in brief

Northern Link

environmental impact statement

September 2008

Dedicated to a better Brisbane

SKM Connell Wagner JOINT VENTURE

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The Environmental Impact Statement ... in brief presents the key findings of the EIS for the Northern Link. A full understanding of the project, the potential benefits and impacts and the proposed mitigation measures may be obtained by reading the group of documents entitled "Northern Link, Environmental Impact Statement" dated September 2008.

Contents

1. Introduction

1.1 Northern Link Proponent

The Proponent for Northern Link is Brisbane City Council. The detailed feasibility studies, of which this Environmental Impact Statement (EIS) is one part, are being managed by the Council's Major Infrastructure Projects Office.

Brisbane City Council will seek an evaluation report for this EIS from the Coordinator-General.

Should the Coordinator-General recommend the Project proceed and Council decide to proceed with procurement, a tendering process would determine the successful entity to own for a specified period, and to undertake the design, construction and operation of Northern Link, within the framework of a public private partnership.

1.2 Background to Northern Link

The Commonwealth Government has supported the establishment and upgrading of land transport networks of national and regional significance through its AusLink program. The Brisbane Urban Corridor, as part of this program, connects the major land transport networks, both road and rail, in the west of the South East Queensland (SEQ) region with the air and sea ports in the east, and with other elements of the national land transport network, such as the Pacific Motorway, the Bruce Highway and the standard-gauge rail link to Sydney.

SEQ is the fastest growing region in Australia, with growth being measured by population growth and economic activity. Growth trends in the region have remained strong for some 20 years, to the extent that the Queensland Government took a series of steps towards managing growth and the effects of such growth. SEQ has attracted on average 55,000 new residents each year over the past two decades. The Brisbane Metropolitan area currently accommodates 1.88 million people, about two-thirds of the region's population. Brisbane is the major employment centre for the region and currently has a population of about one million people.

Northern Link forms part of the TransApex initiative introduced by Brisbane City Council, with the election of Councillor Campbell Newman to the office of Lord Mayor in 2004. Since then, Council has undertaken pre-feasibility studies into the suite of projects put forward under TransApex. The Transport Plan for Brisbane now incorporates Northern Link as one of a series of road transport network upgrades proposed to address the effects of population growth and economic development on travel demand within and beyond the City.

1.2.1 Regional Planning

The Commonwealth Government, through AusLink, continues to support regional development within a framework of planned upgrades to the national land transport network. This network includes both road and rail infrastructure and is concerned mostly with the efficient and sustainable movement of people and goods within regions between activity centres including ports and distribution centres. The Commonwealth Government, in conjunction with the Queensland Government, released its strategy for the Brisbane Urban Corridor in 2007[1].

The strategy outlines five key challenges, including:

- east-west transport efficiency across the broad corridor to the Brisbane CBD and Australia TradeCoast;
- efficient safe and reliable transport;
- improved freight distribution and travel within and around Brisbane including key links that support the AusLink Network;
- preparing for future passenger and freight transport needs; and
- efficient operation of the rail system.

Northern Link is identified in the strategy as a key link to expanding the Brisbane Urban Corridor to include the Centenary Highway and its connections to the existing AusLink Network.

The Queensland Government, through the *South East Queensland Regional Plan 2005 - 2026*, has established a framework for managing regional growth. The *South East Queensland Infrastructure Plan and Program 2008 - 2026* (SEQIPP) provides the mechanism for the timely and efficient delivery of infrastructure to meet the needs of the growing population and economy. Within this strategic framework, the Queensland Government has identified the need to manage traffic congestion arising from population growth and economic activity. The strategic responses include developing public transport infrastructure and services to connect designated activity centres with the Brisbane CBD, increasing road capacity to cater for growth and other, integrated planning measures to manage travel demand. SEQIPP also notes that Northern Link is under investigation by Brisbane City Council.

1. Department of Transport and Regional Services, 2007, Brisbane Urban Corridor Strategy – Building Our National Transport Future, the Commonwealth, Canberra.

Flowing from this regional planning and infrastructure planning regime is the *Western Brisbane Transport Network Investigation*[2] (WBTNI) being undertaken by the Queensland Government. Northern Link is one of a number of road transport options identified in WBTNI in response to increasing travel demand from population growth and economic development.

WBNTI notes that Northern Link would form part of an inner motorway ring system connecting the Western Freeway and Inner City Bypass (ICB), and would provide a continuous motorway system and a secondary freight route to the Gateway Motorway and ATC in conjunction with Airport Link. The anticipated reduction of traffic on the key arterials, such as Milton Road and Coronation Drive, is expected to assist in the implementation of public transport improvements such as the Kenmore to CBD busway.

SEQIPP also identifies the concept planning study for the *Centenary Highway Transit Lanes, Ipswich Motorway to Toowong* project. This study is at the beginning of the planning cycle and neither funding nor a construction time frame has yet been approved. The Queensland Government is working with Brisbane City Council to coordinate planning for the Centenary Motorway[3] with Northern Link. This may also include the procurement of an upgrade of the Western Freeway between Moggill Road and the Northern Link Project concurrently with the procurement of Northern Link.

1.2.2 Local Planning

Transport planning at the local, or Brisbane, level is addressed firstly in Brisbane City Council's vision for the future, *Living in Brisbane 2026*[4], through the expression of 'bold aspirations for an accessible and connected city in 2026'. While promoting a balanced approach to the city's transport needs, Council has committed to green and active transport, effective road networks, effective growth management and connected and engaged communities.

2. Queensland Transport, 2008, Western Brisbane Transport Network Investigation, Queensland Government, Brisbane.

3. The Centenary Motorway includes the Centenary Highway between the Ipswich Motorway and Moggill Road and the Western Freeway between Moggill Road and the Toowong roundabout

4. Brisbane City Council, 2006, Our Shared Vision - Living in Brisbane 2026, Council, Brisbane.

With regards effective road networks, Council's vision is:

> *By 2026, residents and visitors will easily reach all parts of the city. Brisbane's road network will be safe, timely and efficient for all users, delivering economic benefits to the community and business. Subtropical boulevards will be created alongside all major road upgrade projects.* (Brisbane City Council, 2006b, p26)

While both the Queensland Government and Brisbane City Council share the common goal of increasing the mode share of trips made by public transport, there is also a shared understanding that continuing strong population growth and economic development in SEQ and specifically in Brisbane, will continue to demand increased capacity in the road network, including the motorway network. The draft *Transport Plan for Brisbane 2006 – 2026* proposes to establish "*… a safe and efficient road network allowing people and goods to move safely on the road network with environmental impacts minimised*"[5]. The *TransApex* motorway initiatives are an integral component of the balanced approach proposed to address Brisbane's long-term transport needs.

5. Brisbane City Council, 2006, Draft Transport Plan for Brisbane 2006 – 2026, Council, Brisbane

1.2.3 Strategic Planning

The Commonwealth Government, the Queensland Government and Brisbane City Council have recognised that the pressures of continued rapid population growth in the SEQ region need to be managed if economic efficiency, quality of life and environmental conditions are to be sustained.

The Commonwealth Government has identified Northern Link as a possible extension of the AusLink National Network to be extended through the Brisbane Urban Corridor and has committed significant funding to deliver the project over the period 2010 - 2013.

Brisbane City Council has established a vision for a liveable Brisbane through to 2026 to meet the challenges of population growth and economic development. Council's planning is consistent with the Queensland Government's regional planning and infrastructure program, and at the local level, also proposes to integrate transport and land use planning.

In this context, Northern Link is part of a much larger plan and program for establishing the physical and infrastructure framework necessary to meet the demands of rapid population growth in SEQ and the Greater Brisbane Area.

Northern Link Tunnel Allignment

1.3 Purpose of the Environmental Impact Statement

This EIS has been prepared in accordance with Terms of Reference (ToR) established by the Coordinator-General under Sections 29 and 30 of the *State Development and Public Works Organisation Act 1971*.

The purpose of the EIS is framed by the objectives stated in the Terms of Reference. Generally, the purpose of the EIS is to describe the Project and its potential benefits and impacts, and to propose measures to mitigate those impacts to the extent possible. The EIS is intended to inform decision-makers about the scope and implications of Northern Link, and to inform agencies, stakeholders and the community about how the Project might affect their interests.

1.4 Consultation and Engagement

An important source of information underpinning the preparation of the EIS, and in the development of the reference design upon which the EIS is based, was a broad-based process of community and stakeholder consultation.

1.4.1 Process

The consultation process included a preliminary phase and the formal notification phase. The preliminary phase commenced with the release of draft Terms of Reference by the Coordinator-General in December 2007, and continued through concept design development and EIS preparation in mid 2008. The formal notification phase is expected to commence in October and conclude in December 2008.

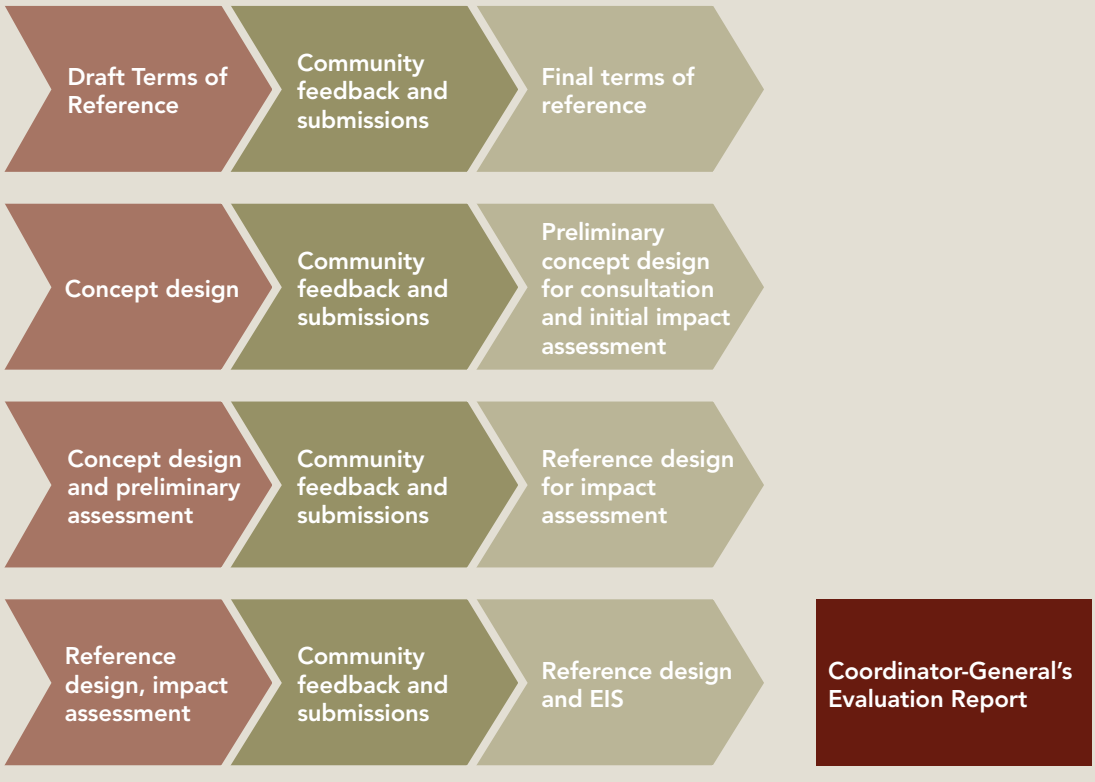
Throughout the consultation process, the approach has been to provide to the community, stakeholders and agencies, information about Northern Link to the extent it was available at the time. Comments received were fed back into the design development and impact assessment processes. A conceptual model of the preliminary consultation process is presented in **Figure 1**.

1.4.2 Preliminary Consultation Program

The preliminary consultation program sought to achieve a number of outcomes.

- Community awareness of the Northern Link proposal and of the EIS process.
- Stakeholder and agency awareness of the Northern Link proposal and of the EIS process.

Figure 1: Community and Stakeholder Consultation



- Participation and input from the community, stakeholders and agencies to help refine the concept design, leading to development of a reference project for assessment in the EIS.
- Awareness and understanding of the potential impacts of Northern Link, should it proceed.
- Understanding of the process for involvement in the consultation process and for the making of submissions to the Coordinator-General.

The preliminary consultation program was delivered through a range of interactions with the community, stakeholders and agencies.

- Community – letters and face-to-face communications with people whose properties would be acquired (surface), distribution of newsletters throughout the study corridor, regular meetings of community reference groups, regular community information sessions, staffed displays at Council libraries, staffed inquiry telephone and email services, regular updates on the EIS website and Council website, and interactions with community groups and individuals seeking further or more detailed information about aspects of Northern Link.
- Stakeholders – scheduled interaction with stakeholders to provide and receive information in relation to specific issues (eg: air quality, cultural heritage including indigenous cultural heritage, Botanic Gardens – Mt Coot-tha (the Botanic Gardens) and use of Council-owned land, Mt Coot-tha Quarry and use for spoil handling, schools, precinct planning, project design issues).
- Agencies – scheduled interaction with State and local government agencies to update on project designs and progress with environmental studies and community feedback, scheduled interaction to address project and project-design issues (eg: connections with State-controlled roads, fire and life safety, air quality).

Considering the level of community involvement in information sessions, staffed library displays, and the formation of local interest and action groups, the preliminary consultation program achieved its intended outcomes. While some aspects of the Northern Link reference project are known to be of concern to local residents, the feedback provided during preliminary consultation has assisted in clarifying the nature and scope of those concerns for inclusion in reporting in the EIS. A graphic summary of the key issues of concern is presented in **Figure 2**.

Some local communities are particularly concerned about the potential impacts of Northern Link. Local community groups, such as Toowong Tunnel Solutions and the Normanby Action Group, amongst others, have provided a focus for the expression of community concerns during the preliminary consultation program. These groups have succeeded in delivering their concerns to the Council and the project team, and in doing so, have served to inform the EIS process.

1.4.3 Engagement

The stakeholder and agency engagement program was typically undertaken on specific issues or interest areas, and included all levels of government, entities responsible for land management, institutions and industry groups.

The Commonwealth Government has been engaged from the inception of the Northern Link preliminary assessment through to the detailed feasibility studies. Northern Link was referred to the Minister for the Environment, Heritage and Arts[6] who determined it was not a "controlled action" under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (Clth) as it would not likely impact a matter of national environmental significance. The Department of Transport and Regional Services was also consulted in relation to the strategic merit of Northern Link in the context of the AusLink National Network. As noted in Section 1.2.1 of this summary, the 2007 Brisbane Urban Corridor Strategy[7] anticipates expansion of the Brisbane Urban Corridor to include links to the Centenary Highway, such as Northern Link, as part of a strategy to enhance cross-city movements of people and goods.

6. Minister for Environment Heritage and Arts has responsibility for implementation of the Environment Protection and Biodiversity Conservation Act 1999.
7. Department of Transport and Regional Services, 2007, 2007 Brisbane Urban Corridor Strategy, Commonwealth Government, Canberra.

Figure 2: Summary of Key Community Issues

Community Issues	Mt Coot-tha	Toowong	Kelvin Grove	Mainline Suburbs
Property impacts – direct		High concern	High concern	
Property impacts – volumetric		Moderate concern	Moderate concern	Moderate concern
Project design (local connection)		High concern	Moderate concern	
Construction (noise, vibration, dust)	Concern	Concern	Concern	Concern
Construction (traffic)	Moderate concern	Moderate concern	Moderate concern	
Local traffic (rat-running)		Moderate concern	Concern	
Traffic (major routes)	Concern	Concern	Concern	
Air quality and location of vent outlets	Moderate concern	Concern	Concern	Concern
Visual impact (surface works)	Concern	Moderate concern	Moderate concern	
Land use and character		Moderate concern		
Community well-being		Moderate concern	Moderate concern	Concern

High concern Moderate concern Concern

The Queensland Government has been engaged on aspects of Northern Link, including:

- strategic transport planning in relation to the Western Brisbane Transport Network Investigation, the South East Queensland Regional Plan 2005 – 2026 and the South East Queensland Infrastructure Plan and Program 2008 – 2026;
- project design issues including road design, fire and life safety design, construction traffic management;
- environmental and planning matters including air quality, noise and vibration, hydrogeology, cultural heritage, land use planning and community impacts; and
- project governance issues.

Brisbane City Council divisional interests have been addressed through a series of project briefings, providing participants with the opportunity to raise issues with the project team. On-going internal communications have sought to resolve a range of matters such as:

- use of the Mt Coot-tha Quarry for the handling and storage of spoil;
- temporary use of part of the Botanic Gardens for the Western Freeway worksite;
- land use and planning implications; and
- potential impacts on a number of Council assets, including the Toowong bus depot, the Toowong Cemetery, Anzac Park and Quinn Park, and the Victoria Park golf course.

1.4.4 On-going Process

The EIS for the Northern Link Reference Project is now available for public comment. Written submissions received in relation to the EIS are taken to be submissions relating to a subsequent development application for impact assessment under the *Integrated Planning Act 1997*.

The Coordinator-General will assess the EIS against the Terms of Reference and must take into account all properly made and other submissions accepted about the EIS. The Coordinator-General may ask the Proponent for additional information in response to matters raised in submissions.

The evaluation of the environmental effects of the Reference Project will be conducted by the Coordinator-General under Part 4 of the State Development and Public Works Organisation Act 1971 (SDPWO Act). The Coordinator-General must, after the end of the submission period, consider the EIS, all properly made and other submissions accepted by the Coordinator-General about the EIS and any other material the Coordinator-General considers is relevant to the project.

The Coordinator-General is required to report on the evaluation of the EIS and may make recommendations and state conditions, including imposed conditions, for the undertaking of the project. The Coordinator-General's Report, with its evaluation, recommendations and conditions will be provided to the Council and will be made publicly available.

It is intended that the process of delivering the Project, following the Coordinator-General's approval of the Reference Project as contained in the Coordinator-General's Report will be in partnership with the private

sector. The request for tenders to deliver the Project would encourage project solutions that are innovative and lead to design improvements over the Reference Project as described in the EIS. The Coordinator-General may also recommend that the request for tender for the Northern Link Project seek innovation aimed at further mitigation of the risk of impact of the Project in a manner that complies with the objectives of the Project.

