserves in the region. Intermittent flooding to 14m AHD resulting from dam construction will impinge on the habitat for this species but it is anticipated that this will have a minor impact, potentially affecting approximately 5-10% of the population in the local area. A more comprehensive botanical survey would provide more detailed information on the distribution of this species and the predicted impact of the development on the local population.

One protected species (*Cycas armstrongii*) was identified within the lease area. Although classified as protected this species is widespread and relatively common in the region and their presence does not preclude development in areas with appropriate approval or zoning.

In the regional context, the proposed development area does not have special ecological or conservation significance. No plant communities of conservation significance or registered sites for flora are located within the lease area. The proposed aquaculture development will not affect any vegetation communities of special conservation significance. No rainforest communities and only very minor areas of mangrove vegetation will be cleared. The *Eucalyptus* woodlands and vegetation within drainage areas is widespread and well represented in conservation reserves elsewhere.

Although the flora of the area does not appear to have special local conservation significance, its value as a habitat and its proximity to Darwin confers considerable local significance in terms of its intrinsic ecological value as a habitat and its educational and recreational values.

4.2.1 Vegetation Clearing

Construction activities will involve clearing large areas of vegetation for farm facilities and linear tracts of vegetation along boundaries and firebreaks (**Figure 20**). The approximate area of land required to be cleared during construction is outlined in **Table 20**.

Table 20
Vegetation Clearing Requirements (ha)

Vegetation Unit	Stage 1	Stage 2	Total (ha)
Upland Communities			
Mixed Eucalypt Woodland	6	8	14
Open Woodland	177.9	228	405.9
Grassland	5	3	8
Drainage Areas			
E. polycarpa open woodland	9	24	33
Mixed species woodland	0	13	13
Riverine Open Woodland	1	14	15
Mangrove Communities			
Tidal Flat Zone	0.9	0	0.9
Tidal Creek Zone	0.2	0	0.2
Rainforest			
Monsoon Vine Thickets	0	0	0
Total (ha)	**200**	**290**	**490**

Vegetation cleared will be pushed into windrows and progressively burnt, minimising adverse effects on air quality in the immediate area.

The clearing of vegetation may lead to habitat degradation from the spread of weeds and erosion, which commonly results from terrain disturbance associated with clearing. The management and control of these issues is discussed in **Sections 4.2.4** and **4.8.2,** and the effects of construction and operation activities on specific vegetation communities is provided below.

4.2.1 Mangrove Communities

Mangrove communities in the lease area will be affected by the proposed development through localised clearing of approximately 1 ha of vegetation. Mangrove communities in and adjacent to the lease area may be indirectly affected by the development, through increased sedimentation (if uncontrolled), alterations to surface water and groundwater flow, and minor alterations in the tidal regime. Infrastructure design parameters will be implemented to minimise potential adverse impacts and a mangrove monitoring program is proposed (**Section 5.4.2)**.

4.2.1.1 Clearing

The clearing of mangroves will be confined to that area necessary for the establishment of required infrastructure for the proposed development. The Hinterland Margin Zone is a diverse and highly productive mangrove zone that is relatively limited in extent (Metcalfe 1999). Where possible, the mangroves bordering the hinterland will be avoided during construction.

Approximately 1 ha of mangroves will be cleared to enable the construction of the pump jetty and supply channel. The construction of channels leading to discharge outlets may also require clearing of a small area of mangroves (approximately 0.1 ha).

It is expected that the gently sloping batters of the supply channel will be rapidly colonised by mangroves.

4.2.1.2 Indirect impacts

Seasonal freshwater inflow and seepage to the mangrove fringe dilutes soil salinity levels and creates conditions more favourable for plant growth. The aquaculture development may result in a reduction of the amount of seasonal freshwater supply to some areas, potentially resulting in mangrove dieback in areas that were previously seepage zones, creek lines or where the exchange water dams have a significant effect on surface and groundwater flow. The supply channel alignment will avoid traversing and truncating any minor tidal channels to reduce interruption to surface water flow. Overland flow of freshwater from the freshwater dam spillway may promote the growth of mangroves in the area.

Construction of the supply channel, pump jetty and 20 ha of exchange water treatment dams (Stage 1) may have indirect impacts on adjacent mangroves. Minor changes in patterns of tidal inundation may result in a gradual shift in species composition over time and dieback can occur if sedimentation (resulting from construction or during operation) reduces aeration within plant root systems (Blasco et. *al,* 1996). To minimise the potential for adverse impact on mangroves:

- Vegetation clearing and construction of earthen bunds will be undertaken in a manner that will minimise the potential for erosion and hence sedimentation in runoff.

- The supply channel will be kept to the minimum width required and will be constructed in a raised embankment, such that the potential for exposure of underlying PASS will be minimised.

Erosion and sedimentation control measures are further detailed in Section 4.8.1.

Mangrove communities have been observed to thrive around prawn farm outlets (Foster & Robertson, 1999). Microbial, algal and macrophyte (large plants and trees) production have been found to increase in response to nutrient inputs (Foster and Robertson, 1999). Hanley and Caswell (1997) studied the impacts on mangroves of nutrient rich flows from sewage outfalls at Buffalo Creek, approximately 25 km to the north of the lease area. Increases in primary production were found in mangrove species monitored over a two-year period, though the increases were only significant during periods of high humidity and rainfall in the early Wet Season.

If nutrient discharges from pond effluent downstream of the proposed prawn farm, reached similar levels to sewage effluent in Buffalo Creek, the impacts on the biota are expected to be very similar. That is, mangrove productivity and growth would show seasonal increases. However, changes in diversity of invertebrate species, particularly crabs, could be expected (Hanley Caswell 1997), which may have associated impacts on mangrove vegetation. Crabs play a significant role in soil aeration, nutrient cycling and seed predation in mangrove areas and shifts in crab species diversity and abundance may have consequences for mangrove vegetation (Robertson 1991).

4.2.2 Woodland Communities

Clearing will be minimised for infrastructure development and fire protection. Predicted direct and indirect impacts on the flora of the survey area are discussed below.

4.2.2.1 Clearing

Clearing of vegetation will be necessary for construction of the production ponds, exchange water treatment pond, freshwater dam, farm buildings, housing, roads, the power plant and the establishment of a pasture area.

Construction of the of Stage 1 and Stage 2 production ponds will involve clearing of approximately 115 ha of *Eucalyptus*–dominated open woodland with minor areas of mixed species woodland associated with a small seasonal creek. The area to be cleared is quite substantial and represents a notable loss of habitat in the local area.

The Stage 1 freshwater dam is located on a small tributary that flows into the north arm of Middle Creek. Although the dam will cover a total area of 20 ha, the amount of clearing necessary will be somewhat less than this. The main vegetation communities affected will be riverine open woodland, which forms a linear corridor along the creek line, and the surrounding *E. polycarpa* open woodlands that fringe the creek.

Woodland vegetation, within a corridor approximately 100 m wide and 0.6 km long, will be affected by the construction and operation of the dam spillway. Vegetation clearing will be restricted to the centre of the spillway area and vegetation to either side and downstream will be retained.

Overall, the estimated maximum area of vegetation to be cleared for both Stage 1 and Stage 2 freshwater dams is 206 ha. Prior to dam construction, all vegetation along the lower levels of the impounded drainage lines will require clearing. In these areas the vegetation will be permanently

flooded to a depth considered lethal to the trees. The main vegetation types affected will be open woodland, *E. polycarpa* open woodland and riverine open woodland communities. These communities do not have special conservation significance. Much of the vegetation fringing the upper levels of both

freshwater dams (at around 13-15 m AHD) will probably be retained as it is expected to survive post-construction hydrological changes.

