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10. Aquatic Ecology

10.1 Introduction

The purpose of this Section is to provide information on the existing aquatic values of the Nerang River that may be affected by the Project. The potential impacts from the construction and operation of the raised dam wall are determined and assessed. Management measures are recommended to mitigate those negative impacts and enhance positive impacts. For detail on the technical background to the findings presented in this Section of the EIS, refer to **Appendix F.10.1**.

The objectives of the aquatic ecology component of the EIS, as specified in the Terms of Reference (ToR) are to:

- describe the existing aquatic values of the area;
- describe potential adverse and beneficial impacts of the proposal on these aquatic values; and
- identify any potential impacts that may occur as a result of the proposed works and provide mitigation measures and recommendations to ameliorate any potential adverse impacts.

No significant flora or fish species as listed under either the *Environment Protection and Biodiversity Conservation Act 1999* or the *Nature Conservation Act 1992* were recorded from the Nerang system during the field investigates reported in the EIS. A number of fish species considered to be to be of conservation importance by the Queensland Department of Primary Industries and Fisheries (DPIF) and the Australian Fish Biology Association may however potentially occur within the Nerang system however further investigations are necessary to confirm or discount their presence.

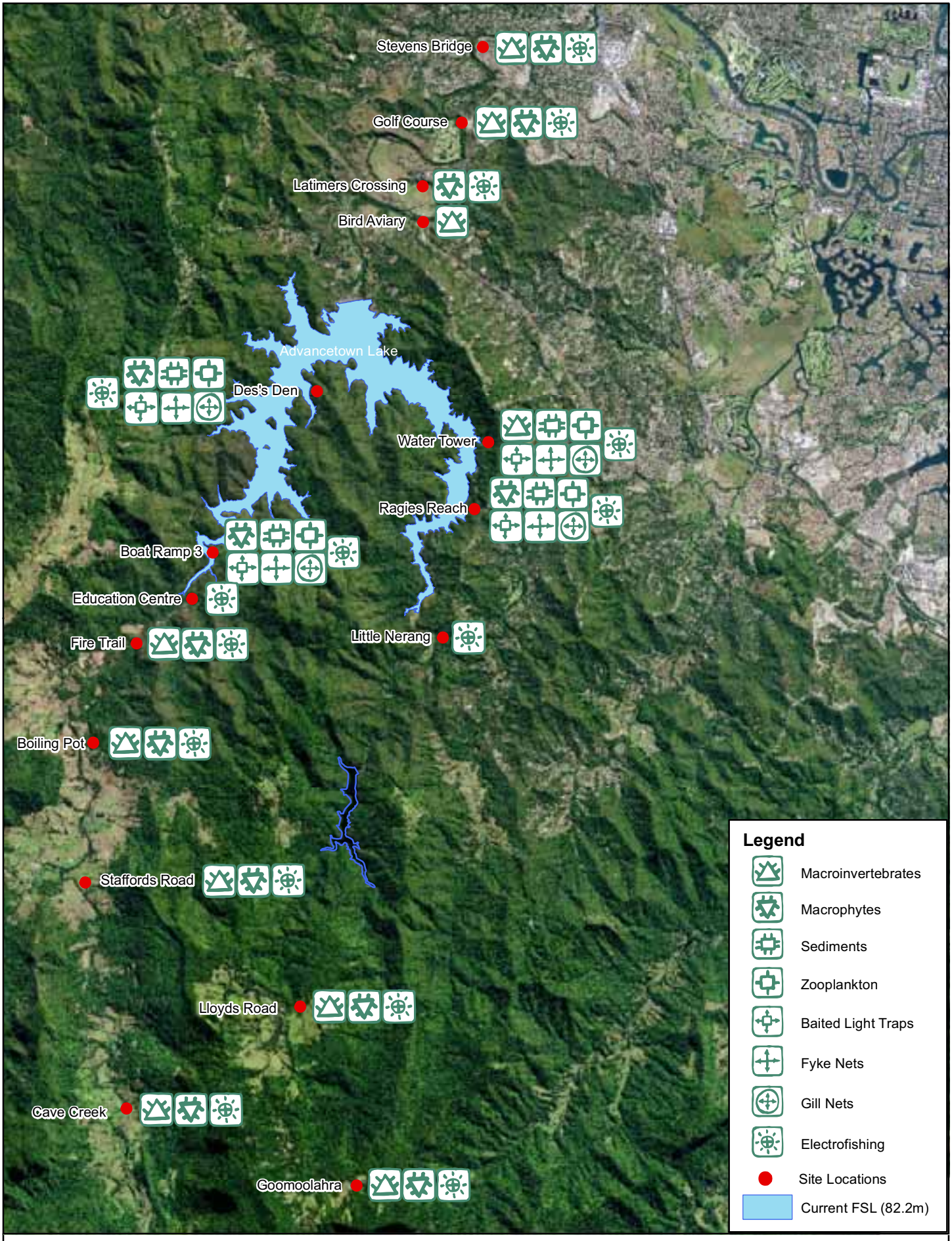
The study area encompasses three major reaches within the Nerang River and Little Nerang Creek. These are the upper reaches of the Nerang River and little Nerang Creek, within the Hinze Dam (Lake Advancetown) and the Nerang River, below Hinze Dam. A total of 16 sites were chosen within the study area for surveys of aquatic habitat, sediment/substrate, macrophytes, macroinvertebrates and fish. Study site locations were selected to provide an indication of the aquatic communities in the upstream and downstream reaches of major freshwater streams and for the impoundment. The location of the study sites is shown in **Figure 10-1**.

10.2 Methodology

Data collected through monitoring programs and numerous scientific studies were reviewed to gain an appreciation of the study area from a aquatic ecology perspective. These included water quality data collected routinely in the lake by Gold Coast Water, Environmental Health Monitoring Program (EHMP) freshwater indicator results, various Gold Coast City Council (GCCC) studies, post stocking fish reports and fish passage assessments.