In this regard, the Reference Project remains open to both changes in design and to its methods of project delivery, including construction, provided any changes comply with the objectives of the Project. Changes to the Project may be brought through the request for tenders to design elements such as the alignment of the tunnels and the location of surface road connections, amongst other things. Changes to project delivery may provide for new processes in construction or spoil haulage.

The SDPWO Act provides a process for the Coordinator-General to evaluate changes to a significant project, previously the subject of an evaluation report by the Coordinator General, including:

- the Proponent requesting evaluation of the proposed change by the Coordinator-General;
- the Coordinator-General referring the details of the proposed change to anyone able to assist in making the evaluation;
- asking the Proponent for further information about the proposed change, its effects on the project or any other related matter;
- requiring the Proponent to publicly notify the proposed change and its effects on the Project.
- The Coordinator-General's evaluation of the proposed change, considering all properly made submissions, the nature of the change and its effects on the project, the project as evaluated under the Coordinator-General's report for the EIS for the project, the environmental effects of the change and its effect on the project.

Finally, the Coordinator-General would prepare a 'Change Report' that would evaluate the effects of any proposed change and may state such conditions as are necessary to address the impacts of the proposed changes. The Change Report must be given to the Proponent and must be publicly notified. The Coordinator-General's Evaluation Report for the EIS and the Change Report both have effect for the final project, however the Change Report prevails to the extent of any inconsistency.

Submissions to this EIS should be in writing, signed by each person making the submission, state the name and address of each person making the submission and state the grounds of the submission and the facts and circumstances relied on in support of those grounds.

Submissions to this EIS should be addressed to:

The Coordinator-General

c/- EIS Project Manager – Northern Link Road Tunnel
Infrastructure Development Division
Department of Infrastructure and Planning
PO Box 15009 City East Qld 4002

northernlink@dip.qld.gov.au

2. Northern Link

2.1 Purpose of Northern Link

In TransApex, Northern Link is envisaged as the critical 'missing link' in the motorway network for travel to and from the western suburbs and beyond. Once completed, the motorway network would provide an effective bypass of the Brisbane CBD for the cross-city movement of people and goods. Northern Link, as part of an overall transport strategy, would help relieve the traffic congestion on the major arterials from the west presently limiting the competitive advantages of the CBD and other designated activity centres in the western suburbs.

Implementation of Northern Link also provides opportunities for enhanced public transport on key arterials, such as Coronation Drive and Milton Road. These arterials are heavily congested in peak periods, limiting their utility as attractive public transport corridors for CBD-bound trips.

2.2 Objectives of Northern Link

The primary objective for Northern Link is to improve east-west cross-city movement of people and freight.

Secondary objectives for Northern Link are:

- Transport network
  - To address deficiencies in the national freight network to improve freight distribution in and around Brisbane.
  - To provide opportunities for additional public transport capacity.
- Environment
  - To protect and, where possible, enhance the environment.
- Social
  - To assist development of a sustainable urban environment for inner-western suburbs.
- Value for money
  - To deliver value-for-money over whole of project life.
- Timeliness
  - To deliver Northern Link by June 2013.

2.3 What is Northern Link?

2.3.1 Project Overview

Northern Link is a motorway link connecting the Western Freeway at Mt Coot-tha in the west, with the ICB at Kelvin Grove in the north, and proposed to be constructed mostly in tunnels deep beneath the inner western suburbs of Brisbane.

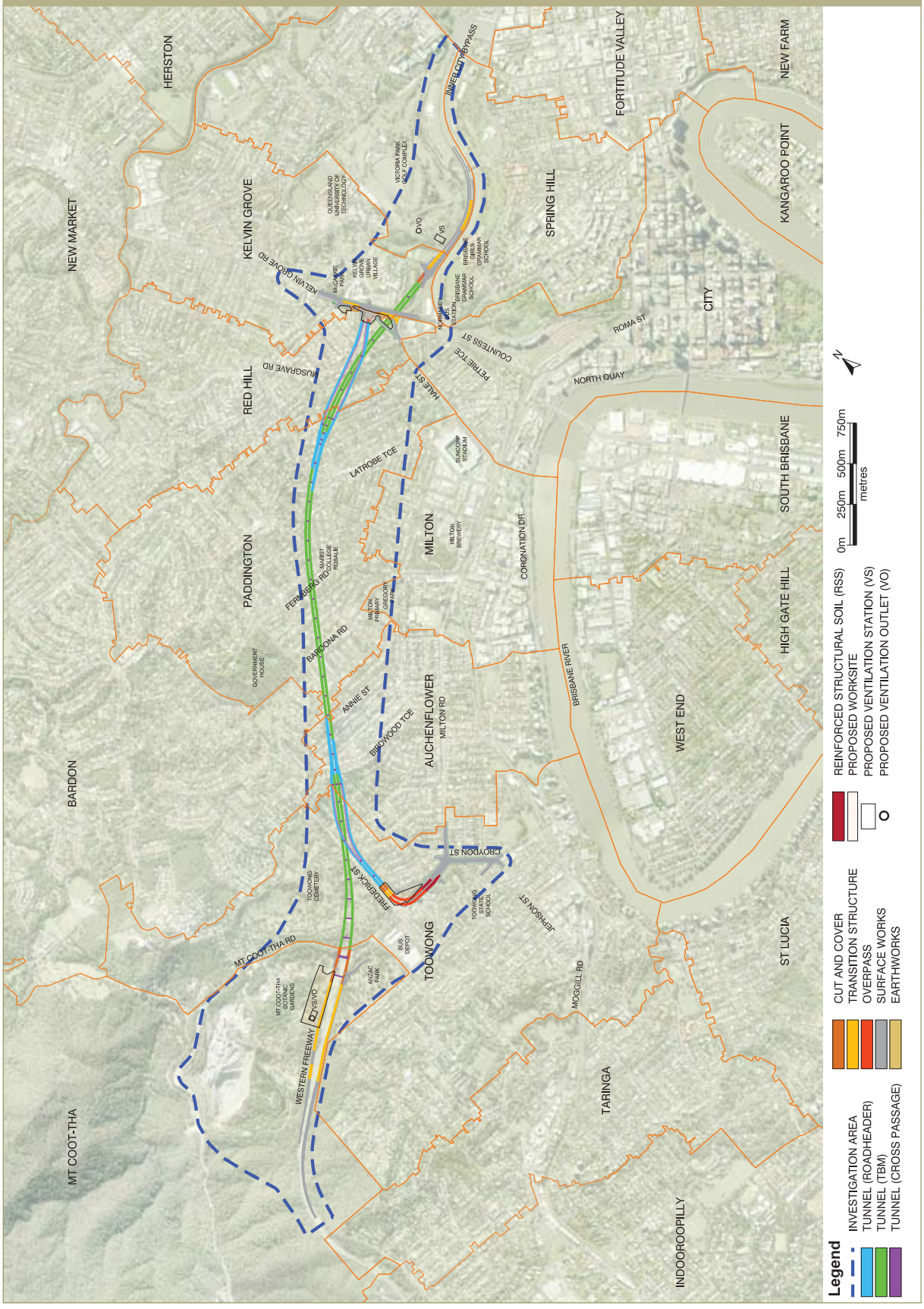
The Project would be approximately 6.4km long, with approximately 4.3km constructed in tunnel, mainly in hard competent rock below residential areas of Toowong, Auchenflower, Paddington, Red Hill and Kelvin Grove. Surface works would extend into Mt Coot-tha and Herston as shown on **Figure 3**. A local connection to Milton Road would be provided east of Frederick Street in Toowong. Another connection is proposed to Kelvin Grove Road at its intersection with Musk Avenue.

Northern Link would be a tolled road delivered by a public private partnership between Brisbane City Council and the private sector, with the support of funding from the Commonwealth Government. While a final decision on the tolls for Northern Link would be made by the Queensland Government and Council, the tolls assumed and modelling for the EIS traffic assessment is $3.93 (expressed in $2008 including GST) for cars and twice that amount for heavy vehicles ($7.86).

Northern Link would include:

- two separate parallel road tunnels, one for eastbound traffic and one for westbound traffic, with two traffic lanes in each tunnel;
- tunnel portals and associated transitions connecting with the surface road network in four locations:
  - on the Western Freeway just west of the Mt Coot-tha Road roundabout at Mt Coot-tha;
  - just east of Frederick Street and north of Milton Road, in the vicinity of Valentine Street in Toowong;
  - on the ICB at Kelvin Grove; and
  - just west of Kelvin Grove Road at its junction with Musk Avenue, also in Kelvin Grove.
- safety systems including safety exits, fire protection and monitoring systems;
- a ventilation system to manage air quality in each tunnel and near portals, including ventilation stations to house the extraction fans and elevated outlets near the portals adjacent to the Western Freeway and the ICB;
- surface road changes to connect the Project with the existing road network;
- traffic management systems including signage, lighting, CCTV and radio/mobile re-broadcast capability;
- electronic tolling, plant monitoring and control systems; and
- a suite of urban design and landscape measures for the above-ground infrastructure, the ventilation station and ventilation outlet, and residual land adjacent to each of the portals.

Figure 3: The Reference Project Design



2.4 Project Design

The reference design for Northern Link, on which the EIS is based, is the product of a series of investigations and design studies commencing with the TransApex pre-feasibility studies in 2004, a preliminary assessment study in 2006-07 [8], and detailed technical studies linked with the EIS in 2007-08. This process of design development has been supported by inputs from the preliminary consultation program, agency engagement and from the EIS technical studies. The reference design is shown in **Figure 3**.

2.4.1 Consideration of the Project Without Connections

During the development of the project, a design without connections at Toowong and Kelvin Grove has been developed (the 'straight through' option). See **Figure 4**.

This option is capable of meeting the strategic needs of the project and work to date indicates that it could produce an acceptable outcome for Council while maintaining significant local community support.

In exploring the opportunities for the project, it needs to be recognized that despite the popularity and acceptability of the straight through option with Council and the local community, by seeking innovation through the tendering process these localised connections may provide presently unrecognised benefits for Council and the community. To this end, the Reference Design submitted for consideration includes connections at Toowong and Kelvin Grove. The reasons for this include:

- It would involve a more comprehensive assessment of the project's benefits and impacts than omitting them - and in the interests of the community these impacts and benefits need to be fully understood.
- It would give the community a complete assessment of the project with connections and a good understanding of the project without connections

It is important to note delivery of the project would proceed as a Public Private Partnership and will allow for bidding consortiums to innovate and propose solutions that lead to design improvements over the EIS Reference Design. Public submissions to the EIS will help the consortiums understand local concerns and aid in the potential development of alternative solutions. While there is some initial preference by Council and the local community for the final design not to contain connections at Kelvin Grove and Toowong (as currently detailed in the reference design), it is possible that through the innovative PPP process, proponents may develop solutions that address the concerns of Council and the local community while still providing some form of localised access to the tunnel.

The preferred tenderer is likely to be announced in mid 2009. In order to achieve the best outcome for Council and the community, tenderers need scope to submit proposals that differ from the EIS Reference Design. Consequently, a Request for Project Change may be lodged with the Coordinator General for public comment at that time.

2.4.2 Design Components

Northern Link consists of a number of distinct components, each of which involves detailed technical consideration of Project objectives and technical design criteria. Such components include:

- tunnel design – structures, geology, drainage, design life and durability;
- road design – surface connections including intersections and in-tunnel roadways;
- ventilation system for maintaining in-tunnel air quality and for managing impacts on ambient air quality;
- fire and life safety system, including evacuation facilities and systems, smoke extraction system, fire control system, closed circuit television (CCTV) and communications system; and
- tollroad control system consisting of traffic management, maintenance, electronic toll collection system.

Tunnel Design

In the absence of common standards for road tunnels, the Northern Link design would draw upon national and international standards, guidelines and practices for both construction and operational phases.

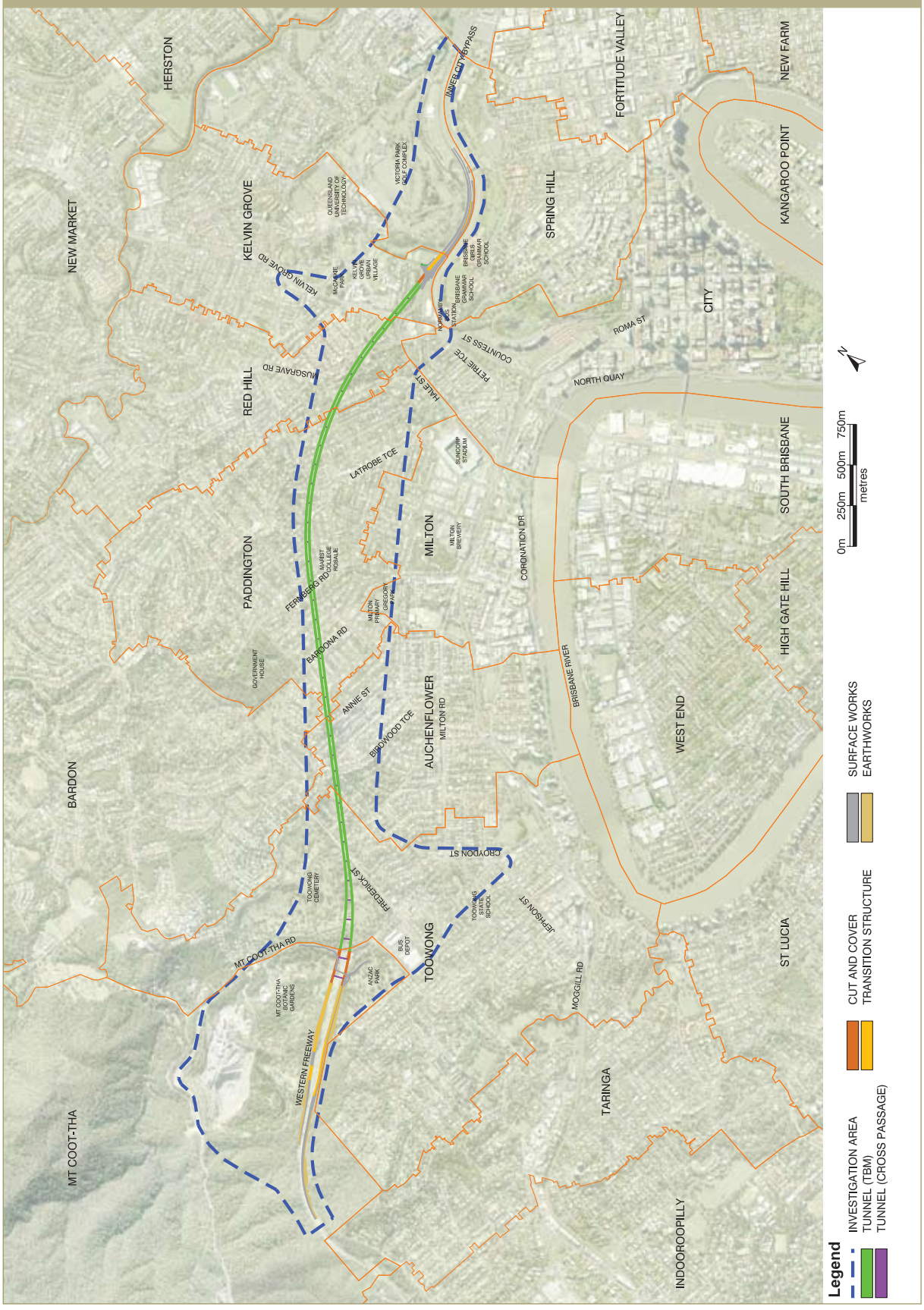
The tunnel design provides for two parallel mainline tunnels, with a minimum separation of at least 10m in the driven tunnel sections. Cross-passages for emergencies and evacuations would connect the two tunnels at regular intervals of approximately 120m along the route.

Generally, the mainline tunnels would traverse deep under the suburbs of Toowong, Auchenflower, Paddington and Red Hill, with the greatest depth exceeding 70m. Due to significant physical relief in the landscape of these suburbs there are a number of sections along the mainline tunnels in which the separation between the surface and the crown of the tunnels is reduced to distances requiring careful construction planning and implementation. In some locations in Paddington and Red Hill, the separation to the surface would be less than 20m.

The connections at Toowong and Kelvin Grove would be designed to respond to alignment, gradient and connection constraints and controls. Generally, each of the connection tunnels would be aligned as close as practical and in parallel with the other tunnel in the combination. Due also to the variable physical relief of the hilly inner western suburbs, some of the connection tunnels would be constructed with limited separation to the surface. In some locations in Toowong, the depth would be less than 20m.

8. Brisbane City Council, 2007, Northern Link Preliminary Assessment Report, Council, Brisbane

Figure 4: The Project Without Connections



Lane widths, separations and shoulders would accord with Queensland Department of Main Roads planning and design standards for road planning and construction. Each mainline tunnel would have two 3.5m wide running lanes, with a 1m wide shoulder on the left hand side and 0.5m on the right, suitable to achieve a design speed of 90km/h for a sign-posted speed of 80km/h. With this lane configuration there would be sufficient room to pass by a stationary vehicle, safely and at an appropriate speed. Typical cross sections for the tunnels are shown in Figure 4-3 in Chapter 4 of the EIS.

The maximum desirable grades for the mainline tunnels would be 5%, with a minimum grade of 0.5% to ensure operation of the in-tunnel drainage system. The maximum desirable grade for the local connection tunnels and ramps would be 7% declining and 5% climbing. The climbing tunnels would need to include two traffic lanes to accommodate slow-moving vehicles in the left-hand lane.

The lane configuration also provides for the use of the tunnels by heavy vehicles, including B-double vehicles, or heavy truck and trailer up to 4.6m in height. B-double combinations 4.3m to 4.6m high may only be used in Queensland on an approved B-double route, which currently exclude the Western Freeway and there is no intention of designating the tunnel for B-double use.

The reference design for Northern Link would allow for the potential movement of surface water and groundwater drainage into each tunnel, with collection and removal via a sump system in the sag or low point for each. Groundwater inflows to the tunnels are expected to be low to very low. The technical studies indicate that the potential for damage to surface infrastructure and structures from dewatering and associated consolidation induced settlement is very low.