An area of 26 ha of terrestrial vegetation may be cleared for dryland sludge disposal and pasture production in Stage 2 of the project. The vegetation of this area is uniform open woodland with variable dominant species including *Eucalyptus miniata, E. tetrodonta* and *Erythrophleum chlorostachys.* Clearing of vegetation will be selective and kept to the minimum necessary for waste recycling for each stage of the development.

During Wet Seasons when the dam fills completely, the local water level will be raised to the 14 m contour, but it is unlikely that this level will be maintained for any longer than one to two months. In drier years, this water level may not be reached in the course of the Wet Season. As the Dry Season progresses, evaporation and draw down for operational use will result in a relatively rapid fall in water level to a base level at around 8 m AHD.

4.2.2.2 Indirect impacts

The Freshwater Dam

Environmental conditions created by dam construction are anticipated to take some time to stabilise. The initially unstable freshwater dam system could encourage the introduction and proliferation of exotic species and terrain disturbance arising from construction of the 1 km dam wall may create conditions suitable for woody weed introductions. Weed management is discussed in Section 4.2.4.

The freshwater dam will create different habitat opportunities for a variety of animal and plant species, by altering natural resources and adding a perennial water supply. Indeed, the dam may contribute to increased biodiversity in an area that currently contains little or no standing fresh water during the late Dry Season.

- *Upstream areas*

  In upstream areas, where existing vegetation may experience only intermittent periods of inundation to depths of several metres, it is likely that a good proportion of the existing vegetation, particularly the Paperbarks (*Melaleuca* spp.) will tolerate the new regime. *Melaleuca* species naturally occur in areas subject to extended seasonal inundation, lasting from 3 to 6 months or more depending on the season. They tolerate such conditions with water-repellent bark and aerial roots to aid aeration during lengthy periods of inundation.

  Upstream areas most affected by the Stage 2 freshwater dam will include the three main drainage area communities (**Section 3.9.2**), which occur along the two branches of the most southerly seasonal creek. Collectively they mainly comprise open woodland and woodland communities in which *Eucalyptus polycarpa, Melaleuca* spp. and *Lophostemon lactifluus* are common to abundant. In Eucalypt-dominated open woodland habitat, which requires well-drained substrates, tolerance of the vegetation to new groundwater conditions (flooding) is less likely.

  Flooding of upstream habitats is expected to have a significant impact on flora of the freshwater dam area. The impact will vary with the level of tolerance of each species to

  periodic waterlogging and altered ground water levels. An increase in water table level may have a negative impact on surrounding Eucalypt woodlands adapted to seasonal drought and rapidly draining substrates.

- *Downstream areas*

  Hydrological changes from freshwater dam construction may impact on downstream flora in several ways. Changes to the pattern of seepage from the hinterland, groundwater flows and surface runoff may alter the supply of water to downstream vegetation. Substantial diversion of seasonal freshwater flows by the dams may cause an increase in soil salinity and water stress in mangroves and brackish creek bank vegetation where previous water regimes diluted the water supply. Conversely, increases in the supply of freshwater, within spillway areas for example, will encourage the growth of downstream mangroves, sedges and wetland vegetation.

The Pasture Area

Sludge from the production ponds will be highly saline and rich in nutrients, particularly nitrogen and phosphorous. After desalinisation and spreading onto suitably prepared land, the sludge will be used to fertilize pasture species and recycle nutrients.

Native grass species and pasture species will be planted to biofilter the runoff from high nutrient sludge and to stabilise the substrate in cleared areas. The species selected for this purpose will be carefully chosen, excluding known environmental weeds.

The sludge disposal area will be adequately bunded to contain high salt/nutrient sediments. However, peak storm events may cause flooding which would potentially overflow these bunds. Tail water drains will be designed to collect excess stormwater from recycling areas for diversion into the exchange water treatment dams.

Other

Associated impacts on flora may result from broad changes in drainage and the potential for increased erosion and downstream sedimentation from clearing and terrain disturbance. However, the majority of the production pond area is well contained by bund walls, thus the potential for erosion and sedimentation to impact on surrounding vegetation both within and outside the project area is greatly minimised. Results of monitoring of the impacts of Stage 1 will be used to modify Stage 2 operations if required.

4.2.3 Other Impacts

Fire management measures employed on the lease area (**Section 4.9**) will result in a reduction in the frequency of widespread, high intensity fires. This will result in a gradual decrease in annual grasses such as *Sorghum* that provide abundant fuel for annual fires. Reduced fire frequency will also lead to shifts in species composition towards a denser mid-stratum layer that will most likely include fire-sensitive monsoon forest species (J Brock, pers. comm.). The grading of extensive linear corridors for fire breaks and trails may encourage the spread of weeds into areas where they were previously absent. Annual weed surveys will allow the identification of any spread of exotic grasses including *Pennisetum polystachion* and *Andropogon gayanus* and, if required, management measures will be employed to limit their proliferation.

Flooding of upstream habitats is expected to have a significant impact on the flora of the proposed freshwater dam areas. However, habitat creation may in fact ensue, with increases in natural resources from the extra water. Consequently new supplies of food and water will then be available to fauna. The freshwater dams are likely to be colonised by a number of wetland plant species and wildlife species, being particularly attractive to many wading birds and frogs. It is anticipated that environmental

conditions within the new wetland created by construction of the freshwater dam will take some time to stabilise and this potentially unbalanced freshwater ecosystem may encourage the introduction and spread of exotic species such as *Salvinia molesta*.

Native plant species such as the reed *Eleocharis* spp., *Melaleuca* spp., and *Lophostemon* may proliferate in the swampy areas along the margin of the dam. Seepage from the freshwater dam may provide an increased supply of freshwater to some downstream areas depending on volumes and direction of seepage. Increased seasonal freshwater supplies will increase the distribution of upper tidal flat mangroves, reeds and sedgeland.

Management commitments to control or minimise potential adverse effects that the project's construction and/or operation may have on vegetation are outlined below.

Vegetation Management (non-weed species)
Ponds, dams and infrastructure will be located such that areas to be cleared are minimised. **All dam walls will be constructed with the toe graded, and compacted to avoid smothering of mangrove pneumatophores in adjacent mangrove forests.** **The saltwater supply channel will be constructed in a raised embankment, such that the potential for exposure of underlying potential acid sulfate soils will be minimised.** **The saltwater supply channel will be constructed across contours to minimise disturbance to tidal flows and to reduce the likelihood of water ponding.** **Construction design measures to minimise the effects of erosion and sedimentation will be implemented.**

4.2.4 Weeds

Overall, the lease area is relatively free of weed infestations.

Terrain disturbance, clearing of native vegetation and nutrient enrichment of normally nutrient poor substrates could facilitate the proliferation of weed species. In particular, clearing linear tracts of vegetation for fire breaks and roads may lead to habitat degradation from erosion and the spread of weeds. The introduction of weeds could lead to environmental decline and loss of biodiversity through the exclusion of native plant species.
Of primary concern are the introduced grasses such as *Pennisetum polystachion, P. pedicellatum* (Mission Grass) and *Andropogon gayanus* (Gamba Grass). The floating aquatic fern, *Salvinia molesta,* could also become established in the freshwater dam area. Aquatic weed growth such as

Typha, will be minimised by the expected rapid draw down of water in the freshwater dams early in the Dry Season for production requirements, resulting in an unstable margin. Native species such as the reed *Schoenoplectus* sp. and *Eleocharis* spp. may also proliferate in the swampy areas of the freshwater dam margin.