Despite these studies, significant information gaps were identified and field surveys were required to be undertaken, including the following:

- descriptions of the substrate were opportunistically gathered above the Hinze Dam at five sites in the Nerang River and at three sites in the Little Nerang Creek;
- sonar was used to map areas of hard and soft sediment within the existing FSL of Hinze Dam to estimate the proportion of rocky and silty sediments within the system, particularly within the littoral zone during periods of stratification;
- soft sediments were collected at five sites within the water storage using an Eckman Grab sampler. These were subjected to chemical analysis to enable characterisation of the material, including nutrients, moisture content and organic content along with a suite of metals;



N

0 1.25 2.5 5

Kilometers

Scale - 1:110,000

Projection: MGA Zone 56

Figure 10-1

Site Locations & Survey Types

Hinze Dam Stage 3 EIS

- a further five soil samples were collected from between the existing full supply level (FSL) and the proposed new FSL ('inter-FSL') and were subjected to the same suite of analysis to enable an assessment of the extent to which the sediments within the littoral zone will be altered by increased water level;
- observation of the main substrate features for the majority of the freshwater reach below the dam wall was recorded during a longitudinal survey conducted by kayak;
- aquatic vegetation surveys for reaches of the Hinze Dam catchment, within the Nerang River and Little Nerang Creek upstream of Hinze Dam, within Hinze Dam and downstream freshwater reaches of the Nerang River;
- to compliment studies previously undertaken upstream of Lake Advancetown by Aquateco (2006), macroinvertebrates were sampled at three sites on the Nerang River below the Hinze Dam;
- individual amphibians and reptiles were collected ancillary to fish surveys and mammals were observed opportunistically during surveys;
- electrofishing was performed at fifteen sites within the catchment; and
- baited light traps, fyke nets and gill nets were set for fish at four sites in the impoundment.

The surveys reported in the EIS occurred between March and May 2007. As a result a seasonal comparison has not been reported in the EIS. Future aquatic surveys will be completed to gather further data, to allow a comparison between seasons. These surveys will be conducted in consultation with DPIF.

10.2.1 Agency Discussions

A series of meetings have been held with DPIF to discuss the need for a fish transfer device on the raised dam and the aquatic ecology survey approach used for the EIS. Members of the Alliance and DPIF staff made a joint site inspection of the dam and nearby watercourses on 6 November 2006 to inspect the condition of the Nerang River, Little Nerang Creek and the dam. This inspection provided background to ongoing discussions on the need for, and type of fish transfer device to be built as part of the Project.

DPIF has devised a tool for assessing streams and habitat with regard to the need for a fish transfer devise. The Alliance and DPIF both have used this tool at Hinze Dam and scored the site against the criteria included in the tool. These criteria include catchment condition, stream condition, water quality, fish habitat and presence of existing barriers to fish movement. This resulted in a score of approximately 35 points, which is generally consistent with the assessment provided by DPIF. This score is well above the threshold score (24 points) that confirms the need for a fishway.

As a result, agreement has been reached on the need for upstream fish passage. The Alliance is progressing the design of a trap and transfer fishway as part of the Project.

Further meetings with DPIF have been held on the type of fishway that should be provided and the aquatic surveys. DPIF and the Alliance have agreed that a trap and transfer fishway will be provided for upstream fish passage. **Section 3** of the EIS provides a description of the trap and transfer fishway that is proposed by the Alliance.

10.3 Existing Environment

10.3.1 In-lake Aquatic Habitat

The Hinze Dam provides habitat for a variety of aquatic organisms.

Basin morphology and storage water level has a role to play in the availability of aquatic habitat, particularly during times of stratification. A storage that is deep and steep sided will have less available habitat than a shallow, expansive storage when the depth to the thermocline is comparable. Conversely, habitat compression (squeeze) tends to be more significant in shallow storages during drawdown scenarios, as there is a proportionally greater loss of littoral habitat for every unit of vertical water level fall.

Stratification is of interest in the context of the Hinze Dam, as the presence of anoxic conditions below the thermocline reduces the available area of benthic habitat. The area of substrate that is within the epilimnion, containing sufficient oxygen to support aquatic life and experiencing sufficient penetration of light to support photosynthesis, is known as the littoral zone. The variability in the depth of the epilimnion from season to season results in continual expansion and squeeze of the littoral habitat.

The rise and fall in water level can also influence the physical nature of the substrate within the littoral zone. For example, a lake near FSL may contain a high proportion of rocky substrate or woody debris, whilst substrate at a lower level may be predominantly sand or silt. Thus, as water levels fall the habitat changes from rock to silt, a change that may well result in shifts in species assemblages as mobile species migrate to areas closer to being their preferred habitat.

The carrying capacity of the storage with respect to aquatic fauna is likely to be determined by the area of habitat available during periods of stratification. During periods of holomixis (complete mixing of the lake), the carrying capacity for these species may be temporarily increased, although it is likely that many species would still favour the warmer, shallower margins of the lake where the forage is more abundant. It is likely that the raising of the dam will initially result in increased growth rates, condition and/or overall numbers of many species in the shorter term, due to the sudden increased availability of habitat for shelter, forage or spawning. However, this is likely to return to a more sustainable equilibrium in the years after the raised dam is commissioned.

10.3.2 Sediment/Substrate

Sediments are important sinks for contaminants that can ultimately end up in the water column and have effects on aquatic organisms. The substrate is also an important determinant of habitat quality.

With the exception of the site on the Little Nerang Creek between the Hinze and Little Nerang Dams, all upstream sites are comprised largely of a combination of bedrock, boulder, cobble and pebble, with generally low levels of embeddedness. Riparian zones in the catchment upstream of Hinze Dam are generally in good condition and low-intensity agricultural land use is thought to make a minimal contribution to upstream sediment loads. Minor silt and/or sand substrates may exist in some deeper pools, however the steep gradient and flood prone nature of the upper catchment are likely to result in frequent flushing of this material into Advancetown Lake. The regulation of this system may have resulted in some potential accumulation of sediment in deeper pools between the Little Nerang and Hinze Dams.

The substrate within the dam is comprised of both soft sediments (silt/sand) and hard substrate (rock or highly compacted sediment). Sediments collected from below the current water level were finely divided and were dark brown to black in colour. Water quality data were not collected at the time that sediments were taken, but sonar data indicated the presence of a thermocline at approximately 9.5m depth. Despite this observation, material collected at all five sites using the grab apparatus were notably free of the hydrogen sulphide odours typical of anoxic sediments. All sediment samples from below the water level were unconsolidated and contained relatively high moisture content (71.4 – 83.2%). It is likely that this reflects the deposition of allochthonous material as a result of sedimentation within the lake. This would have been contributed to by the decomposition of vegetation inundated when the dam was first created, as well as the downslope migration of material brought into the lake via the Nerang River, in particular the Nerang Catchment (much of the material contributed by the Little Nerang system would be expected to have been trapped by the Little Nerang Dam). Dams constitute obstacles for longitudinal exchange along fluvial systems and so result in “discontinuities” in the river continuum. Sediment is a sink for nutrients and the impoundment impedes sediment and associated nutrient transport downstream.

Soil removed from between the current FSL and proposed new FSL was very dry (<29% moisture), hard and lighter in colour. Despite these samples being collected from within areas of largely grassy vegetation, they appeared to contain a lower proportion of organic material than submerged sediments. Evidence of erosion of unvegetated drainage lines along steeper areas of shoreline may indicate that these soils are prone to dispersion.