The portal for each of the tunnels would be situated at an elevation above or clear of flood waters in a one in 10,000 year ARI [9] event, whereas the surface connecting roads would be above or clear of a one in 100 year ARI event. Similarly, all plant and equipment such as the ventilation station and tollroad control centre would be designed and constructed to be clear of a one in 100 year ARI event.

Surface Connections Design – Western Freeway

The reference design for Northern Link connection at the Western Freeway takes into account the future planning requirements of the Department of Main Roads for the Western Freeway to include three lanes each way to the existing Mt Coot-tha Road roundabout, including two general purpose lanes and a transit lane (T2). Northern Link ramps and portals would be provided on the outside of the existing Western Freeway allowing capacity for the future road widening of the Western Freeway, with the transit lanes (T2) on the inside.

There would be no permanent road works west of the Toowong roundabout. The Mt Coot-tha roundabout would be retained in its present configuration.

The existing cycle and pedestrian route along the Western Freeway, and the new overpass presently being constructed by Department of Main Roads (DMR), would be relocated to accommodate the Northern Link exit ramp. The connections and functions for this route and overpass would be maintained as planned by DMR.

Surface Connections Design – Toowong

The Toowong connection would be via grade-separated, two-lane east-facing ramps connecting with Milton Road and Croydon Street. Similarly, grade-separated, two-lane ramps from Milton Road west of Croydon Street, would connect into the Toowong tunnel ramps. Milton Road would be widened between Sylvan Road and Croydon Street, from its existing two lanes in each direction, to three lanes in each direction, in addition to the lanes connecting with Northern Link. In this section, Milton Road would be widened to include 10 traffic lanes, with four of those being for Northern Link connections.

The Toowong Roundabout, Frederick Street, and the existing elevated ramp from Frederick Street to Mt Coot-tha Road would not be affected by the Project design.

The lanes from Northern Link would be directed into Croydon Street through the upgraded, signalised intersection. No direct access would be provided to Milton Road or Morley Street. Croydon Street would be widened between Sylvan Road and Milton Road, from its existing two lanes in each direction to three lanes in each direction, with a diverging lane turning left into Milton Road and a diverging lane turning left into Sylvan Road. In this section, Croydon Street would be widened to include six traffic lanes plus diverging lanes.

Normanby Fiveways

9. ARI: The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. Source: Australian Government – Bureau of Meteorology, http://www.bom.gov.au/hydro/has/ari_aep.shtml

The pedestrian crossing on the western approach to the intersection of Milton Road and Croydon Street would be removed. The pedestrian crossings at the eastern approach to the intersection of Milton Road and Croydon Street, and Milton Road and Morley Street would be maintained through the provision of pedestrian crossings on three of the four approaches. The on-road cycle paths on Sylvan Road and its connection with the Western Freeway and the Bicentennial bikeway would be maintained. The on-road cycle paths would be maintained on the Sylvan Road approaches to the Croydon Street/Jephson Street/Sylvan Road signalised intersection.

Surface Design – Inner City Bypass

The ICB at present is configured with three lanes in each direction. With Northern Link, the lane configuration at the ICB connection would be expanded to provide two lanes each way for the Northern Link and two lanes each way for the ICB. For east-bound traffic, Northern Link would surface via cut and cover construction and transitions west of the Inner Northern Busway, with the traffic lanes merging into the ICB via outside lanes before the land bridge at York's Hollow.

For west-bound traffic, a transition in the centre of the ICB would provide two direct lanes to Northern Link, with traffic flows from the ICB to Hale Street maintained through a lane drop and a divergence at the Land Bridge to create two lanes that would continue to Hale Street. The divergence to Ithaca Street would be maintained.

Local connections with Kelvin Grove Road, Ithaca Street and Victoria Park Road would be maintained.

The surface connections between Northern Link and the ICB and the local road network would not prejudice any possible future implementation of the known schemes for the City West initiatives of the Queensland Government.

Kelvin Grove Urban Village

Surface Design – Kelvin Grove

Northern Link would provide direct connections to Kelvin Grove Road for both general traffic and possibly for express buses from the western suburbs. The connections would occur on Kelvin Grove Road at the intersection with Musk Avenue, to provide a four-way, signalised intersection.

The Northern Link off-ramp to Kelvin Grove Road includes a widening of the two-lane tunnel to three lanes approximately 220m from the signalised intersection with Kelvin Grove Road, providing:

- a dedicated, free-flow, single left lane to merge with Kelvin Grove Road northbound; and
- two lanes providing a right turn to Kelvin Grove Road (southbound). The outside lane of this configuration would also provide a connection to Musk Avenue.

Northern Link would be accessed from Kelvin Grove Road from the north and south as well as from the existing loop that connects Musgrave Road with Kelvin Grove Road (northbound).

Access from Kelvin Grove Road (southbound) would be provided through a diverge adjacent to the median of Kelvin Grove Road south of Blamey Street. The diverge would lead directly into the tunnel via a cut and cover portal avoiding the signalised intersection of Kelvin Grove Road, Musk Avenue and the Northern Link southbound off ramp.

Access from Kelvin Grove Road (northbound) would be provided through a single left lane diverge north of the ICB to a cut and cover tunnel. Combined with a merge from the Musgrave Road loop, this connection would create a two lane on-ramp tapering to one lane within the tunnel prior to merging with the on ramp from Kelvin Grove Road (southbound). This on ramp would also avoid the intersection of Kelvin Grove Road, Musk Avenue and Northern Link.

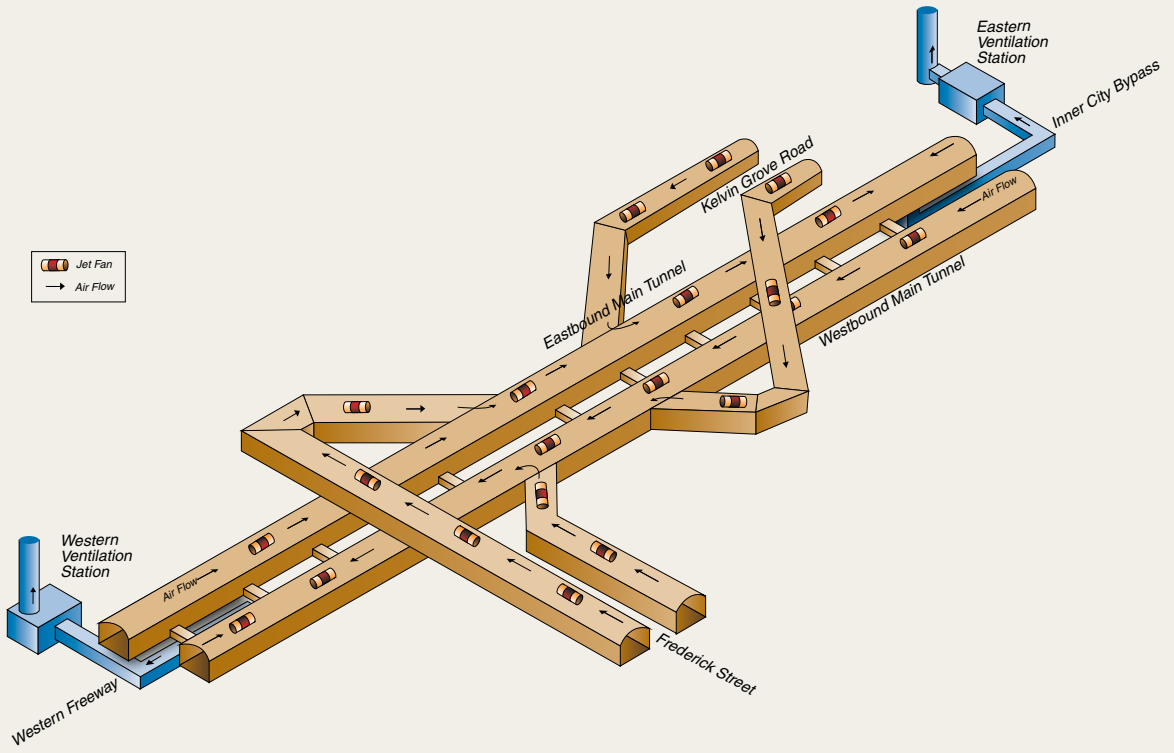
Surface works on Kelvin Grove Road would extend from Ithaca Street to Blamey Street. The existing Kelvin Grove Road through lane capacity would be maintained. Some modifications of the Kelvin Grove Road/Blamey Street intersection would also be required, with all turning movements maintained.

Lower Clifton Terrace would become a cul-de-sac with access only from Musgrave Road, while Westbury Street would have access via a new service road to Victoria Street. Victoria Street would no longer have direct access to Kelvin Grove Road.

Tunnel Ventilation Design

Northern Link would be equipped with a longitudinal ventilation for each of the two mainline tunnels. With this approach, there would be a ventilation station and a ventilation outlet for each of the mainline tunnels situated near the outbound portal. Each of the local connection tunnels would also be ventilated with this system so that in-tunnel air would be drawn back within the tunnel, to the mainline tunnel for collection and

Figure 5: Schematic Design – Ventilation System



removal at the extraction point upstream from the outbound portal. See **Figure 5**.

The ventilation system would be designed to achieve stringent international standards[10] for in-tunnel air quality. The primary objective for in-tunnel air quality is to attain and maintain user safety due to visibility and acute health responses. A summary of the design criteria for the ventilation system is presented in **Table 1**.

The ventilation station and the ventilation outlet for Northern Link would be situated as follows.

- Western – the ventilation station would be situated on Council owned land on the Mt Coot-tha side of the Western Freeway approximately 400m west of Mt Coot-tha Road and to be cut into or partially buried within the forested slope of the hillside in this location. The outlet would stand above the ventilation station to achieve a minimum height of 20m or RL66.4m.
- Northern – both would be on Council owned land within the Victoria Park Golf Course with the ventilation station partially buried in the hill on the eastern side of the Inner Northern Busway and north of the ICB. The ventilation outlet would be situated approximately 150m to the north, on a topographic rise on the eastern side of the busway. The ventilation outlet would achieve a minimum height of 15m or RL57.1m.

The selection of the sites for each of the ventilation stations and ventilation outlets was subject to a number of criteria and was incorporated in the preliminary consultation program. The primary criterion was the requirement of easy achievement of the stringent goals for ambient air during 'worst case' operating conditions. Community comments related principally to concerns about the potential impacts on air quality and community health, with considerable interest also relating to visual impact and perceptions impacting on property values. Each of the sites selected responded well to the selection criteria.

There was also a high level of interest in whether filtration equipment would be installed. While the Project design does not propose the installation of filtration equipment, it does allow for the retro-fitting of filtration at each of the ventilation stations, should monitoring indicate a need for it.

Tollroad Control Centre and Traffic Management

A Tunnel Control Centre would be located adjacent to the Western Freeway within the rehabilitated worksite area. Fire protection, traffic management and control,

10. PIARC: World Road Association or l'Association mondiale de la route.

Table 1: Tunnel Ventilation Design Criteria

Criteria		Measure
Carbon monoxide (CO)	at any time under free-flowing conditions	70ppm
	at any time in peak or congested conditions	90ppm
Nitrogen dioxide (NO_2)		1 ppm average
Visibility*	in free-flowing traffic	0.005 m^{-1}
	in congested traffic	0.007 m^{-1}
Portal discharge		No net discharge at peak conditions

Table Note:
* The measure applied to visibility refers to an 'extinction or visibility coefficient' based on the decay of a light beam as it passes through smoky air - K = 0.003m-1 describes clear tunnel (visibility several hundred meters) and K = 0.007m-1 describes a foggy atmosphere

communications and emergency procedures to provide for safety management would be provided and managed from the Tunnel Control Centre. A secondary depot for maintenance and emergency vehicle parking could also be provided near the ICB connection.

Emergency and Other Services

A critical component of Northern Link is the fire and life safety system. This would be a completely integrated system of measures and procedures designed and operated to ensure there would be minimal risk to users and employees of the Project in all circumstances. The fire and life safety system would comprise a number of key elements including:

- an incident detection system;
- an alarm and communication system;
- a smoke hazard management system;
- a deluge system for fire management;
- fire fighting facilities;
- structural fire resistance;
- emergency exits via cross-passages at 120m intervals along the tunnels;
- emergency lighting and signage; and
- a back-up power supply.

2.5 Construction of Northern Link

The construction methodology will ultimately depend on the contractor requirements and detailed engineering. The following elements of construction have been identified for the purposes of assessing a Reference Project construction methodology in the EIS.

2.5.1 Construction Program and Responsibilities

Should Northern Link be approved and proceed, construction would take approximately 3.5 years, with the Project likely to be open to traffic by mid 2013.

The construction of the proposed works would involve three key phases, namely:

- pre-construction activities such as design and site establishment;
- construction of project works; and
- commissioning.

The responsibility for undertaking and completing construction of the Project in accordance with the Coordinator-General's conditions and any other approvals required by legislation, would rest with PPP Co.[11]

2.5.2 Tunnel Construction

The driven mainline tunnels between the Western Freeway and the ICB would be constructed mostly by two, open, hard-rock tunnel boring machines (TBMs), launching from cut and cover works on land adjacent to the Botanic Gardens at Mt Coot-tha. The cut and cover construction would serve as an effective, acoustic enclosure for the launch of each of the TBMs. The TBMs would be removed from the mainline construction in cut and cover works situated within the ICB corridor.

The tunnels serving the surface connections at Kelvin Grove and Toowong would be constructed by roadheaders launching from cut and cover construction or from within ventilated, acoustic enclosures. The dimensions of the connection tunnels would vary to allow for safe and efficient traffic flows both at the surface and in the underground junctions with the mainline tunnels. Construction on these tunnels would commence from worksites at Toowong and at Kelvin Grove, with roadheaders progressing towards the mainline tunnels at the same time. Roadheaders would be launched at these worksites from within ventilated acoustic enclosures.

11. PPP Co: the entity appointed by Brisbane City Council to design, build, own and operate Northern Link for an agreed period, most likely to be 45 years.

The mainline tunnels and the local connection tunnels would be lined with a waterproof membrane but may not be completely watertight. The connection tunnels constructed by roadheader would be lined with a waterproof membrane, which would control the flow of groundwater over the crown and walls of the tunnels.

Cut and cover tunnel construction would be required to establish the launching points for driven tunnelling at each of the connections. The extent of cut and cover construction at both the Toowong connection and the Kelvin Grove connection is limited in comparison with the overall tunnelling task, due to the topography in those locations. More extensive cut and cover construction is required to establish both the in-bound and out-bound connections at the Western Freeway and at the ICB.

At the Western Freeway, detailed design would need to address a range of factors including the need to maintain traffic capacity through the Mt Coot-tha roundabout, hydrogeological conditions and adjacent land uses. At the ICB, detailed design would need to address the need to maintain traffic capacity on the ICB, local hydrology, existing infrastructure and adjacent land uses.

Construction management and impact monitoring would be provided for both driven tunnelling and cut and cover construction to predict and then avoid or minimise, mitigate and manage the potential effects of construction on the properties above the mainline tunnels and the connection tunnels. A performance-based approach to environmental management is proposed, in combination with an effective method of on-going monitoring of key indicators, communication and consultation, complaints management, reporting and corrective actions. Also, on-going consultation with near neighbours would be required to ensure concerns are understood and addressed.

2.5.3 Surface Construction

Each of the tunnel connections would entail sections of cut and cover construction and sections of open trough excavation, possibly involving the use of drilling and blasting techniques due to the high rock strength and hardness. For this reason, drilling and blasting may also be required in some sections of underground works.

Surface roadworks would also be required to provide the lanes and ramps into and out of the tunnel connections. Such roadworks would be constructed at grade in the case of the Western Freeway and ICB connections, and in decline ramps, elevated structures and reinforced earth ramps in the case of the Kelvin Grove and Toowong connections.

Surface construction works would be subject to environmental management measures to avoid where practicable, or to minimise, mitigate and manage the effects of construction on nearby properties and their occupants. The EIS presents a performance-based approach to achieve the environmental objectives for the construction phase.

The surface works on heavily-trafficked arterials, such as the ICB, Kelvin Grove Road and Milton Road would require effective traffic management practices to minimise the disruption to traffic flows, especially in the peak periods. For the reference project, the traffic management measures presented in the EIS assume the maintenance of traffic lanes, although with diversions, through and around these worksites, most of the time. There may be periods when lane closures are required to undertake night works as a means of avoiding peak traffic flows. Approvals from relevant authorities would be required, along with a community notification process, ahead of such measures.

2.5.4 Spoil, Handling and Haulage

Spoil from TBM construction will report back to the Western Freeway worksite. From there, spoil would be transported by conveyor to the Mt Coot-tha Quarry for storage and treatment in accordance with their existing environmental authority.

The majority of the spoil from the Toowong worksite would also be transported by road to the Western Freeway worksite, and then by conveyor to the Mt Coot-tha Quarry. Unsuitable material would be transported from the worksite by road directly to the Swanbank landfill placement site. Spoil from the Kelvin Grove worksite, and from the ICB portal, would be transported by road to placement site(s) within the Port of Brisbane.

The estimated quantities of spoil to be generated during the construction of Northern Link are presented in **Table 2**.

The proposed Mt Coot-tha conveyor would be enclosed to mitigate potential impacts from noise and dust. The proposed conveyor would negate the need for nearly 65,000 loaded truck trips during the construction period. This is approximately half of the total truck trips that would be required if a conveyor to the quarry was not used for the project.

2.5.5 Traffic Management Under Construction

The maintenance of traffic flows on the key arterials, such as the Western Freeway, Milton Road, Kelvin Grove Road and the ICB, is a primary objective for traffic management measures during construction of Northern Link.

Changes and potential disruptions to traffic and access arrangements during the construction phase are always of concern to residents, local businesses and community facilities. At the same time, it is also important for construction traffic to have safe and efficient access to the construction worksites, and for the workforce to be able to move safely within the worksites.

Access to each of the worksites would be provided to achieve construction efficiency while minimising impacts on the traffic flows on adjacent roads. For the Western Freeway and Toowong worksites, construction vehicles would enter via left-in, left-out access arrangements, while access to the Kelvin Grove worksite would be controlled by traffic signals for trucks entering and leaving the worksite. Access to each of the ICB worksites would require trucks to enter and leave the site in the same direction as the traffic flow.

