Northern Link

TECHNICAL REPORT NO. 5

SURFACE WATER

- May 2008

Contents

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1. Surface Water Resources – Existing Environment

This chapter discusses the existing surface water environment within and adjacent to the Northern Link study corridor. The watercourses potentially affected by the proposed Project and the importance of these watercourses are described in the context of their catchment characteristics. The quality of water in these waterways is assessed from past or continuing monitoring programs. Environmental values of the waterways are discussed and water quality objectives are defined in line with existing local, State and national guidelines.

1.1 Legislation and Regulatory Framework

1.1.1 Environmental Protection (Water) Policy 1997

In Queensland, the *Environmental Protection (Water) Policy 1997* (EPP(Water)) is the governing legislation in relation to water. The EPP(Water) is subordinate to the *Environmental Protection Act 1994* (EP Act). The objective of the EPP(Water) is to achieve the object of the EP Act in relation to Queensland's waters. The object of the EP Act is to:

> *"Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development (ESD))".*

This is achieved through the EPP (Water) by providing a framework for:

- Identifying environmental values for Queensland waters;
- Deciding and stating water quality guidelines and objectives to enhance or protect the environmental values;
- Making consistent and equitable decisions about Queensland waters that promote efficient use of resources and best practice environmental management; and
- Involving the community through consultation and education, and promoting community responsibility.

This policy and legislative framework set the broad goals for design criteria.

1.1.2 Water Act 2000

The *Water Act 2000* provides for the sustainable management and efficient use of water and other resources by establishing a system for the planning, allocation and use of water. This Act sets out a regulatory framework for Queensland's water industry and advocates the principles of Ecologically Sustainable Development.

One of the primary objectives of the Act in terms of sustainable management of water resources is to contribute to the maintenance or improvement of naturally occurring water resources, including the protection of watercourses, lakes, springs and aquifers from degradation and, where possible, improving the physical integrity of these resources.

1.2 Environmental Values and Water Quality Objectives

Environmental values (EVs) are the qualities of a waterway that the community considers important to protect. These reflect the ecological, social and economic values and uses of the waterway and are often used to help define appropriate guidelines and water quality objectives (WQOs) for water management strategies.

The National Water Quality Management Strategy (NWQMS) and EPP(Water) promote the sustainable management of water resources by determining EVs (or uses) of waterways and corresponding WQOs (also known as targets) for different indicators of water quality (ie pH, nutrients and toxicants). The Queensland Environmental Protection Agency (EPA) has released specific EVs and WQOs for waters in Moreton Bay and South East Queensland (EPA, 2006a and 2006b).

1.2.1 Key Guidelines and Policies

In determining appropriate water quality objectives (WQOs) and environmental values (EVs) relevant to the proposed Northern Link Project the following documents have been reviewed:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) – These provide guideline values or descriptive statements for a range of indicators used to ensure protection of aquatic ecosystems and human uses of waters (eg primary recreation, human drinking water, agriculture, stock watering). These guidelines:
  - Protect and manage environmental values supported by water resources;
  - Outline the management framework recommended for applying the water quality guidelines to the natural and semi-natural marine and freshwater resources in Australia and New Zealand; and
  - Provide advice on designing and implementing water quality monitoring and assessment programmes.

  The ANZECC (2000) guidelines are based on assessment of broad scale data sets and it is therefore recommended that, where available, locally relevant guidelines are adopted.

- South East Queensland Healthy Waterways Strategy 2007-2012 – The SEQHWS serves as the Moreton Bay Water Quality Improvement Plan (WQIP) within the framework of the Australian Government's Natural Heritage Trust Coastal Catchment Initiative. The strategy:
  - Provides a policy and planning framework for the adoption and implementation of Water Sensitive Urban Design throughout SEQ;
  - Comprises actions to manage and limit the occurrence of coastal blooms of the toxic cyanobacteria, *Lyngbya majuscula;*
  - Aims to enhance protection and conservation measures in the region; and
  - Includes 12 separate Action Plans which are "issue-based, "enabling", and "area based".

- Queensland Water Quality Guidelines 2006 (QWQG) (EPA, 2006a) – These have been developed by the Queensland EPA using data derived from local reference sites, and are intended to address the need identified in the ANZECC (2000) guidelines to adopt locally relevant guidelines. These guidelines:
  - Provide values that are tailored to specific Queensland regions and water types
  - Provide a process/framework for deriving and applying local guidelines for waters in Queensland (ie more specific guidelines than those in ANZECC (2000).
- Environmental Protection (Water) Policy 1997 (EPP (Water)), (EPA, 2007). The aim of this policy is to achieve the objectives identified by the *Environmental Protection Act 1994* (EP Act), which endeavours to protect Queensland's waters while allowing for ecologically sustainable development. This is achieved through:
  - The identification of environmental values (EVs) for Queensland waters (aquatic ecosystems, water for drinking, water supply, water for agriculture, industry and recreational use)
  - Determining or stating water quality guidelines and water quality objectives (WQOs) which will enhance or protect the environmental values of the water body under investigation.
- Brisbane City Council Water Quality Objectives 2000 (WQO), (BCC, 2000). These water quality management guidelines have been developed by Brisbane City Council to provide an understanding of the key issues and appropriate measures to provide for the effective management of water quality impacts associated with development activities. The guidelines identify the key issues which need to be addressed during the planning, design, construction and operation phases of a development.

  The BCC publication, '*Guideline on Identifying and Applying Water Quality Objectives in Brisbane City*', assists in protecting the environmental values in and around affected receiving waters.

- Water Resource (Moreton) Plan 2007 - As a requirement of the Water Act 2000 the Water Resource (Moreton) Plan 2007 has been developed for the sustainable management of water resources to meet Queensland's water requirements. The WRP provides a framework for the management of available water resources through a strategic reserve, while protecting the existing water entitlements. The social and cultural values of communities within the plan area are considered within the WRP, as are the environmental needs of the area and the desire to achieve ecological outcomes consistent with maintaining a healthy riverine environment (NRW, 2007).

1.2.2 Identified EVs and WQOs

The proposed Project Area is located within Basin No. 143 (part), which includes all creeks of the Brisbane River estuary other than Oxley Creek (EPP (Water), 1997). Watercourses in the vicinity of the Project Area are defined by the EPP (Water) as being lowland freshwaters (in terms of the creeks and tributaries of the Brisbane River) and mid-estuary (in terms of the Brisbane River in this area). The EPP(Water) classifies this area as Level 2, which refers to an aquatic ecosystem which is slightly or moderately disturbed (EPA, 2007). The Environmental Values for the watercourses and receiving environments of the project area have been determined from the EPP (Water).These EVs are summarised in Table 1-1.

- **Table 1-1 Environmental Values for the watercourses and receiving environment of the project area**

Water Use	Brisbane River Estuary – estuarine and enclosed coastal	Brisbane River – tidal creeks and drains - estuarine (incl. Enoggera Creek and Toowong Creek)	Brisbane River – freshwater creeks and drains	Toowong Creek - freshwater	Other wetlands or lakes (ie Victoria Park wetland)
Aquatic Ecosystem	ρ	ρ	ρ	ρ	ρ
Human consumer	ρ				
Primary recreation (eg swimming)	ρ				
Secondary recreation (eg boating)	ρ	ρ	ρ		
Visual recreation	ρ	ρ	ρ	ρ	ρ
Drinking water					
Industrial use	ρ				
Cultural and spiritual values	ρ	ρ	ρ	ρ	ρ

Source: EPP(Water) (EPA 2007)
Table Note:
ρ Identifies the Environmental Values of the watercourse

Table 1-2 illustrates the Water Quality Objectives identified by the Brisbane City Council (BCC), EPP(Water) 1997 and ANZECC (2000) applicable to the water types in the vicinity of the Northern Link project corridor.

