Effect of Proposed Actions including Offsets on Net Load and Impact on Environmental Water Quality

PACIFIC REEF Fisheries

Summary

The Environmental Protection Agency has sought further information on the nature and basis of the offset proposed under the Guthalungra Aquaculture Project. This report provides additional information, and should be read in conjunction with Sections 5.1, 7.2 to 7.5 and 7.18 of the Supplementary EIS.

Government regulations and guidelines are currently silent on the issue of offsets. In spite of this, the Guthalungra Aquaculture Project will provide strong and clear leadership to the Queensland Aquaculture Industry in regard to the implementation of offsets. The project also allows the State of Queensland to implement actions to meet obligations under the Reef Water Quality Protection Plan to reduce diffuse source nutrient input to the Great Barrier Reef Lagoon.

This report finds that the major source of nutrients in the Great Barrier Reef lagoon, and therefore probably in the Don River Catchment, is resuspended terrigenous sediments that are released during significant rainfall events. A wide range of nutrient loading of the Don River Catchment occurs as a result of the amount of rainfall received in any particular year. Depending upon rainfall, sediment release can vary by multiples of hundreds of thousands of tonnes, nitrogen by multiples of thousands of tonnes and phosphorus by multiples of hundreds of tonnes.

The offset proposed under the project will result in a net reduction of sediment entering the Great Barrier Reef lagoon. It will also reduce the diffuse source nutrients entering the lagoon and provides a mechanism by which the State can meet its' obligations under the Reef Water Quality Protection Plan.

The report compares natural and constructed wetlands as means for processing runoff to reduce sediment load to in-shore waters. This report recommends natural rehabilitation of terrestrial and wetland habitat as it -

- allows normal successions of plants;
- allows the formation of natural community structure and therefore development of habitats suitable for endemic fauna species;
- takes advantage of the proximity of similar ecosystems nearby;
- avoids the risk of selecting inappropriate target species that don't then form functional groupings.

This report also finds that although the efficiency of nutrient removal by wetlands is not definitive and will vary with hydraulic loading, it is likely that rehabilitated wetlands will remove at least 80% of sediment, 50% of nitrogen and 55% of phosphorus from runoff flows. The benefit of rehabilitating wetlands is likely to accrue rapidly and continue for the life of the project.

Nutrient loads into the Don River Catchment have been investigated and alternative offsets have been considered. The principles of equivalence (like for like) have been applied and it is concluded that there are no additional or alternative offsets available to the proponent.

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General

Nutrient cycles in the environment are, in general, well understood. Nutrients are input to an environment either from an external source or by fixation from the atmosphere. Some nutrient is immediately lost by sequestration or volatilisation. The remaining nutrients stimulate primary production resulting in algae and other plant production and subsequently feed into animal production processes. Upon the death of the plants and animals, the nutrients are recycled by bacteria into primary production.

A balanced supply of nutrients is required for a healthy ecosystem. Too little nutrient and the ecosystem will not be productive, too much and the production tends toward eutrophication with boom bust cycles of production. Under this scenario, biodiversity is adversely impacted as the environment favours species that would normally be present in lesser numbers and periods of low dissolved oxygen associated with "bust" cycles cause mortality of both plants and animals.

It is important in managing such environments that appropriate consideration is paid to the nutrient balance in the environment. It is also important to note that most environments have the capacity to buffer the effects of additional nutrient inputs. Coastal zones have a degree of robustness in their capacity to deal with nutrient input associated with the source of nutrients, the state of the nutrient (ie bound or free, redox state etc) the time over which the nutrient is added and the rate of dilution of the nutrient. Robustness may reflect in the response of an environment to additional nutrient input. For instance an ecosystem relatively deprived of nutrients may respond with increased seagrass production if additional nutrients are added. Alternatively, an ecosystem that has little or no additional capacity to buffer nutrient inputs will respond by increased algal blooms, shading of benthic organisms and changes in biodiversity.