Staging of works at all sites would allow the existing number of through lanes to be provided past the sites at most times, though temporary alignment changes would be required. As a result, the level of through traffic intrusion into adjacent areas is expected to be small. Occasional short duration partial closures are likely, for example for intersection works. These would be scheduled to minimise their impact.

Bus routes and schedules would not be affected by construction. However, bus stops adjacent to the Toowong worksite and Kelvin Grove worksite would require temporary relocation during construction.

Emergency service vehicle routes would not be affected by the construction of the Project.

Pedestrian access, pedestrian crossings, cycle access including the Western Freeway pedestrian and cycle overpass now under construction, would be maintained around all worksites, though some temporary closures and diversions would be required. These will be detailed in the Construction Traffic Management Plan (CTMP), should the Project proceed.

Traffic management measures specific to each of the Northern Link worksites would be required prior to the commencement of traffic movements into those worksites. This EIS establishes the principal management objectives for the construction traffic management plans.

2.5.6 Environmental Management During Construction

Northern Link would be a major construction project to be undertaken over a period of 3.5 years, in and beneath the inner western and inner northern suburbs of Brisbane. These suburbs are home to long-established communities. The construction program must be delivered within a framework of environmental management which is:

- open and transparent in terms of the roles and responsibilities for satisfaction of approvals and conditions, and meeting the environmental objectives for Northern Link;
- responsive to reasonable community concerns as well as for communicating with and addressing community concerns; and
- responsive to environmental impacts specific to these suburbs, desirably within a performance-based system based on predictive modelling, mitigation, management, corrective actions and reporting.

The EIS provides a draft Outline Environmental Management Plan (EMP) for the construction phase of the Project. This draft Outline EMP establishes the environmental objectives for the construction phase, derived from a combination of the technical studies, community consultation and agency inputs. The environmental objectives are suggested for inclusion in any conditions the Coordinator-General may impose, should the EIS and Northern Link be approved to proceed.

View over Paddington

Table 2: Total Spoil Quantity Estimates and Placement Locations

Worksites and Construction areas	Mt Coot-tha Quarry (bcm)	Swanbank (bcm)	Port of Brisbane (bcm)	Spoil Quantity Estimate (bcm)
Western Freeway	840,000	265,000		1,105,000
Toowong	240,000	20,000		260,000
Kelvin Grove			300,000	300,000
ICB construction area			25,000	25,000
TOTAL	**1,080,000**	**285,000**	**325,000**	**1,690,000**

Table Note: 'bcm' means bank cubic metre. A bank cubic meter represents the contents of a cubic meter of rock in situ, before it is excavated.

2.6 Property and Native Title

2.6.1 Property Requirements

The anticipated number and type of properties required for the Reference Project is identified in **Table 3**.

Of the total 116 properties required for the Project, 94 lots would be required as whole lots and 22 lots would be affected by a partial land take. The Reference Project also anticipates 614 parcels of land would be affected by volumetric title reconfiguration (subdivision) and acquisition to provide separate tenure for the underground tunnels while retaining the surface title rights by the existing owners. Compensation would be payable to the owners, for the loss of the volumetric lot in accordance with the *Acquisition of Land Act, 1967*.

2.6.2 Native Title

There are two registered native title claims under the Commonwealth *Native Title Act 1993*. These claims have been made by the Jagera People[12] and the Turrbal People[13]. Each claim covers areas of Crown Land across large areas of the City of Brisbane, including the EIS study corridor and beyond. A native title assessment of relevant properties will be carried out.

To the extent that Native Title exists in relation to any land affected by Northern Link construction or long term operations, native title will either be suppressed, for the construction period, or extinguished by resumption of any native title in relation to the area of the operational tollway. Either of these processes would require compliance with the *Native Title Act 1993*. The Jagera and Turrbal people would be consulted and/or negotiations carried out to ensure clearance is obtained.

2.7 Environmental Impact Statement and Approvals

The Coordinator-General of Queensland declared Northern Link to be a significant project for which an EIS is required on 31 October 2007 under Section 26(1) (a) of the *State Development and Public Works Organisation Act 1971* (SDPWO Act). Consequently, an EIS is required to be prepared for consideration by the Coordinator-General to ensure that the environmental values of the study corridor are recognised and any project-related impacts managed adequately.

A referral was made to the Commonwealth Minister for the Environment and Heritage under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) to determine whether the Project and its associated works are a 'controlled action' under the Act. The Delegate of the Commonwealth Minister for the Environment and Heritage determined on 6 December 2007 that the Project does not constitute a controlled action pursuant to s75 of the EPBC Act.

Victoria Park

2.7.1 Approvals Pathway

The 'approvals pathway' for the Project includes a combination of the SDPWO Act and the *Integrated Planning Act 1997* (IPA). The SDPWO Act sets out the process to be followed for a significant project for which development approvals are required under the IPA.

The EIS in Chapter 19 lists the likely approvals required for the project in detail. In summary, the primary approvals for the project are likely to include those identified in **Table 4**.

While the Environmental Protection Agency has advised its intention to add Ventilation Outlets from road tunnels to Schedule 1 of the EP Regulations as an ERA from 1 January 2009, no details regarding the governance or management of this activity has been made available. Development approval may also be required for this element of the Project.

All necessary development approvals, environmental licences and authorities would be required prior to the commencement of relevant works. The Coordinator-General, in his evaluation of the Northern Link EIS, may state conditions for these approvals, and also impose conditions where no other relevant approvals exist.

12. Federal Court number: QUD6014/03 NNTT number: QC03/15
13. Federal Court number: QUD6196/98 NNTT number: QC98/26

Table 3: Anticipated Property Requirements

Location	State	Council	Private	Total
Red Hill/Kelvin Grove	4	8	30	42
Mt Coot-tha/Toowong	1	7	66	74
TOTAL	**5**	**15**	**96**	**116**

Table 4: Summary of likely approvals for the Project

Activity	Relevant Legislation	Determining Authority
Development		
Material change of use for ERA*	Environmental Protection Act Integrated Planning Act	Environmental Protection Agency
Material change of use involving land on EMR or CLR	Environmental Protection Act Integrated Planning Act	Environmental Protection Agency Brisbane City Council
Development on a State heritage place	Queensland Heritage Act Integrated Planning Act	Chief Executive, Environmental Protection Agency
Development on a local heritage place	BCC City Plan 2000 Integrated Planning Act	Brisbane City Council
Operational work (eg: excavation or filling for spoil placement, clearing of native vegetation on freehold land) – if required	Integrated Planning Act	Brisbane City Council
Reconfiguration of a lot	Integrated Planning Act	Brisbane City Council
Building work for demolition of character housing in a demolition control precinct.	BCC City Plan 2000 Integrated Planning Act	Brisbane City Council
Environmental		
Disposal permit for contaminated land	Environmental Protection Act	Environmental Protection Agency
Taking, using, keeping or interfering with a protected animal or plant	Nature Conservation Act	Environmental Protection Agency
Development in Brisbane Forest Park	Brisbane Forest Park Act	Brisbane Forest Park Administration Authority
Potential acid sulphate soils management plan	State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils	Dept Natural Resources and Water Environmental Protection Agency
Disposal permit for contaminated land	Environmental Protection Act	Environmental Protection Agency
Other		
Works on or connecting with a State-controlled road	Transport Infrastructure Act	Dept of Main Roads
Works that interfere with a railway	Transport Infrastructure Act	Queensland Rail
Road closure	Land Act	Dept Natural Resources and Water
Local actions (eg: blasting)	Local laws	Brisbane City Council
Approved CHMP	Aboriginal Cultural Heritage Act	Dept Natural Resources and Water

Table Note:
* ERA: environmentally relevant activity - could include chemical storage - including dangerous goods storage, sewage treatment, extracting rock or other material, crushing and screening, concrete batching plant and water treatment.

3. Need for Northern Link

With sustained rapid population growth and economic development in SEQ and in Brisbane since the late 1980s, all levels of government have recognised the importance of continual enhancement for critical infrastructure, including transport infrastructure.

Northern Link is proposed as part of an overall, balanced approach to addressing the existing and forecast future pressures on Brisbane's transport system, set out in the *Draft Transport Plan for Brisbane 2006 – 2026*[14].

3.1 Population Growth

The SEQ region will continue to experience rapid population and employment growth. The population of the Brisbane Metropolitan Area is forecast to be 2.53 million in 2026 and employment is forecast to increase by over half a million to almost 1.5 million in 2026. **Table 5** presents the estimated population, employment and person trips for the Brisbane Metropolitan Area for a medium series population scenario.

The Queensland Government has been planning for and managing population growth in SEQ through a regional planning process since the late 1990s. Recent changes to legislation now provide greater force, in law, to the regional planning measures including those relating to regional transport planning.

3.2 Transport Need

3.2.1 Growth in Travel Demand

Under the pressure of population and employment growth, the estimated growth in the travel task (in terms of person trips) and vehicle travel demand in the network is significant. **Figure 6** summarises the estimated growth in the travel task (in terms of person trips) by the various travel modes – vehicle, public transport, and walk/cycle travel. This demonstrates how travel demand is forecast to grow across all modes.

Table 6 summarises the growth in travel demand at the metropolitan level. Although public transport use is expected to grow substantially, vehicular trip demand is forecast to be 34% higher than current levels, reaching 5.5 million vehicle trips on an average weekday.

As well as significant growth in travel demand there will also be significant changes to the distribution of travel generators. For example, traffic forecasts for the period 2007 – 2026, indicate increased road travel demand associated with the Western Corridor, the ATC and designated activity centres such as the CBD, Toowong, Indooroopilly and the University of Queensland at St Lucia. The projected pattern of employment distribution for the metropolitan area and the Western Corridor proposed in the SEQ Regional Plan, also would be more decentralised than the current situation elevating further the importance of high-quality, efficient transport connections between these major economic drivers to the regional, State and national economies.

The current national road network route between the Brisbane metropolitan region's western connections, the Cunningham and Warrego Highways, and the Gateway Motorway, known as the Brisbane Urban Corridor, lies south of the Brisbane River and is highly congested. The natural desire would be for a line of travel, on a shorter high-quality route north of the river from the western gateway to the Brisbane Airport and the ATC.

The forecast growth to key trip generators served by Northern Link is strong (eg: ATC North by 178%, Western Corridor by 122%). **Figure 7** shows the future scale of travel to these regions relative to the Central

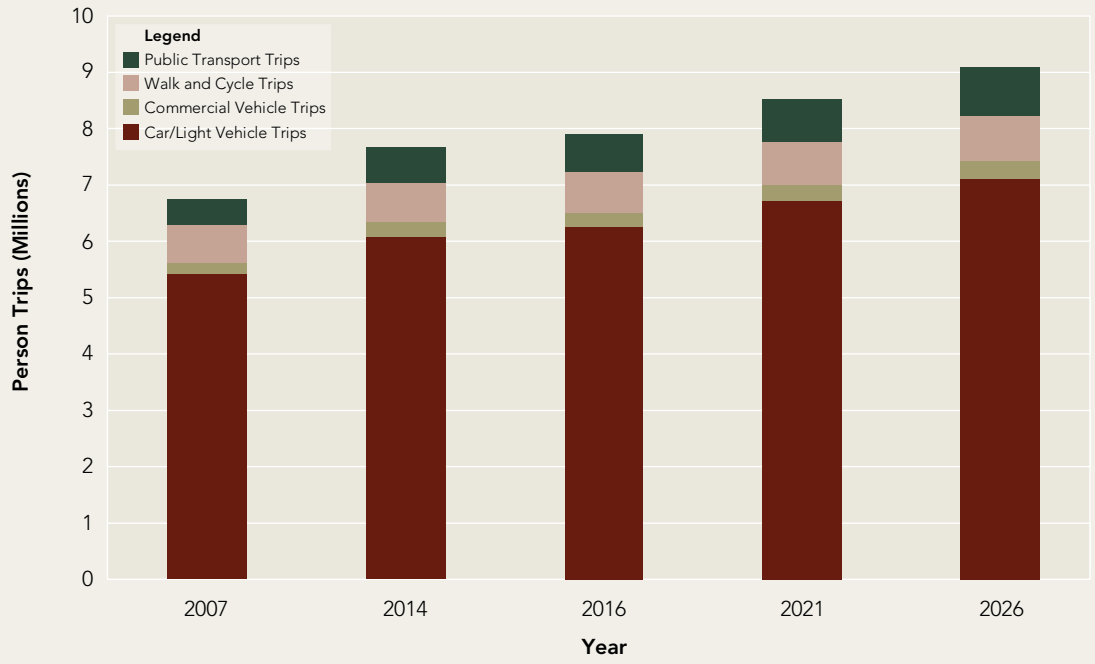
14. Brisbane City Council, 2006, Draft Transport Plan for Brisbane 2006 – 2026, Council, Brisbane

Table 5: Brisbane Metropolitan Area Population Forecasts

Year	Population[1]	Employment[2]	Total Person Trips[3] (average weekday)
2007	1,880,000	964,000	6,529,000
2014	2,126,000	1,185,000	7,400,000
2016	2,197,000	1,237,000	7,637,000
2021	2,370,000	1,373,000	8,228,000
2026	2,533,000	1,484,000	8,783,000

Table Notes:
1) PIFU Medium Series from SEQ Economic and Forecasting Study (2007).
2) NIEIR employment opportunities SEQ Economic and Forecasting Study (2007).
3) Person trips by all modes including walk/cycle and excluding commercial vehicles.

Figure 6: Forecast Growth in Average Weekday Travel Demand Within Brisbane Metropolitan Area (Person Trips)



City. By 2026, vehicle travel demand to the ATC (North) is forecast to exceed current traffic levels to the CBD. Similarly, travel demand to the Inner West area that includes the activity centres of Toowong, Indooroopilly and the University of Queensland at St Lucia is forecast to be 18% higher than current levels by 2026.

3.2.2 Impact of Growth on Road Network

As both road and public transport networks face the pressure of accommodating increases in travel demand within and across the Brisbane Metropolitan Area, journey times would increase.

Figure 8 illustrates that average peak period journey speeds would decrease progressively compared to current levels.

3.3 Justification for Northern Link

Northern Link would address strategic transport needs by:

- supporting the preferred future development pattern, population and employment growth within the SEQ Regional Plan by improving connectivity and transport system capacity to cater for major growth areas (eg: Western Corridor) and economic activity centres (eg: CBD, ATC);
- reducing congestion and through-traffic in the inner west, supporting the growth of designated activity centres, and improving local connectivity and accessibility;

Table 6: Forecast Growth in Weekday Travel Demand in Metropolitan Area

Parameter	2007	2014	2016	2021	2026
Total Person Trips by Motorised Travel Modes (includes public transport trips)[1]	5,884,000	6,690,000	6,910,000	7,464,000	7,986,000
Public Transport Trips	464,000	599,000	670,000	742,000	866,000
% PT Trips[2]	7.9%	9.0%	9.7%	9.9%	10.8%
Car/Light Vehicle Trips	3,879,000	4,385,000	4,498,000	4,855,000	5,150,000
Commercial Vehicle Trips (heavy vehicles)	210,000	251,000	261,000	288,000	310,000
Total Vehicle Trips	4,089,000	4,636,000	4,759,000	5,144,000	5,460,000
% Growth in Vehicle Trips compared to 2007		13%	16%	26%	34%

Table Notes:
Source: Northern Link Traffic Model
1) Totals include travel from within area to and from locations outside the Brisbane metropolitan area.
2) % Public Transport is expressed as a proportion of person trips by motorised modes

