7.2 Surface Water Quality

7.2.1 Objectives

The objectives of this section of the EIS is to:

- describe the existing environmental values of the area;
- describe potential adverse and beneficial impacts of the proposal on the environmental values;
- outline cumulative impacts on environmental values;
- present environmental protection objectives, standards and indicators for monitoring; and
- examine the viable strategies for managing impacts for inclusion within an environmental management plan.

The potential impacts and likely consequences which are addressed in this section are illustrated in

Policy and Legislation

Legislation, Policy and Best Practice Documents Relevant to Water Quality

The following documents were reviewed to identify the key environmental values and applicable water quality objectives for the Hinze Dam catchment, incorporating the Nerang River:

- Australian Drinking Water Guidelines 2004;
- Environment Protection Act 1994;
- Environmental Protection (Water) Policy 1997;
- Nerang River Environmental Values and Water Quality;
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines); and
- Water Resources (Gold Coast) Plan 2006.

Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (the ADWG) provide a framework for good management of drinking water supplies that, if implemented, will assure safety at point of use (NHMRC 2004). The ADWG are not Government legislation or policy, providing best practice guidelines, for determining appropriate drinking water quality. The ADWG are intended for use by the community and all agencies with responsibilities associated with the supply of drinking water (NHMRC 2004).

The ADWG addresses the microbial limits, the physical and chemical requirements and the radiological limits of drinking water while also discussing the specific methods associated with the chemical treatment of drinking water. The requirements for designing a rigorous water quality monitoring program, with suitable levels of quality control are also stipulated and should be considered in the design of the monitoring program for Hinze Dam.

Environmental Protection Act 1994

The objective of the Act is to protect Queensland's environment, while allowing for development that improves the total quality of life, now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development). This Act is the overarching legislation under which the Environmental Protection (Water) Policy 1997 was developed.

Figure 7-16 Potential Project Impacts and Consequences . The potential impacts and likely consequences have also been discussed in the context of future water quality conditions. The potential ecological impacts have been addressed in the terrestrial ecology and aquatic ecology sections (see **Section 9** and **Section 10** of the EIS).

7.2.2 Policy and Legislation

Legislation, Policy and Best Practice Documents Relevant to Water Quality

The following documents were reviewed to identify the key environmental values and applicable water quality objectives for the Hinze Dam catchment, incorporating the Nerang River:

- Australian Drinking Water Guidelines 2004;
- Environment Protection Act 1994;
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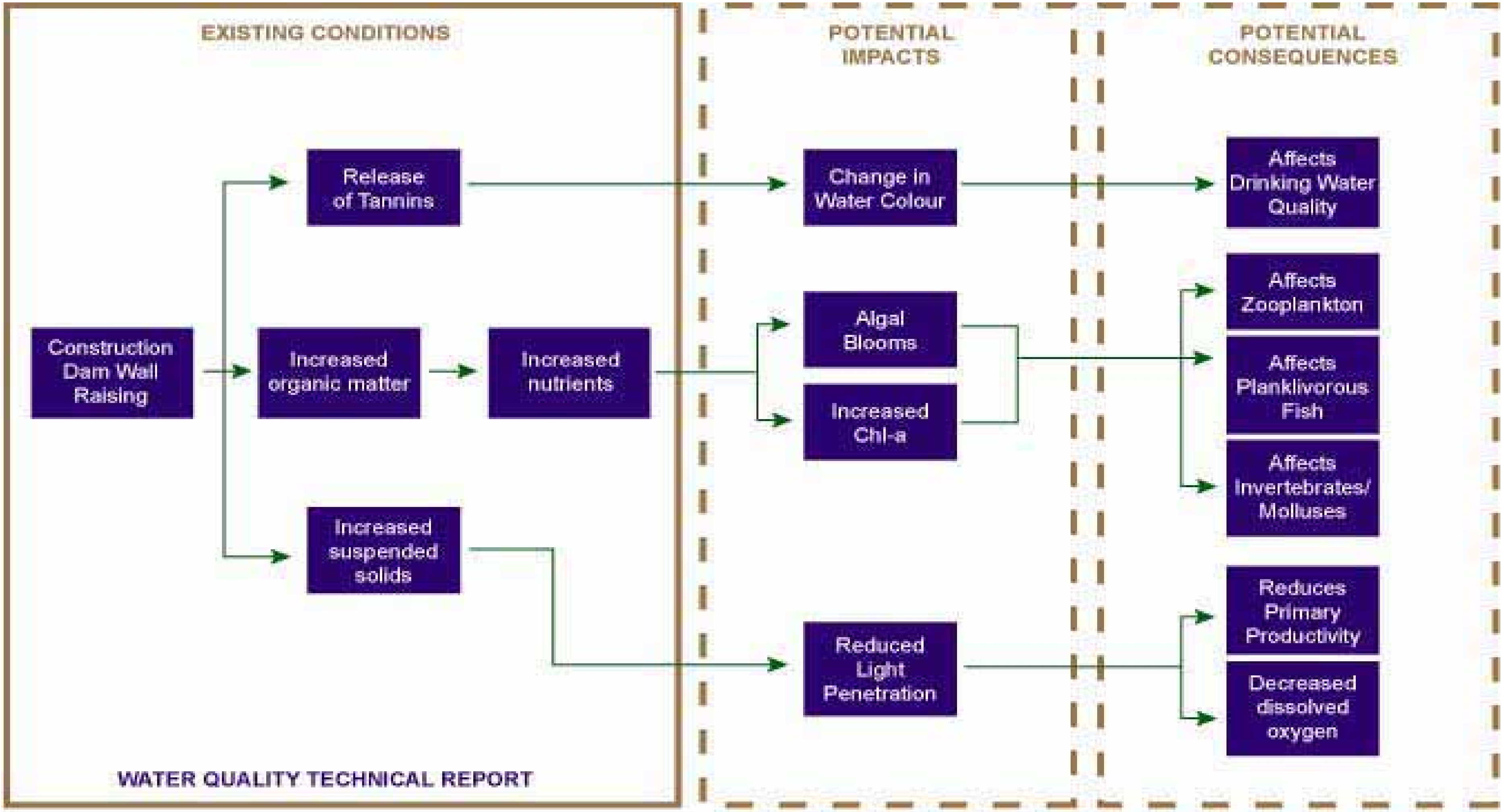
- **Figure 7-16 Potential Project Impacts and Consequences**



Environmental Protection (Water) Policy 1997

The *Environmental Protection (Water) Policy 1997* (EPP (Water)) is subordinate legislation under the *Environmental Protection Act 1994*. This policy contains a set of guidelines for the waters of Queensland. This policy is consistent with and should be seen as an extension of the *National Water Quality Management Strategy* and the *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 Guidelines for Fresh and Marine Water Quality* (Environmental Protection Agency (EPA) 2006a).

The EPP (Water) describes the process for determining which water quality guidelines to use in water quality planning and decision making (EPA 2006a). In general, where there is more than one set of applicable guidelines, the most local accredited guideline information shall take precedence over broader guidelines (EPA 2006a). Where the Queensland Water Quality Guidelines (QWQG) provide values for Queensland waters that are more localised than the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) Guidelines, the QWQG take precedence over the (broader) ANZECC guidelines (EPA 2006a). Further to this, for a number of indicators, notably toxicants, there is little or no local information. For these indicators the ANZECC guidelines remain the fundamental source of information (EPA 2006a).

The EPP (Water) identifies Environmental Values (EVs) for waters (including beds and banks) in Queensland. EVs describe the natural qualities and/ or beneficial uses of a water body that are to be protected (Environment Australia 2002). Where these EVs are not listed, the Policy identifies qualities of a water body to be enhanced or protected.

Water Quality Objectives (WQOs) are established as quantitative targets to protect or enhance the EVs identified for a water. WQOs can be set for physical, chemical and biophysical components or indicators of aquatic environments (Environment Australia 2002) generally referred to as guidelines that protect the stated EVs for a water body. The Nerang River and its tributaries are listed under Schedule 1 of this policy.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines)

The ANZECC guidelines are part of Australia's National Water Quality Management Strategy (NWQMS) and relate to New Zealand's National Agenda for Sustainable Water Management (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000). The purpose of the guidelines are to provide both government and the community with a sound set of tools for assessing and managing ambient water quality in natural and semi-natural water resources (ANZECC and ARMCANZ 2000).

The ANZECC guidelines aim to protect environmental values through management goals that focus on issues (concerns or potential problems) (ANZECC and ARMCANZ 2000). Despite this, the guidelines are not mandatory and due to the vast range of environments, ecosystem types and food production systems in both Australia and New Zealand, it is recognised that a three-tiered approach including national, state or territory, and regional or catchment scales are required (ANZECC and ARMCANZ 2000).

In accordance with this recognition, the Queensland Water Quality Guidelines (QWQG) were developed to provide state-wide guidelines. In addition to this, the QWQG also provide the framework for establishment of local and regional guidelines.

Nerang River Environmental Values and Water Quality Guidelines

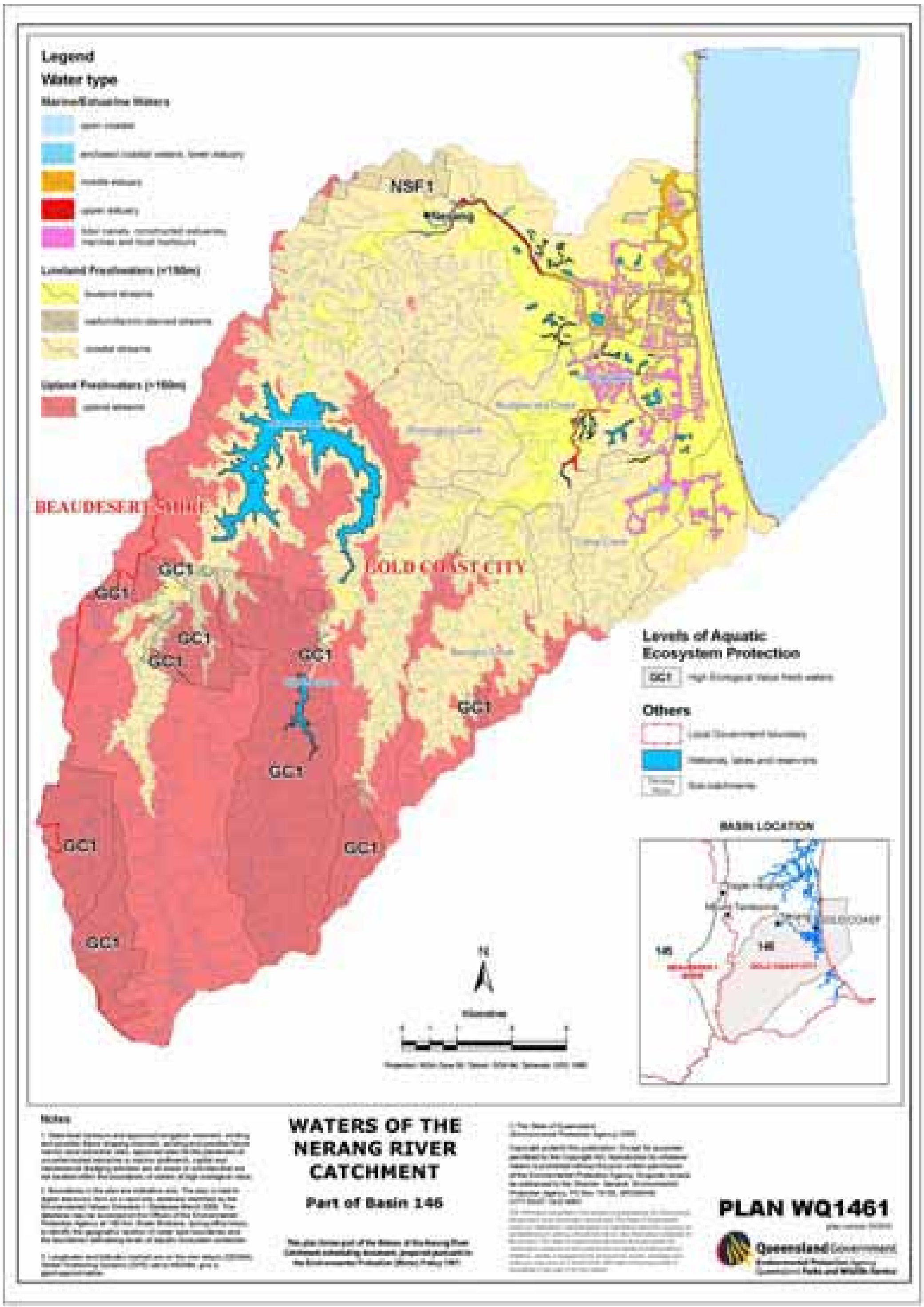
The *Nerang River Environmental Values and Water Quality Guidelines (2006)* contains environmental values and water quality objectives for waters in the Nerang Catchment and are listed under Schedule 1 of the EPP (Water).

The QWQG states that where more locally relevant guidelines are appropriately developed and meet relevant technical requirements then they would take precedence over the regional/sub-regional guidelines established within the document (EPA 2006b). Therefore the *Nerang River Environmental Values and Water Quality*

*Guidelines (*EPA 2006b*)* have been used, along with the QWQG for assessing water quality objectives of this Project*.*

Error! Reference source not found. identifies the waters of the Nerang River Catchment, all of which are considered and included in the *Nerang River Environmental Values and Water Quality Guidelines* (EPA 2006b*)*. Although the Enclosed Coastal Waters/Lower Estuary does not appear on this figure, this area is referred to in the *Nerang River Environmental Values and Water Quality Guidelines* (EPA 2006b*)*. The *Nerang River Environmental Values and Water Quality Guidelines (*EPA 2006b*)* set out the environmental values for each identified water area/type within the catchment.

- **Figure 7-17 Waters of the Nerang River Catchment**



The environmental values (EVs) identified for Hinze Dam are:

- Aquatic Ecosystems;
- Human Consumer;
- Primary Recreation;
- Secondary Recreation;
- Visual Recreation;
- Cultural and Spiritual Values; and
- Drinking Water (EPA 2006b).

Different levels of protection and hence different water quality objectives are presented in the guidelines for different environmental values. **Table 7-27** illustrates the WQOs to protect the aquatic ecosystem environmental values within Hinze Dam.

Table 7-27 Water Quality Objectives - Aquatic Ecosystem EVs

Water Area/Type	Level of Protection	Water Quality Objective
Freshwater lakes/reservoirs	Aquatic ecosystem – slightly to moderately disturbed (level 2)	■ Turbidity: <6 NTU ■ Suspended solids: <8mg/L ■ Chlorophyll a: <4 µg/L ■ Total nitrogen: <400 µg/L ■ Oxidised N: <80 µg/L ■ Ammonia N: <20 µg/L ■ Organic N: <320 µg/L ■ Total Phosphorus: <50 µg/L ■ Filterable reactive phosphorus (FRP): <20 µg/L ■ Dissolved oxygen: ($20^{th} \rightarrow 80^{th}$ percentile) % saturation 85% - 110% ■ pH: 6.5 – 8.0

Table 7-28 illustrates the WQOs to protect human use environmental values.