Care must be taken to consider fundamental issues of water flow and dilution in a coastal ecosystem when evaluating likely impacts of additional nutrient inputs to that ecosystem. One example occurs with an upstream nutrient input to a coastal stream that is only slowly diluted through tidal exchange while the water quality and tidal exchange regime near the mouth of the stream allows for suitable buffering of additional nutrient input to the system at that point. In general, nutrient inputs into open (oceanic) or semi-closed (bays) systems are able to be accepted to a far greater extent than in stream systems.

Nutrient cycles and processes in semi-enclosed waters of the Great Barrier Reef.

Source of nutrients

Nutrient in coastal water columns may be derived from:

- mainland discharges from runoff and groundwater;
- point source discharges;
- atmospheric fallout;
- wind driven upwelling;
- fixation of atmospheric nitrogen; and
- regeneration from coastal sediment (Gabric and Bell, 1993).

Understanding the relative size and state of each nutrient source is important to understanding the impacts of additional nutrients. In in-shore waters, whilst runoff is

important (Gabric and Bell, 1993), other factors may play significant roles. Nitrogen fixation can be an important component of nutrient input to inshore waters. Carpenter and Price (1977) found that *Trichodesmium* spp., similar to that which comprises a major component of the phytoplankton in the Great Barrier Reef lagoon, fix 20% of the daily nitrogen requirement in the euphotic zone of the Caribbean. In the Baltic, Rosenberg *et al*. (1990) estimated 50% of the nitrogen supply was from atmospheric input including nitrogen fixation.

Resuspension of sedimentary nutrients constitutes a transfer of nutrients from bottom sediments to the water column and constitutes the most important source of nutrients for primary production in coastal zones. Resuspension of as little as 1 cm of sediment (compared with the actual zone of physical reworking which is 3 – 5 cm) by wind events would significantly increase the total nitrogen in overlying water in the Great Barrier Reef lagoon (Ullman and Sandstrom, 1987). Further, resuspension of sedimentary nutrients was considered to be a causative factor in the development of algal blooms in the central Great Barrier Reef lagoon (Gabric *et al*., 1990).

Walker and O'Donnell (1981) in a study of the nutrient loading of Cleveland Bay, 125 km to the north west of Abbot Bay, summarised their findings as:

1. There was a strong relationship between nitrogen, phosphorus, light attenuation and wind run in Cleveland Bay,
2. Changes in the attenuation coefficient result largely from changes in the amount of suspended sediment and detritus,
3. 80% of the particulate matter and nutrients entering the bay from runoff was in inorganic form.

Much of the nutrients in sediments may have originally come from terrestrial runoff. (Gabric and Bell, 1993). Thus prevention of additional sedimentation from runoff is an important strategy for limiting nutrient input into coastal aquatic environments.

Within sediments, denitrification is favoured in environments such as Cape Bowling Green Bay (Ullman and Sandstrom, 1987), which is immediately to the north of Abbot Bay, where low organic carbon and high sedimentation rates prevail. In these circumstances, NH_4^+ is oxidised to NO_2^-or NO_3^- prior to reduction to N_2 and release to the atmosphere (Ullman and Sandstrom, 1987). Resuspension of the surface layers of sediment thus releases NH_4^+, NO_2^- or NO_3^- before reduction can occur, which are then available for primary production. Even when considering the nutrient fluxes of rivers such as the Burdekin, which delivers over 11,000 T of nitrogen to the reef annually, Ullman and Sandstrom (1987) found sediments to be the principle source of dissolved N to the Great Barrier Reef lagoon.

Phosphorus, however, appears to be influenced by runoff events rather than resuspension (Eyre, 1993). This is probably because the trivalent phosphorus is more tightly bound to sediment particles than the monovalent nitrogen molecules (Eyre, 1993).

Primary production

Primary production in reef and other waters is largely affected by turbidity. Brackish and turbid plumes from the Burdekin River carry a pulse of nutrient rich water, which would be expected to produce a plankton bloom in the lagoon (Ullman and Sandstrom, 1987). However, such blooms often do not eventuate in the Great Barrier Reef (Gabric *et al*., 1990) or elsewhere (Cadee, 1978; Aller *et al*., 1985), probably

because the nutrients are carried with high levels of terrigenous sediments, which limit light penetration. Light penetration is also limited in cases where sediment is resuspended and is largely due to presence in the water column of sediment and detritus, rather than algal blooms resulting from increased nutrients in the water column (Walker and O'Donnell, 1981).