Figure 7: Forecast Growth to Key Trip Generators

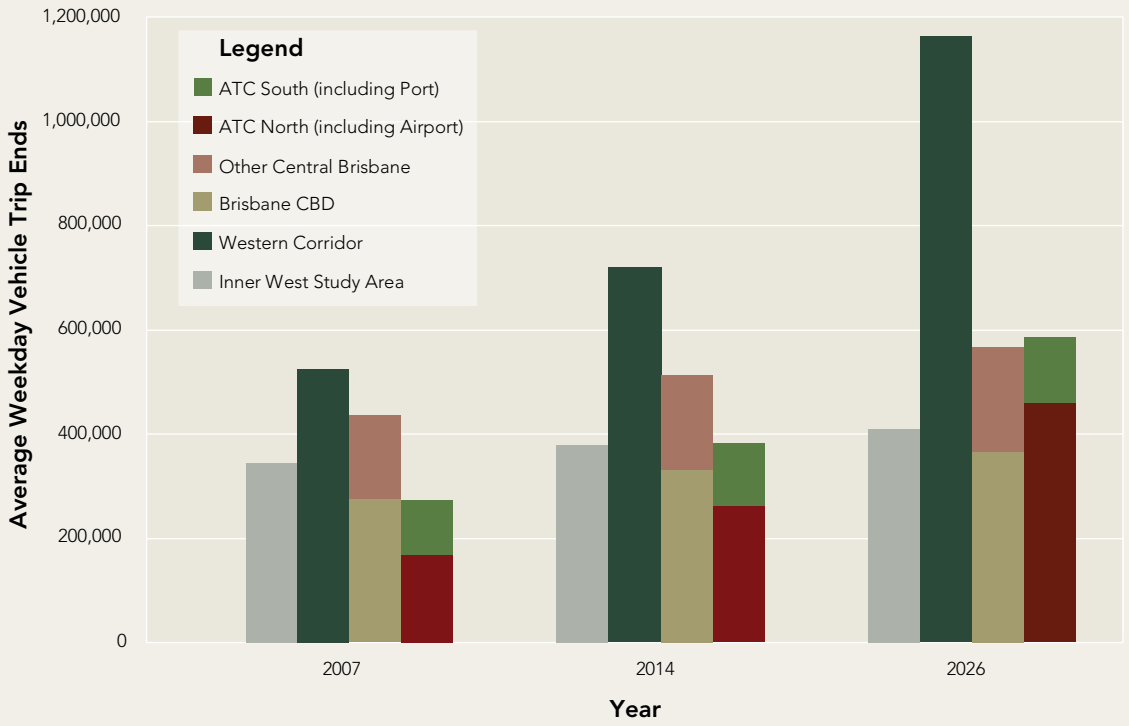
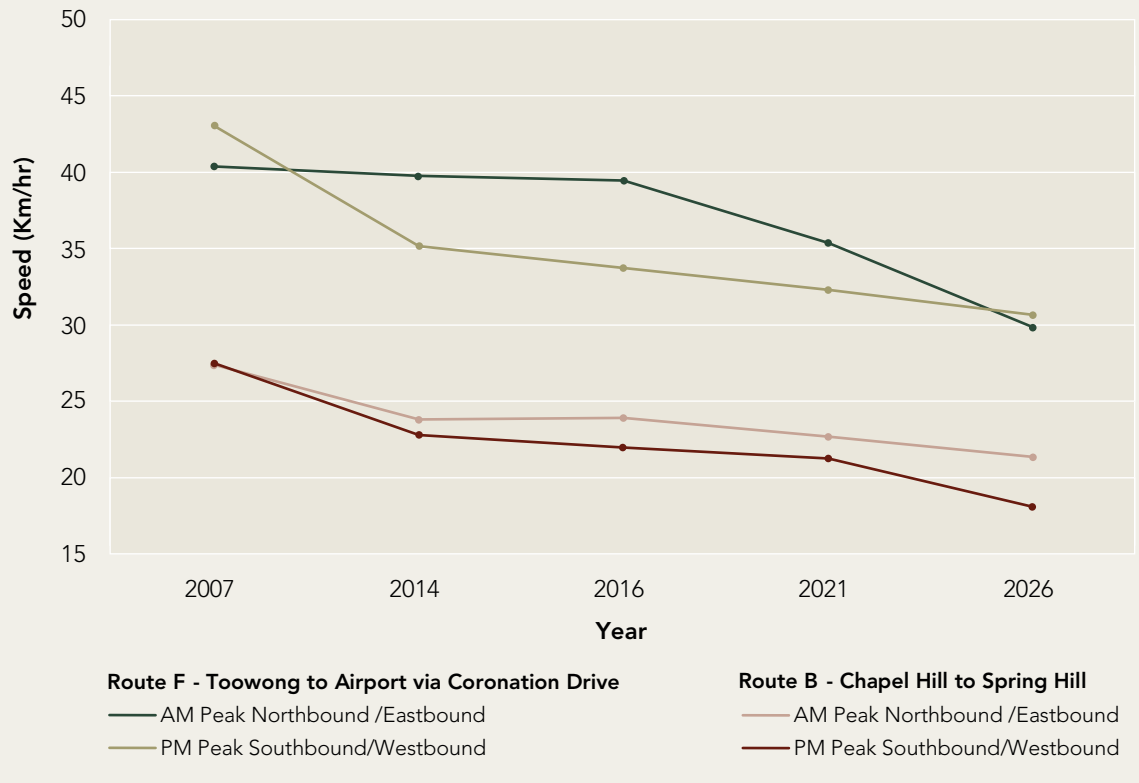


Figure 8: Comparison of Travel Speeds on Select Journeys



- improving east-west transport efficiency by improving journey times and travel reliability from the Western Corridor and western suburbs to the ATC, the CBD and the regional roads in the northern suburbs, by providing a motorway-standard link between the Western Freeway and the ICB;
- supporting public transport by providing opportunities for direct use by express bus services from the Western Corridor and the western suburbs to the CBD, and by relieving congestion on existing major bus routes such as Coronation Drive, Milton Road and Moggill Road; and
- providing opportunities to improve pedestrian and cycle environment in the inner west suburbs and reducing traffic levels on the surface network.

3.3.1 Travel Time Benefits

The travel time benefits offered by Northern Link are significant as illustrated in **Table 7**.

As per the table, benefits are also forecast for traffic choosing to use the un-tolled, surface routes instead of Northern Link.

Figure 9 shows an example of the improved travel accessibility that could be achieved for trips originating in Indooroopilly with and without Northern Link.

Figure 9 also demonstrates the considerable savings in total travel time across the road network as a consequence of Northern Link.

Figure 10 illustrates the shift in travel from the local road system, including arterial roads, to the motorway system with the completion of the missing link between the Western Freeway and the ICB.

3.3.2 Environmental Benefits

Northern Link would bring about a range of environmental benefits which have been monetised for the purpose of the economic assessment of the Project. The anticipated environmental benefits include reductions in traffic noise and air pollution along roads and corridors predicted to experience a reduction in traffic, as well as wider network benefits such as improved traffic flows during peak periods. The predicted environmental benefits are predicted to deliver economic benefits of approximately $70 million.

Table 7: Effect of Northern Link on Travel Times (AM peak)

Key Routes	Without Northern Link (min)	With Northern Link		Northern Link Time Benefits	
		On Surface (min)	Via NL (min)	On Surface (min)	Via NL (min)
2007					
Western Corridor to ATC/Airport	69	-	-	-	-
Indooroopilly to Chermside	34	-	-	-	-
Toowong to Airport	30	-	-	-	-
Centenary Bridge to ICB Land Bridge	21	-	-	-	-
Chapel Hill to Spring Hill	19	-	-	-	-
Toowong to Newmarket	14	-	-	-	-
2014					
Western Corridor to ATC/Airport	58	57	46	-1	-12
Indooroopilly to Chermside	35	33	20	-2	-15
Toowong to Airport	29	27	14	-2	-15
Centenary Bridge to ICB Land Bridge	24	23	12	-1	-12
Chapel Hill to Spring Hill	21	19	10	-2	-11
Toowong to Newmarket	16	15	9	-1	-7
2026					
Western Corridor to ATC/Airport	70	69	55	-1	-15
Indooroopilly to Chermside	42	34	20	-8	-22
Toowong to Airport	38	35	19	-3	-19
Centenary Bridge to ICB Land Bridge	26	22	9	-4	-17
Chapel Hill to Spring Hill	24	20	9	-4	-15
Toowong to Newmarket	18	16	9	-3	-9

Figure 9: Change in 2026 Travel Time from Indooroopilly with Northern Link (AM peak)

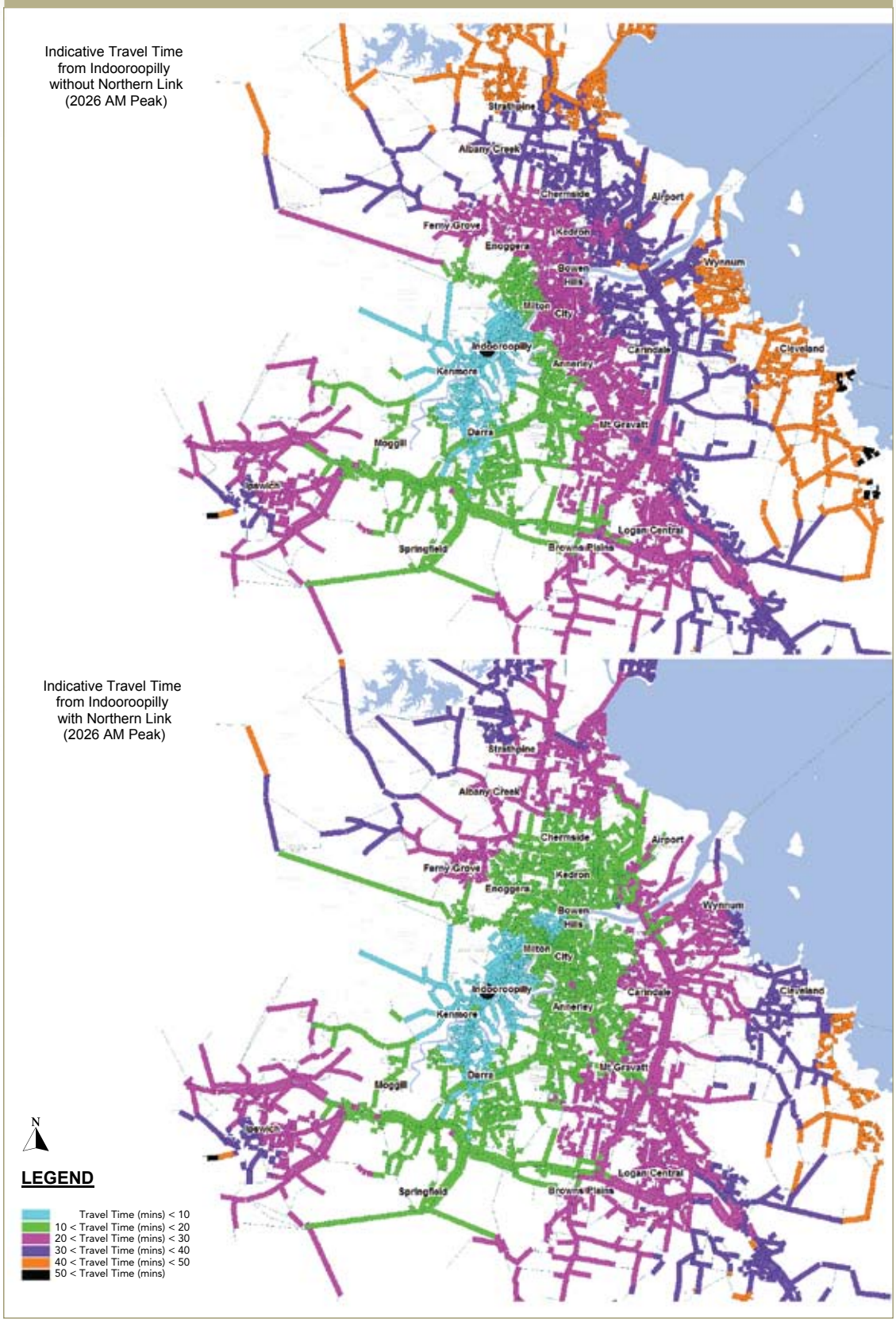
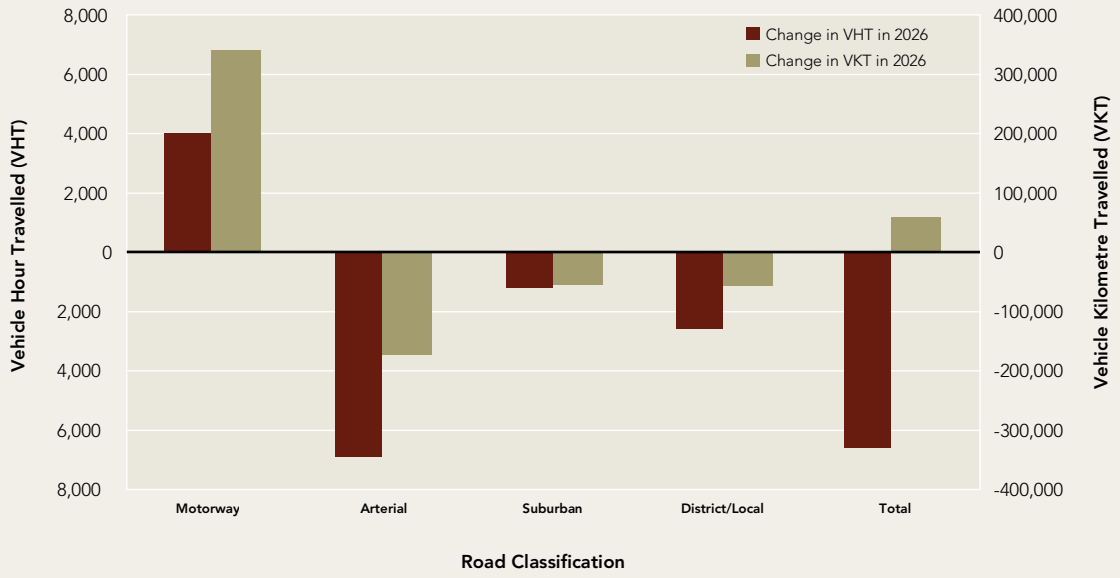


Figure 10: Changes in Network Performance – with Northern Link



3.3.3 Social Costs of Traffic Congestion

The social costs of congestion are expressed in terms of:

- reduced accessibility within and between communities and to community facilities and services;
- reduced accessibility to employment and a wide choice in employment opportunities;
- diminished urban and environmental amenity;
- increased risk of traffic accidents and reduced road safety, especially for pedestrians and cyclists;
- reduced opportunities for public transport to achieve mode share targets, with the attending social benefits of an effective and efficient public transport system; and
- increased travel times and reduced travel time reliability, making journeys uncertain and costing in terms of personal time.

Northern Link, as part of an overall, balanced approach to Brisbane's transport challenges, would assist in addressing the present and growing impacts on community well-being summarised above. The Project would lead to improvements in the liveability of the inner western suburbs, and would improve the accessibility of a range of key services, such as the high order education, health care, recreation and leisure facilities, and commercial and professional services available in the designated activity centres in and adjacent to the study corridor. Residents in and adjacent to the study corridor would also experience improved accessibility across and along the presently congested arterial corridors.

3.3.4 Economic Benefits of Northern Link

The benefit cost ratio (BCR) for the Project as calculated from the cost benefit analysis model is 1.2. The BCR of 1.2 indicates that the Project provides a 20% return over the discounted value of the investment for the 45 year assessment period.

Northern Link would support the continued economic development of the SEQ Region, and the Brisbane metropolitan area by filling the 'missing link' and completing the alternative motorway network between the Western Corridor growth area, the Brisbane CBD and the Australia TradeCoast (ATC), and the designated activity centres of the University of Queensland, the University of Technology at Kelvin Grove (QUT), Toowong and Indooroopilly. Each of these centres are significant employment centres and economic engines in the regional context, with greater contributions to the State and national economies from the CBD, the ATC and the University of Queensland and QUT.

Employment growth to 2026 for the Brisbane CBD and for the ATC is strong, leading to anticipated levels of 190,000 jobs and 80,000 jobs respectively. Investment in infrastructure and business in these major centres also is predicted to be strong. For example, the Brisbane Airport is expected to attract more than $2 billion in infrastructure investment and $2 billion in business development over the next 10 years.

The Western Corridor, supported by the SEQ Regional Plan as the focus for much of the regional population growth, already accommodates 16,000 small businesses, with more than 30 businesses with an annual turnover in the range of $50 million to $200 million. As a major new urban growth area likely to

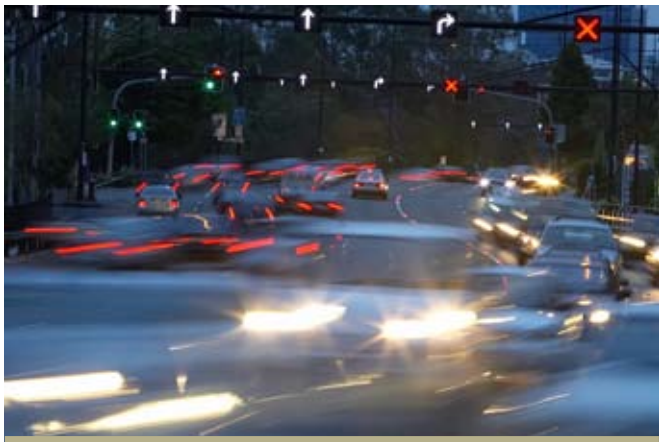
double, or more, its current population in the next 20 years, the Western Corridor requires the creation of a large number of jobs, through economic growth and investments in infrastructure and services. Aerospace, freight, training and education have been identified as industries with high growth potential due to the proximity to Amberley airbase and existing campuses.

In addition, Northern Link would contribute to economic activity through both direct and in-direct employment benefits, capital expenditure benefiting the construction and allied service sectors and on-going expenditure through the operation and maintenance of the Project.

At the local level, employment and business activity on a regional or metropolitan scale is concentrated in centres as listed below.

- Milton – commercial and business centre, including major activities such as the Milton Brewery and Suncorp Stadium.
- Auchenflower – including the Wesley Hospital.
- Toowong – including regional commercial and profession services, shopping, entertainment and leisure facilities.
- St Lucia – the University of Queensland and CSIRO.
- Kelvin Grove – Queensland University of Technology and Kelvin Grove Urban Village.
- Herston – Royal Brisbane Hospital.

Consistent with the strategic directions of the SEQ Regional Plan, City Plan and the Transport Plan for Brisbane, Northern Link would benefit and support economic activity and employment in each of these centres either directly or indirectly by relieving traffic flows on congested arterial routes such as Coronation Drive and Milton Road. Enhanced accessibility between employment centres and residential dormitories is critical to sustainable economic growth in each of these centres. Each of these centres is expected to grow in terms of output and employment over the period to 2026 and will rely upon an upgraded transport system, in which enhanced road capacity and enhanced public transport capacity are both important.



Coronation Drive Traffic

3.4 Alternatives

The EIS considers potential alternatives to Northern Link, in the form of scenarios that seek to optimise public transport and optimise surface road transport in the project corridor (without a tunnel). These scenarios are assessed against the Project together with a 'do nothing' or 'do minimum' option.

3.4.1 Optimise Public Transport

The optimised public transport scenario focuses on bus transport for commuter travel and heavy rail for the movement of freight from the Western Corridor to the Australia TradeCoast. Possible upgrades to the transport network required for the public transport option include:

- development of a high-capacity busway, or dedicated bus lanes, connecting the Centenary suburbs at Mt Ommaney within the Centenary Highway – Western Freeway corridor to connect with dedicated, priority bus lanes on Milton Road, then via Hale Street to link into the Inner Northern Busway station at the Normanby for CBD trips and for north-bound trips on the Northern Busway;
- implement capacity enhancement schemes on local roads including:
  - dedicated, priority bus lanes on Milton Road, in addition to the existing 4 lanes for general traffic and also on Hale Street in addition to the existing 6 lanes for general traffic;
  - upgrade Kelvin Grove Road and the Normanby busway station to provide for north-bound, cross-city bus trips from the busway station; and
  - provide dedicated, priority bus lanes along Moggill Road from Kenmore to Indooroopilly, including a connection with a new busway station at Indooroopilly to join with the rail corridor into the city.
- provide high-quality bus connections between Darra station and a possible future Mt Ommaney busway station;
- provide an extension of the Northern Busway to Toombul to provide a connection with Airtrain to Brisbane Airport and for the extension of services to Australia TradeCoast (North);
- bring forward the implementation of WBTNI option 11 from a medium term delivery (up to 15 years) to short-term delivery (within 5 years) – busway linking Kenmore and the CBD running generally in or adjacent to the rail corridor from Indooroopilly to Toowong, and then along Coronation Drive to the Riverside Expressway; and
- upgrade the rail capacity on the Western Railway, if possible, between Darra and Bowen Hills for the movement of general freight to northern Brisbane and for distribution at Banyo / Toombul / Hendra for Brisbane Airport and Australia TradeCoast (North).