A number of management strategies will be employed to minimise the potential for the establishment of new weed species. The following priorities will be adopted:

- prevention of weed introduction into intact natural habitats and areas disturbed by construction and operational activities; and
- minimisation of environmental changes that will encourage the spread and proliferation of non-native species.

These priorities will be achieved by adopting the following management commitments.

Weed Management
Weeds will be removed from areas around farm buildings and controlled in accordance with DPI&F requirements. **Heavy equipment to be used in earthmoving will be washed down prior to entering the lease area.** **When equipment is being used in areas with existing infestations, care will be taken not to spread seed to new areas, particularly for Class B species.** **Species for pasture production will be selected in consultation with Parks and Wildlife Commission of the Northern Territory and the DPI&F.** **Production usage will draw down the freshwater dam on a seasonal basis, discouraging growth of aquatic and semi aquatic species.** **Annual weed monitoring will be undertaken.**

4.3 FAUNA

4.3.1 Terrestrial Fauna

The proposed project would involve the clearing of approximately 490 ha of woodland habitat. This is a significant amount of habitat loss, which will result in the displacement of most fauna species occurring there. However, the lease area is not considered to be a significant area for fauna, and is not a significant habitat for any threatened species. The woodlands habitat which occurs on the project area is very widespread in the Darwin region.

No wildlife habitats or sites of high conservation importance, such as monsoon forest or wetlands, were found on the project area. The most important wildlife habitat in the area is the mangroves. Since the project is designed to minimise any loss of mangroves, there will be little direct impact on this habitat. Flow on effects, such as loss of freshwater input and nutrient rich discharges may affect

mangrove habitats at a local level, but these effects are not expected to be widespread, and thus terrestrial fauna inhabiting the mangroves would not be significantly affected.

The freshwater dam is likely to be colonised by a number of wildlife species. The dam would be attractive to many wading birds, and development of the dam would likely result in the enhancement of the area for water birds and frogs.

4.3.2 Marine Fauna

It is considered that the proposed aquaculture development has no potential to significantly impact upon the Darwin Harbour barramundi population. Griffin (2000) indicated that the Darwin Harbour barramundi stock probably spawn in the vicinity of Lee Point and Shoal Bay as there is very little suitable nursery habitat within the Darwin Harbour. No supralittoral swamps have been identified within the lease area. There will be minimal disturbance of the intertidal salt flats, over which barramundi may periodically feed. Exchange water discharges will be managed to minimise impacts on any barramundi that may be in the vicinity of the outflow during discharge events (**Section 4.6.2**) and the proposed development will not prevent the migration of barramundi into the upper fresh water reaches of rivers upstream from the lease area.

Disease control management will be used to minimise the potential for significant impacts upon stocks of wild prawns and mud crabs. Construction of the saltwater supply channels and the exchange water discharge ponds will be managed to minimise the physical impact upon wild prawn and mud crab habitat (**Sections 4.4** and **4.6.2**). Quality of the discharged exchange water will be managed to minimise the potential for significant impacts upon marine fauna in the receiving environment.

Hanley Caswell (1997) noted a decreased diversity and abundance of invertebrates downstream of nutrient rich flows from sewage outfalls at Buffalo Creek. Increased numbers of *Perisesarmid* crabs were noted and thought to be a consequence of algal growth encouraged by elevated nutrient levels as a result of the discharge of wastewater.

1. Fauna Management

Quality of water discharge from the treatment ponds will be monitored prior to release and appropriate mitigation/management measures employed to protect the receiving waters.

Disease control management measures will be implemented to minimise the potential for significant impacts upon stocks of wild prawns and mud crabs.

4.4 PRAWN STOCK - QUARANTINE, DISEASE MANAGEMENT AND CONTAINMENT

All post larvae will be purchased from hatcheries that can provide veterinarian certification of ‘disease free’ status. As an additional safeguard, quarantine facilities comprising large holding tanks (within a steel frame shed) will be utilised for the arrival of post-larvae to the farm. The post-larvae will be kept in the holding tanks for a period of five days whilst technical staff check them for disease. The water supplied to these ponds will be recirculated and the prawns, and associated water, will not be released until the prawns have tested as "disease-free".

Any dead stock, or stock suspected of being disease-carrying, will be removed and buried. The buried prawns will be heavily limed to increase decomposition.

All quarantine and disease control (including disposal of diseased stock) will be carried out in accordance with the Aquavet Plan (in preparation) prepared by the Ministerial Council on Forestry, Fisheries & Aquaculture.

Stock escape from the production ponds will be prevented by a pond wall freeboard of 0.5 m. Each pond will also be drained via a monk structure, which will be screened with suitable size mesh (matched to the size of the stock). The monk will be designed to ensure that stock do not escape during a maximum rainfall event. In addition, a screened structure will be constructed at the discharge point to hold the discharge back at certain times of the day, depending on the tide.

2. Disease and Stock Management

All post larvae will be purchased from hatcheries that can provide veterinarian certification of 'disease free' status.

Quarantine facilities will be utilised for new stock.

Water utilised in the quarantine facilities will be recirculated, and only released when the new stock has been declared "disease free".

Stock escape will be prevented by pond design measures.

Dead and/or diseased stock will be collected and buried, with a heavy application of lime to assist decomposition.

4.5 HYDROLOGY

4.5.1 Stage 1 Development

Stage 1 includes the following construction that will alter the natural hydrological patterns of the lease area:

- A freshwater dam at the headwaters of the north arm of Middle Creek, with a surface area of 20 ha and a storage capacity of approximately 460 ML. The dam wall will be constructed to a height of approximately 15m AHD (a maximum wall height of 7.5 m) including a spillway located at the southern end of the dam wall.
- A 20 ha exchange water treatment pond, located between the mangroves and the proposed production ponds.
- A saltwater supply channel.
- Production ponds (27 ha).
- Farm infrastructure including buildings, roads, canals and cleared areas.

The construction of the Stage 1 freshwater dam will remove a significant proportion of the annual freshwater streamflow into the north arm of Middle Creek. The dam will divert streamflow away from

the natural drainage line directly downstream of the proposed dam wall. Overflow from the spillway will be directed back into the natural channel approximately 400-500 m downstream of the proposed dam wall. All stream inflows in excess of the reservoir capacity will flow through the dam and spillway and return to the natural drainage paths.

The exchange water treatment pond will consist of low earthern embankments adjacent to the mangrove fringe at the base of the proposed production ponds. The embankments of the exchange water treatment ponds will block natural drainage lines for the catchment directly to the north-east of the embankment. The runoff from this area will be collected in stormwater canals and redirected to culverts under the exchange water treatment pond embankments or to discharge points at the end of the embankments. Runoff that would naturally enter the mangrove areas as sheet flow will now enter as stream flow at defined discharge points. There is a potential for increased erosion at these locations due to concentration of flow. Where required channels will be lined to minimise erosion.