Throughout the freshwater reach below the Hinze Dam, the substrate was found to consist mainly of cobble and pebble, with occasional patches of boulder or bedrock. There was dense coverage of aquatic macrophytes, dominated by noxious aquatic weeds. In some places this growth, along with the minimal environmental flow, had trapped some silt and sediment. There were occasional deeper holes, particularly toward the lower sections, in which the substrate was not visible but is likely to contain at least some silty material by virtue of slower flow velocities, excessive aquatic plant growth and agricultural/semi-residential land use patterns.

10.3.3 Aquatic Plants

Aquatic macrophytes, or plants which are visible to the naked eye, are made up of emergent, floating and submerged plants. Macrophytes play an integral role in an aquatic ecosystem. They act as physical filters, nutrient sinks, sediment stabilising agents, habitat and food (for aquatic fauna). Aquatic macrophytes are also important for carbon dioxide (CO_2) fixation, dissolved oxygen (DO) production and nutrient cycling.

Nineteen species of aquatic macrophytes were recorded during field surveys including seven introduced species (**Table 10-1**).

Table 10-1 Aquatic Vegetation Identified at Study Sites

Aquatic Vegetation type	Species	Reach			
		Lower Freshwater	Upper Freshwater	Hinze Dam	Status
Floating Azolla	*Azolla* spp.	X	X		Native
Water Hyacinth	*Typha latifolia*	X			Introduced
Duckweed	*Lemna* spp.	X			Native
Salvinia	*Salvinia molesta*	X			Introduced
Cape Waterlily	*Nymphaea caerulea*	X			Introduced
Water Snowflake	*Nimphoides indica*				Native
Hornwort	*Ceratophyllum demersum*	X			Native
Parrots Feather	*Myriophyllum aquaticum*	X			Introduced
Water Thyme	*Hydrilla verticillata*	X			Native
Common Reed	*Phragmites australis*	X		X	Native
Slender Knotweed	*Persicaria decipiens*	X			Native
Curly Pondweed	*Potamogeton crispus*	X			Native
Waterwort	*Elatine gratioloides*	X			Native
Ribbonweed	*Vallisneria* c.f. *nana*	X	X		Native
Cladophora	*Cladophora* spp.	X	X	#	Native
Apiaceae	*Hydrocotyle ranunculoides*	X			Introduced
Clubrush	*Isolepis c.f. fluitans*		X		Native
Cumbungi	*Typha latifolia*	X	X		Introduced
Fanwort	*Cabomba caroliniana*	X			Introduced

assumed present but not confirmed

The freshwater reaches above Hinze Dam were generally shallow (<0.5m) and were comprised of bedrock substrate with sand in silt in the deeper holes. Terrestrial vegetation was frequently observed overhanging the channel and providing shaded conditions. Small sections of this reach had reeds or rushes along the bank margins. Apart from this, aquatic vegetation was relatively sparse and dominated by *Azolla* and *Cladophora*, *Isolepis* c.f. *fluitans* and *Vallisneria* c.f. *nana.*

There was found to be sparse littoral vegetation within the dam. The only vegetation found were lone stands of *Phragmites* sp. The lack of aquatic vegetation within Hinze Dam is possibly due to:

- the variability of water level inhibiting the proliferation of littoral communities;
- steep lake bed morphology; and
- moderate turbidity and therefore limited euphotic zone.

Downstream of the Hinze Dam to Weedons Crossing in Nerang was largely dominated by introduced species. There has been substantial encroachment of riparian and aquatic vegetation into the channel of the Nerang River, including invasive alien species as well as opportunistic native species, effectively reducing channel size. The floating macrophytes, Water Hyacinth (*E. crassipes*) and Salvinia (*Salvinia molesta)* were the most abundant along with thick stands of Cumbungi (*Typha latifolia*). Weed infestations were prevalent along most of this reach indicating problems with eutrophication. The section of the river that flows through the Grand Golf Course had noticeably less weeds, mostly likely associated with the use of herbicides in the area. The terrestrial weed Singapore Daisy (*Sphagneticola trilobata*), which is listed as a Class 3 pest plant under the *Land Protection (Pest and Stock Route Management) Act 2002*, was also encroaching upon the river from the bank of many areas within this reach.

10.3.4 Invertebrates

During studies undertaken by Aquateco (2006) in the 2005-2006 period the upper Nerang and Little Nerang catchments appeared to be in relatively good condition. At most of the monitoring sites there was a diverse range of habitat types available to aquatic biota. Many of the readily identifiable indicators of declining ecosystem health were notably absent, for example:

- there was no evidence of filamentous algal growth on rocky substrates or in the vicinity of culverts and bridges suggesting good water quality with respect to nutrient loads;
- there was little, if any, indication of erosion or depositional processes at any of the sites. Water clarity was generally excellent and the degree of embeddedness of rock and cobble substrates was generally exceptionally low. Scouring or channelisation were not observed at any of the sites;
- well vegetated riparian zones generally contributed to excellent bank stability and provided shading and, in some instances, trailing branches. Perhaps the most noticeable environmental impact is the invasion of exotic vegetation within the riparian zone;
- agriculture within the catchment is relatively light and in most places stock access to the streambanks is limited by riparian vegetation and fencing;
- PET richness, species richness, OE50 and OE50 signal scores across the catchment were generally indicative of high quality habitat and excellent water quality; and
- OE50 vs OE50 signal plots generally group the sites within a range typical of healthy aquatic ecosystems (**Figure 6.2** in **Appendix F.10**), although some sites appear to have been impacted by factors other than water quality.

In contrast to the Aquateco (2006) study of the upper catchments, the monitoring sites downstream of the dam appeared to be in very poor health when surveyed in April 2007:

- filamentous green algae covered almost every horizontal surface, often floating to the surface in thick mats;
- riparian health was variable, with some reaches exhibiting good native riparian assemblages, but most areas overrun with exotic weeks;
- the river was frequently choked with Cumbungi (*Typha latifolia*)or Water Hyacinth (*Typha latifolia*) and in many places there were thick mats of Salvinia (*Salvinia molesta*) present;
- there was very little clear substrate as most of the river bed was choked with macrophytes. Agriculture was moderate, but stock were permitted to access the river in many places and there were numerous areas in which rubbish had been dumped;

- OE50 scores were generally lower, but signal scores were within a more normal range, suggesting impacts other than water quality may be affecting macroinvertebrate health; and,
- PET richness was low at these sites, potentially indicating poor water quality.

There was a general trend towards less diverse macroinvertebrate communities with lower PET richness the further a site was from the headwater areas. This is typical of most river systems, as the cumulative effects of upstream land use intensify the pressure on sites lower in the catchment. However, there was a clear decline in the macroinvertebrate assemblages at all downstream sites compared with sites above Hinze Dam. This is likely to be the combined result of more intensive agricultural land use (primarily cattle grazing), increased urbanisation and poor flow variability as a result of regulation of the river at Hinze Dam.