While CityCat ferry services provide an important linkage between the city and suburbs along the Brisbane River, and to the University of Queensland at

St Lucia, ferry services have a limited catchment and therefore a limited demand for services. Improvements to the existing pedestrian and cycleway network would aim to attract more pedestrian and bicycle traffic to the existing Bicentennial Cycleway, such upgrades would address radial, CBD-based trips, and would not address the identified need for cross-city movements.

3.4.2 Optimise Surface Road Transport

For the purpose of addressing the Terms of Reference, the optimised surface road transport option would focus upon optimising the performance of Milton Road as the key route for cross-city travel and Coronation Drive for CBD-destination travel. The network upgrade option is assumed to include the following road upgrade measures.

- Cross-city travel – significant widening of the Milton Road corridor, including enhancements to the Mt Coot-tha roundabout and the Toowong roundabout, in addition to widening of Hale Street and the ICB connections with Airport Link and CLEM7. These widenings would need to be supported by a priority traffic flow system through signalised intersections.
- Radial (city-centre) travel – widening of Coronation Drive and implementation of a priority flow system in traffic signals for through lanes and key intersections, and widening or provision of a surface road alternative to High Street Toowong.

The existing network upgrade option would involve an extensive range of property, community and environmental impacts.

- Extensive property acquisitions along Milton Road, mostly on the northern side to avoid the Western Railway corridor and along Coronation Drive on its northern side or structures standing within the Brisbane River.
- Property acquisitions would affect a combination of heritage sites (Milton Brewery, St Francis Theological College and Christ Church, Milton); residential properties in Toowong, Auchenflower, Milton and Paddington; commercial areas at Auchenflower and Milton; and recreation and open space areas at Toowong and Milton including Suncorp Stadium.

Normanby Busway Station

- Environmental impacts would include construction impacts (noise and vibration, dust, night lighting, drainage, water quality) and operational impacts (increased road traffic noise, surface release of motor vehicle emissions).

3.4.3 'Do Minimum' Option

For the EIS, a 'do nothing' or 'do minimum' scenario has been adopted for comparison with the alternatives proposed in the Terms of Reference. However, the road transport network in SEQ and the Brisbane metropolitan area is changing as a consequence of projects presently under construction (eg: Gateway Motorway Upgrade, Ipswich Motorway – Logan Motorway interchange, Clem Jones Tunnel (CLEM7[15]), Hale Street Link) and already committed and about to commence construction (eg: Airport Link, Airport Roundabout Upgrade, Northern Busway).

Both the SEQ Infrastructure Plan and Program (SEQIPP) and the Brisbane Long Term Infrastructure Plan, linked with the Transport Plan for Brisbane[16], have established priorities for investment in transport infrastructure at the regional and local levels respectively.

In the 'do minimum' scenario, enhancements to the land transport system are identified in the:

- South East Queensland Infrastructure Plan and Program 2008 – 2026 (SEQIPP); and
- Brisbane Long-Term Infrastructure Plan, including the Brisbane Road Action Plan 2008[17].

While the 'do minimum' option represents a balanced approach to road and public transport infrastructure, forecast growth in population and economic activity indicate that travel demand would exceed capacity enhancements proposed in the 'do minimum' scenario.

3.4.4 Analysis of Alternatives

A comparative analysis of the alternatives to Northern Link was based upon a combination of:

- project objectives as outlined in Section 2.2;
- national transport network objectives as expressed in the AusLink National Network strategy;
- regional transport planning objectives as expressed in the South East Queensland Infrastructure Plan and Program (SEQIPP);
- metropolitan transport planning objectives as expressed in the Transport Plan for Brisbane (TP4B); and
- objectives for Living in Brisbane 2026.

The options considered in the comparative analysis include the projects and initiatives in SEQIPP and TP4B, excluding Northern Link. None of them satisfied completely the project needs or the strategic objectives, demonstrating the need for a multi-layered

15. Formerly known as the North-South Bypass Tunnel (NSBT).
16. Brisbane City Council, 2007, *Draft Transport Plan for Brisbane 2006 – 2026*, Council, Brisbane
17. Brisbane City Council, 2008, *Road Action Program 2008*, Council, Brisbane *(http://www.brisbane.qld.gov.au/Brisbane City Council:BASE:1182833713:pc=PC_3224)*

response to transport planning at the regional and metropolitan levels. The impacts of implementing either the public transport option or the existing road network upgrade option are considered to be significant in terms of property, and impacts on community, environmental and economic attributes. For these reasons, neither of the options are likely to be supported either by government or by the community.

3.5 Oil Price Vulnerability

Whether the future outlook for global oil supplies is optimistic or pessimistic, there is consensus that the world's crude oil resource is finite. There is a market expectation that technological advances would respond to the need for alternative energies for transportation and industry and to extend the transition period to alternative fuel sources. While such technological advances are in development, governments are seeking practical steps to limit oil and petroleum usage wherever possible.

3.5.1 Future Developments

Transport systems that rely on petroleum-derived fuels at present will progressively move to development of alternative fuel sources. This transition has been foreshadowed the Taskforce Report to the Queensland Government[18] and the Hirsch Report to the US Government[19] (Hirsch et al. 2005).

Although the future is uncertain, it is likely that a number of criteria would drive the market development of these alternatives. One criterion likely to drive the consumer market is the flexibility of personal movement afforded currently by the private motor car and other forms of private motor vehicles. The freedom of movement afforded by private vehicles has led that mode to gain global dominance in personal and industrial land transport.

Whatever the future holds for land transportation, it is highly likely that road networks will continue to serve a critical function in society and in the economy for the movement of people and goods to places of common interest and commerce.

18. Queensland Government, 2007, Queensland's Vulnerability to Rising Oil Prices, (McNamara) TaskForce Report, Queensland Government, Brisbane.
19. Hirsch R.L, Bezdek R. and Wendling R., 2005, Peaking of World Oil Production: Impacts, Mitigation and Risk Management, US Government, Washington DC.

CLEM7 construction at Bowen Hills

3.5.2 Personal Economics

Petrol and diesel fuel prices have risen steadily over the last 30 years, almost doubling between 1999 and 2006 (Queensland Government, McNamara 2007) with a further 15-20% increase in the last two years. Throughout this period, demand has steadily increased in line with increased motor vehicle registrations in all States and with increased population in Queensland in particular. There is no evidence that price increases have had any long-term effect on motor vehicle use, especially in urban areas.

The form and density of most Australian cities, including Brisbane and the other major centres in SEQ, demand a degree of reliance on private motor vehicle travel, at least to a public transport node. Notwithstanding increases in fuel prices, measures are required to manage traffic congestion in urban areas in the short and medium term, in anticipation of the implementation of effective travel demand management.

Having regard to historic fuel price increases, there is no rigorous means by which to determine whether there is a threshold price level at which a radical change in travel behaviour would occur and what that level might be.

3.5.3 Government Policy Framework

The vulnerability of Queensland industry and way of life to rising fuel costs and ultimately declining fuel resources was comprehensively assessed by a Queensland Parliamentary Taskforce[20]. The Queensland Government is yet to release its policy position in response to these recommendations and other factors. Consequently, there is no coordinated policy position against which this or any other infrastructure project could be meaningfully assessed.

In the interim, the proposed investment in road and other transport infrastructure contained in the SEQ Regional Plan and SEQIPP, may be taken as the formal policy position of the Queensland Government with regards travel demand management, public transport and other measure to address the impact of rising fuel prices on SEQ society and economic activity.

3.5.4 Transport Technology Development

Dramatic improvements have marked the design and performance of internal combustion engines and motor vehicles throughout the 20th century and up to the present day (eg: the recent trend towards hybrid-powered motor vehicles and small, highly efficient vehicles for urban travel). Improvements in motor vehicle technology have been driven by a number of factors including cost, reliability, comfort, ease of maintenance and fuel efficiency, but the attraction and

20. Queensland Government, 2007, *Queensland's Vulnerability to Rising Oil Prices*, Taskforce Report 'McNamara Report', Brisbane

flexibility of independent travel has led the overriding demand from consumers. This has not changed and is not expected to change over the life of Northern Link.

The Queensland Government Taskforce Report (2007) cites three potential pathways currently emerging for passenger/freight transport [in Queensland]. These include:

- diesel hybrid, moving into electric vehicles;
- hydrogen fuel cells, either with internal fuel reformation on board (including gas, ethanol) or hydrogen supply networks; and
- CNG/LPG gas, moving into gas-electric hybrids.[21]

All major car manufacturers are researching, building and testing motor vehicles that are powered by alternatives to conventional gasoline engines.

3.5.5 Trends in Motor Car Ownership

A comparison of the global oil price (US$) per barrel with Australian car sales between 1996 and 2007 indicates that car sales have continued to grow despite sharp increases in the price of oil. Between 2005 and 2006, the oil price jumped $19.47, increasing by approximately 36% over the year. However, car sales continued to grow over the same period, with 33,000 more new cars sold than the previous year, exceeding one million new car sales for the first time in Australia[22].

21. Queensland Government, 2007, *Queensland's Vulnerability to Rising Oil Prices*, Taskforce Report 'McNamara Report', Brisbane
22. The Age, 2007, Aussie car sales top seven figures, http://www.theage.com.au/news/Business/Aussie-car-sales-top-seven-figures/2007/07/04/1183351264102.html, July 04 2007.

Australian car registrations have grown steadily between 1971 and 2006, despite significant oil price fluctuations over the same period, including the high prices experienced during the 1970s oil crisis, as demonstrated in **Figure 11**.

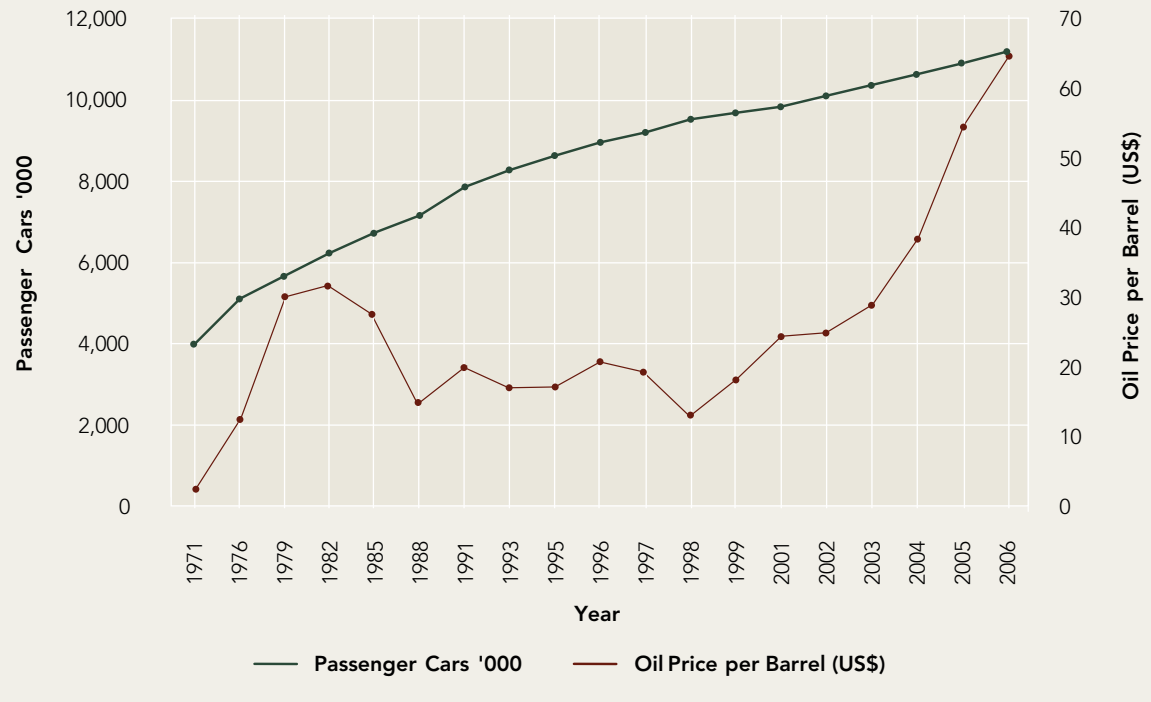
3.5.6 Summary – Oil Price Vulnerability

While there is agreement in the literature that global oil resources are finite, there is no consensus regarding the potential impacts on travel behaviours and travel demand. There is evidence that the motor vehicle industry is moving towards alternative fuel sources, reinforcing the view that for most people, some form of motorised personal transport is necessary to the extent of not being impacted completely by rising fuel prices.

While the Queensland Government is yet to determine a policy position with regards oil price vulnerability for transportation and economic development, the SEQ Regional Plan and SEQIPP are taken to reflect the current policy with regards transport planning and travel demand management.

A sensitivity test was carried out using the Northern Link Traffic Model to explore a potential response to rise in fuel prices. The overall forecast traffic volumes on Northern Link were found to be similar to those forecast with standard operating cost assumptions.

Figure 11: Australian Car Registrations compared to Global Oil Price



Source: US Energy Administration, 2008a; 2008b, BITRE 2008:62.

4. Traffic and Transport

4.1 Study Approach

The well-established process for assessment of the traffic and transport impacts of Northern Link took into account:

- areas likely to be affected by traffic and transport aspects of the Project;
- suitable relevant data;
- the existing status of the transport network;
- the effects of the Project on traffic, public transport, cyclists and pedestrians; and
- the cumulative effects of the Project, in conjunction with known infrastructure projects in the north and western suburbs of Brisbane; and those emerging from contemporary transport plans, strategies and studies for SEQ.

4.1.1 Modelling and Forecasting

Traffic and transport modelling was used to describe and assess the existing traffic flows and system performance, supplementing traffic counts and other observed data to generate estimates of existing conditions via modelled data. Modelling was also employed to forecast traffic conditions and network performance at specific years in the future.

The model used a range of inputs to predict transport and traffic demand. The modelling of future transport networks, both without and with the Project, included future projects currently under construction and programmed for completion prior to Northern Link opening in 2014. Such projects include:

- CLEM7;
- Airport Link;
- Northern Busway;
- Airport Roundabout Upgrade and Brisbane Airport Northern Access;
- Gateway Upgrade Project (GUP);
- Hale Street Link; and
- Ipswich Motorway Upgrade (Rocklea to Riverview).

Future traffic and transport conditions were modelled and assessed at a strategic level to analyse the city-wide transport network implications of Northern Link for areas such as the Western Corridor, Brisbane CBD and the Australia TradeCoast. The strategic model was the Northern Link Traffic Model, based upon the Brisbane Strategic Transport Model (BSTM) which provides average weekday travel demand forecasts for the Brisbane Metropolitan Area up to and including the year 2026.

Modelling at a detailed local level, covering Inner West Brisbane, addressed local traffic and transport effects of Northern Link within the suburbs of Milton, Paddington, Auchenflower, Bardon, Toowong, Taringa, Indooroopilly, St Lucia and parts of Kelvin Grove and Herston. At a local level, the effects of the Project on local intersection performance were examined using the SIDRA software with data extracted from the city-wide model.

Future traffic and transport conditions with the project, such as travel demand, travel times, travel speeds and the operating level of service of the road network and intersections, were forecast for 2014 (the year of project opening), 2016, 2021 and 2026 for scenarios without, and with, the project.

4.2 Existing Transport System Performance

Existing traffic levels, movement patterns, road network performance and intersection operating characteristics were determined from a range of observed and modelled data for the Brisbane Metropolitan Area and the Inner West area. **Table 8** presents a summary of current traffic flows and the percentage of commercial vehicles across the inner west Brisbane road network.

Table 8: Existing (2007) Traffic Volumes – Inner West Brisbane (Two-way Totals)

Road	Location	AWDT[1]	AADT[2]	% CV[4]
State Strategic				
Centenary Highway	At Centenary Bridge	86,800[3]	80,600[3]	5.9%
Western Freeway	North of Moggill Rd Interchange, Indooroopilly	76,500	71,200	4.7%
Regional Radial				
Moggill Road	East of Russell Terrace, Indooroopilly	40,700	37,800	6.6%
Moggill Road	East of Brisbane Boys College Entrance	38,500	35,800	6.0%
High Street	West of Benson Street, Toowong	32,400	30,100	1.7%
Milton Road	East of Croydon Street, Toowong	52,900	49,200	5.9%
Coronation Drive	West of Land Street, Auchenflower	62,600	58,200	6.7%
Milton Road	East of Castlemaine Street, Milton	51,500	47,900	8.5%
Coronation Drive	East of Cribb Street, Milton	90,100	83,800	6.7%
Kelvin Grove Road	North of School Street, Kelvin Grove	50,500	47,000	5.1%
Musgrave Road	West of Cochrane Street, Paddington	31,400	29,200	2.7%
Regional Ring				
Inner City Bypass	Landbridge, Spring Hill	79,200	73,700	11.0%
Walter Taylor Bridge	Indooroopilly	32,500	30,200	4.6%
Miskin Street	North of Ascog Terrace, Toowong	10,500	9,700	3.8%
Frederick Street	South of Victoria Crescent, Toowong	33,500	31,100	3.9%
City Distributor				
Brisbane Street	North of Josling Street, Toowong	37,100	34,500	3.4%
Sylvan Road	East of Milton Road, Toowong	8,400	7,800	3.2%
Caxton Street	West of Hale Street, Paddington	22,900	21,300	6.0%
Jephson Street	North of Sherwood Road, Toowong	13,000	12,100	5.2%
Local Streets				
Eagle Terrace	West of Roy Street, Auchenflower	4,100	3,800	3.2%
Haig Road	West of Barona Road, Milton	6,500	6,100	5.0%
Park Road Mid-block	North of Gordon Street, Milton	12,147	11,300	7.6%
Morley Street	North of Milton Road, Milton	3,900	3,600	1.7%

Table Notes:
Source: Northern Link Traffic Model and 2007 traffic counts.
1) AWDT - Average of five (5) working days
2) AADT – Average of the full seven (7) day week
3) Modelled volume within 5 to 10% of DMR permanent count.
4) Vehicle type has been based on AustRoads (2004) as follows: Cars and light vehicles – Classes 1and 2, Commercial Vehicles – Classes 3 to 12

4.2.1 Key Findings

Key findings from the assessment were as follows.