Table 7-28 Water Quality Objectives - Human Use EVs

Environmental Value	Water Type/Area	Water Quality Objective
Protection of the human consumer for oystering	Coastal and estuarine waters	Objective as per AWQG (2000) and *Food Standards Code, Australia New Zealand Food Authority*, 1996 and updates, including median faecal coliforms <14 most probable number (MPN) per 100mL with no more than 10% of samples exceeding 43 MPN per 100mL. Health of Individual Oysters - absence of pollutant induced disease or deformity. Tissue – No evidence of pollutant accumulation.
Protection of the human consumption	Coastal, estuarine and freshwaters	Objective as per AWQG (2000) and *Food Standards Code,* Australia New Zealand Food Authority, 1996 and updates. Fish and Crab Health Health of Individuals – absence of pollutant induced disease or deformity Tissue – no evidence of pollutant accumulation
Suitability for primary contact recreation	Coastal, estuarine and freshwaters	Objectives as per AWQG (2000), including: ■ Median faecal coliforms <150 organisms per 100mL or median enterococci organisms <35 organisms per 100mL; and ■ Secchi depth >1.2 m. Objectives for blue-green algae as per Department of Natural Resources Mines and Water guidelines.

Environmental Value	Water Type/Area	Water Quality Objective
Suitability for secondary contact recreation	Coastal, estuarine and freshwaters	Objectives as per AEQG (2000), including median faecal coliforms <1000 organisms per 100mL or median enterococci organisms <230 organisms per 100mL.
Suitability for visual recreation	Coastal, estuarine and freshwaters	Objectives as per AWQG (2000), including water being free from: ■ Floating debris, oil, grease and other objectionable matter; ■ Substances that produce undesirable colour, odour, taste or foaming; and ■ Undesirable aquatic life, such as algal blooms, or dense growths or attached plants or insects.
Protection of cultural and spiritual values	Coastal, estuarine and freshwaters, ground waters	Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans.
Suitability for drinking water supply	All freshwaters including ground waters	Local WQOs for drinking water supply are provided in Table 1.5. Also refer to AWQG (2000) and Australian drinking water guidelines (ADWG) (2004) that discuss how to manage the catchment to minimise the risks to drinking water supply. ADWG also provides health guideline values for potable water at the tap.

Table 7-29 illustrates the WQOs which pertain to primary contact recreation environmental values for management of blue-green algae in contact recreation areas.

■ Table 7-29 Primary Contact Recreation Environmental Values

Hazard Status	Guidance Level or Situation	Health Risks	Recommended Actions
High	Cyanobacterial scum formation in contact recreation areas or >100,000 cells total cyanobacteria mL-1 or >50 µg/L-1 chlorophyll-a with dominance of cyanobacteria	■ Short-term adverse health outcomes such as skin irritations or gastrointestinal illness following contact or accidental ingestion	■ Immediate action to prevent contact with scums ■ Signs to indicate HIGH alert level – warning of danger for swimming and other water contact activities
Moderate	20,000 – 100,000 cells total cyanobacteria mL-1 or 10-50 µg/L-1 chlorophyll-a with dominance of cyanobacteria	■ Short-term adverse health outcomes e.g. skin irritations, gastrointestinal illness, probably at low frequency	■ Signs to indicate MODERATE alert level – increased health risk for swimming and other water contact activities
Low	<20,000 cells total cyanobacteria mL-1 or <10 µg/L-1 chlorophyll-a with dominance of cyanobacteria	■ Short-term adverse health outcomes unlikely	■ Signs to indicate cyanobacteria either absent or present at low levels

Table 7-30 depicts the WQOs for protection of drinking water environmental values in the vicinity of off-takes, including groundwater before treatment.

■ Table 7-30 Drinking Water Environmental Values

Indicator	Hazard and Critical Control Point (HACCP) rating (refer notes 1, 2, for explanation of HACCP levels)
Suspended Soils	■ Level 1: 30mg/L [1] ■ Level 2: 100mg/L [2]
Blue-green Algae (Cyanobacteria)	■ Level 1: > 2000 cells/mL [1] ■ Level 2: > 5000 cells/mL [2]
Algal Biomass	■ Level 1: > 30,000 cells/mL Cylindrospermopsin or Microcystin 1 ■ No Level 2: [2]
Algal Toxin	■ Level 1: 0.1 µg/L Microcystin of 0.2 µg/L Cylindrospermopsin 1 ■ Level 2: 4 µg/L Microcystin or 1 µg/L Cylindrospermopsin 2
Taste and Odour	■ Level 1: 5 µg/L Geosmin or 10 µg/L MIB or 10 µg/L combined Geosmin and MIB 1 ■ Level 2: > 30 µg/L of both Geosmin and MIB combined 2
Cryptosporidium	■ Level 1: > 0 cyst 1 ■ Level 2: 10 cysts per 10 L 2
Giardia	■ Level 1: > 0 cyst 1 ■ Level 2: 10 cysts per 10 L 2

Indicator	Hazard and Critical Control Point (HACCP) rating (refer notes 1, 2, for explanation of HACCP levels)
E coli	▪ Level 1: >10 cfu/100mL 1 ▪ No Level 2 2
Total Coliforms	▪ Level 1: >500 cfu/100mL 1 ▪ No Level 2
Total Nitrogen	▪ Level 1: >0.75 mg/L 1 ▪ Level 2: >2mg/L 2
Total Phosphorus	▪ Level 1: >0.05 mg/L 1 ▪ Level 2: > 0.1 mg/L 2
Manganese (Soluble)	▪ Level 1: 50 µg/L 1 ▪ Level 2: 200 µg/L 2
Iron (Soluble)	▪ Level 1: 100 µg/L 1 ▪ Level 2: 250 µg/L 2
Turbidity	▪ Level 1: 10 NTU 1 ▪ No Level 2 2
Colour	▪ Level 1: 50 Hazen units 1 ▪ No Level 2 2
Conductivity	▪ Level 1: 250 uS/cm 1 ▪ Level 2: >50% change from long term median (no treatment options to remove salt) 2
Dissolved Oxygen	▪ Level 1: <4 mg/L at surface 1 ▪ No Level 2 2
Pesticides	▪ Level 1: Above detectable limits specified by Qld Health Scientific Services 1 ▪ Level 2: Notification of spills or illegal dumping 2
Hydrocarbons	▪ No Level 1 1 ▪ Level 2: Notification of spills or illegal dumping 2

Source: Based on advice from Gold Coast Water 2005
Notes:
1. "Level 1" means Level 1 Hazard and Critical Control Point (HACCP) response rating, namely – treatment plant process change required to ensure water quality and quantity to customers is not compromised.
2. "Level 2" means Level 2 Hazard and Critical Control Point (HACCP) response rating, namely – Treatment plant process change required but water quality and quantity to customers may still be compromised.

Water Resources (Gold Coast) Plan

The key ecological outcomes (objectives) for waters identified in the Gold Coast Resource Plan area are as follows:

- for Coomera River within the area known as Canungra Land Warfare Centre, including, in particular, Back Creek, and other waters of high ecological value under the Environmental Protection (Water) Policy 1997, including, in particular, Tallebudgerra Creek and Currumbin Creek, to minimise changes to the flow regimes of the waters;
- for Nerang River upstream of the Hinze Dam and Little Nerang Creek upstream of the Little Nerang Dam:
- to minimise changes to river-forming processes;
- to minimise changes to the flow regime;
- for Coomera River estuary;
- to minimise changes, as far as practicable, to freshwater flows into the Coomera River estuary;
- to minimise changes to the freshwater inflows to Coombabah Lake; and
- also, an ecological outcome for water in the plan area is to minimise changes, as far as practicable, to the volume and seasonality of freshwater flows into Moreton Bay and the Broadwater.

Gold Coast Water Catchment Management Strategy 2006

The strategy addresses the following issues:

- catchment Management;
- water quality protection;
- raw water supply to customers;
- legislative compliance; and
- recreation facility management.

The development and implementation of the strategy helps ensure that all legislative requirements are met. The strategy has two main objectives that relate to the Project:

- protect and improve the quality of water held in storage in Hinze and Little Nerang Dams; and
- meet Council's commitment for recreational usage of dams and surrounds.

7.2.3 Key Environmental Values

The key environmental values within the Hinze Dam catchment are described in the following sections.

Upper Nerang River

The Upper Nerang River includes areas upstream of the Hinze Dam, which encompass a network of creek and river systems including Nixon Creek and the upper Nerang River along the western arm (Numinbah Valley), and Little Nerang Creek along the eastern arm of the Hinze Dam catchment, which abuts Springbrook National Park. The high environmental values identified for this section of the upper catchment include aquatic ecosystems, visual amenity, cultural and spiritual values and drinking, irrigation and stock watering.

The Nerang River and Little Nerang Creek, upstream of (Hinze Dam have undergone minor to moderate change from reference condition, although impacts of water resource development are greater in Little Nerang Creek due to the effects of Little Nerang Dam (NRMW 2006b). Freshwaters flowing through Numinbah State Forest are classified as having High Ecological Values (GC1) (see **Figure 7-17**).

EPA (2006) states that for high ecological value waters, the generic ANZECC/ARMCANZ (2000) guideline is that there should be no change to existing condition. The no change criterion implies that not only the median but also the entire distribution of indicator values should remain unchanged (EPA 2006). EPA (2006) states that in order to fully assess this, it is necessary to first establish the true distribution of values of all relevant indicators in the high ecological value waterbody. Therefore, the baseline conditions of the upper catchment (which include GC1) need to be documented, prior to any future water quality monitoring.

Hinze Dam

Hinze Dam has a number of environmental values which require protection in accordance with the Nerang River Environmental Values and Water Quality Objectives (EPA 2006b). These include: drinking water objectives, aquatic ecosystem, human consumption (of fish and shellfish); primary (swimming), secondary (boating) and visual recreational activities; cultural and spiritual, and drinking water. The catchment of Hinze Dam includes the Numinbah Valley and Springbrook Plateau, with about 77% of this area covered by native bushland most of which is contained within state forests and national parks (NRMW 2005).

Although swimming in the Hinze Dam is not encouraged, a number of water based recreation activities occur, such as fishing and boating.

Little Nerang Dam

The Little Nerang Dam is located upstream of Little Nerang Creek and is identified as having the same environmental values to be protected as Hinze Dam (EPA 2006b). These include aquatic ecosystem, human consumption (of fish and shellfish); primary (swimming), secondary (boating) and visual recreational activities; cultural and spiritual, and drinking water. It contains waters which are classed as slightly to moderately disturbed.

Little Nerang Dam was completed in 1962 and until the completion of the Hinze Dam supplied the water requirements of the Gold Coast. The scheme draws its supply from a mass concrete dam with gates constructed across Little Nerang Creek. The water flows by gravity pipeline to the Mudgeeraba Water Treatment Plant (NRMW 2005).

Lower Nerang River

The Lower Nerang River, downstream of Hinze Dam, includes a freshwater component and an estuarine and closed coastal component, which flows into the Gold Coast Broadwater. The Lower Nerang (freshwater component) contains a number of environmental values, only one, irrigation, being identified of high importance.

The estuarine and marine (coastal) components of the Lower Nerang River contain a number of environmental values which have been identified by EPA (2006) and include aquatic ecosystems, human consumption (of fish and shellfish); primary (swimming), secondary (boating) and visual recreational activities; cultural and spiritual, industrial, aquaculture, wild oyster populations and seagrass beds.

Mudgeeraba Creek

Mudgeeraba Creek, including Bonogin Creek is located downstream of the Hinze Dam, and includes both freshwater and estuarine reaches. The environmental values of high significance identified for the freshwater reaches of Mudgeeraba Creek include aquatic ecosystems, human consumption (of fish and shellfish), visual recreation and aquaculture.

Open Coastal Waters

The open coastal waters of the Coral Sea have a number of environmental values which are of significance and require protection under EPA (2006), namely aquatic ecosystem protection, human consumption of fish and shellfish, primary, secondary and visual recreation and cultural and spiritual values. The southeast Queensland Regional Coastal Management Plan (EPA 2006), identified areas of coastal biodiversity significance, specifically the area of special interest for whales and dolphins.

7.2.4 Water Quality Monitoring Programs

Ecosystem Health Monitoring Program (EHMP)

The Ecosystem Health Monitoring Program, facilitated through the Moreton Bay and Catchment Partnership, is a regional program involving the EPA, Department of Natural Resources and Water (DNRW), local councils and universities. This program monitors marine, estuarine and freshwaters delivering a regional assessment of the ambient ecosystem health for the 18 major catchments in southeast Queensland.

The 2006 Report Card assigned a C+ (fair) grading to the Nerang Catchment, compared to a B+ (good) grading in 2005. This reporting indicates a deterioration in overall ecosystem health over the past year, with streams described as in fair condition. The Nerang River maintained good ecosystem health with a B grading achieved on both the 2005 and 2006 Report Cards, with low levels of nutrients and turbidity reported throughout the river in 2006.

Gold Coast City Council Monitoring Programs (GCCC)

Gold Coast City Council currently monitors water quality in the Nerang Catchment at 13 sites in the marine and freshwater sections of the Nerang River and at 15 sites in the upper catchment (seven sites in the Springbrook area and eight sites in the Numinbah area). Sampling occurs monthly for the Nerang River and upper catchment sites.

The Resource Inventory of Hinze Dam Catchment was produced for Gold Coast City Council in 2002 and presents water quality data collected within the Springbrook and Numinbah valleys. Key findings of this report include:

- water quality monitoring from 1992 to 2000 in the Numinbah Valley indicated most mean values comply with ANZECC guidelines, with natural sources, animals, agricultural practices and the human population concentration as the major sources of contaminants (Whitlow 2002); and
- water quality monitoring from 1995 to 2001 in Springbrook Creeks recorded mean concentrations of nitrogen and phosphorus within ANZECC guidelines. Isolated elevated E.coli values were also recorded within the seven year monitoring program across different creeks (Whitlow 2002).

Gold Coast Water (GCW)

Gold Coast Water currently undertakes monitoring at two locations in Hinze Dam at the upper and lower intakes. These locations are monitored on a weekly basis.

Hinze Dam Alliance

The Hinze Dam Alliance performed a once off sampling event in February 2007 to obtain more recent chlorophyll-a data for Hinze Dam (see **Appendix F.7.2**). The chlorophyll-a data was added to the historic water quality data set for calculating medians for Hinze Dam, as collected by Gold Coast Water.

7.2.5 Water Quality Data

Upland Streams

Water quality data reported from the GCCC Program from sites within the upland streams were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-31**. The location of the monitoring sites are shown on **Figure 7-18**.