The circumstances described in the above studies match the observations made of water quality in Abbot Bay by the proponent. There is an increase in phosphorus in Abbot Bay during rainfall and subsequent runoff, but increases in the total suspended solids and nitrogen appear to be more closely related to wind events than rainfall events.

Current nutrient loading in the Don River Catchment

Water Quality Action Plan

The proposed prawn farm constitutes part of the Don River catchment, which is described as 3695 km^2 in area (GBRWQAP). It has been estimated that there are currently 509,528 T of sediment, 812 T of total nitrogen and 178 T of total phosphorus entering the Great Barrier Reef Lagoon through the Don Catchment each year (GBRWQAP). These nutrients are diffuse source nutrients derived from runoff over what is largely deforested grazing land, although some horticulture is conducted in the catchment. The catchment is characterised by long dry periods during which significant degradation of the land occurs, followed by short periods of heavy rainfall, the runoff from which carries significant quantities of nutrients from denuded grass lands.

National Pollutant Inventory

The data listed on the National Pollutant Inventory (NPI; http://www.npi.gov.au/) for the Bowen Shire listed pollutants released to air but no reports of pollutants released to waters. In 2004/05, 110T of ammonia, 3400 T of oxides of nitrogen and 6900 T of particulate matter were released to air in the Bowen Shire. No records listed release of phosphorus in the Bowen Shire in 2004/05.

The NPI assessed only point source and not diffuse loads on the environment in 2004/05.

Other point source pollutant loadings

Two point source loadings on the aquatic environment in the Don River Catchment have been identified. These are 1) the sewage outfalls administered by the Bowen Shire Council around the town and 2) the discharge from GFB Fisheries Ltd.

Data obtained from the Bowen Shire Council (Gary Martin, personal communication) shows that 6.1 T of total nitrogen and 5.7 T of total phosphorus was released to the environment through the Muller's Lagoon outfall during 2005.

Data from GFB Fisheries Ltd (EPA, Annual return NR0449) shows that 14.3 T of nitrogen and 1.35 T of phosphorus were released into Saltwater Creek from the fish farm in 2005/06.

Current nutrient loads from runoff passing through the proponents property

Approximately 43 km^2 of the catchment drains via surface channels through the proponent's property to the Great Barrier Reef Lagoon, either through the saltpan or freshwater wetlands. The catchment on the proponent's property is similarly

comprised of deforested grazing land with some horticulture and therefore represents a reasonable sample of the total Don River catchment. It is estimated, on a proportional basis, that approximately 5,936 T of sediment, 9.44 T of nitrogen and 2.07 T of phosphorus runs off from the portion of the Don River catchment that drains through the proponent's land.

An additional undefined area drains to the lagoon via the Elliot River. Although the proponent has control over some part of the riparian area of the northern bank of the Elliot River, it is not clear and therefore not possible to estimate, what influence flow through that riparian area would be on nutrient discharge to the lagoon.

Description of prawn farm discharge.

The proposed prawn farm will discharge 453 T of sediment, 34 T of nitrogen and 3.4 T of phosphorus directly into the lagoon via a point source discharge. The modelling of water flow in this area indicates that it will generally be carried north out of the area affected by the Don River into that affected by the Burdekin River which is a much larger source of nutrient input to the lagoon. Available modelling of discharge impacts is discussed in greater detail in Appendix Q, GAPFR, 2003. Prior to release, the prawn farm discharge will be treated with sand filtration and subsequent polishing pond processes to ensure water quality is the highest achievable with current technology.

Proposal for Offset – Rehabilitation of 240 Ha to natural state.

Summary

The proponent will remove cattle from the undeveloped area of Lot 370, which is severely degraded by over grazing. This area includes extensive saltpan and mangroves and includes the riparian areas of the Elliot River on the northern side and of an oxbow lake. The total area of exclusion is approximately 240 Ha of which approximately 59 Ha is wetland. This area of wetland comprises approximately 15 Ha of saltflats, 25 Ha of riparian zone and mangroves along the Elliot River, 8.5 Ha of oxbow lake, and 10.5 Ha of freshwater wetlands.