PET is an index of stream health that is used in the AusRivAS modelling. It is a well used measurement of the community diversity, using the invertebrate taxa: the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies). The PET index quantifies diversity and stream health by scoring each site. This can be used in the future to measure change over time or compare with other waterways where studies have been carried out.

10.3.5 Fish

In addition to indigenous fish species, Hinze Dam has been a stocked recreational fishery since 1991. Stocking has historically included Australian Bass, Golden Perch, Silver Perch, Mary River Cod and Saratoga. In addition to these native species, there are a number of exotic species that have been recorded from the dam. **Table 10-2** presents a species list constructed from the surveys performed during this Project. A total of 25 species were identified in total during field investigations. Of these, two were introduced noxious species, Platy (*Xiphophorus maculatus*) and Gambusia (*Gambusia holbrooki),* while one, Barred Grunter (*Amniataba percoides*) is non-indigenous to the area. Detailed descriptions of the fish populations that have been found or that are expected to be found in the Hinze Dam catchment are presented in the Aquatic Biology Technical Report in **Appendix F.10** of EIS. **Table 10-2** summarises fish that were encountered or fish that may be present in the Hinze Dam catchment. Fish that have been translocated are summarised in **Table 10-3** and noxious species presented in **Table 10-4**.

Although their presence in the Nerang system is unconfirmed, Harris (2006) predicted that two additional species of interest to the Australian Society for Fish Biology (ASFB) could be present in the Nerang system:

- Freshwater Mullet (*Myxus petardi*) is a catadromous species, migrating to estuaries to spawn. If present in the Nerang system, it would probably be restricted to the reach below the dam wall, since there is no possibility of recruitment to the upstream reaches. The species is considered by the ASFB to have intermediate conservation status due to widespread habitat loss as a result of river regulation.
- Purple-spotted Gudgeon (*Mogurnda adspersa*) is considered endangered under the IUCN (2006) due to its declining geographic range as a result of urbanisation, catchment impacts and river regulation. If present below the dam wall, this species may be impacted upon by further declines in habitat quality as a result of reduced flood passage.

Species Requiring Upstream or Downstream Passage

Migratory fish species that have been confirmed present in the system during these surveys and may be impacted upon by the Project are discussed below.

Marbled Eel or Longfinned Eel (*Anguilla reinhardtii*) was recorded above, below and within the dam. It is a catadromous species, requiring access to the ocean to spawn, with juvenile fish migrating well up into river systems, where they reside and mature. It is thought that adult fish die following spawning in deep oceanic waters off New Caledonia.

A. reinhardtii was moderately abundant at the upstream sites, although all fish recorded were mature individuals of 550 – 1050mm length. Downstream of the dam wall this species was in greater abundance, with some large individuals recorded, but the majority of fish were in the <300mm size class (juveniles). This is evidence that the population has been impacted upon by the lack of fish passage at the existing dam wall, with juveniles downstream of the dam and adults upstream. Upstream populations may comprise of remnant individuals (there are records of *A. reinhardtii* exceeding 40 years of age), and/or minimal recruiting by juveniles from the downstream population. As this species is unable to spawn in fresh water, the sustainability of the upstream population is strongly dependent on recruitment, hence facilitation of upstream passage for this species is critical.

The need to facilitate downstream migration is far less clear and is logistically more challenging. It is likely that some downstream passage occurs via the spillway when the dam is overtopping, although high mortality rates are an inevitable outcome. The upstream habitat of *A. reinhardtii* has been severely reduced in South East Queensland and Northern NSW.

Short-finned Eel (*Anguilla australis*) has similar migratory requirements to *A. reinhardtii* but was less prevalent within the Nerang system, being recorded on the Springbrook Plateau at the Goomoolahra site (six individuals) and in Hinze Dam (one individual). They are a smaller species than *A. reinhardtii*, being less than 1m in length when fully grown (~ 1.5 – 2.0m). All fish captured during the 2007 surveys were relatively mature, being with 200 - 600mm in length. This species has not been recorded during EHMP surveys.

The presence of this species on the Springbrook Plateau indicates either that they have navigated the Goomoolahra Falls, or that they have been stocked into a farm dam and have subsequently escaped.

As with *A. reinhardtii*, the loss of available habitat and land locking of mature fish by man-made barriers has increased steadily on a regional level and has probably reduced the number of mature fish able to migrate to oceanic spawning grounds.

Impediments to Fish Passage

Above Hinze Dam

Aside from Hinze Dam itself, there are few, if any, artificial barriers to fish movement in the upper Nerang River. However, many natural rock bars, boulders and small waterfalls might impede fish passage, particularly during periods of low flow. In some places, these impediments might also create velocity barriers that impede the passage of some species during high flow periods. Lack of regulation of the upper reaches, along with the rapid hydrological response to rainfall events creates highly variable hydrology in this reach of the river, hence upstream and downstream movement of many fish species probably occurs opportunistically when the flow rates over or through a particular structure permit.

Above Hinze Dam, fish movement into Little Nerang Creek is limited by a number of structures both man made and natural. Multiple natural barriers to fish passage can be expected to exist in this area, but like the upper Nerang, hydrological variability would probably present opportunities for migratory fish to pass these structures.

Impediments to Fish Passage within Hinze Dam

The wall of the Hinze Dam comprises a zoned earth and rockfill main dam and a saddle dam with a concrete gravity spillway. The storage is comprised of two distinct arms extending along the flooded valleys of the Nerang River to the east and the Little Nerang Creek to the west.

The dam is surrounded principally by forested land. Low water levels at the time of this assessment had resulted in a band of shoreline between the current water level and full supply level that had been colonised by terrestrial grasses. Falling water levels had resulted in a second, narrower band of exposed sediment at the waterline.

As is typical of many storages, the complex topography of the drowned river basins has resulted in a complex shoreline with numerous inlets and occlusions. This has resulted in a relatively long shoreline for the size of the

lake and provides extensive littoral habitat. Conversely, the steep banks reduce the area of littoral habitat, the water depth falling steeply in close proximity to the shoreline in many places.

There is a paucity of woody debris within the dam, with the existing terrestrial vegetation having been removed prior to commissioning of the storage. At the time of these surveys there was virtually no aquatic macrophyte component to the available habitat, possibly due to the relatively rapidly falling water levels and steep basin morphology. Rugged, submerged rocky substrates, areas of soft sediment and topographic relief therefore comprise the bulk of the benthic habitat, with occasional remnants of woody vegetation.

At the time of these surveys Hinze Dam was stratified, and the thermocline clearly provided habitat for pelagic species (probably Saratoga and Australian bass), which were clearly evident on sonar traces.