Table 7-31 Upland Streams Water Quality Evaluation

Water Quality Parameter	Nerang River Catchment Objectives	N2	N1	S7	S6	S5	S4	S3	S2	S1
Turbidity (NTU)	<25 NTU	2	3	2	2	2	6	3	3	1
Chlorophyll *a* (µg/L)	<2 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Nitrogen (µg/L)	<250 µg/L	n/a	255	505	490	240	470	340	425	295
Oxides of Nitrogen (µg/L)	<40 µg/L	n/a	18	343	284	68	226	165	215	131
Ammonia N (µg/L)	<10 µg/L	n/a	19	26	19	12	19	9	19	15
Organic N (µg/L)	<200 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Phosphorus (µg/L)	<30 µg/L	n/a	48	10	11	12	18	10	13	9
Filterable Reactive Phosphorus (FRP) (µg/L)	<15 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dissolved Oxygen (% saturation)	20^{th} – 80^{th} percentile; 90-110%	82-99	89-113	61-71	55-69	81-92	75-87	86-93	75-83	76-91
pH	6.5-8.2	6.8	6.8	5.3	5.1	5.8	5.6	6.4	6.1	6.3

Source: GCCC
Table Notes: Data Period: January 2005 – February 2007. Median values calculated from surface water data (0.2m). Number of samples for Numinbah = 24; number of samples for Springbrook = 26.
The shaded values within the table represent exceedances of the catchment objectives

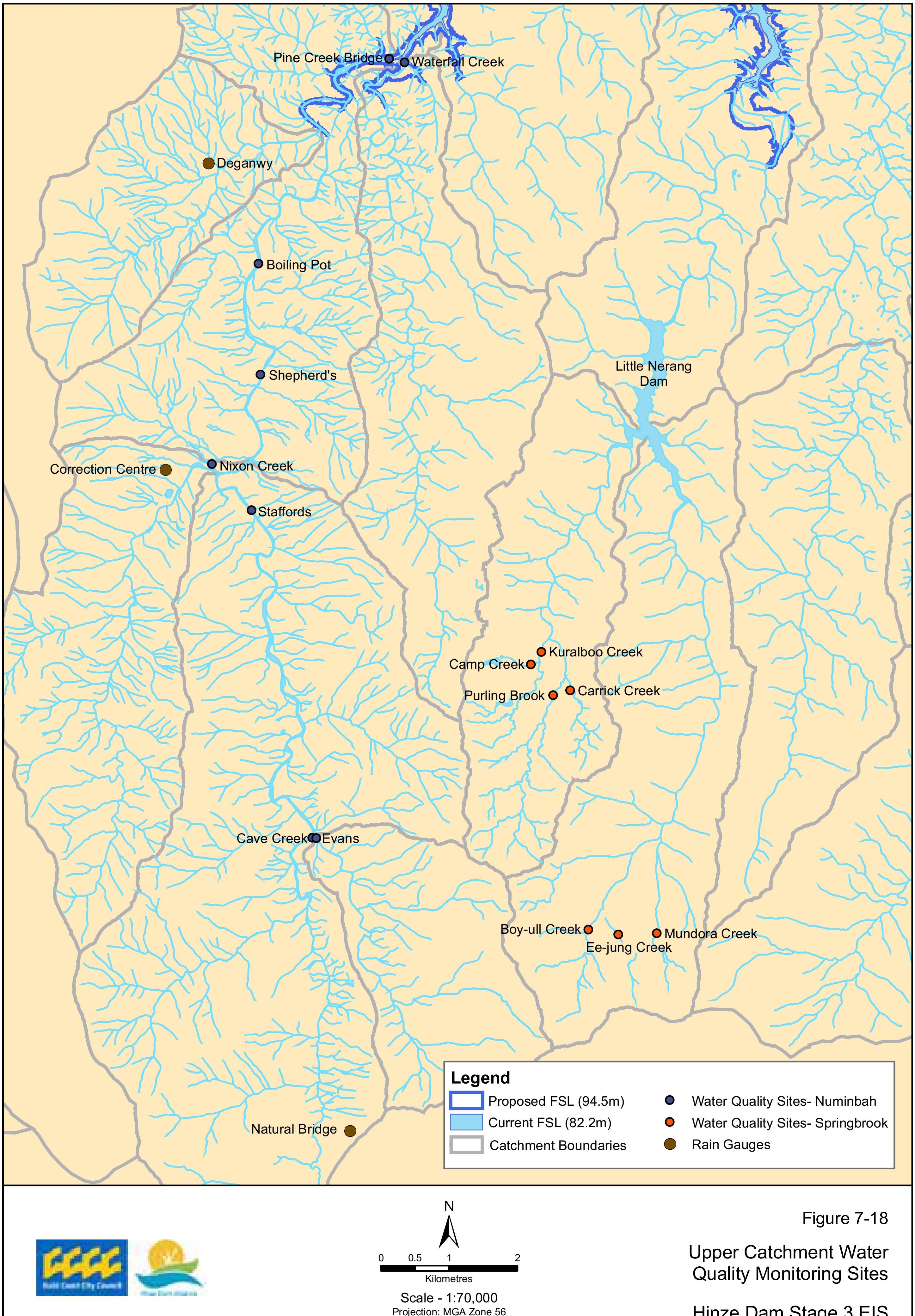


Figure 7-18

Upper Catchment Water Quality Monitoring Sites

Hinze Dam Stage 3 EIS

The water quality results reported in **Table 7-31** indicates overall non-compliance with Nerang River Water Quality Objectives for Numinbah and Springbrook sites. Median concentrations of total nitrogen, ammonia–N, dissolved oxygen and pH values failed to meet the relevant WQO's. Elevated nitrogen values may be attributed to geological features or groundwater influences in the upper catchment.

Freshwater Lakes

Data obtained from the GCW and ALLIANCE programs (see **Figure 7-19**) from sites within Hinze Dam were evaluated against the Nerang River Water Quality Objectives. The results of this evaluation are contained in **Table 7-32**.

Table 7-32 Freshwater Lakes/Reservoir Water Quality Evaluation

Water Quality Parameter	Nerang River Catchment Objectives	Lower Intake	Upper Intake
Turbidity (NTU)	<5 NTU	1	1
[1]Chlorophyll *a* (µg/L)	<5 µg/L	<5	<5
Total Nitrogen (µg/L)	<300 µg/L	350	385
Oxides of Nitrogen (µg/L)	<10 µg/L	11	14
Ammonia N (µg/L)	<10 µg/L	14	17
Organic N (µg/L)	<270 µg/L	n/a	n/a
Total Phosphorus (µg/L)	<10 µg/L	13	13
Filterable Reactive Phosphorus (FRP) (µg/L)	<5 µg/L	n/a	n/a
Dissolved Oxygen (% saturation)	20^{th} – 80^{th} percentile; 90-110%	90-107	81-105
pH	6.5-8.0	7.6	7.5
[2]Iron-total(µg/L)	300	80	90
[3]Manganese (µg/L)	1700	30	40

Table Notes: Data Period: January 2005 – February 2007. Median values calculated from surface water data (0.3m). [1] Chlorophyll *a* samples taken by SKM on 13/3/2007 at 0.2m (one off sampling event only), see Appendix A. [2] Iron guidelines have low reliability trigger values and so an indicative guideline of 0.3µg/L is used based on Canadian guidelines. [3] Manganese values based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). Number of samples for lower and upper intakes =112.

The shaded values within the table represent exceedances of the catchment objectives

Median concentrations of total nitrogen, oxides of nitrogen, ammonia–N, total phosphorus and dissolved oxygen (upper intake only) were reported as slightly elevated with respect to the Nerang River Water Quality Objectives.

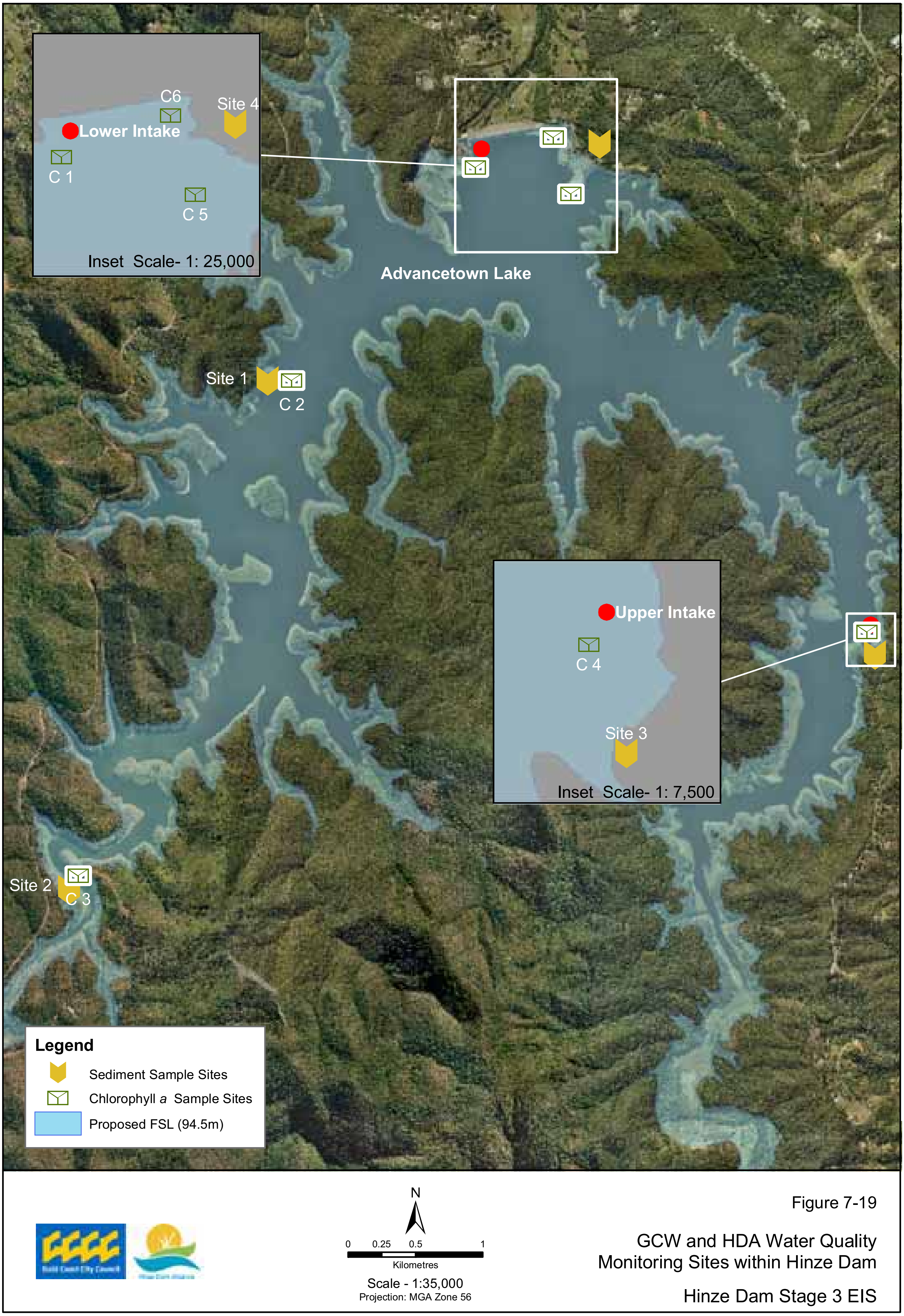


Figure 7-19

GCW and HDA Water Quality Monitoring Sites within Hinze Dam

Hinze Dam Stage 3 EIS

Advancetown Lake

Data obtained from the GCW monitoring program from sites within Hinze Dam (see **Figure 7-19**) were evaluated against Nerang River Water Quality Objectives and are summarised in **Table 7-33**. The water quality results indicate overall compliance with Nerang Water Quality Objectives for drinking water supply in the vicinity of off-takes, including groundwater, before treatment water quality evaluation with GCW data.

Table 7-33 Drinking Water Environmental Values

Water Quality Parameter	Hazard and critical control point (HACCP) rating	Upper Intake
Suspended Soils	■ Level 1: 30mg/L [1] ■ Level 2: 100mg/L [2]	n/a
Blue-green Algae (Cyanobacteria)	■ Level 1: > 2000 cells/mL [1] ■ Level 2: > 5000 cells/mL [2]	n/a
Algal Biomass	■ Level 1: > 30,000 cells/mL Cylindrospermopsin or Microcystin [1] ■ No Level 2: [2]	n/a
Algal Toxin	■ Level 1: 0.1 µg/L Microcystin of 0.2 µg/L Cylindrospermopsin [1] ■ Level 2: 4 µg/L Microcystin or 1 µg/L Cylindrospermopsin [2]	n/a
Taste and Odour	■ Level 1: 5 µg/L Geosmin or 10 µg/L MIB or 10 µg/L combined Geosmin and MIB [1] ■ Level 2: > 30 µg/L of both Geosmin and MIB combined [2]	n/a
Cryptosporidium	■ Level 1: > 0 cyst [1] ■ Level 2: 10 cysts per 10 L [2]	n/a
Giardia	■ Level 1: > 0 cyst [1] ■ Level 2: 10 cysts per 10 L [2]	n/a
E coli (cfu) (n=104)	■ Level 1: >10 cfu/100mL 1 ■ No Level 2 [2]	<1
Total Coliforms	■ Level 1: >500 cfu/100mL 1 ■ No Level [2]	n/a
Total Nitrogen (µg/L) (n=36)	■ Level 1: >750 µg/L [1] ■ Level 2: >2000 µ/L [2]	403
Total Phosphorus (µg/L) (n=36)	■ Level 1: >50 µg/L [1] ■ Level 2: > 100 µg/L [2]	15
Manganese (Soluble) (µg/L) (n=157)	■ Level 1: 50 µg/L [1] ■ Level 2: 200 µg/L [2]	<0.01
Iron (Soluble) (µg/L) (n=36)	■ Level 1: 100 µg/L [1] ■ Level 2: 250 µg/L [2]	62
Turbidity (NTU) (n=157)	■ Level 1: 10 NTU [1] ■ No Level 2 [2]	2.0
Colour (HU) (n=157)	■ Level 1: 50 Hazen units [1] ■ No Level 2 [2]	13
Conductivity (µS/cm)	■ Level 1: 250 uS/cm [1] ■ Level 2: >50% change from long term median (no treatment options to remove salt) 2	n/a
Dissolved Oxygen (mg/L) (n=157)	■ Level 1: <4 mg/L at surface [1] ■ No Level 2 [2]	6.50
Pesticides	■ Level 1: Above detectable limits specified by Qld Health Scientific Services [1] ■ Level 2: Notification of spills or illegal dumping [2]	All readings below detection limits
Hydrocarbons	■ No Level 1 [1] ■ Level 2: Notification of spills or illegal dumping [2]	n/a

Source: Based on advice from Gold Coast Water 2005

Notes:

1. "Level 1" means Level 1 Hazard and Critical Control Point (HACCP) response rating, namely – treatment plant process change required to ensure water quality and quantity to customers is not compromised.

2. "Level 2" means Level 2 Hazard and Critical Control Point (HACCP) response rating, namely – Treatment plant process change required but water quality and quantity to customers may still be compromised. Data period: 2003-2006. n = number of samples.