Initially, the area degraded by cattle grazing including the wetlands will be allowed to rehabilitate naturally, although a weed management plan will be put in place immediately to remove the declared plants. In the event that natural rehabilitation processes prove to be too slow to be effective, active revegetation of the area will be undertaken.

This offset is expected to provide a number of benefits.

The principal benefit is to significantly increase the efficiency of nutrient removal by wetlands of runoff from 43 km^2 of grazing land thereby providing an active contribution to meeting the objectives of the GBR Water Quality Action Plan and mitigating against the release of nutrients in the outfall of the prawn farm.

Other benefits that will accrue are:

- Return the Oxbow Lake to a condition approximating the pre-white settlement state, thereby enhancing the cultural experience of indigenous people for whom this is an important site.

- Enhance the habitat available for wetland fauna species and provide further refuge for rare and endangered species currently found on adjacent wetlands.
- Enhance the terrestrial habitat and provide the opportunity for regeneration of natural sensitive coastal communities of flora and fauna.

Current status of area to be rehabilitated

Ecotone Environmental Services (Appendix M, GAPR 2003) described the wetland and terrestrial habitats.

The saltpan habitat was described as “extensive areas of hypersaline flats largely devoid of vegetation but with isolated individuals or patches of samphire and salt couch” fringed by “typical salt couch grassland occurring in a narrow band between the terrestrial grassland community and saltflats”.
Similarly the oxbow lake comprises “extensive areas of hypersaline flats largely devoid of vegetation”.
The mangroves and riparian area of the Elliot River was described as “narrow bands of low diversity *Avicennia marina* dominated communities with *Aegialitis annulata* along the seaward margin” and “low grassland dominated by exotic species with woody weedy shrubs to 4m”. This area is currently showing signs of extensive erosion.
The freshwater wetlands were recorded as “largely permanent lagoons have been created by damming natural ephemeral drainage lines. Emergent and floating macrophytes are present”. However, recent observation reveals that these lagoons do dry and are grazed by cattle and pigs.
The terrestrial zone of the area to be rehabilitated comprises a mix of two habitat types. The first, open woodland dominated by *Corymbia tesselaris* contains “ground cover is highly variable, dominated by grasses or forbs, weeds are abundant”. The second, “low grassland dominated by exotic species with isolated woody weeds to 4m”.

Damage to the area as a result of previous land management practices is readily observed with extensive areas of bare ground, widespread weed infestations and localised erosion. The current state of the land is clearly shown in Figures 1 to 8 below.

Figure 1. General degradation of the terrestrial environment by grazing of cattle

Figure 2. View of a freshwater marsh/farm dam showing erosion and denuding of forbs by grazing

Figure 3. Cattle paths and eroded areas in the oxbow lake

Figure 4. Cattle paths and erosion at the edge of the salt marsh

Figure 5. Cattle paths and erosion at the upper edge of the inundation of the salt marsh

Figure 6. Grazed areas of the riparian zone of the Elliot River.

Figure 7. Comparison of grazed (left of fence) and ungrazed (right of fence) areas f mangrove and saltpan. Note the differences in vegetation on either side of the fence in the fore and middle ground.

Figure 8. Grazing and erosion of denuded ground in and around the farm dam.

Natural vs active revegetation of degraded wetland areas

The goal of rehabilitation of offset areas is to return a damaged ecosystem to a more natural condition, and to provide a natural mechanism for removing nutrients from overland water flows. Concerns have been raised over the efficiency of regenerating the wetland by allowing initial natural revegetation as compared with active revegetation of degraded habitat.

Natural rehabilitation is considered to have a number of benefits. Chiefly among these, natural rehabilitation allows plants capable of colonising and surviving in the particular environments to do so. Natural rehabilitation allows normal successions of species to occur and is therefore likely to be more successful than if plants chosen on the basis of their availability or ability to be propagated are planted. Further, natural rehabilitation allows the formation of a natural community structure suitable as habitat for other species, which is not always the case with artificial plantings. Cord grass in natural marshes in California mostly exceed 60 cm, the height necessary for colonisation by the Clapper Rail. By comparison, constructed marshes have few cord grass stems over 60 cm and have a much lower rate of colonisation by Clapper Rails than natural marshes (Zedler, 1993).