Table 1-2 Water Quality Objectives relevant to the Northern Link Project area

Water Quality Indicator		BCC		EPP (Water)		ANZECC (2000)	
		Fresh water	Estuarine	Fresh water	Mid/upper Estuarine	Lowland River	Estuarine
Chlorophyll-a (µg/L)		8	10	8	10	5	4
TP (µg/L)		70	70	70	60	50	30
FRP (µg/L)		35	25	N/A	N/A	20	5
Organic N (µg/L)		500	380	N/A	N/A	N/A	N/A
Suspended Solids (mg/L)		15	30	15	30	N/A	N/A
TN (µg/L)		650	450	650	450	500	300
NO_x (µg/L)		130	25	N/A	N/A	40	15
NH_4(µg/L)		35	40	N/A	N/A	20	15
Turbidity (NTU)		20	20	20	20	6-50	0.5-1.0
DO % sat	Lower	80	80	80	80	85	80
	Upper	105	100	105	100	110	110
pH	Lower	6.5	6.5	6.5	6.5	6.5	7.0
	Upper	8.5	8.5	8.5	8.5	8.0	8.5

Table Notes:
N/A – Not Available
TN – Total Nitrogen
NO_x – Oxides of Nitrogen
DO – Dissolved Oxygen
µg/L – micrograms per litre
FRP – Filterable Reactive Phosphorus
TP – Total Phosphorus
NH_4 - Ammonium
DO % sat - Dissolved Oxygen percentage saturation

Water quality objectives can be developed at different spatial scales (eg national, state, local). The *Environmental Protection (Water) Policy 1997* outlines the process for determining which water quality guidelines (ie national, State, local) to use in water quality planning and decision-making. In summary, where there are more than one set of applicable guidelines, a local, accredited guideline shall take precedence over broader guidelines (EPA, 2005).

1.3 Existing environment

This section identifies and assesses the existing surface water resources in the study corridor and adjacent areas. Water quality of the aquatic systems traversed by the study corridor and the receiving environment downstream of the proposed Project, which may potentially be affected by construction and operational activities have been considered. This includes:

a) An assessment of the existing water quality of waterways and wetlands.

b) An assessment of the environmental values of the waterways and wetlands.

Under the Water Act 2000, a watercourse refers to:

a) *A river, creek or stream in which water flows permanently or intermittently in a natural channel, whether artificially improved or not.*

b) *Or in an artificial channel that has changed the course of the watercourse. It also includes the bed and banks and any other element of a river, creek or stream confining or containing water. The watercourses within the project area all fall under this definition and will be assessed as such.*

1.3.1 Brisbane River Catchment description

The Brisbane River catchment covers 13,500 km^2, extending from the Great Dividing Range to Moreton Bay. This area includes 850 km of river and lakes and 50 major creeks of which the Brisbane River is the largest. The variable land use in the catchment includes significant areas of urban, grazing, cropping and forested lands, with approximately 14% of the catchment uncleared. The Brisbane River consists of upper, mid and lower Brisbane catchments, which have been classified to improve strategic management and ecosystem health assessment. The lower Brisbane catchment is a highly modified environment and approximately 52% of the catchment has been urbanised. Relatively natural bushland habitat comprises 29.7% of the catchment and 4.3% is managed forest. In the upper areas of the catchment some grazing and agricultural activities occur (Healthy Waterways, 2007).

The Brisbane River catchment drains into the Brisbane River estuary which flows into Moreton Bay (1,523km^2 in area), an area of national and international significance. Moreton Bay was designated a marine park area in 1993 and includes one of Queensland's internationally recognised RAMSAR wetland sites, which is also listed in the Australian Directory of Important Wetlands.

The Brisbane River estuary is a tide-dominated delta, with a well-mixed circulation, a naturally high turbidity and a low sediment trapping efficiency. The natural tidal limit of the Brisbane River was historically only 16 km, but channel dredging has increased the upstream tidal limit, which now extends 85 km upstream. Flushing times for the Brisbane River range from 110 days at the mouth of the River to 189 days at the Bremer river confluence (73km upstream) (Healthy Waterways, 2007).

During 2006-2007 there was a significant reduction in rainfall across SEQ when the region was subject to severe drought conditions. The lack of rainfall resulted in low or no-flow in many streams across the catchment. This reduction in freshwater runoff has also resulted in the estuarine reaches of the rivers recording higher salinity levels as tidal ranges penetrate further up into the estuaries (EHMP, 2006-2007).

The study corridor is located within the lower Brisbane catchment, which covers approximately 980km^2, from the river mouth in Moreton Bay to Mount Crosby Weir, located approximately 90km upstream. There are several tributaries in the lower Brisbane catchment including Toowong Creek, Sandy Creek and Breakfast/Enoggera Creek. The Breakfast/Enoggera Creek catchment covers an area of approximately 90km^2. The headwaters of Enoggera Creek are within Brisbane Forest Park eventually discharging into the Brisbane River at Newstead, near Kingsford Smith Drive (BCC, 2000).

1.3.2 Surface water resources and drainage characteristics

The study corridor does not directly intersect any major waterways. This is due to the extensive hard surfacing, channelling and underground piping which has been put in place throughout this area of the city, although some fragmented sections of the creeks outside of the inner city area are still visible (ie parts of Toowong Creek). Several minor waterways intersect the study corridor, particularly at the Western end in the upper reaches of Toowong Creek Catchment (refer to Figure 1a and Section 1.3.2.1). At the Eastern end of the study corridor a small section of a minor waterway intersects the study corridor in the vicinity of the ICB at Victoria Park Golf Course (refer to Figure 1c and Section 1.3.2.3). As these minor waterways form part of the stormwater conveyance drainage system, they are likely to be intermittent in nature, flowing only following precipitation, and subject to direct inflows of urban runoff, characterised by elevated concentrations of nutrients and suspended sediments. Within the study corridor the catchments of significance in terms of surface drainage are located at the western and eastern ends of the project area.

The major waterways which could potentially be affected by construction activities and/or operation of the Project were identified as:

- Brisbane River
- Breakfast/Enoggera Creek
- Toowong Creek

The location of these waterways and their catchments in relation to the study corridor are illustrated in Figures 1, Figure 1a, Figure 1b and Figure 1c.

LEGEND

- Sub-Catchment Boundary
- Study Area Corridor
- Stormwater Open Drain
- Stormwater Pipe Network
- Stormwater Drain
- Major Creek
- Minor Creek

Water Quality Rating

- Toowoong Creek
- Enoggera Breakfast Creek

0 1000 2000

metres

Scale 1: 50,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 1

Surface Water - Overview

Northern Link

SKM Connell Wagner JOINT VENTURE

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LEGEND

- Sub-Catchment Boundary
- Study Area Corridor
- Stormwater Open Drain
- Stormwater Pipe Network
- Stormwater Drain
- Major Creek
- Minor Creek

0 200 400
metres

Scale 1: 10,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 1A

Surface Water - Overview

Northern Link

SKM Connell Wagner
JOINT VENTURE

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1.3.2.1 Western end of study corridor