As water depth increases, stratification of the water body results in lower temperatures, and reduced oxygen concentrations at depths greater than 12 m. **Figure 7-20** and **Figure 7-21** show the thermocline and associated reduction in dissolved oxygen levels for both intakes within the dam. This decrease in DO can be caused by the decomposition of organic material and ammonia nitrification resulting in ammonia production and dissolution of iron and manganese oxides.

- **Figure 7-20 Median temperature and Dissolved Oxygen Values for Upper Intake**

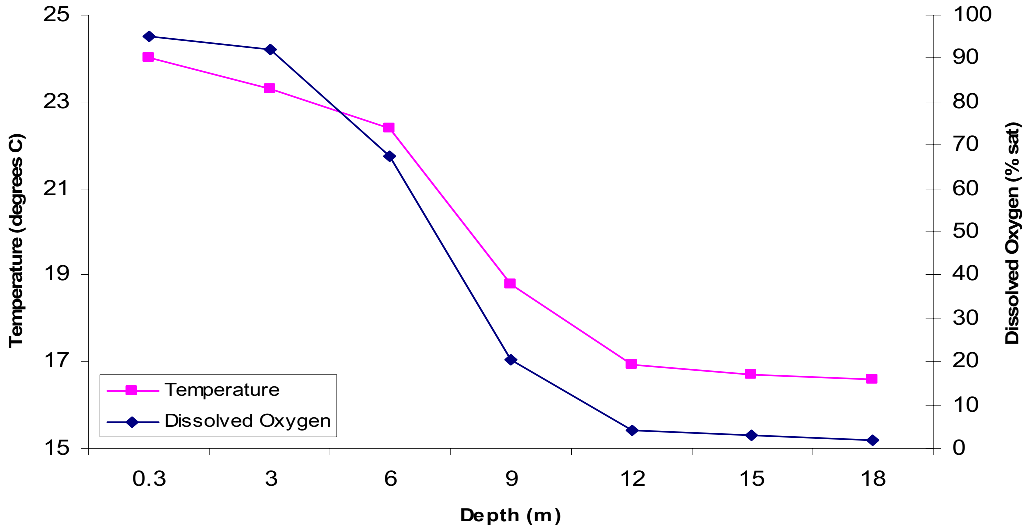


Figure notes: Data collected by GCW. Data Period: January 2005 – February 2007. Number of samples = 112

- **Figure 7-21 Median Temperature and Dissolved Oxygen Values for Lower Intake**

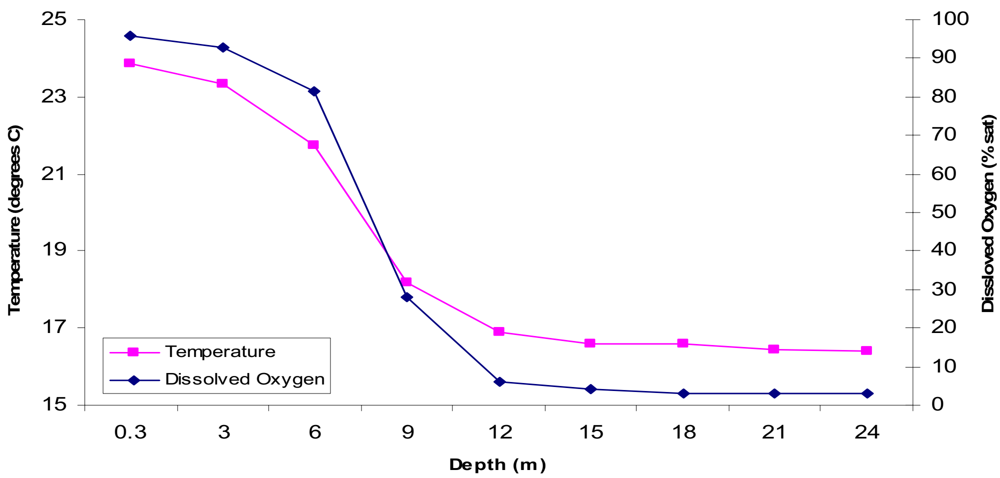


Figure notes: Data collected by GCW. Data Period: January 2005 – February 2007. Number of samples = 112

Lowland Streams

Data collected from the GCCC program reported from sites within lowland streams (see **Figure 7-22**) were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-34**.

Table 7-34 Lowland Streams Water Quality

Water Quality Parameter	Nerang River Catchment Objectives	Pony Club	Latimers Crossing	Hinze Dam (North of wall)	N8	N7	N6	N5	N4	N3
Turbidity (NTU)`	<6 NTU	3	2	1	2	2	2	3	5	2
Chlorophyll *a* (µg/L)	<4 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Nitrogen (µg/L)	<400 µg/L	370	310	330	230	310	340	n/a	930	265
Oxides of Nitrogen (µg/L)	<80 µg/L	n/a	n/a	n/a	12	10	31	n/a	560	14
Ammonia N (µg/L)	<20 µg/L	n/a	n/a	n/a	12	15	20	n/a	37	17
Organic N (µg/L)	<320 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Phosphorus (µg/L)	<50 µg/L	34	21	19	23	37	46	n/a	91	39
Filterable Reactive Phosphorus (FRP) (µg/L)	<20 µg/L	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dissolved Oxygen (% saturation)	20th – 80th percentile; 85-110%	83-99	70-95	49-83	85-93	95-110	83-95	94-108	74-92	83-99
pH	6.5-8.0	7.3	7.2	7.1	6.8	7.6	7.0	7.5	6.8	6.9

Table Notes: Data Period: January 2005 – February 2007. Median values calculated from surface water data (0.2m). Number of samples = 24

The water quality results reported in **Table 7-34** indicates overall compliance with Nerang Water Quality Objectives, with the exception of dissolved oxygen at six of the nine sites and nutrients at N4. Lowland streams downstream of Hinze Dam recorded median dissolved oxygen values lower than the objective range. Elevated nitrogen and phosphorus were recorded in the Numinbah valley at site 4 (downstream of Numinbah Valley Correctional Centre).

Upper Estuary

Data collected from GCCC and EPA programs reported from sites (see **Figure 7-22** and **Figure 7-23**) within the Upper Estuary were evaluated against the Nerang River Water Quality Objectives. This assessment is detailed in **Table 7-35**.

Table 7-35 Upper Estuary Water Quality Evaluation

Water Quality Parameter	Nerang River Catchment Objectives	EPA Site 1908	EPA Site 1909	EPA Site 1910	GCCC Site 0A
Turbidity (NTU)	<25 NTU	7	7	7	5
Chlorophyll *a* (µg/L)	<8 µg/L	6.1	6.7	7.6	n/a
Total Nitrogen (µg/L)	<450 µg/L	380	400	440	500
Oxides of Nitrogen (µg/L)	<15 µg/L	5	4	8	n/a
Ammonia N (µg/L)	<30 µg/L	9	7	13	n/a
Organic N (µg/L)	<400 µg/L	374	388	415	n/a
Total Phosphorus (µg/L)	<30 µg/L	41	42	52	57
Filterable Reactive Phosphorus (FRP) (µg/L)	<10 µg/L	9	8	9	n/a
Dissolved Oxygen (% saturation)	20th – 80th percentile; 80-100%	79-101	78-100	74-100	73-95
pH	7.0-8.4	7.7	7.6	7.5	7.2
Secchi depth (m)	20th percentile >0.5m	0.7	0.7	0.6	0.3

Table Notes: GCCC Data Period: January 1995 – February 2007, EPA Data Period: October 2002 – February 2007. Median values calculated from surface water data (0.2m). Number of EPA samples = 53; number of GCCC samples = 128.

The water quality results indicate overall compliance with Nerang River Water Quality Objectives, with the exception of dissolved oxygen, nutrients (particularly total phosphorus) and secchi depth. All sites exceeded total phosphorus objectives, with elevated nitrogen reported in the upper reaches. At all sites, the lower limit of the dissolved oxygen range were below the lower limit of objectives.

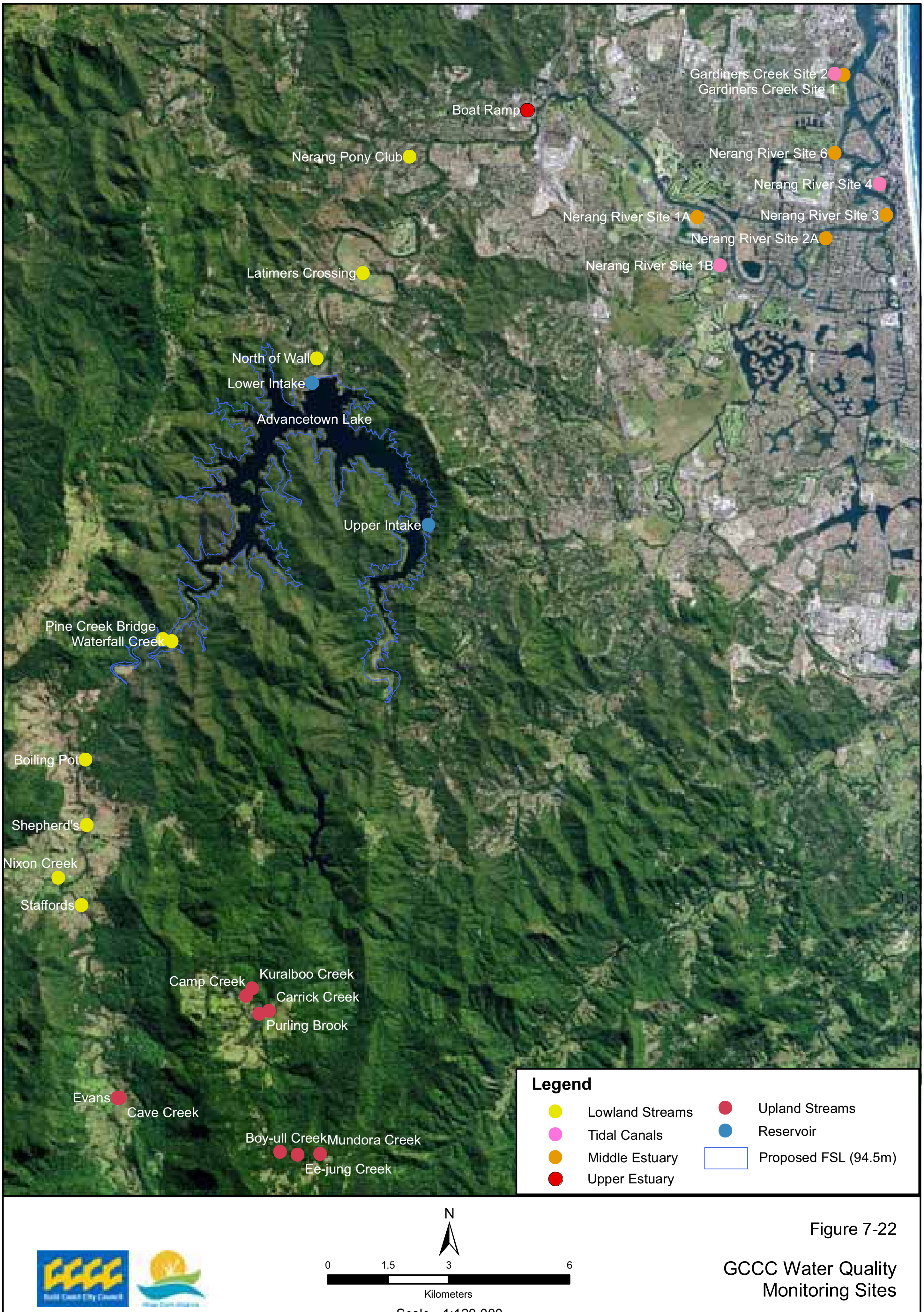
Mid Estuary

Data collected from GCCC and EPA programs reported from sites (see **Figure 7-22** and **Figure 7-23**) within the mid estuary were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-36** and **Table 7-37** Mid Estuary Water Quality – GCCC Program .

Table 7-36 Mid Estuary Water Quality – EPA Program

Water Quality Parameter	Nerang River Catchment Objectives	Site 1901	Site 1912	Site 1916	Site 1903	Site 1904	Site 1905	Site 1906	Site 1907
Turbidity (NTU)	<5 NTU	3	3	3	3	4	4	6	6
Chlorophyll *a* (µg/L)	<4 µg/L	1.7	2	2	2.4	2.7	2.9	3.7	4
Total Nitrogen (µg/L)	<300 µg/L	150	160	170	200	235	250	290	310
Oxides of Nitrogen (µg/L)	<10 µg/L	4	5	9	12	14	15	16	13
Ammonia N (µg/L)	<15 µg/L	5	6	9	11	15	17	17	18
Organic N (µg/L)	<250 µg/L	138	152	152	173	206	215	251	288
Total Phosphorus (µg/L)	<30 µg/L	17	17	18	22	23	24	27	31
Filterable Reactive Phosphorus (FRP) (µg/L)	<10 µg/L	5	6	7	7	8	7	7	9
Dissolved Oxygen (% saturation)	20th – 80th percentile; 80-100%	93-99	93-99	92-98	89-97	86-96	85-96	85-96	80-94
pH	7.0-8.4	8.1	8.1	8.1	8.0	7.9	7.9	7.8	7.7
Secchi depth (m)	20th percentile >1.0m	1.8	1.6	1.6	1.4	1.2	1.0	1.0	0.8

Table Notes: Data Period: October 2002 – February 2007. Median values calculated from surface water data (0.2m). Number of EPA samples = 53.