- The Western Freeway is a regional motorway linking with the Ipswich Motorway via the Centenary Highway. It connects to MetRoad 5 which includes Frederick Street, Boundary Street and Jubilee Terrace, and to Milton Road, via the heavily-congested Toowong roundabout. The Toowong roundabout carries over 6,000 vehicles per hour during the evening peak.
- Moggill Road-Coronation Drive and Milton Road cater for the major proportion of the traffic task in inner western suburbs of Brisbane. Each route is heavily congested in peak periods and each is constrained by a large number of traffic signals and direct access to properties. There are 12 signalised intersections along Milton Road between the Toowong roundabout and the CBD, a distance of 3.2km. There are 25 signalised intersections along Moggill Road-Coronation Drive route between the Western Freeway at Indooroopilly and Milton, a distance of 6.4km.
- Frederick Street carries 33,500 vehicles per weekday and is one of Brisbane's most heavily trafficked, and congested, two lane roads.
- Over the last 20 years the population in the Brisbane metropolitan area has increased by 60%, however traffic volumes using Coronation Drive and Milton Road have doubled (or increased by 100%), with a daily traffic increase on the Western Freeway during the same period of over 130%. Peak hour demands through the Toowong roundabout have increased by 30% in the morning peak and 60% in the evening peak over the same period, and high demands have spread through longer periods of the day.
- Both Coronation Drive and Milton Road carry approximately 75% of vehicles making cross-city travel movements between the western suburbs, Ipswich and beyond with northern suburbs, ATC and southside suburbs, via the Captain Cook Bridge and William Jolly Bridge. Only 25% of traffic on Milton Road and Coronation Drive relates to with central-city travel.
- Milton Road currently provides a freight route between the Western Freeway and the CBD, and areas served by the ICB. Commercial vehicles comprise between 6% and 8.5% of traffic that use this congested road in the inner west area.
- Travel speed on both Coronation Drive and Milton Road fluctuate along the corridor due to traffic congestion at numerous locations, often resulting in long delays and unreliable journey times during peak periods. Travel time unreliability on congested roads impacts on productivity for businesses and industry.
- Congested traffic conditions on the arterial roads has created the pressure for through traffic use of some local streets, with consequential negative effects on the amenity of some residential areas in the inner west.
- The inner west suburbs are well served by public transport. Milton Road carries over 120 buses per day and Coronation Drive over 820 buses per day, serving commuters from both a local and wider catchment area in Brisbane. The Ipswich Railway carries about 136 passenger train services per weekday. Bus services in the inner west area are affected by congestion on the road system.
- As the Western Freeway terminates at the Toowong roundabout and then connects to congested arterial roads, there is a major gap in the strategic road network that principally affects efficiency, safety and reliability of travel between the west and eastern and northern areas of the metropolitan region. A direct, high quality connection that serves the desire line for cross-city travel between the west and the east, which includes the ATC, is missing from the current network structure.

4.2.2 Future Conditions Without the Project

Future traffic forecasts have been based on a medium series population outlook[23] for the Brisbane Metropolitan Area. This provides a basis to examine the implications of a regionally significant road such as the Northern Link.

Future conditions without Northern Link would be likely to include:

- a sustained growth in vehicle travel demand would occur both within the Brisbane Metropolitan area level and in the Inner West area, even with significant growth in public transport mode share rising from 8% to 11% by 2026 (ie: with a doubling of public transport trips);
- overall traffic movements within the Inner West area would grow by approximately 25% for the period, even as congestion levels of the road network rise significantly;
- strong growth in trips generated to key land-uses in the west, east and north of Brisbane, increasing the cross-city private vehicle and freight travel demand through the Inner West area. The Western Corridor has a forecast increase of almost 180% in vehicle demand from 2007 to 2026 due to significant population and employment growth as identified in the Regional Plan's Preferred Pattern of Development. To the north-east of the Inner West area vehicle demand is forecast to increase by over 120% at the ATC (North);
- public transport would cater for the majority of growth in demand for travel to the Central City; however some growth in vehicle demand would also be evident. Travel demand to the Inner West area, which includes activity centres at Toowong, Indooroopilly and St Lucia is forecast to increase by 18% by 2026;

23. PIFU Medium Series from SEQ Economic and Forecasting Study (2007)

- a progressive increase in congestion on the road network and decline in peak period journey times is forecast due to increased travel demands, particularly on Coronation Drive and Milton Road. Intersections along both routes which provide key local traffic connectivity, such as Cribb Street, Park Road, Baroona Road and Croydon Street would operate with high delays; and
- much of the traffic congestion that would occur in the inner west Brisbane's road system would be caused by cross-city traffic being forced to use the roads through the suburbs. Commuters would seek to avoid the highly congested regional routes and divert to city distributors and local streets eroding amenity within the local urban area. Without the Project, examples of roads with high traffic growth include Caxton Street, +70% vehicles per day by 2026, Eagle Terrace and Haig Road; both +120% and Morley Street + 200% traffic increase by 2026, compared to the current situation.

4.3 Operational Effects

4.3.1 Demand for Northern Link

Once operational, Northern Link would fulfil a traffic function of regional significance by providing a cross-city connection for trips between the western, eastern and northern areas of the Brisbane metropolitan area. Initial weekday traffic use of Northern Link would be 57,000 vehicles per day[24] rising to 75,900 vehicles per day in 2026. The proportion of commercial vehicles forecast to use Northern Link in 2026 is 5.4%.

Use of the Northern Link mainline tunnel and its connections is summarised in **Table 9**. The Western Freeway would be the primary western connection, catering for 72% of traffic use, and the ICB would be the primary eastern connection, with a forecast use of 55% of traffic in 2026.

The forecast movement patterns of Northern Link users in 2026 are illustrated in **Figure 12**. Northern Link would carry mostly cross-city travel, representing over 81% of all trips. Approximately 21% of trips would be for travel to the ATC. Radial travel would be a secondary function, accounting for 19% of all trips through Northern Link.

For commercial vehicles using Northern Link, one-third of these would be ATC trips, from a total of 95% of commercial trips for cross-city use.

From all connections, Northern Link would provide predominantly for cross-city travel. Characteristics of the connection use include:

- the Western Freeway would contribute over 70% of the traffic that enters Northern Link at its western connection. The Toowong Connection provides a secondary role;
- the straight-through connection to and from the ICB would cater for over half of the traffic movement;
- use of the Kelvin Grove connection would be distributed in similar proportions to the north and south;
- the Toowong connection would play a significant role in catering for traffic between the designated activity centres in the inner western suburbs and the ICB and Kelvin Grove Road north;
- the Toowong connection would be more strongly linked to travel between cross-city destinations via Airport Link, Kingsford Smith Drive and CLEM7, rather than central-city related travel; and
- the majority of traffic using the Kelvin Grove connection for Northern Link trips would travel west via the Western Freeway.

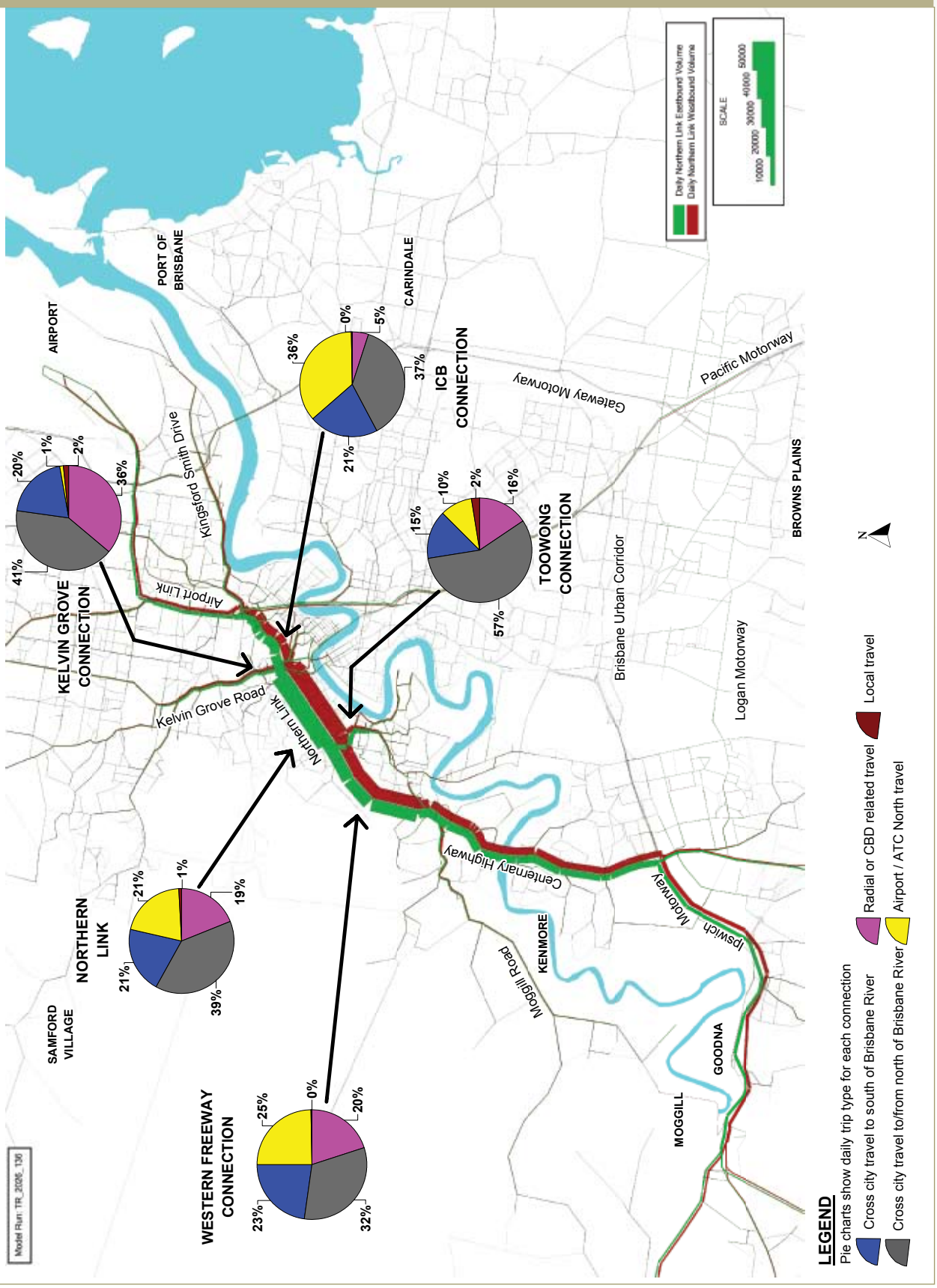
24. Allowing for a ramp-up period

Table 9: Northern Link Traffic Use – Average Weekday Traffic Volumes[(1)]

	Daily Traffic 2014 - opening (vpd)	Daily Traffic 2014 (vpd)	Daily Traffic 2026 (vpd)	%
Western Connections				
Western Freeway	27,500	39,300	54,300	72%
Croydon Street	11,900	17,000	20,700[3]	27%
Other Toowong Approaches	500	700	940[2]	1%
Total	**39,900**	**57,000**	**75,900**	**100%**
Eastern Connections				
ICB	21,800	31,100	41,900	55%
Kelvin Grove Road (north-facing)	8,400	12,000	16,000	21%
Kelvin Grove Road/Musgrave Road (south-facing)	9,700	13,900	18,000	24%
TOTAL	**39,900**	**57,000**	**75,900**	**100%**

Table Notes:
1) EIS traffic forecast is based on a car toll of $3.93 (expressed in $2008 including GST).
2) Forecast entry traffic to Northern Link in 2026 using east facing on-ramp of 940 vpd comprises 360 vpd approaching from Morley Street via right turn, with 580vpd from Milton Road east.
3) Forecast exit traffic from Northern Link in 2026 to Croydon Street includes 140 vpd proceeding to Morley Street and 110 vpd proceeding to Milton Road east via indirect routes.

Figure 12 Daily Travel Patterns for Northern Link



4.3.2 Traffic Volume Effects, Mitigations and Benefits

As Northern Link functions as a cross-city travel route, traffic volume effects are forecast beyond the corridor due to regional traffic re-distributing to alternative routes to access the facility, and in some case these offer beneficial reductions in total traffic use of regional routes. Key findings include:

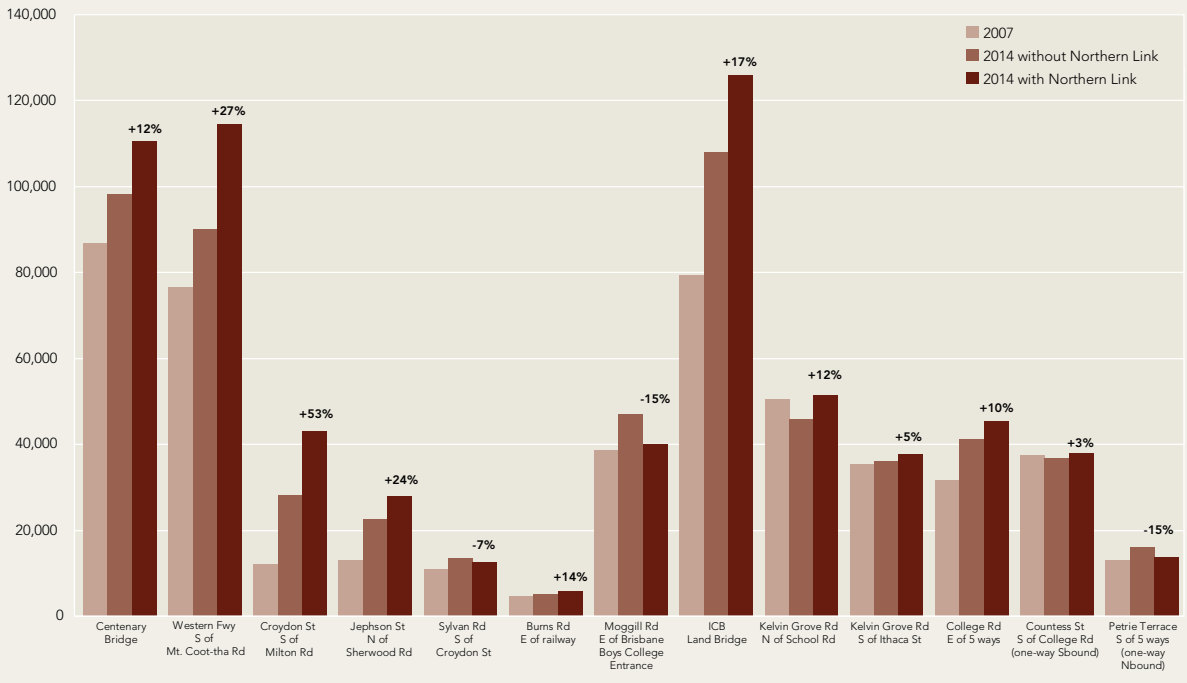
- traffic relief by 2026 on several regional corridors, including the Ipswich Motorway east of the Centenary Highway, Riverside Expressway, CLEM7, Ipswich Road and Fairfield Road;
- traffic reductions through the CBD, particularly on Ann and Turbot Streets;
- traffic reductions on MetRoad 5 corridor, with a 14% traffic decrease forecast on Jubilee Terrace in 2026 and 11% on Frederick Street;
- negligible overall traffic changes within the Airport Link/Lutwyche Road corridor and on Kingsford Smith Drive;
- a small reduction in traffic use of Hale Street Link, with Northern Link reinforcing the use of the motorway-standard ICB and CLEM7 for longer-distance cross-river travel; and
- negligible change in traffic volumes on the Walter Taylor Bridge in Indooroopilly, although some users will re-distribute to travel via Northern Link rather than via the Moggill Road – Coronation Drive corridor.

Figure 13presents the average weekday traffic forecasts on the connecting routes to Northern Link for 2014 the scenario with and without the Project illustrating the immediate effects. The weekday traffic for 2007 is also presented for comparison.

The longer term effects of the Project on connecting routes are as follows.

- At the Centenary Bridge, average weekday traffic demands with the Project would be 110,400 in 2014 rising to 137,400 in 2026. By 2026 peak period congestion is forecast at the Centenary Bridge both without and with Northern Link. With peak spreading in the network over the next 20 years, it is reasonable to assume that a four lane cross-river facility could carry an AWDT of up to 140,000 vehicles per day.
- In 2014, average weekday traffic on the Western Freeway north of Moggill Road is forecast to reach 114,500 vehicles per day with Northern Link. This is similar to the traffic levels carried during 2007 on the four lane section of the Gateway Motorway north of Kingsford Smith Drive (112,000 AAWT). By 2026 traffic is forecast to increase by around 30% to 138,000 vehicles per day in 2026 compared to the scenario without the Project. The forecast demands would be within the anticipated traffic lane capacities at that time. SEQIPP provides for upgrading of this route, anticipated as the addition of a transit (T2) lane in each direction by 2016.
- Traffic increases of 60% on Croydon Street are forecast to 45,900 vehicles per day by 2026. Such increases would be accommodated by the widening of Croydon Street to a divided six lane road and intersection upgrades at Milton Road/Croydon Street/Morley Street and Jephson Street/Sylvan Road.