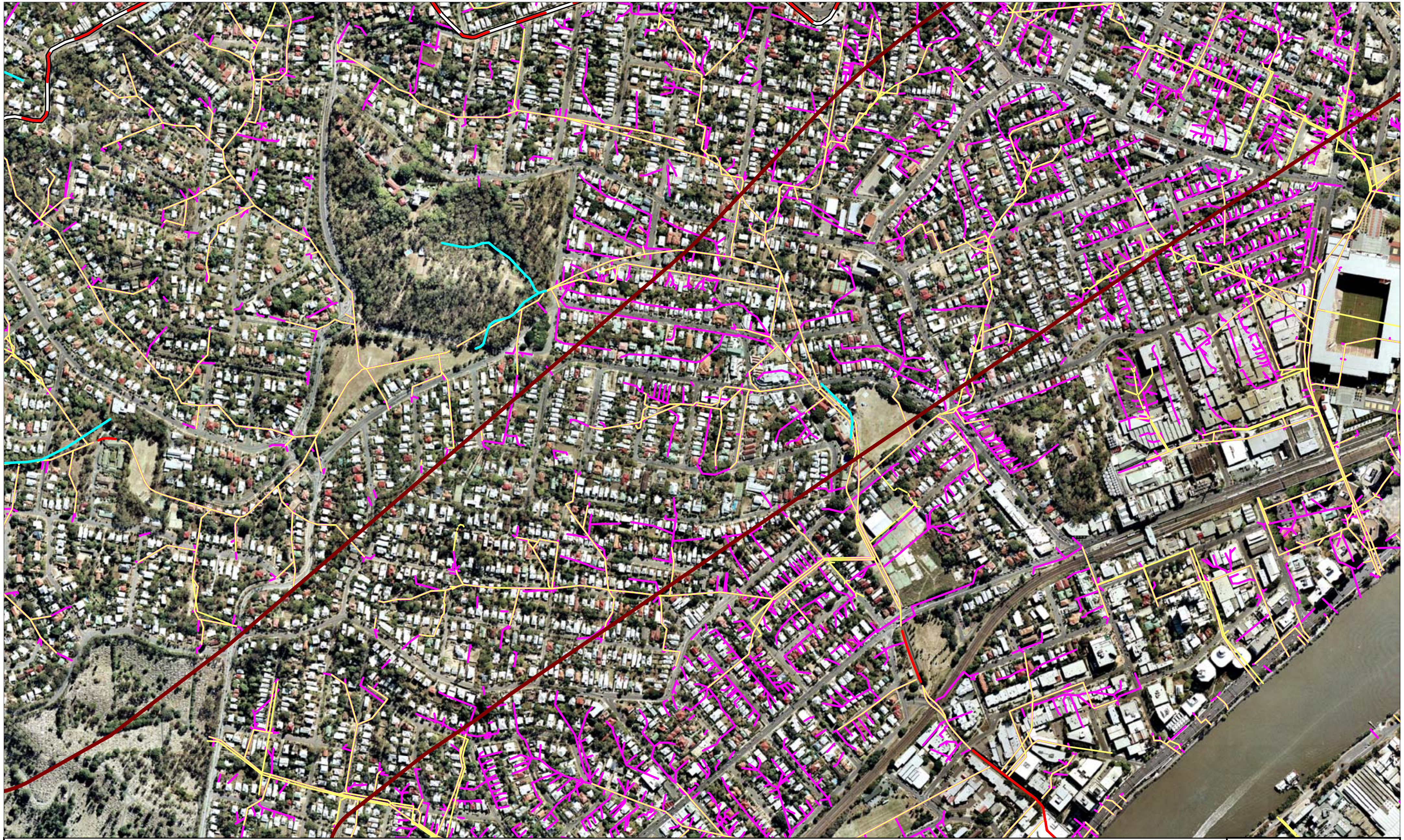
The main areas of interest located at the Western end of the study corridor include the headwaters of Toowong Creek, the Mt Coot-tha Quarry, and the drainage lines which include artificial lagoons within the Mt Coot-tha Botanic Gardens and Toowong Cemetery.

At the extreme In this section of the study corridor, drainage flows through open gullies within Brisbane Forest Park before passing under the Western Freeway and Milton Road and into an urban stormwater system which discharges ultimately into the Brisbane River (refer Figure 1a).

Surface water runoff crossing the study corridor enters Toowong Creek and drains south to the Brisbane River west of Toowong Village. Runoff from the next drainage line to the north, encompassing most of the Botanic Gardens, Mount Coot-tha Quarry and the valley up to Sir Samuel Griffith Drive

The hydrology and drainage characteristics of the Mount Coot-tha Quarry area have been significantly altered as a result of quarry operations. The Quarry area contains an active pit, which is steep sided with a large enough volume to contain large rainfall events preventing surface runoff into the surrounding catchment. The rest of the Quarry area includes storage and benching of the quarry walls, which prevents direct drainage down the face of the excavation (refer Technical Report No 6 - Flooding potential). Any surface water flowing from the quarry area is directed and captured in small sedimentation ponds. Water leaving the sedimentation ponds flows through the Botanical Gardens. Surface water drainage subsequently passes under the Western Freeway, via two existing culverts. Soon afterwards it passes into underground stormwater drains and is joined by an overland flow path, draining the larger, more southerly valley of the Toowong Cemetery. In the event of high rainfall or flooding events, an existing basin formed upstream of the Western Freeway acts to detain water and reduce significant surface water flows.

The minor creek channel, which passes through the Toowong Cemetery, originates as a grassed natural channel in the upper catchment and passes through the Toowong Cemetery as an open concrete-lined drain. The local drainage within the cemetery is well defined and does not interact with neighbouring watercourses or floodplains. The channel exits the site under Mt Coot-tha Road passing under several buildings and roads and runs as an open channel before reaching the catchment outlet under the Milton Road roundabout, where the culvert flows into the stormwater network. The stormwater network collects surface water runoff from the local streets and urban areas and eventually discharges to the Brisbane River at Auchenflower adjacent to the Wesley Hospital.



LEGEND

Sub-Catchment Boundary
Study Area Corridor
Stormwater Open Drain
Stormwater Pipe Network
Stormwater Drain
Major Creek
Minor Creek

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 1B

Surface Water - Overview

SKM Connell Wagner JOINT VENTURE

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1.3.2.2 Central section of study corridor

Midway along its length the study corridor is crossed by a minor stream that rises in Bardon, crosses Rouen/Boundary Road near Rainworth Road just south of Government House to follow the western section of Baroona Road to the Rosalie Shopping Centre then south across Milton Road at Torwood Street and into an open concrete-lined drain to reach the Brisbane River just east of the Lang Parade/Coronation Drive intersection (Figure 2). The tidal influence of the Brisbane River extends at least as far as Milton Road so the concrete channel contains saltwater except in times of stormwater runoff when flow to the river is induced. North of Milton Road this stream has been largely modified due to urban development and is confined within a major stormwater pipe network (Figure 1b).


- *Figure 2 :Open concrete-lined tidal drainage channels downstream of the study corridor at Milton Park and Kilroe Street prior to discharge into the Milton Reach of the Brisbane River*

Throughout most of the study corridor, extensive networks of underground stormwater pipes convey runoff from impervious surfaces such as roads and roofs into the Brisbane River. These major alterations to the natural catchment hydrology have resulted in an increase in the volume, time of concentration and frequency of surface water runoff discharging to the receiving waters.

1.3.2.3 Eastern end of study corridor

The Eastern end of the study corridor is located within the Breakfast Creek/Enoggera Creek catchment. The majority of the catchment in the study corridor consists of relatively steep, undulating terrain. In this area the catchment is heavily urbanised, with a high degree of imperviousness and an extensive network of stormwater pipes throughout the catchment (Figure 1c). This network has only limited capacity and significant overland flows currently occur under moderate to large rainfall events.

At the Eastern end of the study corridor the most significant features from a drainage and water quality perspective are the Victoria Park Drain at Herston and York’s Hollow, a culturally significant wetland within Victoria Park (Figure 3). The York’s Hollow wetland was part of the original lagoon system in the area, which was rehabilitated and remodelled as part of the Inner City Bypass project in 2000. This wetland provides an important habitat for waterbirds and acts as a fish refuge/breeding area.

- *Figure 3: York's Hollow, Victoria Park a culturally significant wetland habitat within Victoria Park adjacent to the Inner City Bypass*

The catchment for the Victoria Park drainage system extends from the suburb of Red Hill, with a defined flowpath beginning west of Kelvin Grove Road, flowing through the Kelvin Grove Urban Village, the Brisbane Grammar School playing fields on Victoria Park Road and along the Inner City Bypass (ICB). The stream runs parallel to the ICB and includes significant above and below ground drainage infrastructure. Within Victoria Park a major detention basin is sited between the ICB and the multi-story hospital car park in Herston Road. The outlet from this basin discharges to an underground brick arch drain/reinforced concrete pipe (Figure 4) which runs beneath the north-western corner of the RNA showground before discharging into Enoggera Creek. This existing drain from Victoria Park is a diversion of a stream which previously ran through the RNA showground discharging into the Brisbane River at Newstead, upstream from Breakfast Creek.