The saltwater supply channel will consist of a 30 m wide canal extending through approximately 300m of mangrove area. The channel will have raised embankments on each side with vehicular access along the embankments. While some alteration to the natural tidal movement can be expected, the main tidal movement in the area is considered to be along the proposed alignment of the saltwater supply channel, therefore minimising erosion potential. The channel embankments will block any lateral tidal movement across the alignment of the channel. Lateral tidal movements will occur through either tidal channels or by sheet flow through the mangroves/minor salt flats. Some scouring along the base of the saltwater supply embankment may occur as the tidal waters create new tidal channels to adjust to altered hydrological conditions. Due to the potential for erosion the saltwater supply channel will be protected by rock armour and a compensatory tidal channel will be constructed if required. Additional proposed management techniques to control erosion are outlined in Section 4.8.1.

Construction of production ponds will provide a barrier to natural drainage patterns. Stormwater will be diverted around the production ponds by stormwater channels of sufficient design capacity to accommodate the probable maximum precipitation (PMP) event.

Other proposed farm infrastructure includes farm buildings, access roads and cleared areas (eg carparking). These facilities will have the following effects on the hydrological characteristics of the area:

- Construction of farm buildings and cleared areas (eg. carparking areas) will slightly increase the volume and peak flows of storm runoff for these areas. The anticipated increase in runoff volume is anticipated to be minor and will be compensated by the capture of direct rainfall onto the producation ponds and freshwater dams.

- Construction of farm buildings will divert natural drainage patterns. Sufficient drainage channels will be constructed around buildings and where possible stormwater will be redirected towards natural drainage lines with appropriate hydraulic design to transition flow to the downstream natural landform.

- Access tracks constructed across the lease area may impede or divert natural drainage.

4.5.2 Stage 2 Development

Stage 2 development includes the following construction that will affect the hydrological regime of the lease area:

- A freshwater dam at the headwaters of the south arm of Middle Creek. The freshwater dam will have a surface area of 186 ha and a storage capacity of approximately 5,500 ML. The dam wall will be constructed to a height of approximately 14m AHD (a maximum wall height of 13 m).

- Extension of production pond area to 115 ha and exchange water treatment ponds to 80 ha.

- A freshwater supply channel connecting the Stage 2 freshwater dam and the production ponds.

- Additional farm infrastructure, including farm buildings, roads, cleared areas, pasture areas and pond sediment stockpiles.

The Stage 2 freshwater dam will consist of a dam wall approximately 1 km in length. A spillway will be located at the southern end of the dam wall. The dam is anticipated to intercept a significant proportion of the stormwater stream flow that would naturally drain into Middle Creek. In addition, the dam will divert streamflow away from the natural drainage line directly downstream of the proposed dam wall. Overflow from the spillway will be directed back into the natural channel approximately 500m downstream of the proposed dam wall.

The extension of the production ponds and exchange water treatment pond will divert natural drainage patterns. Stormwater will be managed around the production ponds with drainage designed for the PMP event.

The additional farm buildings, cleared areas and access tracks will increase the volume and peak flows of storm runoff for these areas and divert natural drainage patterns. Drainage channels will be constructed around buildings and where possible stormwater will be redirected towards natural drainage lines with appropriate hydraulic design to transition flow to the downstream natural landform.

The freshwater supply channel to be constructed between the Stage 2 freshwater dam and the production ponds will impede the natural drainage paths for the catchment to the east of the channel. Stormwater drains will be constructed along the edge of the channel to direct stormwater into either the Stage 2 freshwater dam or through a culvert placed under the freshwater supply channel that will connect to natural drainage lines flowing into the north arm of Middle Creek.

4.5.3 Storm Surge and Flood Levels

The Vipac report (No: 24113-1) *Greater Darwin Cyclone Storm Surge Risk*, Northern Territory Department of Lands, Housing & Local Government, August 1994, analyses the peak combined sea level predictions for numerous locations in the Greater Darwin region. The nearest location to the lease area is Channel Island, where the 1 in 100 year and 1 in 1000 year peak combined sea level prediction is 5.1 m AHD and 6.4 m AHD, respectively. The saltwater settling channel, adjacent to the mangroves, will be constructed to a height of 6.5 m AHD (4.0 m AHD base, with 2.5 m embankment). The main infrastructure of the proposed development will therefore be constructed above the 1 in 100 year peak combined sea level prediction for Channel Island. The peak combined sea level prediction for the aquaculture development lease area is anticipated to be less than for Channel Island.

There are no streamflow gauges currently located on the Blackmore River and DLPE has not produced flood level information for the Blackmore River (pers. comm DLPE). However, it is considered that the relatively low topography of the catchment, the relatively wide tidal channel, the close proximity to Darwin Harbour and the attenuation effect of the mangroves would reduce the likelihood of the lease area being flooded from Blackmore River. To accurately determine flood level heights of the Blackmore

River a complete catchment analysis would be required.

4.5.4 Groundwater

Multiple bores (a minimum of two) will be established within the lease area to obtain potable (eg drinking, showering, septic), landscaping and factory production water requirements from the groundwater supply. An estimated 2,250 L/day will be required for Stage 1 and approximately 70,000 L/day for Stage 2.

The water quality of the groundwater from the Burrell Creek Formation in the region and the potential for saltwater intrusion into the underlying aquifer has not been assessed. Extraction of groundwater for potable water supplies at the Blackmore River lease area is not expected to have significant impact on saltwater intrusion into the underlying aquifer. However, any proposal to extract the quantities of groundwater proposed in Stage 2 of the development will require the analysis of the potential for saline intrusion into the underlying aquifer.

4.5.5 Adjacent Developments

Future planning schemes for the Greater Darwin Area include the construction of a new suburb 'Weddell' to be located to the east of the lease area. The construction of residential suburbs in the catchment of the proposed Stage 2 freshwater dam will have the following effects on the hydrological characteristics of the area:

- Runoff from urban areas is typically greater than for equivalent natural bushland sites. If runoff from Weddell is released into the catchment of the Stage 2 dam there will be a subsequent increase in runoff to supply the dam.

- If the runoff from Weddell is released into the catchment for the Stage 2 dam it is likely that water quality in the reservoir will deteriorate. The highest concentration of contaminants in urban runoff can generally be expected at the beginning of the Wet Season ie "first flush" phenomenon.

- If stormwater runoff from Weddell is diverted away from the Stage 2 dam catchment there will be a decrease in runoff to supply the dam.

If urban development occurs in the upper catchment of the Stage 2 freshwater dam, a program of water quality monitoring will be instigated.

3. Surface Water and Groundwater Management

Erosion control measures (Section 4.8.1) will be implemented in areas where diversion of flow may result in scouring.

Project layout will be designed to minimise adverse impacts on surface water drainage.

Farm alignment/design will avoid interruption to tidal movement.

Sufficient drainage channels will be constructed around buildings and stormwater will be directed towards natural drainage lines, with appropriate hydraulic design to transition flow to the downstream natural landform.

Overflow from the freshwater dam spillway will be directed back into the natural channel, downstream of the dam wall.

The main infrastructure of the proposed development will be constructed above the 1 in 100 year peak combined sea level prediction for the region.

An analysis of the potential for saline intrusion into the underlying aquifer will be undertaken prior to the development of Stage 2 of the project.

If urban development occurs in the upper catchment of the Stage 2 freshwater dam, a program of surface water quality monitoring will be instigated.

4.6 WATER QUALITY

4.6.1 Production Water Quality

The nutrient content of the pond water will be determined by feed and fertilizer inputs and by water exchange. Water quality within the ponds will be systematically monitored, with samples being tested on a six-hourly basis. Parameters to be monitored are pH, DO, temperature, salinity and turbidity. Data will be stored and processed in a central farm computer system.