In further studies of the Californian coastal marsh systems, it has been concluded that "Specific ecosystem types will develop best if located near or adjacent to and existing ecosystem of the same type. Some desired species can be transplanted, but the rest of the native community must invade and establish on its own" (Zedler, 1996).

To reduce the cost and enhance success, it has been proposed that restoration efforts could be streamlined by limiting initial plantings to a few key members of the target community (Zedler *et al*., 2001). However, identification of functional groups in wetland communities has proved elusive (Sullivan & Zedler, 1999). Unforeseen synergistic effects between species occur in wetlands that are being rehabilitated, with some species facilitating the survival of other rare species through competition with dominants (Zedler *et al*., 2001). Similarly, an enhanced ability to sequester nitrogen in species with limited canopy biomass was not predicted (Zedler *et al*., 2001). It is apparent from these studies that selecting species for planting on preconceived notions of appropriateness may compromise biodiversity and/or the ability of the resultant wetland to sequester nutrients.

However, it is recognised that rates of natural colonisation may be too slow to provide the level of improvement necessary to achieve the water quality outcomes sought by the proponent. In this case, active revegetation of the area will be undertaken.

The decision to engage in active revegetation will be taken after two years since it is expected that this time would be the earliest that the first stage of prawn production would come on-stream. Further, leaving the decision regarding active revegetation for such a period will allow identification of the species that have naturally colonised and which are therefore most appropriate to use for the purpose.

The proponent has experience in revegetation of wetlands, having engaged in a project to construct a mangrove wetland on its farm at Alva Beach. In that case, many planted mangroves have not survived, while naturally colonising species of mangroves have thrived (Figures 9 and 10).

Effect of channelling rainfall runoff through rehabilitated wetlands.

It is widely recognised that wetlands process runoff water removing solids, nitrogen and phosphorus. Artificially constructed wetlands can provide 100% nutrient removal in some cases (Romero *et al*., 1999) and are used for treatment of sewerage, dairy and swine wastes (Hunt and Poach, 2001). Similarly, diversion of runoff from channels onto flood plains can significantly reduce the loss of sediment from the land to inshore waters (John and Klein, 2003).

The efficiency of natural wetlands, however, is poorly understood. Aspects such as hydrology and hydraulic loading rates are important to the efficiency of any wetland. Revegetation is likely to improve wetland nutrient retention efficiency, but the literature is unclear regarding the degree of impact. Darke and Megonigal (2003) found that plant height and density are correlated with sediment removal at some sites. In that study, up to 90% of the sediment was removed by the wetland. Between 28% to 50% of TSS was found to be removed in a study in coldwater environments in Sweden (Tonderski *et al*., 2005) while 67% - 72% reduction in TSS was achieved in a study by Schulz *et al.* (2004).

Nitrogen is also considered to be efficiently removed from water by wetland systems. Efficiency of N removal has been found to be high, being measured at 100% (Romero *et al*., 1999) and 82.2 to 86.3% (Debusk and Reddy, 1987), although only 41% - 53% N was removed from relatively high nutrient trout farm discharge (Schulz *et al.,* 2004).

Studies of P removal by wetlands are fewer and less conclusive with resuspension of particulate matter to which P has bound apparently an important process. Between 10% and 31% of P was removed by wetlands in Sweden (Tonderski *et al*., 2005) although those authors claimed that the wetlands were more efficient at removing P than N. Phosphorus content of high nutrient trout farm discharge applied to wetlands was reduced by 19% - 30% (Schulz *et al.,* 2004).

Concerns have been raised regarding the efficiency of wetlands in removing nutrients under periodic flood regimes such as those that prevail at Guthalungra. The question put is would a wetland be as efficient if it was subjected to short periods of high flows rather than longer periods of low flows. Craft *et al*. (1988) sampling soils from marshes on the North Carolina coast found that nitrogen, phosphorus and organic carbon pools were greatest in soils of irregularly flooded marshes.