- *Figure 4: Victoria Park detention basin outlet and stormwater culverts from the Inner City Bypass*

LEGEND

- Sub-Catchment Boundary
- Study Area Corridor
- Stormwater Open Drain
- Stormwater Pipe Network
- Stormwater Drain
- Major Creek
- Minor Creek

0 200 400

metres

Scale 1: 10,000 (A4)

N

NORTHERN LINK
ENVIRONMENTAL IMPACT STATEMENT

Figure 1C

Surface Water - Overview

NorthernLink

SKM Connell Wagner
JOINT VENTURE

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1.3.3 Surface water quality

1.3.3.1 Monitoring programs

A number of water quality monitoring programs have been undertaken to observe the condition and characteristics of the estuary and tributaries of the lower Brisbane catchment area. Those relevant to the proposed project corridor include the city-wide water quality monitoring program and the Healthy Waterways Ecosystem Health Monitoring program, which are summarised in Table 1-3

- **Table 1-3 Review of Regional Water Quality Monitoring Programs**

Monitoring	Conducted by	Date	Program
City-wide Assessment	EPA and BCC	October 1999 - April 2000.	A City-wide assessment of water quality was undertaken of Brisbane's creeks providing the most extensive spatial assessment of water quality in the Brisbane area. Monitoring was conducted approximately six times a year at 0.2 m depth. Water quality within Toowong Creek was identified as poor
Healthy Waterways EHMP	Moreton Bay and Catchment Partnership. A regional program involving the EPA, DNRM, local councils and research organisations	2006 - 2007	The Ecosystem Health Monitoring Program (EHMP) is one of the most comprehensive marine, estuarine and freshwater monitoring programs in Australia. This monitoring program provides a regional assessment of the ambient ecosystem health for the 18 major catchments in SEQ. The water quality monitoring program is conducted on a regular basis with annual report cards produced reflecting the status of the water quality in each catchment. The EHMP Annual Report 2006-2007 identified that the tributaries of the Lower Brisbane River catchment remain in a poor condition in terms of their water quality. The Brisbane River Estuary, has shown some improvement when compared to previous years, with an improvement in nitrogen and dissolved oxygen levels adjacent to the Oxley WWTP discharge.

1.3.3.2 Water quality assessment

The relevant data for both the City-wide assessment of Brisbane creeks (Webb, 2001) and the EHMP Healthy waterway monitoring programme have been evaluated against the BCC WQOs, EPP(Water) WQOs and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). The Water Quality Objectives for each of these guidelines, pertaining to the water resources of the Project area, are provided in Table 1-2.

1.3.3.2.1 City-wide water assessment of Brisbane's creeks (1999-2001)

Existing water quality data were obtained from the EPA monitoring program as part of their City-wide assessment of Brisbane's creeks (Webb, 2001). These data were gathered from selected creeks in Brisbane between October 1999 - April 2000 and water quality monitoring sites relevant to this Project are shown in Figure 1. The results of the City-wide assessment do not represent the most up-to-date water quality conditions for these creeks. However, the monitoring programme does provide water quality data for Toowong Creek which is not available as part of the EHMP data set.

1.3.3.2.1.1 Toowong Creek

The lower section of Toowong Creek is tidally influenced. The extent of saltwater intrusion up the creek will vary seasonally and as a result of the tidal influences of the Brisbane River. During the drier winter months, and during prolonged dry periods (ie droughts), the saltwater wedge will extend further up the creek. Extreme high tide events will also facilitate this movement of saline and brackish water. Conversely, during the wet season, high rainfall and localised flooding events will result in increased catchment runoff. In large enough quantities, an inflow of fresh water will displace the brackish/saline water along the entire length of the creek to the confluence with Brisbane River. Periods of high rainfall and increased catchment runoff are likely to result in an increase in the sediment, nutrient and contaminant (heavy metal or hydrocarbon) loadings entering the creek environs and downstream receiving waters (Lower Brisbane River) potentially impacting on the water quality of the aquatic environment.

Water quality results for Toowong Creek (monitoring site 3) from the City-wide monitoring assessment (Webb, 2001) were evaluated against Brisbane City Council's water quality objectives (BCC WQO), Queensland's Water Quality Objectives (QWQO) and ANZECC (2000) guidelines and are summarised in Table 1-4 in terms of compliance. Median values for the parameters measured at monitoring site 3 are identified in **Appendix A.**

- **Table 1-4 Toowong Creek (estuarine reach) – Comparison of Water Quality from monitoring site 3 with the Water Quality Objectives**

Parameter	Site 3 compared with BCC WQO	Site 3 compared with EPP (Water)	Site 3 compared with ANZECC (2000)
Oxygen % sat	Not Met	Not Met	Not Met
pH	Met	Met	Met
Chlorophyll-*a*	Met	Met	Met
Turbidity	Met	Met	Not Met
Nitrogen (ammonia) as N	Met	N/A	N/A
Nitrogen (oxidised)	Not Met	Not Met	Not Met
Nitrogen (total) as N	Not Met	Not Met	Not Met
Phosphorus (dissolved reactive) as P	Not Met	Not Met	Not Met
Phosphorus (total) as P	Not Met	Not Met	Not Met

Table Note: N/A - Not available

The water quality of the estuarine reach of Toowong creek at monitoring site 3 (refer Figure 1) was poor, with nutrient concentrations (especially oxidised nitrogen) exceeding BCC WQOs, QWQGs and ANZECC (2000) water quality guidelines. The increase in nutrient levels in this area was attributed to tidal exchange from the adjacent Brisbane River estuary (Webb 2001). Dissolved oxygen concentrations also failed to meet desired water quality objectives. Low chlorophyll-a concentrations indicate that algal productivity within the system is minimal, however this is typical of brackish-saline systems.

1.3.3.2.1.2 Breakfast Creek/Enoggera Creek

Breakfast Creek/Enoggera Creek is north of the proposed project area at the Eastern end of the study corridor. Breakfast Creek/Enoggera Creek does not directly intersect the study corridor, however, a major detention basin within Victoria Park discharges via an underground brick arch drain into Enoggera Creek. As a result, construction activities from the Eastern end of the project area, if not adequately mitigated, have the potential to increase the concentration of sediments, nutrients and contaminants (hydrocarbons and heavy metals) entering the lower reach of Enoggera Creek.

Water quality results for Enoggera Creek (monitoring site 17) from the City-wide monitoring assessment (Webb, 2001) were evaluated against Brisbane City Council's water quality objectives (BCC WQO), Queensland Water Quality Objectives (QWQO) and ANZECC (2000) guidelines and are summarised in Table 1-5 in terms of compliance. Median values for the parameters measured at monitoring site 17 are identified in **Appendix A.**

- **Table 1-5 Enoggera Creek WQ Evaluation with the Water Quality Objectives**

Parameter	Site 17 (Median value) compared with BCC WQO	Site 17 (median value) compared with EPP (Water)	Site 17 (median value) compared with ANZECC (2000)
Dissolved Oxygen % sat	Met	Met	Met
pH	Met	Met	Met
Chlorophyll-*a*	Met	Met	Met
Turbidity	Met	Met	Not Met
Suspended solids	Met	Met	Met
Nitrogen (organic) as N	Met	N/A	N/A
Nitrogen (ammonia) as N	Met	Met	Not Met
Nitrogen (oxidised)	Not Met	Not Met	Not Met
Nitrogen (total) as N	Not Met	Not Met	Not Met
Phosphorus (dissolved reactive) as P	Not Met	Not Met	Not Met
Phosphorus (total) as P	Not Met	Not Met	Not Met

The water quality of Enoggera Creek at monitoring site 17 (refer Figure 1) was poor. Overall nutrient concentrations of nitrogen (total and oxidised nitrogen) and phosphorus exceeded BCC WQOs, QWQGs levels and ANZECC (2000) water quality guidelines. The increase in nutrient levels in this area was also attributed to tidal exchange from the adjacent Brisbane River estuary (Webb, 2001). Median values for dissolved oxygen, chlorophyll-a, suspended solids, and pH, all met the BCC WQOs, QWQG levels and ANZECC (2000) water quality criteria. Turbidity at this site was in exceedence of the ANZECC (2000) guidelines.