The regime of feed will be determined by the results of water quality analysis (in particular, dissolved oxygen). It is intended to run the farm on the computer program “Pondman 2” a system

developed by the CSIRO Marine Research, CRC. Stocking levels, water exchange, feed and aeration regimes will be set with reference to the water quality parameters.

4. Water Quality (Production Ponds) Management

A program of water quality testing will be undertaken.

Stocking levels, water exchange, feed and aeration times will be determined with reference to water quality parameters.

4.6.2 Waste Water Discharge

Discharge of discharge water to the environment will occur during operation of the aquaculture project. Accordingly, an application for a Waste Discharge Licence under the *Northern Territory Water Act (1992)* will be sought form DLPE.

4.6.2.1 Discharge water composition

Natural TSS levels in the Blackmore River system experience substantial fluctuations depending on total suspended solid (TSS) levels of rainfall runoff and the existing tidal conditions. Therefore the intake water from the Blackmore River for aquaculture production may contain existing high TSS levels. This suspended solid matter will predominantly be settled out of the water column in the wide, slow flowing saltwater supply channel before placement into the production ponds.

Production pond effluent can potentially contain high levels of nutrients and suspended solids. Final discharge of water from the aquaculture development will be into Middle Creek via a drainage channel. The environmental impact of such release on flora and fauna in the area will depend upon the discharge water composition after treatment, and the propensity of the discharge water to be diluted by its receiving waters.

Following consultation with CSIRO Marine Research, CRC, the management of discharge water quality will involve preventative and minimisation measures, supported by appropriate environmental monitoring.
Stocking levels in the production ponds and the water exchange, feeding regime and fertilisers inputs to these ponds will be determined with reference to water quality monitoring. Discharge from the production ponds will be channeled to the exchange water treatment pond(s) where the concentration of nutrients and suspended solids will be reduced. The potential amount of suspended solids and nutrient removal by the exchange water treatment pond(s) will be variable. Management aim to continually improve the environmental management of the lease area by incorporating the latest waste prevention and treatment technology.

In order to quantify the amount of nutrients that are released by the production process into the environment water samples will be collected from the discharge channel prior to release and analysed for TSS, total nitrogen (TN) and total phosphorous (TP). The monitoring of TSS, TN and TP is standard industry practice for the quantification of the environmental impact of prawn farm discharge water on receiving waters.

CSIRO Marine Research estimates of the reductions in levels of TSS, TN and TP from the implementation of a properly functioning water exchange treatment pond is presented in **Table 21**.

Table 21

Estimated Reduction in TSS, TN, and TP after Treatment

Water Quality Parameter	Volume Generated from Stage 1 Pond (kg/day)	Volume Reduced Via 20 ha Treatment Pond (kg/day)	Net Increase/(Reduction) (kg/day)
Total Suspended Solid	Unable to be quantified	Unable to be quantified	Projected net reduction
Total Nitrogen	30 to 60	33 to 100	27 / (70)
Total Phosphorous	3 to 6	4 to 10	2 / (7)

Note: 1. Derived from data obtained from CSIRO Marine Research, CRC.

The discharge water will be released to Middle Creek between 20 minutes and 5 hours after the Darwin high tide (when the outgoing tidal range is greater than 2m) in order to maximise the flushing and dilution into the Blackmore River receiving waters. By releasing on an outgoing tide, movement of the discharge water into the mangrove system (which will also be draining) will be minimised.

Release will occur when the outgoing tide is of sufficient height to allow drainage into Blackmore River and Darwin Harbour. Discharge water will undergo substantial dilution in Blackmore River and Darwin Harbour and the flushing characteristics of Blackmore River will provide substantial water exchange.

5. Discharge Water Management

Management measures will be implemented to minimise the nutrient load and level of suspended solids generated in the production pond water.

Exchange water treatment pond(s) will be used to reduce the concentration of nutrients and suspended solids from the production pond effluent.

Prior to release of water into the receiving environment, a program of discharge water testing will be undertaken.

Discharge water will only be released during outgoing tides when the tidal range is greater than 2 m.

Accidental or unauthorised release of discharge water will be prevented by the use of locks on all critical valves.

4.7 GENERAL WASTES

4.7.1 Sludge

When the solid material (sludge) builds up in the supply channel and the discharge water pond to the point where desilting is required, the material will be removed and deposited into the solids desalination bays. At this stage, the sludge is expected to be highly saline and have elevated nitrogen and phosphorous levels.

The sludge is likely to remain in the desalination bays for several Wet Seasons, such that salinity levels are reduced through rainfall infiltration. As only a sparse coverage of vegetation will exist in area any leachate from the sludge is considered unlikely to have any significant environmental impact.

In-situ conductivity readings of the sludge material will be taken periodically. Once salinity levels are sufficiently reduced the weathered sludge material will then be transferred and spread over the established pasture area. Established pasture vegetation species will minimise run-off, assist with stabilisation, and act as a biofilter.

A bund wall to contain runoff during most storm events will isolate the pasture area. However, peak

storm events may cause flooding which could potentially overtop the bund. To accommodate this, tail water drains will be designed to collect excess storm water from the pasture area for diversion into the farm discharge. If overflow occurs, the impact associated with elevated nutrient loads in runoff waters will be minimised through dilution during peak storm events.

4.7.2 Sewage, Domestic Discharge water and Miscellaneous Wastes

Sewage and domestic discharge water will be treated by septic tank systems designed in accordance with Territory Health guidelines. It is anticipated that there will be no significant impact on the biophysical environment from the on-site disposal of sewage and domestic discharge water.

Potentially contaminated washdown water from vehicle and plant cleaning will be directed through a TIT and discharged to either an absorption trench or lagoon system.

Domestic waste, including hard rubbish and food scraps, will be temporarily stockpiled in an allocated area of the borrow pit and either buried or disposed to municipal landfill in accordance with DLPE and Shire of Litchfield guidelines.

6. General Waste Management

Sludge will not be transferred from the solids desalination bays to the pasture area until *in-situ* conductivity measurements indicate a sufficient reduction in salinity levels.

A bund wall will be constructed to contain runoff from the pasture area.

Tail water drains will be constructed to collect excess stormwater from the pasture area for diversion into the exchange water treatment ponds.

Sewage and domestic waste water from residences and buildings will be treated by septic tank systems designed in accordance with Territory Health guidelines.

A triple interceptor trap (TIT) will be installed to remove potentially oily waste water from vehicle and plant washdown.

Waste oil will be disposed off-site by a licenced waste management contractor.

4.8 SOIL DISTURBANCE

4.8.1 Erosion and sedimentation control

All construction works will be undertaken in the Dry Season.

The majority of the production pond area will be well contained by bund walls, minimising the potential for erosion and sedimentation. Access roads constructed on the lease area will be drained with side gutters and runoff drains. These drains will be constructed parallel to the contours to prevent scouring and erosion. Ongoing maintenance of all road surfaces and embankments will be undertaken to ensure their integrity.

To minimise erosion all embankments will be compacted during construction and between 0.1 m and 0.2m of lateritic gravel will be compacted on the crests and sides of the pond walls. The embankment to the saltwater supply channel will be armoured with rock rip-rap. Ongoing maintenance of the saltwater supply channel embankment constructed through the mangrove fringe will include:

- Raising the level of the embankment, should settlement occur due to consolidation of underlying mangrove clays.
- Repairs to cracks in the embankment due to differential settlement as a result of consolidation of underlying mangrove clays.