A method for determining wetland efficiency has not been provided during extensive discussions with the Qld Environmental Protection Agency. In a letter dated September 1, 2006, the Qld EPA cited nitrogen attenuation in 15 temperate to tropical studies not listed above. These studies have provided an average attenuation of 53% for nitrogen by wetlands. During the discussions with the Qld Environmental Protection Agency it was agreed that conservative values for the efficiency of wetland removal of nutrients would be used. In accord with this agreement, we have used a method and values peer reviewed and published by NSW EPA for assessing the effectiveness of constructed wetlands (NSW EPA, 1997). This method takes into account hydraulic loading rate to determine the efficiency values for calculating nutrient removal by revegetated wetlands (NSW EPA, 1997). This method has resulted in an efficiency of 0.80, 0.50 and 0.55 being used for sediment, nitrogen and phosphorus respectively.

Runoff proportion also varies with rainfall. In determining hydraulic loading rates for the wetland under different rainfall scenarios, the data from Jenkins *et al*. (2002) have been used. Total rainfall for the Guthalungra area were taken from data provided by the Department of Natural Resources and Mines (http://www.nrm.qld.gov.au/watershed/precomp/121002a/121002a.htm) for the Elliot River at Guthalungra.

Rate of accrual of the benefit of the offset

Accrual of the benefit of wetland rehabilitation and the impacts of nutrient discharge would occur over disparate time frames. It is anticipated that the project would take at least two years following completion of licensing to reach the point of discharging pond effluent. In addition, it is proposed to develop the project in three stages. These factors mean that any impact of the pond discharge on the environment will be likely to begin in year 3 and increase in years 4 and 5.

However, on the basis that successful licensing is completed, rehabilitation of the wetlands can begin at once. Therefore, it is anticipated that reduction of nutrients entering the lagoon would begin to occur in year 0 of the project. Thus, the impact of rehabilitation will be underway prior to discharge of prawn effluent and there is limited likelihood of the activities of the proposed farm causing a short-term nutrient problem.

Concerns have been raised regarding the rapidity with which wetlands can develop to efficiently remove nutrients. In studies of similar systems, processes related to hydrology, sediment deposition and the rates of soil C and N accumulation, developed almost instantaneously with the establishment of vegetation, and young (1- to 3-yr-old) constructed marshes trapped sediment and sequestered N at higher rates than comparable reference marshes (Craft *et al*., 2003).

Maturation of a wetland to achieve biodiversity similar to natural wetlands is likely to take many years, however, and will depend upon the nature of the pulsed events (Zedler and Calloway, 1999) such as rainfall extent and duration. Development of mature wetland above ground vegetation biomass have been observed to take up to 9 years in some systems (Craft *et al*., 2002) while development of nutrient cycles and soil characteristics have been observed to take over 30 years in the same systems (Craft *et al*., 2002). Similarly, sub-surface deposit feeders did not reach populations equivalent to natural marsh land for 25 years, although taxa with planktonic dispersal stages achieved similar densities to natural marsh lands within three years (Craft and Sacco, 2003) with the rate of deposition of organic carbon significantly influencing the rate of development of in-fauna (Sacco *et al*., 1994).

Offset equivalence

The company has undertaken a scan of the policy environment of offsets for development impacts in Queensland. Government regulations and guidelines are currently silent on the issue of offsets, however the proponent is providing leadership to the Queensland aquaculture industry in regard to the implementation of offsets. Offset equivalence is important and so the issue is addressed briefly here.

Comparison of the nature of nutrients in discharge vs those in runoff.

The nature of the nutrients being removed vs those discharged has been raised as a consideration of offsets.

Nutrients contained in runoff are largely particulate and negatively buoyant. Both phosphorus and nitrogen are reversibly bound to soil particles, which sink when delivered into inshore waters during calm weather. These particles are resuspended by wind events and so cause ongoing nutrient loading in the water column. The data presented in (Section 5.1, Draft Supplementary EIS) clearly show the impact of resuspended nutrients on water quality in Abbot Bay. Since particles in runoff are terrigenous and consequently negatively buoyant, they rapidly settle and impact on seagrasses in receiving environments.