1.3.3.2.2 Healthy Waterways EHMP monitoring programme

1.3.3.2.2.1 Brisbane River

The Healthy Waterways EHMP monitoring programme has been conducted since 2000 and provides a comprehensive assessment of the conditions of South East Queensland waterways. The EHMP produces annual report cards which indicate the condition of the marine, estuarine and freshwater

water resources within the SEQ region. The 2007 EHMP Report Card for the Lower Brisbane Estuary region showed an overall improvement in water quality condition, with the Report Card grade improving from an F grade in 2006 to a D+ grade in 2007. The nitrogen and dissolved oxygen levels in the middle reaches of the estuary, adjacent to the Oxley WWTP discharge, were much improved on previous years. The freshwater streams and creek systems of the lower Brisbane catchment remained in a poor condition in terms of their water quality, with an overall Report Card grading of F (Healthy Waterways, 2007).

Data from EHMP monitoring sites (collected between November 2003 up to and including October 2007), relevant to the study corridor, were evaluated against BCC WQOs, QWQGs and ANZECC (2000) guidelines to assess the existing status of the water quality for these areas (refer Table 1-6, Table 1-7 and Table 1-8 below). The values for each sampling site and the median water quality values for each parameter are listed in **Appendix B**.

The EHMP monitoring sites for this area include:

a) EHMP Site 703 (Brisbane River AMTD 21.7 km – under the Story Bridge),

b) EHMP Site 704 (Brisbane River AMTD 26.1 km – under Grey Street Bridge), and

c) EHMP Site 705 (Brisbane River AMTD 33.7 km).

- **Table 1-6: WQ Evaluation – EHMP data comparison with BCC Water Quality Objectives**

		Brisbane River AMTD 21.7 km under Story Bridge (EHMP Site 703)			Brisbane River AMTD 26.1 km under Grey Street Bridge (EHMP Site 704)			Brisbane River AMTD 33.7 km (EHMP Site 705)		
	Unit	Season		Total	Season		Total	Season		Total
		Wet	Dry	Median	Wet	Dry	Median	Wet	Dry	Median
Dissolved oxygen	% sat	Met	Met	Met	Met	Met	Met	Not Met	Met	Met
pH		Met	Met	Met	Met	Met	Met	Met	Met	Met
Chlorophyll-a	µg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Turbidity	NTU	Met	Met	Met	Met	Met	Met	Not Met	Met	Not Met
Nitrogen (organic) as N	mg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Nitrogen (ammonia) as N	mg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Nitrogen (oxidised) as N	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Nitrogen (total) as N	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Phosphorus (dissolved reactive) as P	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Phosphorus (total) as P	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met

Table Notes: Compliance based on comparison of the median value of the data set from November 2003 to October 2007
Shaded values indicate exceedance of guideline

Table 1-6 indicates that Total Nitrogen (TN), Oxidised Nitrogen (NO_x), and Phosphorus concentrations (TP and FRP) did not comply with water quality objectives prescribed by BCC at any of the three EHMP monitoring sites assessed. Organic and Ammonia Nitrogen levels complied with BCC water quality objectives at all monitoring sites. Chlorophyll-a concentrations and pH also complied with BCC WQO's at all sites. Turbidity was higher than the WQO and dissolved oxygen concentrations were slightly less than the WQO during the wet season at monitoring site 705.

- **Table 1-7 WQ Evaluations – EHMP data comparison with QWQO's**

		Brisbane River AMTD 21.7 km under Story Bridge (EHMP) Site 703			Brisbane River AMTD 26.1 km under Grey Street Bridge (EHMP) Site 704			Brisbane River AMTD 33.7 km (EHMP) SITE 705		
	Unit	Season		Total	Season		Total	Season		Total
		Wet	Dry	Median	Wet	Dry	Median	Wet	Dry	Median
Dissolved oxygen (% sat)	% sat	Met	Met	Met	Met	Met	Met	Not Met	Met	Met
pH		Met	Met	Met	Met	Met	Met	Met	Met	Met
Chlorophyll-a	µg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Turbidity	NTU	Met	Met	Met	Met	Met	Met	Not Met	Met	Not Met
Nitrogen (organic) as N	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen (ammonia) as N	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen (oxidised) as N	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen (total) as N	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Phosphorus (dissolved reactive) as P	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Phosphorus (total) as P	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met

Table Notes: Compliance is based on comparison of the median value of the data set covering a period from November 2003 to October 2007
Shaded values indicate exceedence of guideline
N/A – Guideline value not available

Table 1-7 indicates that Total Nitrogen (TN) and Total Phosphorus levels (TP) did not comply with water quality objectives prescribed by QWQG at any of the three EHMP monitoring sites assessed. Chlorophyll-*a* levels and pH complied with QWQG at all sites. Turbidity was higher than the guideline and dissolved oxygen concentrations were slightly less than the guideline during the wet season at monitoring site 705.

Table 1-8 WQ Evaluation – EHMP data comparison with ANZECC (2000) WQO's

		Brisbane River AMTD 21.7 km under Story Bridge (EHMP) Site 703			Brisbane River AMTD 26.1 km under Grey Street Bridge (EHMP) Site 704			Brisbane River AMTD 33.7 km (EHMP) SITE 705		
		Season		Total	Season		Total	Season		Total
	Unit	Wet	Dry	Median	Wet	Dry	Median	Wet	Dry	Median
Dissolved oxygen (% sat)	% sat	Met	Met	Met	Met	Met	Met	Not Met	Met	Met
pH		Met	Met	Met	Met	Met	Met	Met	Met	Met
Chlorophyll-a	µg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Turbidity	NTU	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Nitrogen (organic) as N	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrogen (ammonia) as N	mg/L	Met	Met	Met	Met	Met	Met	Met	Met	Met
Nitrogen (oxidised) as N	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Nitrogen (total) as N	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Phosphorus (dissolved reactive) as P	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
Phosphorus (total) as P	mg/L	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met

Table Notes: Compliance is based on comparison of the median value of the data set covering a period from November 2003 to October 2007

Shaded values indicate exceedance of guideline

Table 1-8 indicates that concentrations of Nitrogen (TN and NO_x) and Phosphorus (TP and FRP) did not comply with the ANZECC (2000) water quality guidelines at any of the three EHMP monitoring sites. Turbidity levels also exceeded ANZECC (2000) guidelines at all three EHMP sites in both the wet and dry seasons. Chlorophyll-*a* concentrations and pH complied with the ANZECC (2000) water quality guidelines for estuarine waters at all sites.

1.4 Discussion

The study corridor and surrounding environment has been highly modified with significant alterations to the natural drainage and flow regime. The study corridor does not directly intersect any major waterways although several minor waterways do cross the study corridor, particularly at the Western end in the upper Toowong Creek Catchment. Minor waterways intersecting the study corridor are also present in the mid section and at the eastern end of the project corridor. These waterways are conveyed in underground pipes for a large proportion of their length, therefore these minor waterways are primarily intermittent in nature, flowing mainly during the wet season and thus they are essentially functioning as stormwater drains.

The existing condition of the waterways identified in proximity to the study corridor is influenced by a variety of environmental and anthropogenic factors. Nutrient loadings within the Brisbane River catchment attributable to surface water runoff are both naturally and anthropogenically (human) derived. Anthropogenic sources include wastewater treatment discharges and urban stormwater run-off containing fertilisers, detergents, domestic animal droppings and organic matter deliberately or carelessly discarded into the stormwater drain system (ie grass clippings, sediment from building sites). Natural sources include organic material such as leaf litter and silt/soil from forested areas, fallen leaves from street trees in urban areas and animal droppings from non-domestic animals. Disturbance of natural catchment soils, through the process of development, can result in erosion and mobilisation of sediment with a subsequent increase in the amount of silt delivered to the waterways. Potential water quality impacts may also arise during periods of high rainfall or flooding when high levels of nutrients, suspended solids and other contaminants may be washed downstream from the surrounding catchment areas to the surrounding creeks and receiving waters (Lower Brisbane River Estuary).