To ensure that the flow of discharge water does not cause scouring or erosion, discharge channels to the north arm of Middle Creek will be constructed using rock rip-rap.

The spillways for both the small and large freshwater dams will be stabilised to prevent erosion. The spillways will be excavated into shallow laterite and will be designed to release overflow water in a manner that will minimise channeling and erosion. All excavation areas in the

freshwater dam will self-drain back into the floor of the dam. If required, the flowpath from the spillways to the natural drainage lines will be stabilised to prevent erosion. This may consist of a

0.75 m deep discharge channel excavated to bedrock, drop structures to reduce velocities, channel protection or construction of protective bund walls.

Cleared areas around buildings will be landscaped and maintained to minimise the potential for erosion.

4.8.2 Dust control

The majority of construction activities will be undertaken during the Dry Season. If problematic levels of dust are generated during construction a water cart will be used for dust suppression purposes. Dust will be suppressed with a water cart if any of the following situations occurs:

- Complaints are received from neighbours legitimately affected by the generation of dust from the lease area.
- Dust generation creates an unsafe working environment during construction activities.

The majority of construction activities will be undertaken during the Dry Season. If dangerous levels of dust are generated during construction a water cart will be used for dust suppression purposes.

7. Erosion, Sedimentation, Drainage and Dust Management

All construction works will be undertaken in the Dry Season

Roads will be drained with side gutters and runoff drains.

Embankments will be compacted and have a cover of lateritic gravel.

A lined catchdrain will surround the ponds to collect and channel stormwater runoff.

Where required, channels will be lined with rock rip-rap and the saltwater supply channel protected with rock armour.

Farm alignment/design avoids interruption to tidal movement and surface water flow.

Appropriate dust suppression measures will be instigated where a significant hazard exists.

4.9 FIRE REGIME

It is expected that fire management strategies associated with the proposed development will result in a reduction in the frequency of widespread, high intensity fires in the remaining vegetation. This will result in a gradual decrease in annual grasses such as *Sorghum* that provide abundant fuel for

annual fires. Reduced fire frequency also leads to consequent shifts in species composition towards a denser mid-stratum layer that includes fire sensitive monsoon forest species (Brock *pers comm*).

A Fire Management Plan will be developed in consultation with the Bushfires Council of the Northern Territory and in accordance with Litchfield Shire requirements. The Fire Management Plan will have a number of key objectives, including reduction of flammable fuel loads around housing

and farm infrastructure for fire protection and to prevent extensive, destructive wildfires. Fire management of the lease area will also incorporate broader, landscape–scale objectives including the protection of fire-sensitive species and communities (eg. dry rainforest) and to create a mosaic of burnt and unburnt country that will encourage habitat heterogeneity. Ecologically, patchy burning creates conditions more suitable for a diverse range of fauna and flora, which encourages ecosystem stability.

Firebreaks will be regularly slashed. The alignment and construction of firebreaks will be in accordance with the Fire Management Plan for the lease area, to ensure that negative impacts are reduced. Fire management of the lease area will involve clearing of vegetation along a 4 m wide easement around the perimeter of the lease area. A 20 m firebreak will surround all accommodation buildings and the fenced boundary of each 2 ha allotment will also involve maintenance of a 4 m wide firebreak. A 50 m break will be cleared around all other farm buildings and these wider firebreaks will be landscaped to reduce erosion.

Overall, given that approximately 60 % of the lease area will be cleared for the aquaculture project combined with the natural protection afforded by the mangroves to the west, the boatramp road to the north and the freshwater dam to the south-east, the lease area is relatively well protected from fire.

8. Fire Management

Firebreaks will be formed and regular maintenance of vegetation around infrastructure on the site will be undertaken to reduce flammable fuel loads.

Fire reduction and prevention methods will be coordinated within a Fire Management Plan, which will be formulated in consultation with the Bushfires Council of the Northern Territory.

4.10 BITING INSECTS

The proposed Blackmore River (East) Aquaculture Development will generate permanent and semi permanent bodies of both fresh and saltwater that may constitute breeding sites for biting insects. Whilst existing areas around the farm site are known to act as breeding grounds for insects, it is important that the creation of new breeding habitats is minimised.

On-going monitoring of biting insects will be undertaken, as detailed in **Section 5.4.4**.

4.10.1 Biting Midges

The prime breeding habitat of the principal pest species (*Culicoides ornatus*) is in the upper reaches of the small tidal creeks or at the seaward fringe of extensive mangrove areas, and will generally be at the margin and under a canopy of mangrove vegetation. As the production ponds are to be constructed above the tide margin and not within the mangrove zone, the development is not likely to impact on any of the major pest biting midge breeding sites.

The development of the large area of production ponds, particularly during Stage 2, will create an effective buffer zone between the most productive biting midge sites (the mangrove margins) and the

area to the east of the production ponds. The production pond area will be relatively free of vegetation, and as a consequence wind action will further disrupt biting midge dispersal. In addition, lights will be installed at the mangrove margin of the pond development to attract midges away from sensitive areas such as residential or night use areas.

The project layout maximises the distance between sensitive areas and biting midge sources. However, during periods of extreme pest numbers there is a potential that biting midges may represent nuisance value to staff working within 1.5 km of the mangrove margin.

Insecticide treatment of biting midge larvae in this habitat is unproven, highly impractical and likely to be environmentally unacceptable. Aerosol application for the effective control of adult biting midge also poses practical problems. These include the timing of control, the necessary environmental and weather conditions, access requirements, the non-specificity of most adulticides, and the failure of aerosols to penetrate thick vegetation. During periods of high levels of midge activity it is unlikely that insecticide control of biting midge adults will be able to achieve a significant reduction in pest numbers.

The most practical method to avoid or reduce pest problems in the lease area is to implement personal protection strategies. There are a number of avoidance and personal self-protection measures that can be taken to reduce biting midge pest problems. These include:

- installation of fine insect screens and light proof curtains;
- avoidance of areas of high biting midge activity;
- avoidance of problem areas during peak biting insect activity; and
- application of personal protective clothing and personal repellents at times or locations of exposure to biting insects.

Contractors and permanent staff will be made aware of the biting midge issue during an induction program. Personal protection against biting midges will almost certainly be required over extended periods.

4.10.2 Mosquitos

4.10.2.1 Potential effects of development on mosquito numbers

Earthworks in the tidal area during the construction phase have the potential to create isolated pools of fresh and saltwater. Any retention of water and particularly the colonization of reeds and grasses in temporary or perennial flooded drains or depressions in the lease area could lead to the creation of new mosquito breeding sites. Prolific breeding of both brackish and freshwater species of mosquitoes may occur in these areas unless features are suitably constructed and maintained.

- The proposed location for the exchange water treatment ponds has the greatest potential for tidal margin disturbance and the creation of new mosquito breeding sites. The pond/channel wall will be designed to reduce salt marsh areas adjacent to mangroves (**Figure 21**) and so reduce available mosquito breeding grounds. The water level in the exchange water ponds is likely to be stable thereby providing a habitat that promotes the growth of *Schoenoplectus* and *Eleocharis* reeds. As the water in these dams will probably be brackish, they are likely to breed *Ae. funereus* and *Ae. vigilax* when first flooded, and *Cx. sitiens, Cx. annulirostris, An. hilli, An farauti* and *Cq xanthogaster* if maintained as flooded dams.