The Project will result in the crest height and spillway structure being raised and resulting in a 12.5m vertical rise in full supply level. This will result in a longer shoreline and greater littoral zone when the storage is at higher levels, increasing the habitat available to aquatic species. There is potential to further improve aquatic habitat by allowing some or all of the woody terrestrial vegetation within the new inundation zone to remain standing.

Impediments to Fish Passage Below Hinze Dam – Nerang River

Throughout the reach below Hinze Dam there were obvious signs that the river system was in very poor health, including dense blooms of aquatic macrophytes (with exotic species very strongly represented), thick mats of biofilm on all submerged surfaces including filamentous and riparian zones that were heavily infested with weeds in many areas.

The substrate throughout the reach was almost invariably comprised of hard materials such as bedrock, cobble and boulder, with very little silty habitat evident, although the mildly turbid nature of the water may have concealed patches of silty substrate in a handful of deeper holes.

10.3.6 Amphibians

Only two species of amphibians were encountered during field surveys: Cane Toad (*Bufo marinus*) and the Great Barred Frog (*Mixophyes fasciolatus*).

Distribution and Ecology

The natural range of the Cane Toad, *B. marinus*, extends from the southern United States to tropical South America. They were deliberately introduced from Hawaii to Australia in 1935, to control scarab beetles that were pests of sugar cane but they proved ineffective. Cane Toads occur throughout the eastern and northern half of Queensland and have extended their range to the river catchments surrounding Kakadu National Park in the Northern Territory. In New South Wales they occur on the coast as far south as Yamba and there is an isolated colony near Port Macquarie (Bennett 1996). Cane Toads can breed in most still or slow-flowing water, and tolerate salinity levels up to 15mg/L. Male Cane Toads start calling for mates in early Spring or when water temperatures reach 25ºC. Females lay 8000 to 35 000 eggs at a time and may produce two clutches a year. The eggs hatch within 24-72 hours and the tadpole stage may last from three to twenty weeks, depending on food supply and water temperature - generally a range of 25-30ºC is needed for healthy development. The tadpoles gradually change (metamorphose) into toadlets 1 - 1.5 cm in length that leave the water and congregate in large numbers. Adult toads, toadlets and tadpoles were observed in the Hinze Dam.

The Great Barred Frog, *M. fasciolatus* is a large ground dwelling frog found along the coast and ranges from south-eastern Queensland to the south coast of NSW (Anstis 2002). This species inhabits forests (wet sclerophyll forest and rainforest), in areas with lower precipitation and intermediate temperatures in the warmest (Summer) quarter of the year (Parris 2002). Numerous individual *M. fasciolatus* tadpoles were collected in the fish sampling sites within Springbrook National Park.

Species of Conservation Significance

The Cane Toad (*B. marinus*) is not a declared pest in Queensland so there is no legal requirement to control them (NRW 2006). The Great Barred Frog, (*M. fasciolatus*) is considered to be a species of least concern under the IUCN (Hines et al. 2004).

10.3.7 Reptiles

Two freshwater turtles, Macquarie Turtle (*Emydura macquarii*) and Saw-shelled Turtle *(Elseya latisternum)* were collected during this study. Each individual was identified to species (Wilson 2005), its carapace measured, assessed for good health and released.

Other aquatic or semi-aquatic reptiles that are likely to occur in the Hinze Dam Catchment include the long-neck turtles *Chelodina longicollis* and *Chelodina expansa* as well as the Eastern Water Dragon, *Physignathus lesueurii* (Wilson 2005). The catchment of the Hinze Dam is within the distributional range for these species.

Distribution and Ecology

E. macquarii as a widespread species occurring in the rivers of the Murray-Darling Basin as well as coastal rivers, creeks and wetlands of northern NSW and south-eastern Queensland (Cann 1998; Wilson 2005) where they are generally the predominant turtle species (Chessman 1988). Different sub-species exist in Queensland and it is unknown which sub-species occur within the Nerang Catchment. *E. latisternum* is also widely distributed but tends to prefer swamps, billabongs and creeks more than major rivers (Cann 1998). Both species utilise cloacal respiration and have a preference for well-oxygenated water.

The two species of long-necked turtle usually inhabit permanent billabongs or ponds (Tucker 1999; Arthington 2000) *C. longicollis* can achieve high abundance in ponds on the floodplain (Tucker & Priest 1998) although it has become more difficult to find in eastern Queensland, possibly because of adverse reactions to Cane Toads (Arthington 2000). *C. expansa* is typically found in low density streams in southeast Queensland (Limpus et al. 1997; Arthington 2000).

Freshwater turtles have an extremely varied diet, consisting largely of filamentous algae, vertebrate carrion, detritus, periphyton, aquatic insects, and aquatic plants (Chessman 1986). *E. maquarii* is regarded as a generalist omnivore, eating a wide variety of plant and animal foods. *C. longicollis* is carnivorous, feeding by foraging for moving prey such as macroinvertebrates, small fish and tadpoles (Arthington 2000). *Chelodina expansa* is regarded as a dietary specialist (Tucker 1998), feeding on fish, crustaceans and molluscs in permanent waters. *E. latisternum* is a general carnivore, feeding on carrion and less active prey and thriving on Cane Toads in channels within cane fields (Arthington 2000).

The Eastern Water Dragon, *Physignathus lesueurii*, is very similar to freshwater turtles in both diet and breeding characteristics. Their diet consists of aquatic crustaceans, insects and small vertebrates as well as fruits from riparian vegetation. Studies in other catchments show that this species is able to tolerate conditions in semi-polluted drains and waterways (Arthington 2000).

Species of Conservation Significance

All reptile species sighted, or expected to occur within the study area are regarded as common (Stanger et al. 1998) and are not listed under the Environment Protection and Biodiversity Conservation Act 1999 (EBPC Act). However, Cogger (1993) stated that insufficient information is known about many turtle species for conservation status to be assessed accurately.

10.3.8 Mammals

The Water Rat (*Hydromys chrysogaster*) is widespread in eastern Australia. It was observed during fauna surveys undertaken for this study. The Platypus (*Ornithorhynchus anatinus*) is widely distributed along the east coast of Australia from Tasmania to Cooktown. It too was observed opportunistically during aquatic surveys within Hinze

Dam. Water Mouse (*Xeromys myoides*), although not encountered in this study, has been recorded in the Gold Coast Region and may be present in the Hinze Dam Catchment.

The abundance and distribution of aquatic and semi-aquatic mammals in the inundation area has not been assessed in detail for this EIS. However, they are expected to be present along the inundation length since suitable pool habitat exists. Detailed surveys should be undertaken prior to construction to fill this information gap and provide a baseline for monitoring.