Some information on the current condition of the lower Brisbane catchment and surrounding catchments has been collected through monitoring programmes conducted by BCC, EPA and Healthy Waterways, although relevant monitoring sites for the Toowong Creek and Enoggera Creek/Breakfast Creek were located close to their respective confluences with the Brisbane River, where the water quality was identified as “poor” overall (Webb, 2001). No existing data for monitoring sites located upstream of the study corridor were identified. This is probably due to the fact that the drainages in the study corridor are not continuous, only flowing after rain events and mostly in enclosed stormwater drains.

Further baseline monitoring of the waterways and waterbodies in the vicinity of the study corridor would be recommended, including the establishment of representative monitoring sites both upstream and downstream of the study corridor.

2. Surface Water Resources – Potential Impacts and Mitigation

2.1 Impact assessment

This section provides an assessment of the potential impacts on water quality that may occur during the construction phase and operation of the Project. Any impact to the existing water quality of the receiving waterways, within or downstream, of the project area may threaten the Environmental Values and Water Quality Objectives outlined above.

Waterways within the study corridor drain directly and/or indirectly into the downstream receiving waters of the Brisbane River Estuary. This in turn drains into Moreton Bay, a nationally and internationally significant area, which has been designated as a marine park area and includes one of Queensland's internationally recognised RAMSAR wetland sites.

Mitigation measures are recommended to manage the identified potential impacts during both construction and operation.

2.2 Potential impacts during construction and operation

The main potential sources of pollution during construction and operation include:

- Sediment-laden or contaminated runoff
- Spillage or accidental release of pollutants, including hazardous and chemical substances, as well as litter
- Changes to surface water hydrology

Potential impacts on receiving waterways may be either direct or indirect. Possible direct impacts may result from excavation works in or near drainage lines. Indirect impacts include water contamination due to sedimentation, erosion, changes to quality of road runoff during construction and operation, and potential pollutants from vehicles and busway users.

Further potential impacts specific to the construction phase include:

- Disturbance of acid sulphate soils (ASS) resulting in acidic runoff
- Use of recycled water for construction activities

Potential sources of pollution and impacts during the construction and operation phases of the Project are highlighted in Table 2-1

Table 2-1 Potential sources of pollution and potential impacts during construction and operation phases

Pollutant	Source	Potential Impact
Sediment	Construction activities, such as excavation, earthworks, stockpiles	▪ The build up of sediments in waterways may alter stream hydraulics leading to potential increase in channel scour, riverbank erosion and changes to patterns of flooding
	Abrasion of road gravel and tar	▪ Increased turbidity in waterways that may reduce light penetration and lead to a reduction of aquatic plant growth and smothering of aquatic fauna (including fish eggs and larvae)
Heavy metals		▪ Elevated levels of heavy metals can be toxic to aquatic biota. Uptake may occur through passive uptake across gills or through ingestion of food, resulting in sublethal and lethal effects on aquatic organisms affecting growth, reproduction and behaviour ▪ Heavy metals can be accumulated in the tissues of aquatic organisms and may be bioaccumulated up the food chain, resulting in elevated concentration of contaminants with implications for marine biota, fisheries and aquaculture and human health
Zinc	Tyres	
Copper	Brake pads	
Other common metals	Corrosion	
PAHs, oils and grease and other hydrocarbon products	Exhaust and sump oil	▪ PAHs are known carcinogens and mutagens and can be bioaccumulated by aquatic organisms. High levels of PAH's have implications for aquatic organisms and human health ▪ Oils and grease are unsightly and can damage aquatic ecosystems ie reducing the diffusion of oxygen into the water column and smothering aquatic biota

2.2.1 Sedimentation and runoff

2.2.1.1 Construction phase

Sediment-laden runoff as a result of construction activities is considered a particularly high risk to waterways and the drainage network, adjacent to or downstream of the construction area. Construction activities, if improperly managed, could result in erosion and transportation of sediment off site. These activities include:

- Vegetation clearance
- Excavation and earthworks associated with utility diversion, cut and cover tunnel, embankments and bridges, haul roads
- Stockpiling and transferring of spoil from tunnel construction

2.2.1.2 Operation phase

The main impact to surface water quality during operation will be road runoff, which is likely to contain elevated levels of sediment, heavy metals, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAH's). A road runoff study was undertaken by the Queensland Department of Main Roads in partnership with the Moreton Bay Waterways and Catchment Partnership (MBWCP) and provides an estimate of the relative impacts that road runoff may have on water quality and aquatic habitats in South East Queensland. A summary of the potential construction and operational phase impacts identified by the study is provided in Table 2-1. Road run-off in the tunnels would be collected in sumps at the sag points and periodically pumped out and appropriately treated to achieve desired quality standards before disposal into the stormwater system.

2.2.2 Spillage or accidental release of pollutants

2.2.2.1 Construction phase

During the construction phase hazardous and chemical substances (such as hydrocarbons for fuel, asphalt plumes, cement slurry) may be used and contaminated water from washdown may be generated. These sources would become potential environmental pollutants if not properly managed through appropriate storage, bunding or treatment. Spillage or accidental release of pollutants may have the following impacts on surface water quality:

- Hydrocarbons, heavy metals and other chemicals can result in acute or chronic toxicity impacts to the aquatic biota present and may result in severe disruption to local ecosystem biodiversity
- Oils and grease are unsightly and impact on both in-stream aquatic biota and other fauna dependent on the waterway
- Litter is unsightly, pollutes streams and can be physically harmful to aquatic organisms
- High nutrient concentrations from the accidental release of untreated wastewater from sewer mining, or inappropriate use of recycled water, may result in algal blooms or dominance by aquatic weed species adapted to high nutrient environments. Accidental release of untreated wastewater also presents concerns from a human health perspective.

2.2.2.2 Operation phase

During operation, the main risk of release of pollutants to the surrounding environment is litter, or fuel or chemical spills occurring due to vehicle collision. Depending on the volume of the spill, there is potential to cause significant damage to the terrestrial environment and downstream waterways, as well as potential public health impacts. The potential environmental damage from a spill may be long term, particularly if groundwater contamination occurs, as the effects may persist for many years.

2.2.3 Surface water hydrology

Construction activities for the Project may involve localised changes to the hydrology of the area. While the study corridor does not directly intersect any major waterways, construction may involve permanent or temporary alterations to existing drainage channels and the stormwater network.

Alteration or impediment to stormwater flow may alter the physical dynamics of the receiving waterways, which in turn will have implications for its ecology. In most cases the impacts will only be short-term with temporary impediments including stockpiling of spoil, material storage, equipment and machinery. However, the constructed Project infrastructure may also impede water movement during baseline flows and/or flooding events leading to pooling within waterways or channels, diversion of overland flow, and changes to frequency of flows and quantity and quality of surface water runoff.

- Larger volumes of stormwater runoff will increase flow velocity and, if the drainage channel is not clearly defined, the potential for erosion (particularly during peak flows after storm events) will increase.
- Changes to the quality of surface water through trapping and redirection may result in nutrients (such as nitrogen and phosphorus) and other contaminants bound to soil particles being channelled and transported into the aquatic environment. An increase in nutrients may result in eutrophication (excessive nutrient enrichment) of the aquatic environment increasing the potential for algal blooms to occur, and depleting oxygen levels.
- Pooling of water in drains and channels may provide breeding sites for mosquitoes, which are vectors of a number of diseases. Suitable breeding sites include fresh, brackish and polluted water in constructed drains, depressions, discarded tins and bottles.

2.2.4 ASS

Clearance and construction activities within estuarine areas or those subject to tidal influence may result in the disturbance of acid sulphate soils (ASS). Acid drainage (from ASS) is a potential impact that can impact upon groundwater and surface water quality. Subsequent impacts to downstream surface water quality include a marked decrease of pH and an increase in sulphate and bioavailable heavy metal concentrations. All of which would significantly impact on the flora and fauna of an affected waterway.

Small areas with a low risk of ASS have been identified within or closely adjacent to the study corridor (refer Chapter 6 of the EIS – ASS) and their location with respect to the study corridor is identified below.