- New mosquito breeding sites may be created through the impoundment of freshwater in the proposed dam. The potential for the freshwater dam to form mosquito breeding sites

- depends on vegetation growth, the rate of draw down of water, the presence of fish and the presence of non-draining depressions as the dam level recedes. A stable dam level will encourage *Eleocharis* reed growth around the margins and promote mosquito breeding.

- The salt water supply channel is likely to be colonized by mangroves. This mangrove growth may lead to silt build up in sections of the supply channel and will result in ponding of salt water during periods when there is no supply water conveyed in the channel. If this ponding occurs for periods greater than seven days, it is likely to breed salt-water mosquitoes including *Cx. sitiens* and *An. hill.*

- If ponding occurs in unfilled borrow pits these can become appreciable sources of *Cx. annulirostris* and *Anopheles* species.

- Unlined open stormwater drains containing organically polluted water will breed mosquitoes if there are low flows from leaking ponds or other wastewater sources. Any stormwater drain likely to have continuous Dry Season flow will become a mosquito breeding site. Problem drains will be characterized by extensive grass growth and stagnant pools with green filamentous algae.

4.10.2.2 Management measures

Biting insect management techniques will focus on minimisation of breeding grounds and personal protection rather than insect eradication. Management of biting insect problems will include:

- **Farm Infrastructure Design**

The exchange water discharge point will dispose exchange water direct to a tidal creek. The discharge will be to Middle Creek, which is free draining at low tide and so will reduce the potential of creating new mosquito breeding sites. The internal drainage system and supply channels will be designed to be free draining and will discharge to the exchange water treatment ponds.

Access roads will be constructed along high ground, minimising the need for culverts and the potential for puddle formation. Run-off drainage will be installed to ensure the side drains of the access road do not pond, with run-off drains having sufficient slope to ensure self-emptying without scouring.

Residences and farm buildings will be positioned away from the low-lying areas of the farm and above the 16 m AHD contour. Areas around all buildings will be selectively cleared,

leaving shade trees but opened up sufficiently to enable slashing. All buildings will be gauzed and air conditioned such that insects can be excluded from living areas.

Any borrow pits within the development will be filled or made free draining.

Areas likely to be permanently under water will be cleared of all trees and other vegetation to reduce the organic levels that will promote mosquito breeding. Silt traps will be constructed in the north arm of Middle Creek to trap and remove silt. This will prevent disruption to the free draining nature of the creek. Any appreciable ponding in isolated pools after draw down of water in the freshwater dam will be drained into the central channels. Annual inspections will be undertaken to identify these isolated pools.

- **Farm operation and maintenance**
  On-going management practices to reduce breeding areas for mosquitoes will include aeration of ponds, weed control, regular grading of roads (to avoid the formation of puddles after rainfall) and regular flushing of channels.

  Maintenance of the production ponds should prevent excessive growth of reeds and hence reduce refuge for mosquito larvae from predators. An annual assessment of the extent of reed growth in the freshwater dam will be undertaken to identify potential mosquito-breeding sites that may have developed. Reduction or elimination by weediciding or formalized margins may be required if mosquito-breeding sites have developed. Native fish populations will be maintained in the dam to assist with the control of larval mosquito numbers.

  A field survey of the tidal margin of the development area will be undertaken to locate any *Ae. vigilax* breeding sites. If practical, these sites will be rectified, preferably by filling or draining.

  Regular slashing of cleared areas around buildings will be undertaken to create a less favourable habitat for biting insects in their vicinity. Management will ensure that miscellaneous items, such as used tyres, pipe fittings, oil drums waste plastic sheets and bags, are not left in the open to collect rainwater and create mosquito breeding potential.

- **Induction of staff**
  As part of farm induction, new staff will be advised of the risks associated with mosquitoes and other biting insects. Information provided will include the risk of viral disease, the farm's prevention policy, seasonal variation in insect densities and advice on clothing and repellants. Appropriate clothing, insect repellant and antiseptic cream will be supplied to staff by management on an as-needs basis.

9. Biting Insect Management

Farm buildings and infrastructure will be designed and maintained to minimise the creation of new biting insect breeding grounds.

Native fish populations will be maintained in the freshwater dam to assist with the control of larval mosquito numbers.

Regular clean up of farm grounds will be undertaken to remove potential water containing rubbish.

Drainage will be designed to prevent ponding of water in low lying areas.

All staff will be informed of risks associated with biting insects and the preventative measures available.

Appropriate clothing, repellants and antiseptic creams will be available to all personnel on site.

4.11 EXOTIC SPECIES

Feral animals, especially pigs, have a potential to cause damage to the aquaculture ponds and may require control measures. These measures would depend on the level of the problem, and would be implemented in consultation with the Northern Territory Parks & Wildlife Commission.

Rodents, cats and dogs will be dealt with as the need arises by means of fencing or eradication. Whilst it is not intended to install bird nets from the outset, netting will be installed if water birds cause significant stock losses.

4.12 ARCHAEOLOGY

4.12.1 Background

Section 4 of the *Northern Territory of Australia Heritage Conservation Act 1991,* defines an 'archaeological place' as a "...place pertaining to the past occupation by Aboriginal or Macassan people that has been modified by the activity of such people and in or on which the evidence of such activity exists...". To this end, prescribed archaeological places or objects are "...deemed to be a place or object in respect of which an interim conservation order is in force and shall be deemed to remain so until the Minister...makes or refuses to make a declaration [as a heritage place] in respect of the place or object" (Section 39(1)). This mechanism provides temporary protection to an archaeological site while a decision can be made regarding whether or not it should be preserved.

All six of the archaeological sites and the background scatter identified by Heritage Surveys within the project area fall into the definition of a "prescribed archaeological place or object" as defined in Section

4 of the Act. All of these sites should therefore be regarded as being legally protected under the Act.

Prior to the commencement of construction Phelps/Panizza will seek a permit, under Sections 29 and 39 of the *Northern Territory of Australia Heritage Conservation Act 1991,* to disturb or destroy all archaeological sites likely to be affected by construction and/or operation activities.

4.12.2 Potential Impacts of Aquaculture Farm Construction and Operation

The impact of the proposed aquaculture development upon the archaeological sites located in this study is summarised in **Table 22** below. All six archaeological sites identified during this survey will be destroyed by the proposed development. Isolated artefacts identified during the survey are also likely to be destroyed.

Table 22

Impact of Project Development on Archaeological Sites

Site name	Relationship to proposed development	Impact of proposed development
BR1	Exchange water treatment dam	Destruction
BR2	Exchange water treatment dam	Destruction
BR3	Exchange water treatment dam	Destruction
BR4	Freshwater dam	Inundation
BR5	Freshwater dam	Inundation
BR6	Freshwater dam	Periodic inundation

One of the reasons archaeological resources are regarded as significant is because "they constitute a unique, non renewable data base for reconstructing the cultural past and for testing propositions about human behaviour" (Moratto and Kelly 1978:5). As such a site's scientific significance depends on two characteristics, its representativeness and its research potential.

1. *Representativeness.* This criterion concerns the extent to which the archaeological remains within a particular site are represented at other localities within the region. Unusual or unique sites are normally accorded a higher archaeological significance than sites that are very common. Given that all sites are in a sense unique (Bowdler 1984:2), they are normally considered in terms of categories (such as "quarry" or "knapping floor") when determining how common they are.