Nutrients contained in prawn farm discharge from Pacific Reef facilities are either dissolved or bound into phytoplankton. Unbound nutrients from the discharge of the Guthalungra prawn farm will be present as dissolved inorganic nutrients and, provided there is sufficient light, will be readily incorporated into the organic particulate fraction (phytoplankton). The phytoplankton is neutrally buoyant and so is able to be removed from the immediate receiving environment by currents without settling out onto seagrasses. The form of the nutrients also means that they rapidly enter natural nutrient cycling processes and are much less likely than those contained in runoff to re-enter the system as a result of wind driven resuspension.

Impact of different nutrient sources

Runoff nutrients and prawn farm nutrients are likely to have differing impacts. Nutrients contained in runoff are bound to terrigenous sediment and settle relatively quickly, resulting in smothering of the benthic organisms including seagrasses or corals. Those that do not settle, are present in such concentrated plumes that light attenuation results (Walker and O'Donnell, 1987), limiting primary production and stress to seagrasses and corals. Bongiorno *et al*. (2003) found that physical effect caused by sediment were more likely to cause stress to coral than nutrient effects. Further, Evrard *et al*. (2005) found that particulate organic matter and phytodetritus similar to that found in prawn farm discharge was an important source of nutrients for seagrass.

Therefore, an objective assessment of potential impacts clearly shows that terrigenous sediment and associated bound nutrients in runoff cause both shading and smothering effects. In comparison, low levels of organic suspended solids and dissolved nutrients are readily removed from the immediate discharge environment and are more likely to provide nutrients suitable for enhancing seagrass production than to cause smothering or shading. This assessment was also the essential content of the advice from the Queensland Department of Primary Industries (Appendix 7, Draft supplementary EIS), which stated that there would be no effect of discharge water quality on surrounding seagrasses in Abbot Bay.

Alternative or additional offsets

Consideration of the other sources of nutrient loads into the Don river catchment were discussed above and are summarised in the table below.

Source of nutrient	Total suspended solids (T)	Nitrogen (T)	Phosphorus (T)
Total (GBRWQAP)	509,528	812	178
Largely runoff.			
Discharged to air	6900	3500	-
Bowen Shire Council	-	6.1	5.7
GFB Fisheries	81.4	14.3	1.35

The proponent believes it has identified and will undertake all reasonable offsets available to it. Transfer of 240 ha from commercial production to environmental benefit is considered by the proponent to be a significant contribution to the welfare of the environment of the State. Further, the reduction of sediment load onto the reef from the Don River catchment will assist the State in meetings its obligations to reduce diffuse nutrient input to the Great Barrier Reef as set out in the objectives of the GBRWQAP.

It is not possible to provide nutrient offsets by modifying or influencing another commercial enterprise (eg GFB Fisheries) since the lack of control over that enterprise would compromise any contractual arrangement between the proponent and the State.

It is also inappropriate to provide some offset for nutrients released to water by impacting on nutrients released to air. Nutrients released to air are also largely released by other commercial enterprises. The location of fallout and impact of nutrients released to air is unknown to the proponent.

The release by the Bowen Shire Council will cease within 2 years as a requirement on local government to reduce nutrient discharge from sewerage outfalls.

Net load after accounting for wetland and discharge effects.

The loads into the Don River catchment pre and post project are shown in the table below.

The data are calculated based on median values for rainfall provided by the Queensland Department of Natural Resources (http://www.nrm.qld.gov.au/watershed/precomp/121002a/121002a.htm) with ranges taken from the highest and lowest recorded rainfall (excluding 1993/94 when only 87 mm was recorded at the Elliot River). Runoff was calculated according to Jenkins *et al* (2002) and wetland efficiency according to NSW EPA (1997).

	Total suspended solids (T/annum)[1]	Total nitrogen (T/annum) [1]	Total phosphorus (T/annum) [1]
Pre-project	509,528 (317,593– 2,548,530)	812 (505 – 4,055)	178 (111 – 888)
Post project	505,030 (315,015 – 2,525,182)	836 (531 – 4060)	180 (113 – 885)

[1]Values are median (range) determined by rainfall. Runoff proportion was calculated for each rainfall loading.