- Western section of the study corridor – There is an area of within Toowong Memorial Park on Sylvan Road where the chances of acid sulphate soils occurring are identified as low.
- Central section of study corridor - at the eastern end of Baroona Road. The area of acid sulphate soil transects the central study corridor. An area of medium hazard of acid sulphate soils has been identified in the area of Gregory Park, in the vicinity of Baroona Road and Haig Road. Low hazard acid sulphate soils have been identified extending north of Gregory Park across the study corridor. In this section the tunnels would be well underground with no chance of interfereing with the ASS if they occur there.
- Eastern section of the study corridor - at south-east end of Given Terrace in Neal Macrossan Park. This area is located outside the study corridor and is identified as having a low hazard of acid sulphate soil

It is not expected that any of these areas will be excavated or otherwise disturbed during construction.

2.2.5 Construction water management

The construction phase will require onsite water to be used for construction activities including:

- Dust suppression
- Earth compaction
- Washdown of vehicles and roadheaders
- Grout and shotcrete production

The construction worksites for the Project will be located at the following locations and the daily water supply requirements for construction purposes are identified in Table 2-2

- Western end – Western Freeway worksite (WS1)
- Central section - Toowong worksite (WS2)
- Eastern end – Kelvin Grove worksite (WS3)
- **Table 2-2: Daily water supply requirements for construction**

Worksite	Non-Potable (L/day)	Potable (L/day)	Total (L/day)
WS1	110000	30000	140000
WS2	50000	20000	70000
WS3	50000	20000	70000
	210000	**70000**	***280000***

Approximately 280000 L per day (0.28 ML) will be required for construction purposes at peak demand. If it is proposed to source a portion of the construction water through sewer mining, this would include treating water onsite at the Western Freeway worksite to a high standard in line with Queensland Water Recycling Guidelines (EPA, 2005). Treated water would then be stored onsite, as well as being trucked to the other worksites where it will also be stored in covered tanks for construction use. Reuse of water can benefit the surrounding environment by reducing the demand on potable water supply.

There is a risk that untreated wastewater may be accidentally released, leading to degradation of the surrounding environment. However, specific management measures would be identified in the CEMP and through the environmental approval process to avoid such accidents occurring and to define emergency response and spill containment procedures.

2.2.6 Study corridor - construction phase impacts

2.2.6.1 Western end of study corridor

Construction activities at the Western end of the study corridor may potentially impact on the tributaries of Toowong Creek and drainage lines from Mt Coot-tha Botanic Gardens and Toowong Cemetery.

The key activities and potential impacts in this area, if not properly managed, include:

- Vegetation clearing and establishment of access roads to the Western Freeway worksite leading to sediment-laden runoff
- Diversion of existing drainage channels and underground stormwater infrastructure resulting in a change to surface water hydrology
- Establishment of the Western Connection worksite, including launching of the tunnel boring machines (TBMs) and storage and use of other machinery and equipment, which could lead to a release of water contaminated with hydrocarbons, heavy metals and other chemicals
- Construction of embankments for the elevated road alignment and tunnelling works resulting in sedimentation and runoff, as well as release of contaminated water
- Removal of spoil by enclosed conveyor from the Western Freeway worksite up to Mt Coot-tha quarry could lead to sediment-laden runoff from spoil stockpiles
- Use of improperly treated recycled water for construction activities leading to elevated nutrient and faecal coliform concentrations in runoff

2.2.6.2 Central section of study corridor

The Central section of the study corridor is crossed by a minor stream that rises in Bardon and travels mainly as a piped stormwater network. The only construction activity proposed in this area is underground tunnelling by TBM; therefore, no potential impacts on surface water have been identified.

It is possible that during construction, tunnelling activities may accidentally intersect an underground stormwater or sewer pipe, potentially resulting in contamination. All such underground infrastructure will be clearly identified on plans prior to tunnelling activities commencing and the CEMP will stipulate that site personnel will be briefed on action required should unmapped infrastructure be identified/damaged.

Acid sulphate soils have been identified transecting the central region of the study corridor at the eastern end of Baroona Road. These may present a low to medium risk in the area of Gregory Park, in the vicinity of Baroona Road and Haig Road. Low hazard acid sulphate soils have been identified extending north from Gregory Park across the study corridor. However, it is not expected that these areas will be excavated or otherwise disturbed during construction.

2.2.6.3 Eastern end of study corridor

This section of the study corridor is within the Breakfast Creek/Enoggera Creek catchment. A small area containing overland flowpaths is intersected near the ICB at Victoria Park Golf Course. These overland flowpaths only convey surface water following rainfall. It should also be noted that a major detention basin (located within Victoria Park) discharges by underground drain to Enoggera Creek, consequently any degraded surface water being discharged via this drainage system during storm events could have a direct impact.

The key activities and potential impacts in this area, if not properly managed, include:

- Establishment of the Kelvin Grove worksite, including launching of the roadheaders and storage and use of other machinery and equipment, this could lead to release of water contaminated with hydrocarbons, heavy metals or other chemicals
- Excavation of the cut and cover tunnel works leading to sediment-laden runoff
- Construction of access ramps, transition structures, bridges and surface works for both the ICB Connection and Kelvin Grove Connection, resulting in sedimentation and runoff, as well as release of contaminated water
- Diversion of existing drainage channels and underground stormwater infrastructure resulting in a change to surface water hydrology
- Storage and use of improperly treated recycled water for construction activities leading to elevated nutrient and faecal coliform concentrations in runoff

2.2.7 Study corridor - operational impacts

The likely areas of the Project that may impact surface water quality during operation are the four connection points of the existing road network to the tunnel; Western Freeway, Toowong, ICB and Kelvin Grove Connections. The tunnel will have separate drainage collection systems, which be designed to separately collect tunnel washdown water, any stormwater ingress and any spillage such as chemicals, and petrochemicals. Water from the tunnel collection system will be removed by tanker and taken for offsite treatment or appropriate disposal.

Potential impacts from operation of the Project would include:

- Stormwater runoff, contaminated with suspended sediments, heavy metals and oil, grease or other hydrocarbons
- Accidental spillage of pollutants from a collision or other incident
- Litter
- Increased volume of stormwater runoff and alteration/impediment to its movement
- Failure of the drainage collection system or inability to contain volumes of contaminated water greater than the design volume (ie prolonged heavy rainfall conditions resulting in continuing ingress)

2.3 Mitigation measures

The proposed mitigation strategies will minimise the potential environmental impacts identified above.

2.3.1 Design

The design phase of the Project is the most important phase for integrating water quality mitigation measures to ensure cost effectiveness and functionality. The mitigation measures below will be further refined during the detailed design phase of the Project.

The following areas have been identified as the most likely sources of poor surface water quality associated with the Project:

- Western Freeway Connection
- Toowong Connection
- ICB Connection
- Kelvin Grove Connection

During the operational phase of the Project a number of management options may be employed to effectively manage and treat road runoff. The incorporation of Water Sensitive Urban Design (WSUD) methods enables the effective integration of water cycle management. This is utilised by most local councils for the effective treatment and management of stormwater and is particularly suited to road runoff. Achieving pollutant load reductions prior to discharge would be a principle objective in the design of the stormwater management strategy for the Project. A number of different components and controls would be investigated as part of this strategy, and those considered suitable and most effective would be developed during the detailed design phase. These include:

- Grassed/vegetated swales located alongside roads and ramps
- Batter slopes to be grassed/vegetated and use of rock check dams to slow flow velocity and prevent scour
- Permanent settlement ponds and detention basins
- Use of Stormwater Quality Improvement Devices (SQIDs) to remove gross pollutants such as litter
- Oil/grit separators to remove hydrocarbons and coarse sediments

All permanent water quality treatment control devices would be designed for the adequate control of pollution and sediment and other coarse materials in the event of a flood risk. The adopted regional flood levels for this Project take into consideration the 100 year Average Recurrence Interval (ARI) peak flood level, as well as being designed for the stability of these devices in the event of a 10,000 ARI peak storm event.