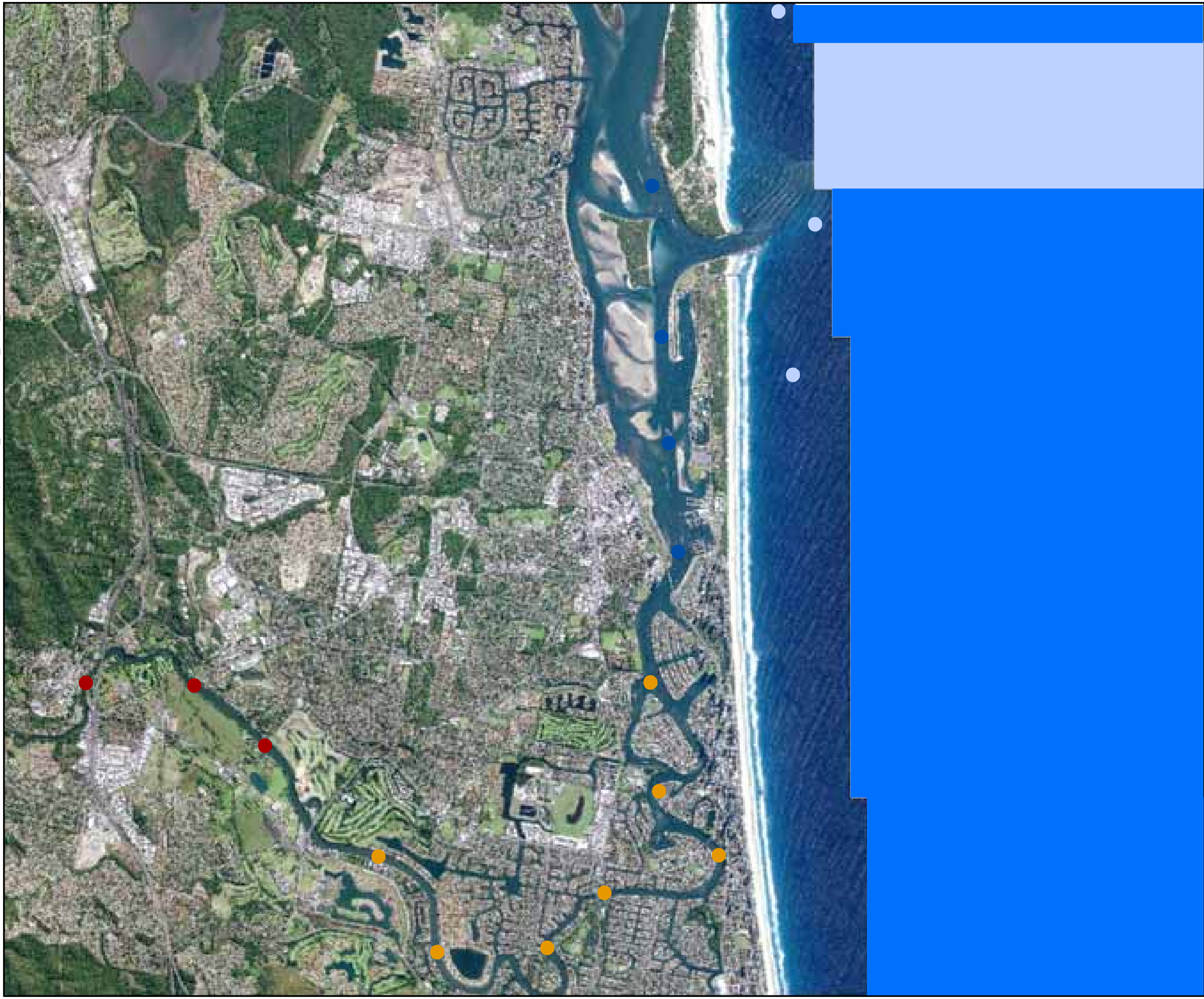


Scale - 1:120,000
Projection: MGA Zone 56

Figure 7-22

GCCC Water Quality Monitoring Sites

Hinze Dam Stage 3 EIS



N

0 0.5 1 2

Kilometres

Scale - 1:70,000
Projection: MGA Zone 56

Legend

- Upper Estuary
- Middle Estuary
- Enclosed Coastal Waters
- Open Coastal

Figure 7-23
EPA Water Quality Monitoring Sites

Hinze Dam Stage 3 EIS

The water quality results reported in **Table 7-36** indicates overall compliance with Nerang Water Quality Objectives, with the exception of slightly elevated median values for turbidity, nitrogen, phosphorus and reduced secchi depth measurements at the upper reaches of the mid estuary section.

The water quality results in **Table 7-37** Mid Estuary Water Quality – GCCC Program indicates overall compliance with Nerang River Water Quality Objectives, with the exception of elevated median values of nitrogen, phosphorus, dissolved oxygen and reduced secchi depth within the upper reaches of the mid estuary.

- **Table 7-37 Mid Estuary Water Quality – GCCC Program**

Water Quality Parameter	Nerang River Catchment Objectives	Gardiniers Creek Site 1	Site 6	Site 3	Site 2A	Site 1A
Turbidity (NTU)	<5 NTU	2	2	2	3	4
Chlorophyll *a* (µg/L)	n/a	n/a	n/a	n/a	n/a	n/a
Total Nitrogen (µg/L)	<300 µg/L	220	240	260	290	360
Oxides of Nitrogen (µg/L)	n/a	n/a	n/a	n/a	n/a	n/a
Ammonia N (µg/L)	n/a	n/a	n/a	n/a	n/a	n/a
Organic N (µg/L)	n/a	n/a	n/a	n/a	n/a	n/a
Total Phosphorus (µg/L)	<30 µg/L	22	21	25	26	35
Dissolved Oxygen (% saturation)	20th – 80th percentile; 80-100%	91-98	86-98	81-95	82-92	73-91
pH	7.0-8.4	8.1	8.0	8.0	7.9	7.7
Secchi depth (m)	20th percentile >1.0m	1.4	1.5	1.3	1.0	0.7

Table Notes: Data Period: January 1995 – February 2007. Median values calculated from surface water data (0.2m). Number of GCCC samples = 128

Tidal Canals

Data collected from the GCCC Program reported from sites (see **Figure 7-22**) within Tidal Canals were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-38**.

- **Table 7-38 Tidal Canal Water Quality**

Water Quality Parameter	Nerang River Catchment Objectives	Site 1B	Site 4	Gardiners Creek Site 2
Turbidity (NTU)	<8 NTU	4	2	2
Chlorophyll *a* (µg/L)	<4 µg/L	n/a	n/a	n/a
Total Nitrogen (µg/L)	<300 µg/L	370	280	280
Oxides of Nitrogen (µg/L)	<10 µg/L	n/a	n/a	n/a
Ammonia N (µg/L)	<10 µg/L	n/a	n/a	n/a
Organic N (µg/L)	<280 µg/L	n/a	n/a	n/a
Total Phosphorus (µg/L)	<25 µg/L	26	24	28
Filterable Reactive Phosphorus (FRP) (µg/L)	<6 µg/L	n/a	n/a	n/a
Dissolved Oxygen (% saturation)	20th – 80th percentile; 85-100%	80-96	84-97	81-95
pH	7.0-8.4	7.7	8.0	8.0
Secchi depth (m)	20th percentile >1.0m	1.0	1.8	1.4

Table Notes: Data Period: January 1995 – February 2007. Median values calculated from surface water data (0.2m). Number of GCCC samples = 128.

The water quality results reported in **Table 7-38** indicates general overall compliance with Nerang River Water Quality Objectives.

Nerang Lower Estuary

Data collected as part of the EPA program reported from sites (see **Figure 7-23**) within the Lower Estuary were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-39**.

▪ Table 7-39 Lower Estuary Water Quality Evaluation with EPA data

Water Quality Parameter	Nerang River Catchment Objectives	Site 117	Site 118	Site 119
Turbidity (NTU)	<8 NTU	3	2	2
Chlorophyll *a* (µg/L)	<2.75 µg/L	1.9	1.5	1.1
Total Nitrogen (µg/L)	<170 µg/L	140	120	120
Oxides of Nitrogen (µg/L)	<4 µg/L	2	2	2
Ammonia N (µg/L)	<11 µg/L	3	3	2
Organic N (µg/L)	<170 µg/L	130	115	111
Total Phosphorus (µg/L)	<25 µg/L	16	14	14
Filterable Reactive Phosphorus (FRP) (µg/L)	<6 µg/L	4	3	4
Dissolved Oxygen (% saturation)	20^{th} – 80^{th} percentile; 90-105%	96-103	96-103	97-106
pH	8.2-8.4	8.2	8.2	8.2
Secchi depth (m)	20^{th} percentile >1.6m	2.3	2.7	2.9

Table Notes: Data Period: October 2002 – February 2007. Median values calculated from surface water data (0.2m). Number of EPA samples = 54.

Table 7-39 indicates general overall compliance with Nerang Water Quality Objectives for the Nerang Lower Estuary.

Open Coastal Waters

Data collected as part of the EPA program reported from sites (see **Figure 7-23**) located along the open coast were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-40**.

Table 7-40 indicates compliance with Nerang River Water Quality objectives for Open Coastal Waters.

▪ Table 7-40 Open Coastal Waters Water Quality

Water Quality Parameter	Nerang River Catchment Objectives	Site 4000	Site 4001	Site 4002	Site 4003
Turbidity (NTU)	<1	0	0	0	0
Chlorophyll *a* (µg/L)	<1 µg/L	0.5	0.6	0.6	0.6
Total Nitrogen (µg/L)	<150 µg/L	110	120	120	130
Oxides of Nitrogen (µg/L)	<3 µg/L	2	2	2	2
Ammonia N (µg/L)	<5 µg/L	2	2	2	2
Organic N (µg/L)	<140 µg/L	106	106	115	116
Total Phosphorus (µg/L)	<16 µg/L	9	9	10	10
Filterable Reactive Phosphorus (FRP) (µg/L)	<5 µg/L	2	2	2	2
Dissolved Oxygen (% saturation)	20^{th} – 80^{th} percentile; 95-105%	96-104%	97-105%	97-104%	97-104%
pH	8.2-8.4	8.2	8.3	8.2	8.2
Secchi depth (m)	20^{th} percentile >5.0m	8.8	10.5	8.2	7.0

Table Notes: Data Period: 2/ 2000 – 2/ 2007. Median values calculated from surface water data (0.2m). Number of EPA samples = 75.

7.2.6 Water Quality Objectives for Human Use

Data collected from the GCCC program reported from sites (see **Figure 7-22**) within fresh, estuarine and coastal waters were evaluated against the Nerang River Water Quality Objectives and are summarised in **Table 7-41**.

Table 7-41 WQOs to Protect Human Use - Fresh, Estuarine and Coastal Waters

EVs	Nerang River Catchment Objectives	Hinze Dam (north of wall)	Latimers Crossing	Pony Club	Site 0A	Site 1	Site 1B
Suitability for primary contact recreation	Median faecal coliforms <150 organisms per 100mL	20	100	80	160	20	40
	Secchi depth >1.2(m)	0.3	0.3	0.3	0.3	1.0	1.0
Suitability for secondary contact recreation	Objectives as per AWQG, including median faecal coliforms<1000	20	100	80	160	20	40

EVs	Nerang River Catchment Objectives	Site 2A	Site 3	Site 4	Site 6	Gardiners Creek Site 1	Gardiners Creek Site 2	Site 8
Suitability for primary contact recreation	Median faecal coliforms <150 organisms per 100mL	20	20	40	20	90	575	40
	Secchi depth >1.2(m)	1.6	1.8	1.8	2.0	1.8	1.3	2.2
Suitability for secondary contact recreation	Objectives as per AWQG, including median faecal coliforms<1000	20	20	40	20	90	575	40

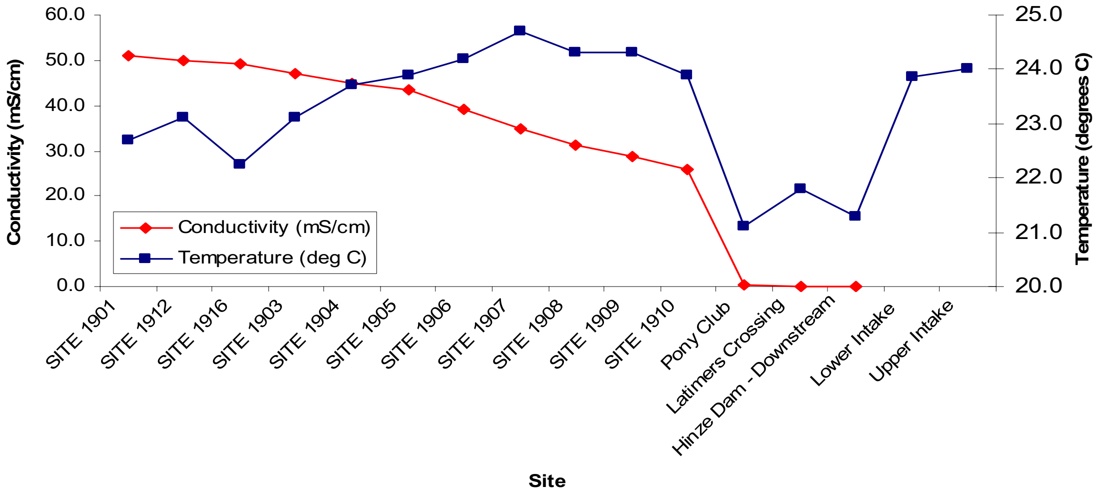
Table Notes: Data Period: January 2003 – February 2007. Median values calculated from surface water data (0.2m). Number of GCCC samples = 61.

Table 7-41 indicates general overall compliance with Nerang Water Quality Objectives for primary and secondary contact recreation. Secchi depth within the freshwater and upper sections of the Nerang River failed to meet objectives. The upstream site of Gardiners Creek was the only monitored site to fail faecal coliform objectives.

From the mouth of the Nerang River, conductivity decreases upstream, as the tidal influence becomes less dominant (see **Figure 7-24**). The tidal limit of the Nerang River is approximately 25km from the river mouth, and just upstream of EPA site 1910. As expected, the upper and lower intakes in Hinze Dam recorded low conductivity median values. Median surface temperatures from the river mouth to the upper intake remain generally constant with higher readings recorded in the middle of the river system which may be attributed to reduced flow and depth.

Water quality within the upper catchment remains generally average with non-compliance against Nerang River Water Quality Objectives in the Springbrook valley, for nitrogen, pH and dissolved oxygen median values. Within Hinze Dam, water quality improves and is typified by low turbidity, chlorophyll a and metal concentrations. Downstream of the dam wall, water quality generally meets objectives with slightly elevated nutrient values in the upper and mid estuary sections of the Nerang River. In the lower section of the Nerang River and open coastal waters of the Coral Sea, overall water quality is good and is typified by low turbidity, chlorophyll a and nutrient concentrations.

▪ **Figure 7-24 Median Surface Conductivity and Temperature**



7.2.7 Key Activities and Potential Impacts

The key activities and potential impacts arising from the Project, which have the potential to influence the drinking water supply and environmental values described in the previous section are examined in this section of the report.

The key activities and issues identified include:

- construction and operation activities contributing to erosion and sediment runoff;
- construction activities contributing to resuspension of sediment from disturbance of stream banks and beds;
- post-construction activities influencing water quality conditions from vegetation inundation associated with raising water levels; and
- construction activities contributing to concrete, chemical and hydrocarbon storage and spills.

Potential Construction Impacts

Environmental flow releases and water for potable use will continue to be drawn from the Hinze Dam during the construction process. There are some key activities which have the potential to compromise water quality and impact on these values. These activities include:

- construction of the embankment, saddle dam and spillway has the potential to cause excessive erosion and sediment runoff;
- the activities associated with the rock quarry and borrow pit, including constructing access tracks, clearance activities, dewatering, loading and haulage, have the potential to cause excessive erosion, runoff and water quality degradation;
- site specific inundation clearing, demolition activities and construction of boat ramps, roadways, the site offices increase the potential for fuel spills and concrete, chemical and tarmac spills into the waterway;
- The use of barges on site has the potential to re-suspend sediments from the bottom of the dam and introduce hydrocarbons from oil and diesel fuel spills;
- construction of the intake tower and fishway will involve a series of concrete pours, using a crane, which has the potential to spill excess concrete, chemical and tarmac spills into the waterway, thereby compromising water quality conditions;

- the site office, workshop and crushing and screening plants generate sewage which has the potential to spill into the waterway and compromise water quality conditions; and
- management of hazardous chemicals and regulated and workshop wastes (metal, tyres, filters, batteries) has the potential to contaminate the waterway.

The main construction related impact to water quality is the potential for soil erosion and increased sedimentation in Hinze Dam and downstream of Hinze Dam. This impact will most likely take place during excavation activities and following the removal of vegetation.