All changes in nutrient load are well within the natural variation observed due to annual variation in rainfall. At full operation, these calculations predict **a net reduction** in sediment load on the immediate receiving environment of 4,574 T of sediment per median rainfall year and a small increase in dissolved nitrogen and phosphorus.

Sections 7.2 and 7.3 of Supplementary EIS Guthalungra Aquaculture Project provide water quality objectives. Those sections refer to the impact of the point source discharge on the immediate environs of the discharge point and therefore do not contradict the pre- and post-project data in the table above, which refers to all nutrient inputs to the Don River Catchment including point and diffuse source data.

Similarly, Table 7.3 of Supplementary EIS Guthalungra Aquaculture Project refers to nutrient loading of Abbot Bay directly from the proposed project and does not account for either the nutrient in intake water nor the nutrient removed by the offset provisions. Thus, the table above provides the clearest description of the **net nutrient input** and therefore the true impact on water quality resulting from this project.

Ensuring the offset

In order to provide comfort to both the State and the company regarding the implementation and future management of the area set aside under the offset proposal, it is expected that there will be a legally binding agreement reached between the regulatory agencies and the Company.

Alternatives for such an agreement include:

- Deed of Agreement;
- Statutory Covenant;
- Voluntary Conservation Agreement.

Deed of Agreement

The Qld Department of Primary Industries and Fisheries routinely implements a Deed of Agreement for mitigation of impacts on fisheries resources. Such Deeds are negotiated individually but are legally binding on both parties.

Statutory Covenants

The Department of Natural Resources and Water website (http://www.nrw.qld.gov.au/land/management/statutory_covenants.html) accessed on December 4, 2006, contained the following advice.

“A statutory covenant is an agreement between two or more persons entered into in writing and under seal, whereby either party promises to perform something, or

abstain from certain actions. Statutory covenants are registered over land by the Department of Natural Resources and Water and thus bind future owners of the land.

There have been some recent amendments to the *Land Act 1994* and the *Land Title Title Act 1994* by means of the *Natural Resources and Other Legislation Amendment Act 2005*.

The Department of Natural Resources and Water has developed comprehensive guidelines to help landholders, government agencies and other interest groups preparing to enter into statutory covenants. These guidelines are temporarily unvailable while they are revised to reflect these changes."

Voluntary Conservation Agreement

Voluntary Conservation Agreements exist between individual property owners and government to conserve areas of natural significance. Voluntary conservation agreements are supported by environmental management plans and statutory covenants to ensure that subsequent land owners are bound by the agreement.

Final form of agreement

It is expected that the final form of any agreement will depend upon negotiations between the various agencies of government and the proponent. However, since the offset is in place to mitigate any impacts of developing an aquaculture enterprise at Guthalungra, it is expected that the agreement will only be in force in the event that the adjacent portions of Lots 8 and 370 are used for aquaculture.

The company prefers a Deed of Agreement, which is considered to provide an appropriate balance of obligation and protection for each party. Such a deed would be supported by a Management Plan submitted to government prior to development proceding.

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Addendum Notes:

1. The proponent has been asked to provide information about the offset addressing the different types of wetland separately. In view of the paucity of data available about wetlands of any kind as discussed above, the proponent considers that such a request is unable to be met with any acceptable degree of rigour. Accordingly, discussion of wetlands is presented as a general form.
2. The proponent has been asked to provide information about the surface flow in the catchment in particular the extent of flows into the wetlands. Appendix H of GAPFR (2003) describes the flood hydrology of the site. All water crossing the site will drain through the lowest lying parts, which are the wetland areas. The range (depending upon rainfall) of impacts on nutrient release in storm water is conveyed in the Table on page 18 of this document.
3. The proponent has been asked to identify the release points of water from each wetland. All water passing through the wetlands on site will enter the Elliot river estuary adjacent to the proponent's property, which is currently degraded riparian areas. The releases are diffuse and the precise location will vary according to rainfall, vegetation regrowth and movement in the sand bars in the estuary.