2.3.2 Construction phase

An Erosion and Sediment Control Plan would be designed and implemented to minimise any transport of sediment from the project area to downstream of waterways. During construction, potential impacts to water quality would be managed through the following measures and controls:

- Maximise the areas of vegetation retained within the project area and progressively rehabilitate cleared sections where appropriate
- Stockpile materials and soils away from natural drainage areas
- Implement mechanisms to slow and/or prevent overland runoff, such as the planting of vegetation and/or the installation of artificial structures (ie geofabric and bunds)
- Effective erosion and sediment control measures to be installed prior to construction works commencing and regularly monitored (daily) and maintained to ensure their continued effectiveness throughout the duration of the construction phase
- Stabilise disturbed areas of soil (where possible) as soon as practical, to minimise soil erosion and avoid downstream sedimentation.

- Chemical storage areas and wash down facilities are to be located away from existing drainage lines and have appropriate bunding and waste water collection mechanisms.
- Chemical and hydrocarbon wastewater must be disposed to a liquid waste disposal facility or company, or treated to an acceptable level for discharge with the permission of the responsible authority.
- Waste storage facilities and spoil placement areas are to be located away from existing drainage lines and have appropriate bunding and drainage mechanisms

2.3.3 Construction Surface Water Quality Monitoring Programme

A water quality monitoring program during construction would be established to ensure compliance with water quality objectives and to enable potential impacts to water quality to be assessed and mitigated. This monitoring programme will include the collection and analysis of surface water samples at selected locations in the Project area.

Establishment of an appropriate monitoring program will provide valuable information on the water quality parameters of the waterways potentially affected by the construction works as well as identifying potential sources of contamination and the extent of potential impacts. *In-situ* parameters that would be measured include pH, conductivity, DO, turbidity, with a visual assessment of each monitoring site for the presence of oil or grease films on the water surface. Samples collected for laboratory analyses would be analysed for such parameters as nutrients, suspended sediment and standard suite of heavy metals (to be determined by the approval conditions for discharge criteria).

Any non-conformances would be reported to the site environmental officer so that corrective action is taken immediately.

Regular inspection of the drainage channels within the construction areas would be undertaken, particularly after rainfall to monitor for areas of ponding. The removal of debris, as well as regrading of the channels would be undertaken, as required, to minimise mosquito breeding and reduce habitat for larvae.

2.3.4 Operational phase

The development and implementation of an Operational Environmental Management Plan will reduce potential operational water quality impacts.

Mitigation measures relating to the operational phase of the Project will include the treatment of road runoff prior to discharge to the environment, through the controls identified during the detail design phase.

2.3.5 Operational Surface Water Quality Monitoring Programme

As runoff from road infrastructure has been identified as a significant contributor of heavy metals and other toxicants to local waterways, an ongoing operational monitoring programme is essential to the assessment and management of potential long-term and cumulative impacts to surface waters. The monitoring program would most likely measure upstream and downstream water quality in relation to the Project and will be developed to address reporting requirements for demonstrating compliance with licence conditions.

The following guidelines will be utilised to establish a sound monitoring programme for the Project:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;
- Queensland Water Quality Guidelines 2006
- EPA Water Quality Sampling Manual 1999.

Water quality will be compared with the WQOs of QWQG and ANZECC 2000. If concentrations are observed to exceed the trigger values, and the water quality is non-compliant with licence conditions, additional investigation and mitigation measures will be implemented as required.

2.4 Conclusion

Degraded stormwater runoff is considered the most likely risk to local waterways during both the construction and operational phases of the Project. Sediment is the most likely contaminant from the construction phase, while litter, hydrocarbons and heavy metals are likely to be the major operational phase contaminants.

Although highly modified and currently disturbed ecosystems, the receiving environment would be sensitive to impacts from a further decrease in the quality of stormwater received through increased sediment loads, nutrient runoff, hydrocarbons and other toxicants derived from construction or operation-related activities.

Potential water quality impacts would be mitigated by carefully considering the proposed construction sequencing, identifying potential risks prior to the commencement of construction works and ensuring that appropriate measures are considered and implemented. Development of a detailed Erosion and Sediment Control strategy, adoption of Water Sensitive Urban Design, and the use of stormwater quality improvement devices (SQIDs) for the operational phase, will minimise any potential water quality impacts.

Monitoring of surface water quality would be undertaken so that any issues are detected early and corrective action may be undertaken.

2.5 References

ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality, volume 1, the guidelines (chapters 1-7). Canberra: Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

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Appendix A: Citywide assessment of water quality in Brisbane's creeks: Toowong Creek (Site No. 3) and Enoggera/Breakfast Creek (Site No. 17)

Water Quality Parameters		Toowong Creek (Site No.3)	Breakfast/ Enoggera Creek (Site No. 17)
Dissolved oxygen (% sat)	% sat	70	73
pH		7.4	7.5
Conductivity	mS/cm	4.405	23.943
Temperature	^{o}C	23.3	25
Chlorophyll-a	µg/L	1.2	2.4
Turbidity	NTU	19.5	19
Suspended solids	mg/L	10.5	25.5
Nitrogen (organic) as N	mg/L	0.350	0.340
Nitrogen (ammonia) as N	mg/L	0.059	0.079
Nitrogen (oxidised) as N	mg/L	0.535	0.43
Nitrogen (total) as N	mg/L	1.005	0.85
Phosphorus (dissolved reactive) as P	mg/L	0.092	0.125
Phosphorus (total) as P	mg/L	0.140	0.175
Faecal coliforms	CFU/ 100ml	1200	700

Source: (Webb 2001) A city-wide assessment of water quality in Brisbane's creeks October 1999-April 2000

Table Note: These values represent the median for each water quality parameter measured

Appendix B: Brisbane River Water Quality Summary

Water Quality Parameters		BRISBANE RIVER AMTD 21.7 km UNDER STORY BRIDGE (EHMP) SITE 703			BRISBANE RIVER AMTD 26.1 km UNDER GREY SREET BRIDGE (EHMP) SITE 704			BRISBANE RIVER AMTD 33.7 km (EHMP) SITE 705		
	Unit	Season		Total	Season		Total	Season		Total
		Wet	Dry	Median	Wet	Dry	Median	Wet	Dry	Median
Dissolved oxygen (% sat)	% sat	80.35	91.3	87.6	81	90.8	86.2	76.15	87.25	81.9
pH		7.94	8.01	7.97	7.81	7.94	7.89	7.73	7.85	7.79
Temp	^{0}C	26.57	19.15	24.12	26.63	19.48	24.14	26.75	19.43	24.41
Chlorophyll-a	µg/L	1.80	1.55	1.7	1.75	1.55	1.65	1.3	1.45	1.3
Conductivity at 25^{0}C	mS/cm	42.9	44.75	44.15	36.65	40.25	39.25	28.2	33.15	32.15
Secchi depth	m	0.68	0.75	0.7	0.68	0.8	0.7	0.5	0.65	0.58
Turbidity	NTU	19	19.5	19.0	19	20	19.5	28.5	18.5	26
Nitrogen (ammonia) as N	mg/L	0	0.01	0.01	0	0	0.0	0.004	0.01	0.00
Nitrogen (organic) as N	mg/L	0.2	0.19	0.19	0.21	0.22	0.22	0.27	0.28	0.27
Nitrogen (oxidised) as N	mg/L	0.42	0.46	0.45	0.74	0.64	0.71	1.10	1.10	1.10
Nitrogen (total) as N	mg/L	0.67	0.66	0.66	0.97	0.88	0.93	1.35	1.3	1.3
Phosphorus (dissolved reactive) as P	mg/L	0.2	0.21	0.21	0.31	0.32	0.32	0.46	0.5	0.48

Phosphorus (total) as P	mg/L	0.23	0.25	0.24	0.32	0.35	0.35	0.5	0.53	0.52

Data Source: Healthy Waterways EHMP Monitoring programme (EHMP 2003 – 2007)

Table Notes:

Values in this data represent the median values for water quality components collected between 3/11/2003 – 9/10/2007

Seasonal Data based on Bureau of Meterology rainfall data: Wet Season – 1 November to 30 April

Dry Season - 1 May to 31 October