Habitat Requirements

H. chrysogaster has broad habitat requirements including permanent headwater streams, slow moving reaches of permanent watercourses and (fresh and brackish) wetlands. They construct a nest at the end of a tunnel in the riverbank or occasionally in logs (Arthington 2000). *O. anatinus* may be found in a wide variety of habitats ranging from large riverine pools to fast flowing riffles. Ideal habitat is found in fairly shallow rivers and streams with relatively steep banks consolidated by the roots of native vegetation and with riparian growth overhanging the bank (Scott & Grant 1997). The presence of overhanging vegetation is an important component for several reasons. Roots help to consolidate the banks and prevent *O. anatinus* burrows from collapsing. Overhanging vegetation provides cover from predators when animals move in and out of their burrows and while they move and forage in shallow riffle areas (Gunninah 1997). However, these animals are able to live in disturbed waterways with little or no riparian vegetation flowing through agricultural lands, at artificial weir sites and in large impoundments (Gunninah 1997).

The semi-aquatic *X. myoides* inhabits saline grassland, mangroves, and freshwater margins (Menkhorst & Knight 2004). This species has a life cycle that depends on mangrove communities as well as a range of other wetland communities for survival. Mangrove and other coastal wetland communities are widely threatened by development for residential and recreational purposes and to a lesser extent for agriculture and aquaculture. Loss of mangroves has lead to a loss of habitat for the water mouse, a main cause of decline in its numbers.

Dietary Requirements

Water Rat diet consists primarily of aquatic invertebrates, fish, frogs and small birds. Mostly nocturnal feeders, they bring food to a platform to be eaten (Menkhorst & Knight 2004). Several middens of mussels were seen during field surveys of the Nerang River below the Hinze Dam. The Water Mouse has a diet of marine and freshwater invertebrates. Platypus have generalist diets, foraging on whatever macroinvertebrates are available in the benthos of pools, although other items including small fish and frogs may also be included. The area of river habitat available to individuals for feeding determines its carrying capacity and any reduction in invertebrate biomass in streams and rivers is of concern for population maintenance (Arthington 2000).

Species of Conservation Significance

The Platypus is listed as common in all states and territories of Australia, except South Australia, where it is listed as Vulnerable (Stanger et al. 1998). The Platypus is listed as Common under the *Nature Conservation (Wildlife) Regulation 1997* Qld. While it is a common mammal, it is generally considered to have cultural significance. The Water Mouse is listed as vulnerable under the EPBC Act.

10.4 Potential Impacts

In many ways the existing dam system has already created a significant impact on the aquatic biota and habitat from both within and up- and downstream of Hinze Dam. The current Hinze Dam and Little Nerang Dam have altered the natural hydrological regimes, presented barriers to fish passage, trapped sediment within the dam and reduced sediment deposition in downstream reaches. It must be noted that this is not a pristine system, although the Project may well exacerbate the existing impacts on aquatic ecology.

10.4.1 In-lake Aquatic Habitat

The impacts of the Project associated with in-lake habitat are largely related to increase water level that may lead to the following impacts:

- the Project has the potential to increase the range of pest fish species through inundation of existing fish passage barriers in upper reaches of the Nerang River and Little Nerang Creek;
- replacement of a small (1.5%) area of lotic (riverine) habitat with lentic (stillwater) habitat in the vicinity of where the Nerang and Little Nerang Rivers enter the dam; and
- the volume of the lake will approximately double following construction of the Project, however the available habitat will increase by only 25%. Hence, doubling of the current stocking rates may result in larger numbers of smaller or poorly conditioned fish.

Table 10-2 Indigenous Species found within Nerang System

Common name	Species	Notes
Australian Bass	*Macquaria novemaculeata*	Naturally occurs in Nerang system, but also stocked into dam. Catadromous species. Adults migrate from river tot estuary to spawn in May- Aug. Juveniles and adults move upstream for dispersal and summer feeding (Sep - Dec).
Australian Lungfish	*Neoceratodus forsteri*	One anecdotal account of lungfish being caught in Hinze Dam by an angler some years ago. Species listed under EPBC due to very limited distributional range. Move up to 25 km within freshwater for habitat/dispersal, prefer still or slow-flowing areas with deep pools. Listed as vulnerable conservation status (EPBC).
Australian Smelt	*Retropinna semoni*	Caught during EHMP surveys of Nerang, Has been caught in the little Nerang system (GCCC 2006). Prefers still or slow moving water. Spends entire life in freshwater although there are some reports of diadromous populations. Strong tendency to gather below barriers in rivers, suggesting that they might migrate (http://www.desertfishes.org/australia/fish/retrsemo.shtml). Mostly thought of as a potadromous species.
Bony Bream	*Nematalosa erebi*	Potadromous species. Migration Aug – Apr. Classified as uncommon in the Gold coast region (Chapple et al. 2004).
Bullrout	*Notesthes robusta*	Possible a catadromous species, usually associated with aquatic vegetation. Species bears dangerous spines and should be handled with care. Classified as uncommon in the Gold Coast region (Chapple et al. 2004), found in the Nerang River below Hinze Dam.
Common Jollytail	*Galaxias maculatus*	Catadromous species. Prefer still or slow flowing habitat. Adult migration occurs Apr – July, juvenile migration Sep - Oct.
Cox's Gudgeon	*Gobiomorphus coxii*	Potadromous species. Classified as uncommon in the Gold Coast region (Chapple et al. 2004) confirmed presence in the Nerang system.
Duboulay's Rainbowfish	*Melanotaenia duboulayi*	Has a preference for slower flowing waters and habitat containing dense macrophytes and/or woody debris.
Dwarf Flathead Gudgeon	*Piylypnodon* sp.	Benthic species that is commonly found in both freshwater and estuarine areas.
Eel-tailed Catfish	*Tandanus tandanus*	Has been recorded from the dam during previous fish surveys. This species occurs in the Nerang River both above and below the dam. Undergoes migrations within the freshwater zones possibly following high flow events.
Empire Gudgeon	*Hypseleotris compressa*	Prefers habitats from upstream flowing areas to coastal swampland. Juveniles undertake massive migrations from flooded mangroves upstream along any flowing water (Jan – Apr), including road edges and agricultural drains, begin to settle out in pebble reaches.
Estuary Perchlet	*Ambassis marianus*	Found in the Nerang River below Hinze Dam. Classified as uncommon in the Gold Coast region (Chapple et al. 2004).
Fire-tail Gudgeon	*Hypseleotris galii*	Potadromous species. Prefer areas with aquatic vegetation.
Flathead Gudgeon	*Philypnodon grandiceps*	A bottom dwelling species that inhabits still or flowing fresh or estuarine waters. Check migration.
Fly-specked Hardyhead	*Craterocephalus stercusmuscarum*	*C. stercumuscarum* lives entirely within the freshwater reaches of river systems and is normally thought to spawn among aquatic macrophytes. Hinze Dam appears to support a reasonable population. Despite widespread distribution throughout southern and eastern Australia, little is known about the spawning and life cycle needs.
Fork-tailed Catfish	*Arius graefei*	Potadromous species.
Freshwater Herring	*Potamalosa richmondii*	Catadromous species.
Freshwater Mullet	*Myxus petardi*	Catadromous migration. Prefer slow-flowing areas, deep pools.
Jungle Perch	*Kuhlia rupestris*	Catadromous. Adults thought to move to inshore reefs to spawn, then return upstream Nov - Feb. Juveniles move upstream for growth (Jan – Apr). Prefer fast-flowing perennial streams, coastal creeks, particularly very small streams on inshore islands and coastal floodplains. Females prefer headwaters.
Honey blue-eye	*Pseudomugil mellis*	Vulnerable conservation status. Migration patterns are unknown. Prefer still areas with extensive vegetation.