An increase in sediment loads into the Hinze Dam will reduce light penetration in the water column, thereby influencing the primary productivity of phytoplankton and benthic algae within the water column and on the bed of the Dam/ Nerang River. Increased dissolved nitrogen and phosphorus levels in the water column from increased organic loads into the Hinze Dam can cause increased rates of eutrophication (algal activity) which may also lead to phytoplankton blooms. This results in excessive algal and reduced dissolved oxygen concentrations in the water column. Increased sediment can also alter downstream sediment loads which may influence deposition rates downstream.

Elevated sediments and nutrients have a major effect on the water purification process. Adverse water quality conditions affects infrastructure and the mechanisms involved to produce drinking water.

Potential Operational Impacts

The operational activities which have the potential to compromise water quality conditions include:

- runoff from roadways may result in increased sediment, heavy metal, petroleum hydrocarbons loads into the waterway. Motor vehicles will be the principle source of pollutants from road runoff, with pollutants derived from tyres, clutch and brake linings, hydraulic fluids, automotive fuels, and particulates from exhaust emissions;
- increasing the height of the dam wall will is designed to increase water levels in the dam by up to 12 m at FSL resulting in changes in stratification within the dam. Thermoclines and anoxic (void of oxygen) layers exist in the dam and the current depths at which these layers occur will change, which has the potential to influence water quality conditions in the Nerang River and potable water sourced from the upper intake;
- inundation of vegetation; and
- potential impacts on water quality from inundation of vegetation has the potential to impact on the 'high ecological value freshwaters', present in the south-western area of the dam.

7.2.8 Vegetation Inundation

This section of the water quality technical report considers the water quality issues associated with inundating the existing vegetation communities around the Hinze Dam.

A variety of issues have been previously highlighted from inundating vegetation in water reservoirs, from impacts to fishing industries, to effects on recreational activities. Key issues which have been identified from the literature include:

- impairment of the water quality supply due to increases in turbidity, increases in colour and development of taste and odour problems;
- increased risk of toxin formation from a shift in algal composition to nuisance algae and increased biomass; and
- impact on ecological health/ environmental values of the Dam and environmental flow waters due to asphyxiation of aquatic organisms through reduced dissolved oxygen (resulting from increased nutrient levels), a shift in algal composition, decomposition of organic matter by bacteria, mobilisation of iron and release of greenhouse and other noxious gases, and a reduction in N/P ratios.

Hinze Dam Stage 2

The Hinze Dam Stage 2 Construction Report described the vegetation clearing process, which was undertaken to remove all vegetation from the inundation area. During these works it was decided to clear and burn all (where possible) vegetation prior to inundation. The clearing works for the Hinze Dam Stage 2 reservoir included the clearing, stacking and burning of all trees, logs, stumps, brush and rubbish within the reservoir impoundment areas between the Stage 1 reservoir full supply level at EL 64.54 and the Stage 2 reservoir level at EL 82.2 (DamCorp 1985). Prior to the Stage 2 clearing, the Stage 1 reservoir had been cleared to several metres above EL 64.5. A considerable amount of regrowth of timber and brush had occurred in this area subsequent to the completion of Stage 1, which had to be cleared in the Stage 2 clearing operations (DamCorp 1985). In addition to this, some trees had fallen into the Stage 1 reservoir, subsequent to its filling and the removal of these trunks was undertaken in the Stage 2 clearing (DamCorp 1985).

Side slopes generally permitted clearing to be done by bulldozers, but in several small areas, slopes were too steep and rocky to be machine cleared and hand clearing associated with log skidders was necessary (DamCorp 1985). The total area to be cleared was about 600 ha (DamCorp 1985). A total of 300ha of this area comprising of the west bank (the Nerang River) from Hinze Dam to near the head of the Stage 1 reservoir on the Nerang River arm and the Little Nerang Creek valley upstream of the Upper Intake was cleared by Council and the remaining 310 ha was cleared by a subcontractor (DamCorp 1985).

Water Quality Considerations

A key impact of vegetation inundation is impacts on water quality due to the decomposition of the vegetation. Several key processes occur and impact upon water quality during this decomposition process.

Dissolved Oxygen

Inundated vegetation in reservoirs undergoes a process of anaerobic decomposition, consuming large amounts of oxygen. The inundation of vegetation produces considerable concentrations of organic matter, which is broken down by micro-organisms increasing the biological oxygen demand in water resulting in a reduction in dissolved oxygen saturation (Health Canada 2004).

Hydrogen Sulphide Emissions

Anaerobic decomposition of organic material can produce noxious gases such as hydrogen sulphide that can be toxic to aquatic life and harmful to machinery (World Bank 1989). If discharged by the dam, downstream fish could be killed (Pereira et al 1994).

Removal of Vegetation

As a result of the aforementioned issues associated with vegetation inundation in reservoirs, generally most new reservoirs will undergo at least partial removal of biomass prior to inundation (IUCN 1997; Bizer 2000).

The perceived benefits of clearing and/or burning include:

- decreased biomass to decompose resulting in maintaining dissolved oxygen levels;
- reductions in the biomass to be inundated resulting in reduced high nutrient levels and reduced length of the initial period in which the soluble iron and manganese levels will be high (MMBW 1975);
- reductions of nitrogen compounds (particularly when biomass is burnt);
- reductions in phytoplankton populations; and
- reduction in release of noxious gases.

Whilst it is generally accepted that vegetation needs to be removed prior to inundations, some of the results of such clearing can have negative implications upon water quality. Such implications include:

- an adverse impact turbidity (MMBW 1975); and
- the use of traditional clearing methods, i.e. bulldozing and burning can increase the thermally stable nutrients such as phosphorus, calcium, potassium and magnesium by liberating them back into the soil (MMBW 1975).

7.2.9 Existing Biomass Surrounding Hinze Dam

To enable an assessment of the impact of the proposed inundation of vegetation on water quality an estimate of the physical amount of above-ground vegetation biomass and labile carbon present was required. This estimate was based on the vegetation present between the FSL of 82.2m AHD and the proposed FSL of 94.5m AHD.

In the first instance, above-ground biomass estimates were assigned, considering the vegetation descriptions contained within **Section 9**, the existing literature used to estimate above-ground biomass (AGO 2003), and the climatic, geologic and soil conditions. These biomass estimates are contained in **Table 7-42**.

- **Table 7-42 Biomass Estimates in Tonnes per Hectare**

Vegetation	Description	Above-ground Biomass (t/ha)	Data Source	Year of Estimate
E. grandis tall open forest on alluvial plains	Tall wet sclerophyll forest (*E. grandis*) on moderate to high fertility soils	436.06	Turner and Lambert, Forest Ecology and Management, 1983	1978
E. tereticornis, *Callistemon viminalis* and *Casuarina cunninghamiana* fringing forest	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	Turner and Lambert, Oecologia, 1986	Unknown
E. siderophloia, *E. tereticornis* and *Corymbia intermedia* open forest on alluvial plains	Tall wet sclerophyll forest (*E. grandis*) on moderate to high fertility soils	436.06	Turner and Lambert, Forest Ecology and Management, 1983	1978
Simple notophyll vine forest often with abundant gully vine forest on metamorphics	Eucalypt and sub-tropical rainforest on grey leached sands.	500.75	Ash and Helman, Cunninghamia 1990	1981 and 1984
Open forest generally with *E. siderophloia*, *E. propinqua* on metamorphics	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	Turner and Lambert, Oecologia, 1986	Unknown
Open forest complex with *Corymbia citriodora*, *E. siderophloia* and *E. major* on metamorphics	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	Turner and Lambert, Oecologia, 1986	Unknown
Non-remnant vegetation	Observed in the field to be 40% of structure of tall Eucalypt forest of mixed species shown above	174.20 = (0.4 x 435.50)	Turner and Lambert, Oecologia, 1986 Field observations	Unknown 2007
Disturbed vegetation	Estimate based on 80% of area cleared with grassland present, with remaining 20% similar in structure to non-remnant vegetation	141.18 = (0.8 x 132.92) + (0.2 x 174.20)	Grassland – Cook and Andrew, Australian Journal of Ecology, 1991 Field observations	1980 2007

Source: Australian Greenhouse Office, 2003, *National Carbon Accounting System Technical Report No. 44: Spatial Estimates of Biomass in 'Mature' Native Vegetation*.

Non-remnant vegetation was estimated to be 40% of the total biomass of Tall Eucalypt forest (above-ground biomass estimate of 435.5 t/ha) surrounding Hinze Dam, based on visual assessments undertaken by the Hinze Dam Alliance field ecology team. The classification of disturbed vegetation was based on the presence of 80% exotic grassland and 20% other non-remnant vegetation.

The area to be inundated between the current FSL and proposed FSL was determined using GIS Mapping and the historic vegetation mapping undertaken around the dam (**Table 7-43**). Considering the area to be inundated and the above ground biomass estimates, the total above ground biomass to be inundated surrounding Hinze Dam was then estimated.

- **Table 7-43 Total Above Ground Biomass Surrounding Hinze Dam**

Vegetation	Description	Above-ground Biomass (t/ha)	Area between current FSL and proposed FSL (ha)	Total above-ground biomass (t)
E. grandis tall open forest on alluvial plains	Tall wet sclerophyll forest (*E. grandis*) on moderate to high fertility soils	436.06	7.52	3,280.28
E. tereticornis, *Callistemon viminalis* and *Casuarina cunninghamiana* fringing forest	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	22.59	9,847.38
E. siderophloia, *E. tereticornis* and *Corymbia intermedia* open forest on alluvial plains	Tall wet sclerophyll forest (*E. grandis*) on moderate to high fertility soils	436.06	13.15	5,727.37
Simple notophyll vine forest often with abundant gully vine forest on metamorphics	Eucalypt and sub-tropical rainforest on grey leached sands.	500.75	1.51	756.25
Open forest generally with *E. siderophloia*, *E. propinqua* on metamorphics	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	92.48	44,964.22
Open forest complex with *Corymbia citriodora*, *E. siderophloia* and *E. major* on metamorphics	Tall Eucalypt forest of mixed species (dominant species *E. seiberi*, *E. muellerana*, *E. oblique*, *E. consideriana*, *E. agglomerate*) on red-yellow podzolics.	435.50	170.36	74,191.78
Non-remnant vegetation	Observed in the field to be 40% of structure of tall Eucalypt forest of mixed species shown above	174.20	88.93	15,493.06
Disturbed vegetation	Estimate based on 80% of area cleared with grassland present, with remaining 20% similar in structure to non-remnant vegetation	141.18	43.59	6,153.86
Total			**450.92**	**160,414.20**

7.2.10 Analysis of Impact from Vegetation Inundation

The total biomass of vegetation to be inundated was used to assess the total biological oxygen demand (BOD) load likely in the dam following inundation (**Table 7-44**). The carbon content within sclerophyll forest and grassland vegetation and the BOD/ carbon ratios were determined based on historic data referenced in Somerville and Lawrence (1973) and Lawrence (unpublished). The derived vegetation masses were based on the assumption that 300 hectares will be cleared (leaving 150 hectares of Eucalypt forest to be inundated) and the cleared area to be replaced with grass vegetation, prior to inundation.

Table 7-44 Estimate of BOD Load from Vegetation Inundation

Decomposition component	Sclerophyll forest vegetation	Grass vegetation	Total
Vegetation mass	63,068,000 kg	39,464,000 kg	-
C content/ kg vegetation mass	0.34 (1)	0.45 (1)	-
Mass C	21,449,000 kg	17,758,800 kg	-
BOD_{20}/kg C	0.25 kg/kg C P(1)	1.47 kg/kg C (1)	-
BOD_{20} vegetation	5,362,250 kg	26,105,436 kg	31,476,686 kg
BOD_{80}/kg C	0.50 kg/kg C (1)	2.14 kg/kg C (1)	-
BOD_{80} vegetation	10,724,500 kg	38,003,832 kg	48,728,332 kg

(1) Features of Cardinia Reservoir Floor affecting water quality (Somerville and Lawrence. (1973) and Murray Darling Basin Vegetation Litter Analysis (Lawrence unpublished).

The re-aeration of the Hinze Dam was then considered in terms of off-setting the BOD loads, which will result in a net depletion of oxygen within the dam. **Table 7-45** illustrates the amount of dissolved oxygen that will enter the water column per day, under different dissolved oxygen concentration scenarios.

Table 7-45 Estimate of Daily Wind Re-aeration of Dam

Surface water DO	Re-aeration DO kg/d
80% of saturation (6.4 mg/L)	9,400
60% of saturation (4.8 mg/L)	18,900
40% of saturation (3.2 mg/L)	28,200
20% of saturation (1.6 mg/L)	37,600

Note: Re-aeration/day = $k_{re\text{-}aeration} \times A_{surface} \times (C_{sat} – C_{surface}) = 0.6 \times 14,700 \times (C_{sat} – C_{surface})$

The estimated dissolved oxygen budgets for the Hinze Dam were then estimated (**Table 7-46**), considering the BOD load in the Dam following inundation, the effective BOD after 50 to 300 inundation days, the re-aeration coefficient and the amount of DO entering the Dam from the upper catchment over a given inundation period.