2. *Archaeological research potential.* This criterion concerns the potential of a site to contribute to timely and specific research questions. A site's potential to contribute towards the resolution of research questions may depend on a number of factors such as its state of preservation and the range of past human activities reflected at that site.

Archaeological sites at Blackmore River are small in size and contain a limited diversity and quantity of archaeological materials. These characteristics, together with the absence of stratified archaeological deposits ensures that the information potentially available from the archaeological sites in the study area is relatively limited. In terms of their morphology, contents and environmental context the sites cannot be regarded as unique or unusual in the context of the Darwin region as a whole. Surface shell scatters and stone artefact scatters represent site types recorded widely across the Darwin region and the type of information available from them is therefore likely to be repeated at many other localities. It

is also relevant to note that sites BR1, BR2 and BR4 have been impacted by erosion and other disturbance associated with vehicle traffic, while Site BR3 is likely to be quite recent in age.

Given these considerations, the archaeological significance of all six of the archaeological sites identified during this study is assessed to be low.

Isolated artefacts of the kind found within the study area are ubiquitous throughout the greater Darwin region (e.g. Hiscock 1994, 1995; Heritage Surveys 1995, 1997a, 1997b). While such materials could potentially make a minor contribution to the resolution of archaeological research questions such as the nature of prehistoric subsistence strategies, such information is likely to be available at many other localities. The archaeological significance of the isolated artefacts identified during this study is therefore regarded as minimal.

4.12.3 Archaeological Management

Ministerial consent to disturb the six archaeological sites will be sought prior to construction. The appointed archaeological consultant advised that no mitigative action is required with respect to the archaeological materials located in the project area.

4.13 RECREATIONAL ACTIVITIES AND SOCIAL ISSUES

The lease area confers limited local significance in terms of its intrinsic recreational values. The area encompassing the proposed development is used by off road motorcycle riders for recreational purposes, on an occasional and informal basis.

Security is of critical importance for the project operation because of the high value of the stock in

ponds and on farm equipment. Once the lease has been finalised, public access to the development area will be closed, limiting in particular the activities of off road motorcycle riders. Areas adjacent to the lease, which will be unaffected by the proposed development, remain available for motorcycle riding.

Recreational fishermen use the adjacent off-site waterways. There will be no limitation to fishermen because of the development. The access to the Middle Arm boat ramp remains as is and the waterways around the farm site will be unchanged and unobstructed other than the installation of the pump jetty. No access to the farm via the jetty will be permitted.

Given the dense population of mangroves between the Blackmore River and the development area and the relatively low elevation of the production ponds in both Stages 1 and 2, adverse affects to the visual amenity of area to boat-borne fishers will be limited solely to the view of the jetty.

The social impacts of traffic generated from the Stage 1 aquaculture development are expected to be minimal. Construction traffic will be generally maintained on-site and operational traffic will generally be below 6 daily vehicular movements. This degree of traffic movement is not expected to contribute significantly to the deterioration of the local road infrastructure and is expected to have minimal impact on local residents.

Operational traffic associated with final development is estimated to be between 18 and 24 vehicles per day. The increased volume of traffic, representing two vehicular movements per hour, based on 12 hours of daylight, is considered to have potential for minor change only and unlikely to increase the deterioration of the local road infrastructure. However, techniques that will be adopted in order to minimise the volumes of traffic generated by the Blackmore River Aquaculture Development will

include:

- on-farm accommodation for staff;
- use of mini buses to convey staff back and forward from town;
- operation of school bus to Blackmore Springs\Palmerston for any children living on-site;
- connection to Northern Territory power grid, reducing the amount of diesel fuel delivered;
- roster for shopping and supplies delivery to on-farm staff by off-farm staff; and possible transfer of cooking, packing and storing functions to a facility in Darwin.

10. Management of Recreational/Social Issues

Farm operation will be organised to minimise the volume of local traffic generated by the aquaculture development.

4.14 HEALTH, SAFETY AND EMERGENCY ISSUES

4.14.1 Security

Security at the entry of the farm will be closely managed on a 24-hour basis with controlled passage for all personnel onto the lease area. Similarly, the boundary of the farm will be fenced and maintained so as to prevent uninvited entry and unlawful removal of stock and/or equipment.

The pump jetty, which will extend 30 m into the Blackmore River, will be signed to warn the public away from the structure. Lighting will be installed along the jetty length, incorporating a solar-powered navigation light. The pumps will be shielded with steel mesh to ensure that the danger of people or objects being drawn into the pump intake is removed.

Unless authorised, no public vehicle will be permitted to enter the farm. Vehicle occupants will be obliged to park and alight from their vehicle and check-in as they pass the gate and transfer to a farm-based vehicle. A similar check-out procedure will apply on departure. No farm-based vehicle will be permitted to leave the lease.
These measures will be put in place for:

- disease isolation (a vehicle from another farm or coastal area cannot contaminate the farm);
- rust prevention (the salt effects will be confined to farm-based vehicles);
- keeping of accurate staff hours;
- prevention of theft of stock (anything removed from the farm will be carried by hand);
- prevention of theft of equipment, fuel and supplies; and
- accurate record keeping for supplies and production.

All critical valves will be secured with locks as required to prevent accidental or unauthorised release of water.

4.14.2 Isolation during the Wet Season

Flooding of the Middle Arm Boat Ramp Road can occur after large rainfall events during the Wet Season. This flooding usually lasts for reasonably short periods of time, with 4WD access generally still possible.

As a contingency against being isolated from town and services and any associated adverse impacts on the health and safety of personnel or on farm operations, management policy will include:

- two weeks minimum supply of all farm necessities, including fuel, prawn feed, food and medical supplies;
- a majority of farm vehicles to be 4WD, including the provision of a small (5-10 tonne) 4WD low ground pressure truck to carry essential supplies;
- a readiness to utilise helicopter services to bring staff in and out;
- provision of on-farm temporary accommodation for workers required or forced by road blockage to stay overnight; and
- staff induction to include flood procedures.

11. Health and Safety

Lighting, signage and mesh barriers will be utilised at the pump jetty on Blackmore River to ensure the pump does not represent a risk to public safety.

Security issues on the farm will be managed by well-maintained fencing and regulated access requirements.

Sufficient medical and food supplies will be kept on-site in the event of short-term isolation due to limitation in access via Middle Arm Boat Ramp Road.

4.15 DECOMMISSIONING AND REHABILITATION

The proposed development is considered to be a permanent development, which will be retained in its entirety. Should abandonment of the aquaculture development (or parts thereof) be required, then the following decommissioning and rehabilitation practices will be applied.

The pumps and jetty will be decommissioned and removed from the Blackmore River. The supply channel, production and treatment ponds will be leveled with a D8 dozer or similar. Concrete and piping will be removed for salvage. Miscellaneous materials such as power lines, pumps, above ground storage tanks and small concrete structures will be removed from the lease area.

In the initial stage, the wall of the freshwater dam will be around 7.5 m in height and this would be leveled by dozer back to the surrounding ground level. The Stage 2 freshwater dam will have a

maximum wall height of 13 m and would be difficult to flatten. Should the dam be decommissioned from its full-scale size a feasibility study will be conducted, in consultation with relevant Authorities, to evaluate the potential benefits of converting the structure into a conservation and recreational area.

All buildings (except concrete footings) and equipment will be removed. On-site access roads will be ripped and graded flat and the regeneration of the vegetation encouraged.