Common name	Species	Notes
Lamprey	*Mordacia* sp.	Lampreys spend most of their adult lives at sea, but adults migrate into freshwater to spawn before dying (i.e. anadromous). Juvenile lamprey migrate back to the oceans to mature.
Long-finned Eel	*Anguilla reinhardtii*	Observed during fish habitat surveys in the Lower Nerang River and freshwater reaches above Hinze dam. Catadromous migraton, adults Dec – May, juveniles Sep- Mar.
Marjorie's Hardyhead	*Craterocephalus marjoriae*	Classified as rare in the Gold Coast region (Chapple et al. 2004). Has been confirmed present the lower Nerang System during EHMP surveys.
Mouth Almighty	*Glossamia aprion*	A mouth brooding species found in dense vegetation in freshwater streams.
Olive Perchlet	*Ambassis agassizii*	Preference for slower flowing and still waters with ample woody debris or rocky habitat. Spawning typically occurs in summer amongst aquatic vegetation and does not require up or downstream migration.
Ornate Rainbowfish	*Rhadinocentrus ornatus*	Considered rare in the Gold Coast region, confirmed presence in the Nerang system.
Oxeye Herring	*Megalops cyprinoides*	Amphidromous species. Classified as uncommon in the Gold Coast region (Chapple et al. 2004). Presence not confrmed in the Nerang system.
Oxleyan Pygmy Perch	*Nannoperca oxleyana*	Protected under the ICUN. Migration patterns are unknown, prefer still or slowly flowing water with aquatic vegetation.
Sea Mullet	*Mugil cephalus*	Catadromous migration Feb- Sep. Found close to coast or within coastal watercourses.
Short-finned Eel	*Anguilla australis*	Prefers still waters, but often found in flowing water, particularly in slower currents. Adults undergo downstream migration (Dec – May) and are thought to die after spawning in the coral sea. Juveniles migrate back from the estuaries to freshwater in (Sep - Jan) in the Nerang system (catadromous). Classified as uncommon in the Gold Coast region (Chapple et al. 2004).
Snub-nosed Garfish	*Arrhamphus krefftii*	Classified as uncommon in the Gold Coast region (Chapple et al. 2004). Presence not confirmed for the Nerang system.
Southern Blue-eye	*Pseudomugil signifer*	Migratory patterns uncertain.
Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	Species in danger of extinction. Lives among weed in slow flowing freshwaters with hard substrates. Migration patterns are unknown, probably move within freshwater for dispersal. Can climb significant waterfalls. Found in all habitats, particularly attracted to small flows. Has not been found in the Nerang system.
Spangled Perch	*Leiopotherapon unicolor*	This species is very tolerant of a very wide range of ambient water quality and habitat conditions. Undergoes nocturnal upstream migration for spawning during Oct – Apr and dams have been known to impact on this process. Potadromous.
Striped Gudgeon	*Gobiomorphus australis*	Potadromous species that inhabit turbid waterholes, slow flowing areas close to coast.
Western Carp Gudgeon	*Hypseleotris klunzingeri*	Prefers slow flowing, heavily weeded and often turbid waters. Thought to be one of the more migratory of the smaller freshwater fishes. Classified as uncommon in the Gold coast region (Chapple et al. 2004), confirmed presence in the Nerang system.

Table 10-3 Translocated Species found in the Nerang System

Common name	Species	Notes
Barred Grunter	*Amniataba percoides*	Inadvertent release to Hinze Dam during fish stocking.
Golden Perch or Yellowbelly	*Macquaria ambigua*	Anadromous. Stocked for as a recreationally significant species.
Mary River Cod	*Maccullochella peelii mariensis*	Endangered conservation status. Stocked to increase geographical range and as a recreationally important species.
Silver Perch	*Bidyanus bidyanus*	Amphdromous migration, potentially threatened conservation status. Stocked as a recreationally important species.
Southern Saratoga	*Scleropages leichardti*	Restricted conservation status. Stocked to increase geographical range and as a recreationally important species. Migratory habits unknown. Prefer upper reaches and turbid areas. It is unknown whether this species reproduces in the Hinze Dam.

Table 10-4 Declared Noxious Species found in the Nerang System*

Common name	Species	Notes
Mozambique Mouthbrooder, Tilapia	*Oreochromis mossambicus*	Released into ornamental ponds and first recorded in South-east Queensland in 1977 and Townsville in 1978. Not yet recorded in the Nerang system.
Platy	*Xiphophorus maculatus*	Escaped aquarium fish now in any coastal drainages in eastern Qld; urban creeks in the Brisbane region and the Wet Tropic Region.
Swordtail	*Xiphophorus helleri*	Escaped from ornamental ponds, now found in coastal drainages of south-eastern Qld; (Heckel) particularly abundant in urban streams of the greater Brisbane region and extending as far west as Ipswich.
Common Carp	*Cyprinus carpio*	Carp were first recorded in Victoria in 1862. It is likely that carp in the Murray–Darling spread from NSW and Victorian populations into Queensland. Carp have considerable potential to spread throughout Australia as a result of their wide environmental tolerances.
Gambusia or Mosquitofish	*Gambusia holbrooki*	Introduced to Brisbane in 1929 (by accident) subsequently spread by the military and local councils as a biological control agent for mosquitoes and hence malaria.
Goldfish	*Carassius auratus*	Escaped aquarium fish tentatively identified at the dam on 6/12/2006.

*declared noxious under the *Fisheries Act 1994*

10.4.2 Sediment and Substrate

The Project will create more area of aquatic habitat. There is however potential for the proportions of sand, silt and rock to be altered within the littoral zone of the existing dam, which may in turn influence the nature and availability of habitat by:

- inundating new substrate that may be substantially different to the substrate currently within the littoral zone;
- inundating vegetation, the decay of which may increase the organic content of the sediments; and
- inundation of the new substrate may introduce nutrients and metals into the dam as sediment analyses found high levels of nitrogen, aluminium and cobalt.