Table 7-46 Hinze Reservoir Dissolved Oxygen Budget

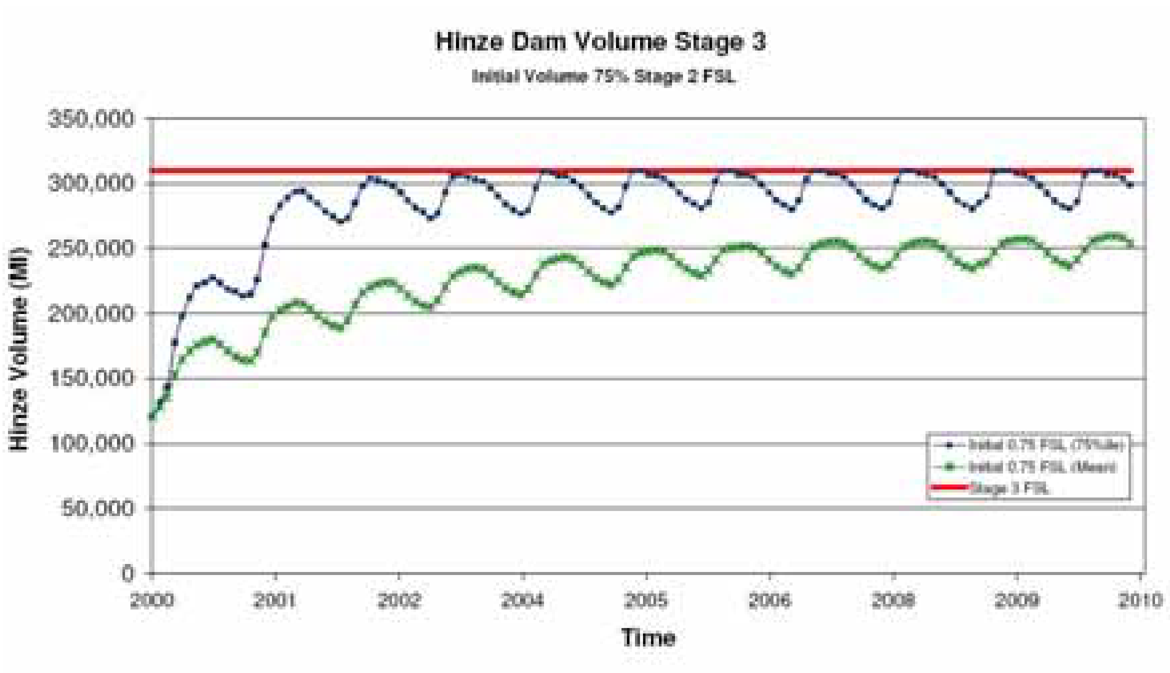
Total $BOD_{80\ days}$ kg	Inundation period days	Effective $BOD_{80\ days}$ kg	Re-aeration for inundation period kg	DO in inflow over inundation period kg	Reservoir DO at start g/m^3	Reservoir DO finish g/m^3
48728332	50	30455208	2646000	1029000	7	0.00
48728332	100	48728332	5292000	1029000	7	0.00
48728332	200	48728332	10584000	1029000	7	0.00
11250000*	200	11250000	10584000	1029000	7	4.85
16550000*	300	16550000	15876000	1029000	7	4.83

Notes: * BOD_{80} threshold levels, which yield >60% saturation (4.8 mg/L)
Effective BOD = Tot BOD80 x Days inundation/80
Re-aeration = kre-aerat x Asurf x (Csat - Csurf)/1000 kg, where kre-aerat is 0.6 m/d, Asurf = 14700 x 106 m2
DOinflow = (Venlarged - Vcurrent) x Cinflow/1000 kg = (310,000 - 163,000) x 7 = 1,029,000 kg
DOfinish = (Vstart x Cstart + ΔMre-aerat + ΔMinflow - ΔMBOD)/Venlarged g/m3

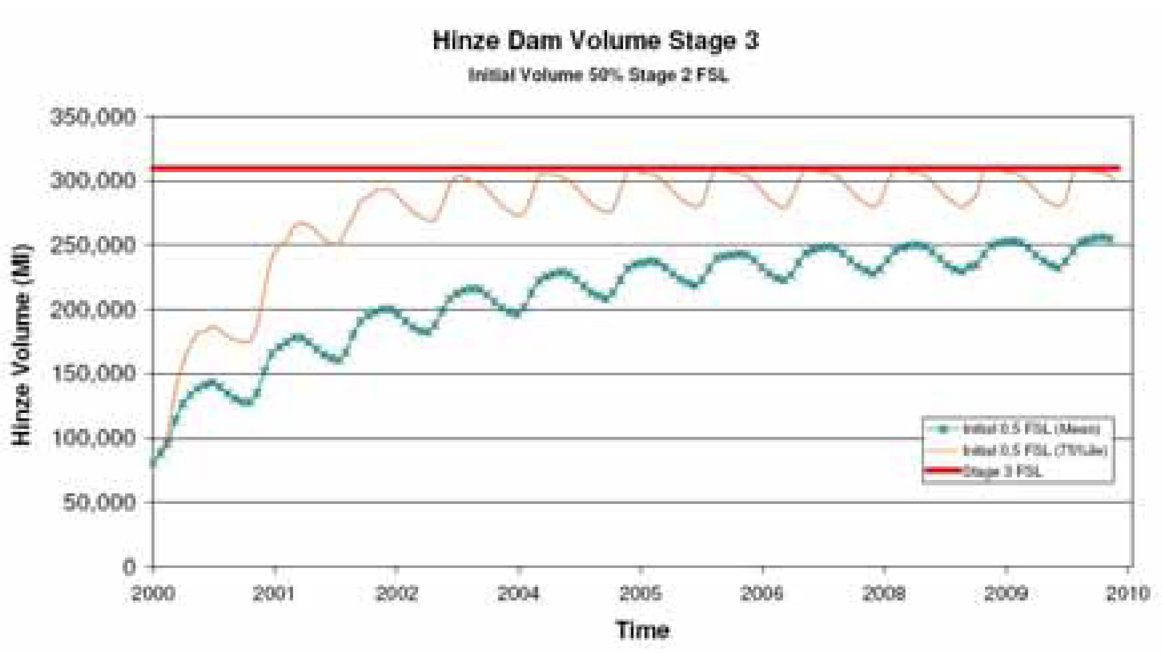
If approximately 80% of the total grass biomass was slashed prior to filling, it would still be insufficient to maintain dam DO at the 60% saturation value (i.e. 4.8 mg/L). It will be necessary to undertake some additional slashing of the sclerophyll forest area ahead of the filling of the dam, yielding a further 70% reduction in sclerophyll forest biomass for the 200 days filling period (resultant DO = 4.85 mg/L), and a further 20% reduction for the 300 day filling period (resultant DO = 4.83 mg/L). It will also be necessary to undertake slashing of the grass vegetation (80% reduction) to maintain DO at >60%.

The 300 day filling period appears to more accurately reflect the time it will take for the Hinze Dam to fill, when compared to the modelling work undertaken which predicts rates of filling under different scenarios (see **Figure 7-25** Predicted Rate of Filling – 75% at Commencement and **Figure 7-26** Predicted Rate of Filling – 50% Full at Commencement). The modeling was based on 10 years of stochastic data, generated by the SCL from the historic sequence. It includes rainfall, evaporation and inflows data.

- **Figure 7-25 Predicted Rate of Filling – 75% at Commencement**



- **Figure 7-26 Predicted Rate of Filling – 50% Full at Commencement**



7.2.11 Impacts from Increased Water Level

There is expected to be some change in water quality from the proposed increase in full supply level, post-construction. A water quality model has been developed to assess the impacts of the Project on the dam water quality. The Project involves raising the existing Hinze dam wall crest height which will increase the dams inundated area by approximately 533 hectares.

This study used the Australian Receiving Water Quality Models (ARWQM) to represent Hinze Dam. Inputs to the model included water quality monitoring data from GCW and climatic data from the DNRW. The performance of the model was assessed against the trigger values identified in the Environmental Protection (Water) Policy 1997 – Nerang River Environmental Values and Water Quality Objectives.

Method

The model used for this study is the ARWQM developed by Lawrence (2007). By drawing on 5 to 10 years of daily rainfall or hydrographic data, a probability plot of in-stream water quality indicator levels was prepared. These probability plots were then compared to the appropriate ecosystem category, the climate or region, and management objective levels. For this study two ARWQM models were setup; the first model representing the existing conditions of Hinze Dam and the second model representing Hinze Dam upon completion of the Project works. Both models used the same data series, water quality parameters and initial water quality values.

Data

Daily time series data were sourced for inflow, rainfall and evaporation at Hinze Dam. Water quality data was required at Hinze Dam, as well as for streamflow in the upper catchment. Inflow and rainfall data at Hinze Dam were sourced from records provided by Gold Coast Water (GCW). The original data set covered the period July 1998 to March 2007, however for modelling purposes this was cut down to the period 01/01/1999 to 31/12/2006.

Daily evaporation at Hinze Dam was sourced from the Gold Coast IQQM WRP model. As this model does not cover the entire period required, a synthetic record was generated using average daily values calculated over the IQQM simulation period of 110 years.

The water quality parameters for Hinze Dam were sourced from weekly sampling data taken at the Upper and Lower Intakes. The data was supplied by GCW and covers the period February 1999 to December 2004. Pollutant load equations were generated based on the relationship between streamflow volume and quality at Site 7 - Pine Creek Bridge, Numinbah catchment. In cases where water quality information was not available default values from the ARWQM manual (Lawrence 2007) were used. Sediment quality data for Hinze Dam required for the model, was sourced from a one-off sediment sampling event in February 2007 undertaken by the Alliance (**Appendix F.7.2**).

Trigger Values

The performance of the dam was assessed against the trigger values identified in the Environmental Protection (Water) Policy 1997 – Nerang River Environmental Values and Water Quality Objectives. The specific values for freshwater lakes and reservoirs within the Nerang River catchment are summarised in **Table 7-47**.

- **Table 7-47 Water Quality Objectives - Freshwater lakes/reservoirs**

Water Quality Parameter	Objective
Turbidity range	5 NTU
Suspended solids	n/d
Chlorophyll	<5 µg/L
Total nitrogen	<300 µg/L
Oxidised N	<10 µg/L
Ammonia N	<10 µg/L
Organic N	<270 µg/L
Total Phosphorous	<10 µg/L
Filterable reactive phosphorous (FRP)	<5 µg/L

Water Quality Parameter	Objective
Dissolved oxygen	(20th – 80th percentile) % saturation 90% - 110%
pH	6.5 – 8.0

Sensitivity Testing

In several cases water quality information was not available for Hinze Dam or the surrounding catchment and default values were used from the ARWQM manual (Lawrence 2007). Due to the number of assumptions made sensitivity analysis was undertaken in order to assess the importance of the default values. This involved establishing an expected range of values for the particular parameters and then testing how movement within this range affected the overall model results.

Results

The overall model results show very little difference in long term water quality within the dam between the current FSL and the Stage 3 FSL. The model passes five of the eight trigger values for both Stage 2 and Stage 3. A summary of the modelled results is presented in **Table 7-48**.

- **Table 7-48 Hinze Dam Water Quality Model Results**

Objective	Trigger Value	Hinze Dam – Stage 2		Hinze Dam – Stage 3	
		Value	Pass/Fail	Value	Pass/Fail
Total Phosphorous (mg/L)	0.010	0.079	Fail	0.087	Fail
Total Nitrogen (mg/L)	0.300	0.146	Pass	0.142	Pass
Chlorophyll *a* (mg/L)	0.005	0.003	Pass	0.003	Pass
Dissolved oxygen (Sr%)	80.00	67.28	Fail	67.22	Fail
low pH	6.50	7.72	Pass	7.70	Pass
high pH	8.00	7.72	Pass	7.70	Pass
Sediment depth (mm)	2	3.36	Fail	3.36	Fail
Total Ammonia (mg/L)	0.9	0.003	Pass	0.003	Pass

The sensitivity analysis undertaken showed that the overall model results were more dependent on the inflow and outflow of water within the dam than on the initial water quality parameters. It was concluded that the default values supplied by the ARWQM manual were suitable for this study.

Discussion and Conclusions

The ARWQM water quality model developed for this study provides a broad overview of the impacts on water quality within Hinze Dam due to inflows and climatic inputs. Two scenarios were assessed; existing conditions (Stage 2) and the Hinze Dam Stage 3 upgrade. Overall the model displayed very little difference in long term water quality within the dam between the Stage 2 FSL and the Stage 3 FSL.

The model has not been used to assess the impact of catchment management practises such as land clearing or the effects from vegetation inundation.

Many assumptions have been made in developing this model due to a lack of available data and time constraints. In cases where water quality information was not available default values were supplied from the ARWQM manual. If further modelling is undertaken using these scenarios the initial assumptions may be checked and updated.

7.2.12 Dam Ecosystem Classification

Ecosystem classification is required in the first instance to identify the broad ecosystem category, its properties and key functional components, as the basis for any future assessment. There is currently no ecosystem classification which can be applied directly for Hinze Dam, however, the lakes classification is suitable in the first instance for assessment the key attributes of Hinze Dam. This includes shallow well mixed areas, as well as deep stratified areas, containing distinct thermoclines (**Figure 7-27**).

Major Management Issues

The major management issues which will potentially impact on water quality conditions in Hinze Dam are shown in

Figure 7-28 and include:

- inundation of dispersive clays by stored water, low in ions and low Ca2+/Na+ ratio, wave erosion, rising water level destabilisation of slopes, leaching of tannins, increased BOD load reduction of Fe3+ and release of Fe2+;
- increased suspended sediments from construction activities, resulting in elevated turbidity/ suspended solids and reduction of light; and
- introduction of organic material causing increased BOD loading, reduction in DO, release of sediment P, release of Fe2+, H2S, CO, CH4.

Major Modifiers

The major ecosystem processes which influence the degree of impact on the dam include:

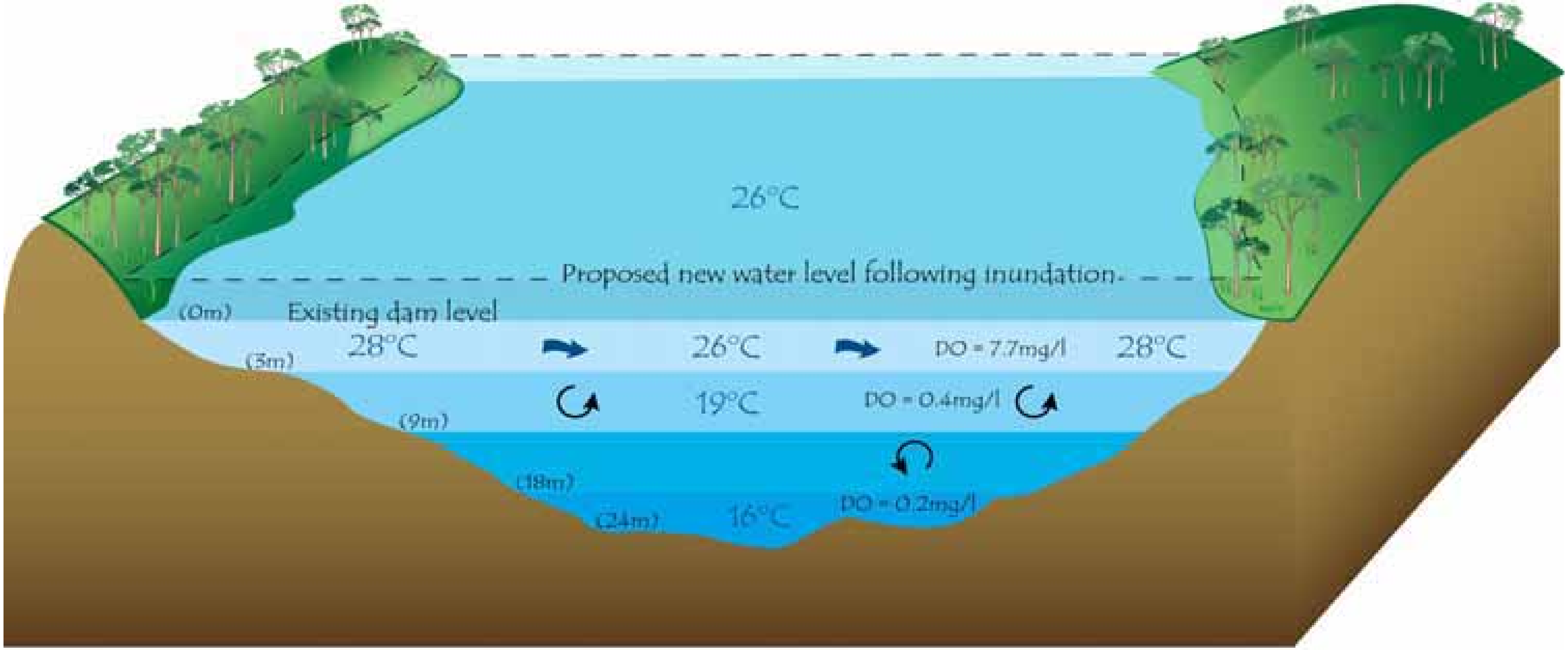
- impairment of aesthetic quality of water supply:
  - vegetation armouring of soil, coarse particle composition (development of sand beaches), composition of C horizon (collapse of shoreline);
  - composition of vegetation, levels of iron in soil, labile C composition of vegetative material, vegetation biomass; and
  - wind and fetch – wave energy, windward slopes, temperature, slope (area of inundation/metre rise).
- increased risk of toxin formation:
  - temperature, slope (area of inundation/metre rise), rate and timing (temperature) of water level rise;
  - vegetation/ soil associations, biomass and labile versus refractory carbon composition;
  - distribution and area, levels of iron and P in soil, labile C composition of vegetative material, vegetation biomass, depth, turbidity; and
- Impact on ecological health/ environmental values:
  - demperature, solar radiation, depth, wind mixing, rate and timing (temperature) of water level rise;
  - vegetation/soil associations, biomass and labile versus refractory carbon composition, distribution and area; and
  - presence/absence of refuges for biota (healthy DO zones), off-take level of environmental flow releases.