The greatest impacts on sediment and substrate are expected to occur in the Nerang River downstream of Hinze Dam, although these effects are experienced currently to an extent:

- reduced downstream flows can result in the deposition of sediments, as the lower energy hydrological regime is insufficient to keep particles in suspension. It can also lead to the proliferation of choking aquatic weed growth;
- a reduction in the frequency of floods (particularly 'bank full' floods), which reduces natural channel forming processes and results in the deposition of sediment at particular points throughout the downstream river system; and
- reduction in sediment load in rivers can result in increased erosion of riverbanks and beds, loss of floodplains and degradation of coastal deltas.

10.4.3 Aquatic Vegetation

A total of 19 aquatic macrophytes, comprising 12 native and seven introduced species were found at sites with the Nerang River catchment. The freshwater reaches above Hinze Dam had generally sparse vegetation consisting of species adapted to fast flowing conditions. Hinze Dam had very little aquatic vegetation whereas the Nerang River below the dam wall was dominated by densely growing exotic weed species. Potential impacts of the Project include:

- inundation and alteration of riverine habitat immediately above the dam thus creating lacustrine habitat, which will most likely cause a shift from lotic communities to lentic communities;
- the creation of new aquatic habitat may lead to the proliferation of weeds, as introduced species are often the first to colonize an area after disturbance;
- loss of existing riparian vegetation and limitations on potential new riparian habitat caused by elevated water levels; and
- reduced frequency of flushing (flooding) flows in the Nerang River below Hinze Dam, thereby having effects on downstream communities.

10.4.4 Aquatic Invertebrates

Unmitigated, the construction of the Project will have two key impacts on macroinvertebrate ecology:

- the drowning of a small area of high quality aquatic lotic habitat at the upper ends of the dam; and
- a reduction of flushing flows in the Nerang River below the dam wall, which can be expected to cause further decline of an already highly disturbed aquatic system.

10.4.5 Fish and Fish Habitat

Potential impacts of the Project on fish and fish passage are:

- further restrictions to upstream fish passage;
- a reduction in flood passage which can be expected to result in further declines in habitat quality;

- availability of increased habitat for fish species; and
- the success of the current upstream and downstream passage of migratory species found within the Nerang system such as the Longfinned Eel (*Anguilla reinhardtii*) and the Short-finned Eel (*Anguilla australis)* is not fully understood although there is evidence that passage is already restricted. If some degree of movement over the current dam occurs, access would be further restricted by the increased wall height.

10.4.6 Amphibians

Impacts of the Project on the Cane Toad (*B. marinus)* populations are not considered pertinent to the EIS as the species are not native nor of conservational significance. The impacts of Project are not likely to impact on the population of Great Barred Frog (*M. fasciolatus)* due to their location atop the Springbrook Plateau. Further studies could be carried out to determine the distribution and abundance of significant frog species in the Hinze Dam area.

Water storages and flow regulation can result in the loss of riffle habitats, and possibly an alteration to macrophyte beds and riparian habitats, which represent important sources of macroinvertebrate food (Tucker 1999; AWT 2001). However, the species that have been observed in the study have successfully inhabited the already highly modified area. The 1.5% loss of riverine habitat estimated for the Project will create more still water habitat. This should provide suitable habitat for many species of turtle providing the inundated area remains well oxygenated (for cloacal respiration). Sediment types at the existing and proposed FSL are quite similar and should not pose a problem to turtle nesting behaviour.

10.4.7 Reptiles

The distribution and abundance of turtle species in the area of proposed inundation has not been previously documented. However, it is reasonable to assume that healthy populations exist because of the presence of suitable habitat. The lack of numbers of species and individuals found within the study area are possible short-comings of the monitoring technique, which was not designed to target reptiles. This gives rise to the need for a more extensive survey method to describe the distribution and abundance of reptiles in the Project area.

10.4.8 Mammals

The Water Rat is reported to be robust and tolerant to water resource development. Permanent inundation of temporary wetlands for water storage has been known to increase abundance of the Water Rat (Woollard et al. 1978). Increased FSL may affect the Platypus through the flooding of burrows. However, Platypus in the Hinze Dam have most likely adapted to fluctuations in water level since these are natural events (high rain levels and flooding) and they have already been subjected to a degree of artificial water level manipulation within Hinze Dam. Lower frequency and duration of flooding to the downstream reach of the Nerang River may benefit mammals in this section due to the prolonged period of calmer conditions. That is, less disturbance to habitat and nesting sites.

10.5 Mitigation Measures

10.5.1 In-lake Aquatic Habitat

- limiting the rate of water level increase over the first few years to alleviate the potential for reduced water quality from inundated vegetation. GCCC needs to provide water supply to the Gold Coast and will fill the dam as quickly as rainfall allows. The way that water quality will be protected is to leave roots intact, leave the understorey in place and implement a range of sediment and erosion control measures to limit the movement of sediment into the dam;
- monitoring of methyl mercury concentrations in recreationally significant fish species annually prior to and following the completion of the Project. This program will be carried out until bioaccumulation can be ruled out through scientific research; and
- although the volume of the lake will approximately double following construction of the raised dam wall, the available habitat will increase by only 25% (as found through habitat modelling). Hence, any future changes to the current stocking rate should take the proportion of available habitat into consideration. If increased stocking rates are contemplated, it is suggested that the increase be capped at 25% higher than the current

rates, unless further studies indicate that the quality of habitat is improved and that the storage can sustain a higher stocking rate. A profitable stocking rate could be reassessed if it is determined that the carrying capacity of the dam has been increased through scientific research.

10.5.2 Aquatic Invertebrates

Performance of further macroinvertebrate surveys during Spring 2007, enabling combined season models to be employed and hence giving a more robust picture of downstream ecosystem health. Ideally, biannual sampling should be repeated over a number of years to establish a more accurate baseline.

10.5.3 Fish and Fish Habitat

- additional fish research is recommended, including fish distribution patterns and fish passage, prior to the commissioning of the raised dam;
- undertake fish surveys for a period of 12 to 18 months to gather information on fish communities within the Nerang and adjacent systems, as background to the design and management of fish passage at the dam. These surveys will confirm of dismiss the presence of *Myxus pertardi*, (Freshwater Mullet) and *Mogurnda adspera*, (Purple Spotted Gudgeon);
- design and construct a trap and transfer fish passage system for upstream movement of fish; and
- pest species will be manually removed when collected in the fish transfer device to avoid there movement into the dam.

10.5.4 Amphibians, Reptiles and Mammals

A more extensive survey method to describe the distribution and abundance of amphibians, aquatic and semi-aquatic reptiles or mammals in the Project area could benefit to thoroughly identify potential impacts.