Key Water Quality Indicators

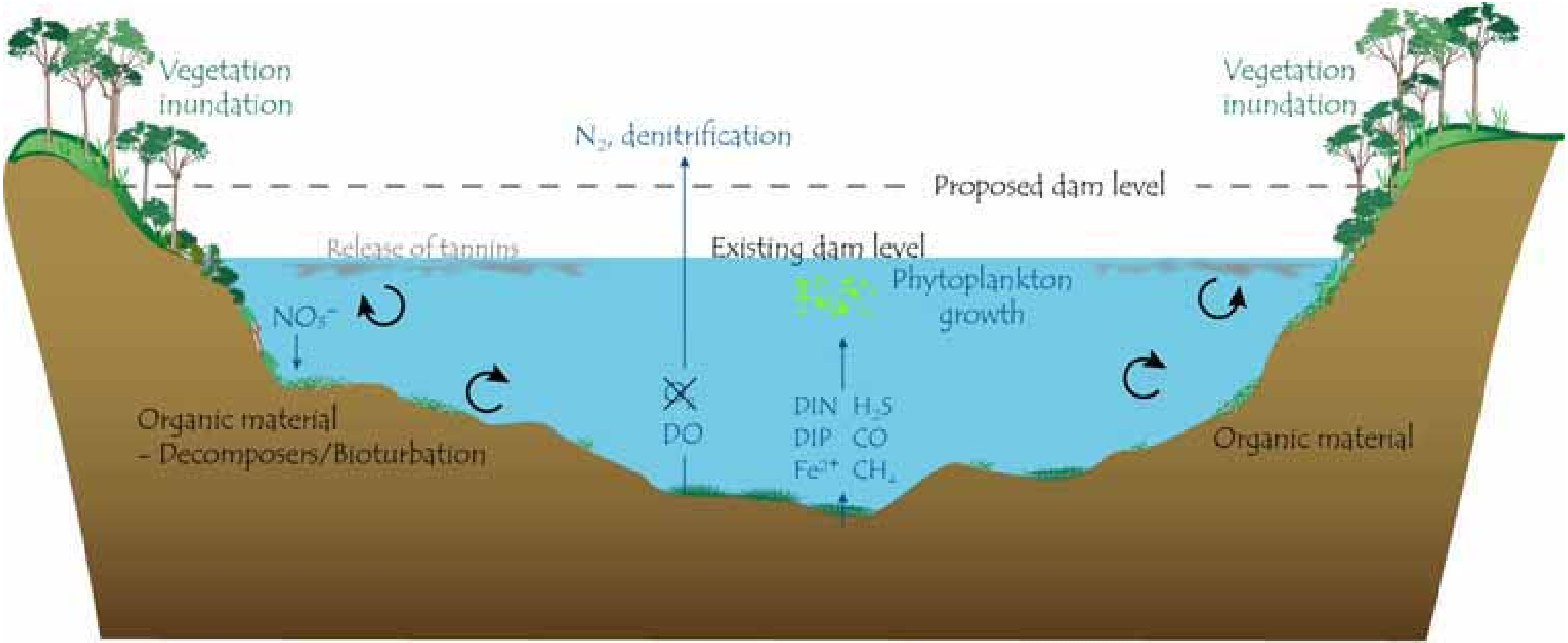
The key water quality indicators, considering the risks identified include:

- turbidity, SS, colour, organic carbon;
- nuisance algae, chlorophyll ‘a’; and
- DO, Secchi Disc depth, algal composition, P, N , Fe and Mn.

Figure 7-27 Conceptual Modelling of Stratification in Hinze Dam



■ **Figure 7-28 State and Function of Hinze Dam FSL**



7.2.13 Mitigation Measures

Construction

Considering the potential soil erosion and sedimentation issues raised from the construction process, the following management mitigation measures will be implemented during the construction stage of the Project:

- clean stormwater will be diverted around the construction sites;
- stormwater collected within the construction site, where applicable, will be diverted into holding/ settlement ponds for treatment and reuse;
- exposed soils will be stabilized by using materials such as mulch, biodegradable matting, and geotextile fabrics;
- revegetation of areas impacted by construction activities;
- the rate of stormwater flow within the construction area will be reduced by using energy dissipation techniques;
- The use of wash down bays to minimise sediment taken offsite by construction vehicles;
- bunding and appropriate storage of fuels and other hazardous/ flammable materials; and
- oil containment booms and oil spill recovery equipment will be available when working on water.

Some sediment laden water may need to be discharged into Hinze Dam and procedures therefore will be implemented to treat sediment laden water including:

- filtering runoff from the site, using hay bales, geotextile fabrics, and silt curtains;
- use of sedimentation basins prior to discharge. Chemical flocculants can also be used to hasten settlement, especially when fine sediments are present. However, the use of flocculants (i.e. aluminium sulphate) will need to be managed from a human health and ecological risk standpoint. The detailed construction EMP to be prepared for the site will contain the appropriate material safety datasheets, if such chemicals are to be used on site;
- targeted water quality within wastewaters discharged from the settlement ponds (due to flooding and excess water discharge) will be monitored for a range of physico-chemical parameters within the dam and in the Nerang River. Bacterial analyses should also be performed downstream of any on site temporary sewage treatment plants, as well as within the dam. This program would complement the water quality monitoring currently being undertaken in the Hinze Dam by GCW and downstream in the Nerang River, by GCCC and the EPA;
- undertaking a routine water quality monitoring program (daily monitoring of physico-chemical parameters and weekly for others) throughout the Dam, which includes the following parameters:
  - turbidity, SS, colour, organic carbon;
  - nuisance algae, chlorophyll ‘a’; and
  - DO, Secchi Disc depth, algal composition, P, N and Fe and Mn.
- Installation of fixed site loggers at the lower intake and downstream of the dam wall, to prevent any impacts to water discharged into the Nerang River and at the upper intake, to ensure that water sourced by the Molendinar WTP is of a satisfactory quality; and
- dredging of sediment basins may be required to maintain capacity. Sediment removed from sediment basins should generally be dewatered on site and used as construction fill material. This dredge material would need to be assessed for contamination prior to disposal.

Operation

The controls to mitigate any environmental impacts from operational activities are detailed in the Operational EMP contained within **Section 19**. The types of management mitigation measures that will be implemented include:

- on-going revegetation/ maintenance of areas impacted by construction activities;
- implementation of appropriate sediment management controls in areas with exposed soils;
- the use of wash bays to minimise sediment taken offsite by maintenance vehicles;
- bunding and appropriate storage of fuels and other hazardous/ flammable materials. Spill containment kits should be available on site;
- undertaking a routine water quality monitoring program throughout the Dam, which includes the following parameters:
  - turbidity, SS, colour, organic carbon;
  - nuisance algae, chlorophyll ‘a’; and
  - DO, Secchi Disc depth, algal composition, P, N and Fe and Mn.
- the water quality monitoring program should also be targeted towards maintaining the water drawn from the upper intake, to ensure that water sourced by the Molendinar WTP is of a satisfactory quality.

Vegetation Inundation

During the construction and inundation period the following management practices will be implemented to mitigate impacts to water quality conditions:

- clearing of 300 ha of vegetation present within the inundation zone;
- undertake some additional slashing of the sclerophyll forest area ahead of the filling, in addition to the initial clearing activities. This will ensure a further 70% reduction in sclerophyll forest biomass (for the 200 days filling period), or alternatively a further 20% reduction (for the 300 day filling period);
- undertake slashing/ burning of the grass vegetation (approximately 80% clearance), which has grown in areas previously containing sclerophyll forest, to maintain DO at >60%;
- remaining vegetation will be cleared or burnt (if applicable) before the last rainy season prior to raising of the completion of construction works to enable rains wash away much of the organic material/ ashes, which would otherwise be trapped in the reservoir and cause increased rates of eutrophication (IUCN 1997);
- some opportunistic water quality sampling will be undertaken in areas containing vegetation which has/ will be inundated, to gain an understanding about the extent of oxygen depletion in these areas. Levels of iron and manganese in the water, as well as hydrogen sulphide should also be monitored in areas where vegetation has been inundated;
- the areas to be inundated within GC1 (High Ecosystem Value, EPA 2006b) (within the Numinbah Valley) will be managed to ensure that water quality conditions are maintained in accordance with the Nerang River Environmental Values and Water Quality Objectives (EPA 2006b). This will include routine monitoring of water quality in the upland streams in areas where vegetation is to be inundated. Some vegetation clearance may also be required to maintain water quality in these areas; and
- fixed site instrumentation will be maintained for the first few years of plant operation to ensure that water quality in the dam is not impacted during filling, which should take approximately two years, based on the modelling undertaken.

7.3 Climate Change Adaptation

Changes in local weather patterns resulting from climate change have the potential to affect the operation of the dam into the future. A climate change risk assessment has been undertaken for the design and operation of the Project.

CSIRO (2006) report that southeast Queensland is likely to become warmer, with more hot days and fewer cold nights. A decline in annual rainfall with higher evaporative demand would lead to a tendency for less runoff into rivers. Droughts are likely to become more frequent and more severe, with greater fire risk. Increases in extreme weather events are likely to lead to increased flash flooding, strains on sewerage and drainage systems, greater insurance losses, possible black-outs, and challenges for emergency services.

The climate change risk assessment is based on climate change scenarios for southeast Queensland in 2030. Two scenarios have been developed by CSIRO (2006) for purposes of risk assessment based on existing climate modelling studies

- a low global warming scenario (0.54 °C by 2030); and
- a high global warming scenario (1.24 °C by 2030).

The two climate change scenarios, with percentage change and uncertainty are presented in **Table 7-49**. The changes in average solar radiation, humidity, and extreme daily wind speed were found to be small and have not been considered.

Table 7-49 Change in Climate for SEQ by 2030, relative to 1990

	Low Global Warming Scenario		High Global Warming Scenario	
Feature	Estimate of Change	Uncertainty	Estimate of Change	Uncertainty
Annual average temperature	+0.6˚C	±0.2˚C	+1.3˚C	±0.6˚C
Average sea level	+3cm	±5%	+17cm	±11%
Annual average rainfall	-1.50%	±6.5%	-3.50%	±15%
Seasonal average rainfall				
▪ Summer	0%	±6.5%	0%	±15%
▪ Autumn	-3%	±6.5%	-7.50%	±15%
▪ Winter	-3%	±6.5%	-7.50%	±15%
▪ Spring	-3%	±1.9%	-7.50%	±4.4%
Annual average potential evaporation	+2.40%		+5.60%	
Annual average number of hot days (>35 °C)	0		+5 days	
Annual average number of cold nights (<0 °C)	0		-5 days	
Extreme daily rainfall intensity (1 in 20 year event)[1]	0%		+30%	
CO_2 concentration	+73 ppm		+102 ppm	

1 – These results are for 2040 as changes for 2030 were not available

Source: Australian Greenhouse Office, 2006

The potential risk to the Project for each of the features has been assessed and mitigation measures have been proposed, where appropriate, in **Table 7-50**.

The greatest potential impacts from climate change are:

- a potential increase in water demand as a result of higher temperatures;
- a reduction in yield as a result of decreased annual rainfall and increased evaporation; and
- a reduction in flood mitigation benefits due to an increase in rainfall intensity.

The Project generally has a limited vulnerability to the impact of climate change and the vulnerabilities that do exist also apply to the existing dam. The potential risks of increased water demand and reduced yield from the dam can be limited through water demand management and the integration of the Project with other water supply infrastructure in south east Queensland.

Predicted increases in tropical cyclone intensity in Queensland have the potential to increase extreme daily rainfall which will decrease the flood mitigation impact of the Project. However in comparison with the existing dam, the Project will reduce the climate change risks from flooding resulting from an increase in rainfall intensity.

▪ Table 7-50 Potential Impacts of Climate Change and Mitigation Measures

Feature	Potential Impact on Project	Mitigation Measures
Increase in annual average temperature	Potential increase in water demand in southeast Queensland for both scenarios	Demand management through relevant water authorities
	Average temperature increase is unlikely to affect reliability of infrastructure or equipment (eg pumps)	N/A
Increase in average sea level	Predicted sea level rise for the high global warming scenario is 17 cm. Potential to have a small reduction in flood mitigation benefits of Project at coastal locations.	Existing hydraulic modelling for the Gold Coast makes an allowance for potential sea level rise and storm surge.
Decrease in annual average rainfall	Potential to reduce the yield from the dam due to predicted decrease in annual average rainfall in southeast Queensland. However, the predicted uncertainty is greater than the predicted decrease.	Integrated water infrastructure in southeast Queensland Water demand management (through relevant water authorities)
Change in seasonal average rainfall	Decrease in rains during autumn, winter and spring is not expected to affect the Project significantly. The larger storage capacity provides mitigation against any impacts.	N/A
Increase in annual average potential evaporation	Potential to reduce the yield from the dam due to predicted increase in average evaporation southeast Queensland. Potential to reduce runoff to the dam due to increased catchment losses leading to a reduced yield from the dam.	Integrated water infrastructure in southeast Queensland Water demand management (through relevant water authorities)
Increase in annual number of hot days	Unlikely to affect reliability of infrastructure or equipment (eg pumps)	N/A
Annual average number of cold nights (<0 °C)	No Impact	N/A
Increase in extreme daily rainfall intensity	Potential to have a reduction in flood mitigation benefits of the Project	Hinze Dam Stage 3 will provide flood mitigation benefits for the Gold Coast community. Although an increase in rainfall intensity may reduce these benefits, the upgrade of the dam will not worsen flooding in this eventuality.
Increase in CO_2 concentration	Small increase in acidity to greater diffusion of CO_2. The expected increase in acidity of water is not expected to affect water quality significantly	Water quality sampling at water treatment plants will be able to determine any long term changes in water quality in the dam.