Figure 13: Average Weekday Traffic on Connecting Routes



- Council has been implementing set-backs as re-developments occur along Jephson Street to improve the traffic capacity of this arterial route progressively over time. The forecast traffic increases with the Project by 2026 would be 28% to 30,400 vehicles per day.
- Compared with the 'without Project' scenario, the ICB would experience forecast increases in average weekday traffic in the order of 20%, resulting in 143,000 vehicles per day by 2026. This is within the traffic carrying capacity of this six lane road link. Weaving movements can be accommodated satisfactorily with the proposed connection layout.
- Kelvin Grove Road to the immediate north of the Project, is forecast to experience a 17% increase in daily traffic by 2026 with effects diminishing further north. Traffic increases can be satisfactorily managed with proposed project intersection works at the connection.
- Traffic volumes on Kelvin Grove Road, Countess Street and Petrie Terrace south of the connection would experience little change. Although traffic from the south facing ramps from Northern Link would use these roads, some users that would have otherwise travelled via Countess Street or ICB to Milton Road or Coronation Drive would divert via the Kelvin Grove Road northern ramps to Northern Link.
- Average weekday traffic increases of less than 15% are forecast on Musgrave Road, between College Road and Hale Street and College Road. No significant effect on level of service during peaks is expected.
- The Traffic Management Plan for the Project would address the need for signal co-ordination to accommodate increased traffic on connecting routes where multiple signalised intersections occur such as Croydon Street-Jephson Street and Kelvin Grove Road.

The effect of Northern Link on traffic volumes within the residential precinct north of Milton Road in the vicinity of the Toowong connection has also been assessed taking into account the potential for use of the Gregory Street- Morley Street route for traffic seeking to access the Northern Link ramp connection. Key findings are as follows.

- Only traffic from the immediate vicinity (forecast as 360 vehicles per day by 2026) would find it beneficial to use Morley Street to access the Northern Link entry ramp via a right turn movement from Morley Street. Approximately 140 vehicles per day are forecast to use Morley Street as an exit route, with this traffic exiting to Croydon Street and then travelling via a circuitous route to access Morley Street.
- Traffic reductions with Northern Link are forecast for the Gregory Street - Morley Street route compared to the situation without the Project. This occurs due to congestion relief effects that Northern Link provides within the major road network and at the Toowong roundabout. In 2026, traffic volumes of 5,000 vehicles per average weekday are forecast on Morley Street. These would be greater than existing levels due to general travel demand increases in the inner western suburbs, and exceed the typical level generally regarded as tolerable within a residential area (4,000 vehicles per day).
- As this precinct will remain challenged over time by through traffic pressures, an expansion of the currently programmed local area traffic management (LATM) scheme for the area would be prudent to further protect the amenity of this residential area. As part of the Traffic Management Plan for the Project supplementary LATM initiatives should be considered for the precinct extending from Milton Road in the south to Birdwood Terrace in the north and from Frederick Street in the west to Wienholt Street in the east.

Improved amenity on many roads in the inner western suburbs would be likely, due to forecast traffic reductions with the Northern Link project. Short term effects are illustrated in **Figure 14** which shows the average weekday traffic for the 2014 scenarios with and without the Project. The weekday traffic for 2007 is also presented for comparison.

Examples of the longer term effect of Northern Link in 2026 compared to the scenario without the Project include:

- reductions in traffic on the Milton Road-Coronation Drive corridors, and other roads used by east-west traffic. This includes traffic reductions of up to 22% on Coronation Drive and 9% on Milton Road;
- the designated Toowong activity centre would benefit from traffic reductions including a forecast decrease by 27% at High Street to 27,400 vehicles per day in 2026, lower than existing traffic levels;
- traffic on Moggill Road through Toowong would reduce by 13% and at Indooroopilly by 5%;
- significant daily traffic reductions on many city distributors such as Sylvan Road south of Croydon Street (-23%), and Caxton Street (-19%) and Latrobe Terrace (-15%) would result in improved amenity for these precincts; and
- reductions in daily traffic are forecast on many local streets throughout the inner west suburbs such as Eagle Terrace (-24%), Haig Road (-30%), Stuartholme Road (-22%), Rainworth Road (-43%), Sylvan Road east of Milton Road (-38%), Morley Street (-25%) and Birdwood Terrace (-38%).

4.3.3 Intersection Performance Effects

The effect of the Project on the performance of intersections within the network has been assessed. Findings are listed below.

- The connections with the surface network have been designed to ensure unimpeded traffic flows. Where possible, grade separations have been used. For locations where traffic exiting the Project would

encounter a potential stop point, analysis has found the level of service and queuing at the exit to be satisfactory in all cases.

- Approximately 40% of the traffic using the Western Freeway would divert to Northern Link, leading to a substantial reduction in traffic using the Mt Coot-tha and Toowong roundabouts. There would be improving travel conditions for commuter and local traffic use, relieving current pressure leading to the use of the local network for rat-running.
- With the Project, an overall improvement is forecast in operating conditions at intersections along on Coronation Drive, Milton Road and Moggill Road, due to traffic relief during peak periods.
- Jephson Street would experience some decrease in level of service associated with increased traffic due to the Project. A significant upgrade to the intersection of Jephson Street and Croydon Street would improve operations.
- In Toowong, relief of traffic congestion is anticipated at the busy High Street/Benson Street/Brisbane Street intersection near the railway station.
- At the intersection of the Western Freeway and Moggill Road (on-ramp), the level of service would decline with the Project but remain satisfactory. At the off-ramp, the level of service would improve with the Project due to traffic re-distribution effects.
- There would be little change at the intersections on Musgrave Road, Countess Street and in the College Road corridor compared to the 'without Project' scenario. This would occur because some existing cross-city traffic between Milton Road and Coronation Drive/Milton Road would transfer to Northern Link.

4.3.4 Network Performance Effects

The impacts of Northern Link on the overall Brisbane Metropolitan Area network performance in terms of overall vehicle kilometres and hours of travel are identified in **Table 10** and shown graphically in **Figure 10**.

Key findings are listed below.

- Reduced travel on lower-order roads in the network (local, district and suburban routes) with the Project as a consequence of redistribution of travel to motorway routes. The arterial network is also benefited by reductions in travel distance and travel time.
- A general lowering of congestion with an overall increase of average network speed.
- A very small (0.1%) increase in overall vehicle kilometres of travel, with an overall 1% reduction in the vehicle hours of travel within the network.
- Reductions in total vehicle hours of travel and vehicle kilometres of travel for commercial vehicles with a shift of use away from lower-order roads and onto motorways. This would provide important benefits to industry through reduced operating costs and improved travel time reliability.

Figure 14: Average Weekday Traffic on Brisbane Inner West Roads

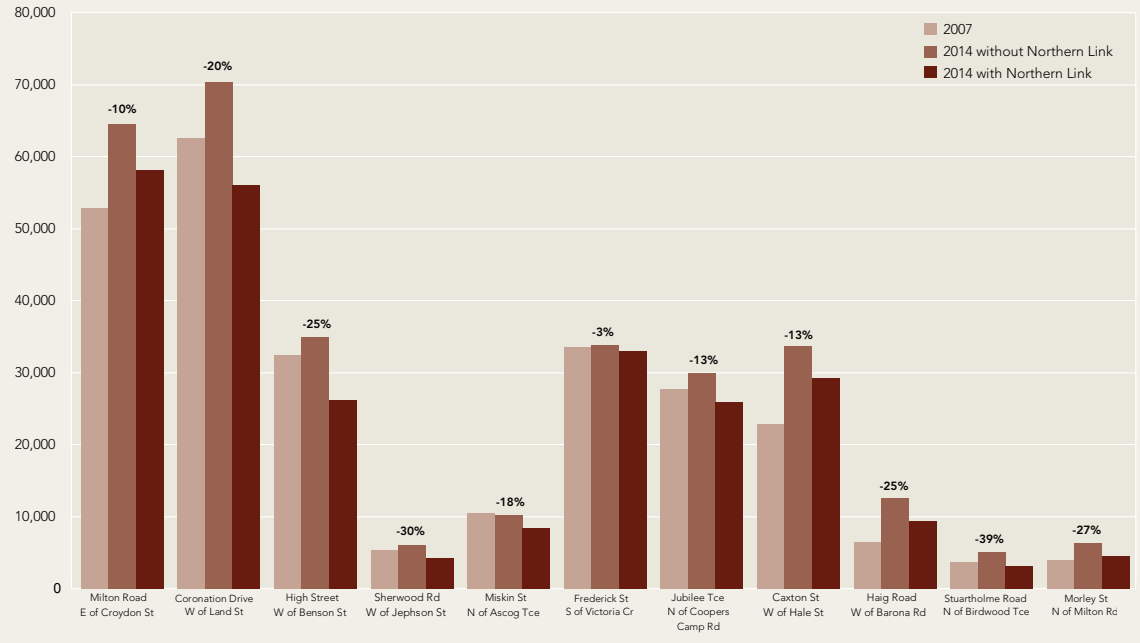


Table 10: Network Performance by Road Type Without and With Northern Link

Road Type	Without Northern Link			With Northern Link			Difference		% Difference	
	VHT[1]	VKT[2]	Speed km/h	VHT	VKT	Speed Km/h	VHT	VKT	VHT	VKT
2014										
Motorway	297,100	24,677,400		301,100[3]	24,772,200[3]		4,000	279,300	1.3%	1.1%
Arterial	444,900	20,442,200		438,000	20,306,900		-6,900	-135,300	-1.6%	-0.7%
Suburban	167,600	8,147,700		166,400	8,121,500		-1,200	-26,200	-0.7%	-0.3%
District	106,300	3,505,100		102,400	3,465,100		-3,900	-40,000	-3.7%	-1.1%
Local	52,100	1,315,500		53,400	1,305,700		1,300	-9,800	2.5%	-0.7%
Total[4]	1,068,000	58,087,900	54.4	1,061,400	58,156,000	54.8	-6,600	68,100	-0.6%	0.1%
2026										
Motorway	412,800	32,754,100		415,400[3]	33,094,000[3]		2,600	339,900	0.6%	1.0%
Arterial	514,700	23,578,300		504,600	23,406,800		-10,100	-171,500	-2.0%	-0.7%
Suburban	200,900	9,624,600		199,100	9,570,000		-1,800	-54,600	-0.9%	-0.6%
District	136,400	4,057,600		133,500	4,013,600		-2,900	-44,000	-2.1%	-1.1%
Local	73,900	1,465,200		73,900	1,451,700		0	-13,500	0.0%	-0.9%
Total[4]	1,338,700	71,479,800	53.4	1,326,500	71,536,200	53.9	-12,200	56,400	-0.9%	0.1%

Table Notes:
1) VHT - Vehicle Hours Travelled on Average Weekday
2) VKT - Vehicle Kilometres Travelled on Average Weekday
3) Includes NL Tunnel VHT and VKT
4) Excludes travel on traffic zone entroid connectors within the model.

4.3.5 Travel Time Benefits

The travel time benefits offered by Northern Link are significant. Key examples of travel time benefits are listed below.

- For travel from the Western Corridor to the ATC area including the Airport, travel time savings of 25%, or almost 20 minutes, would be experienced in both peaks.
- For travel to the Airport from the Inner West peak period travel time savings of 50%, or 20 minutes, would also occur in 2026. These time savings would enable residents of Toowong to access the Airport in about 15 minutes and residents of Indooroopilly would access the Airport in around 20 minutes.
- For routes between the Inner West and the Central City, such as Chapel Hill to Spring Hill, average time savings of approximately 50%, or 10 to 15 minutes, would be experienced in both the morning and evening peak periods in 2026.
- Benefits, although lesser, are also forecast for traffic choosing to use the un-tolled surface routes instead of Northern Link. These travel time savings would be approximately 15% to 30% during the morning peak for routes between the Inner West and the Central City and between 5% and 20% in the evening peak period. This represents travel time savings of up to 9 minutes in the morning peak and 5 minutes in the morning peak.
- For un-tolled surface routes between the Western Corridor and the ATC time savings would be around 5%.

4.3.6 Local Traffic Effects

Northern Link would require changes to local traffic arrangements through access restrictions or changes that would generally be confined to the tunnel portal areas and immediate approaches. Local access effects can be summarised as:

- Western Connections:
  - Western Freeway precinct – access to the area west of Frederick Street including the Botanic Gardens, Anzac Park and the Toowong Cemetery not affected with benefits due to reduced traffic use of the Mt. Coot-tha Roundabout;
  - Toowong – north of Milton Road and east of Frederick Street - minimal effects on local traffic access in this precinct. To assist in the management of extraneous through traffic pressures it is recommended that a local area traffic management scheme be implemented within the Toowong north precinct as described previously; and
  - Toowong – south of Milton Road and east of Miskin Street - moderate effects with the Project design shaped to minimise adverse impact.
- Eastern connection:
  - ICB precinct – the effect of the Project on local access would be minimal;
  - Kelvin Grove – west of Kelvin Grove Road - marginally increased journey times due to road changes however reduced traffic volumes on the local streets within this precinct; and

- Kelvin Grove Urban Village – east of Kelvin Grove Road – minimal effect on local access.

Access to hospitals, access for emergency services and access to rail infrastructure would not be affected by the Project.

4.3.7 Benefits for Bus Travel

Traffic reductions on the surface road network with Northern Link would allow for the potential re-introduction of transit priority initiatives on Coronation Drive. This scenario has been taken into account in the traffic modelling.

Specific benefits for bus travel are as follows.

- The opportunity for Rocket bus services from the Brisbane western suburbs to use Northern Link as an express route from the Western Freeway to access the Inner Northern Busway stations in the CBD. Queensland Transport has identified that approximately 64 planned peak period Rocket bus services each morning and evening could be re-routed travel via Northern Link in 2014 increasing to 92 services by 2026. Commuters using these buses travelling via Northern Link would benefit from daily savings in 2026 of 11 to 12 minutes each way, (ie: 23 minutes per day). Patronage modelling indicates approximately 6,600 patrons would use these services daily by 2026.
- For bus services travelling along Milton Road and Coronation Drive travel time improvements would result due to reduced surface traffic levels, with time savings of approximately 25% forecast in the peak direction.
- There will only be minor effects to existing bus stops due to the Project, all of which can be suitably accommodated within the design.

4.3.8 Effects on Active Transport

Compared to the scenario without Northern Link, the Project would reduce traffic volumes and congestion on many surface roads in the study corridor, including Milton Road and Coronation Drive. This would enable improved access within the study corridor, through improved movement of traffic, including for pedestrians and cyclists.

Northern Link does not permit usage by pedestrians and cyclists. The Project's design has ensured that connectivity for pedestrian and cycle movements is maintained around the tunnel portals and their connections to the surface road network as identified below.

- Western Freeway Connection - existing connectivity and function of the Western Freeway bikeway and the planned Cycle and Pedestrian Bridge would be maintained.
- Toowong Connection – signalised pedestrian crossings would be maintained at intersection of Milton Road/Croydon Street/Morley Street on three of the four approaches. Pedestrian crossings of all

approaches would be maintained at the Croydon Street/Jephson Street/Sylvan Road signalised intersection.
- The on-road bike path on Sylvan Road and its connectivity with the Western Freeway and the Bicentennial bikeways would be maintained, with improved safety due to traffic reductions in Sylvan Road.
- ICB Connection – no impact on the off-road bikeway adjacent to the southern side of the ICB or on the bikeway and pedestrian paths on the ICB land bridge.
- Kelvin Grove Connection - pedestrian facilities would maintain the current linkages between the Kelvin Grove Urban Village and the community to the west of Kelvin Grove Road. Pedestrian crossing facilities at the Kelvin Grove Road/Musk Avenue/Northern Link ramps intersection would be provided.
- Pedestrian crossings would continue to be accommodated at the signalised intersection of Kelvin Grove Road and Blamey Street.

4.3.9 Road Safety

The effects of the Northern Link on road safety have been assessed and an overall improvement is forecast due to the Project. Key findings include:

- an overall reduction of forecast crashes on major routes in the inner west in 2014 and 2026 with Northern Link of 3.4% and 2.0% respectively;
- an overall reduction in forecast crashes on Coronation Drive (18%) and Milton Road (6.5%) in 2026;
- part of the MetRoad 5 north of the Toowong Roundabout up to and including Rouen Road experiences road safety benefits on average of 11%;
- the Western Freeway east of the Northern Link Western Freeway ramp connections would have an overall reduction in crashes would be expected (21%). To the west of the Northern Link ramps an increase in crashes (31%) in 2026 is forecast due to the increase in traffic volumes along this section of the Western Freeway. However, the combined overall increase in the number of crashes would be small; and

- traffic relief forecast on a range of other regional routes south of the Brisbane River (such as Ipswich Road and Fairfield Road) that are heavily used by freight, and these locations would also benefit from crash reductions.

4.4 Cumulative Effects with Other Projects

The cumulative traffic impacts of Northern Link have been analysed within the traffic modelling scenarios, with known infrastructure projects in the north and western suburbs of Brisbane including CLEM7, the Gateway Upgrade Project, Airport Link, Northern Busway (Windsor to Kedron), Airport Roundabout upgrade, Hale Street Link, Ipswich Motorway Upgrade and the Centenary Highway and Western Freeway transit lane project (identified within SEQIPP).

Potential cumulative construction effects would arise from the overlap of haulage and delivery route traffic associated with Northern Link with similar activities on other known projects. The two proposed spoil haulage routes that have the potential to overlap with construction activities of other projects are summarised as follows.

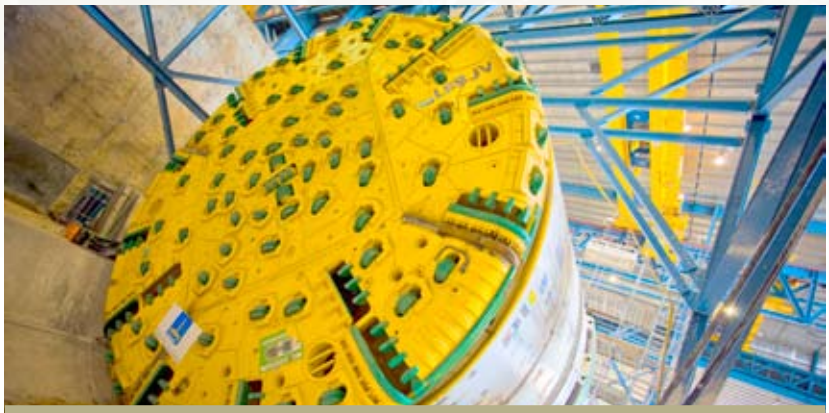
- Haul route to spoil placement site at Port of Brisbane - anticipated at 50 trucks per day to and from the Kelvin Grove worksite and ICB work area between July 2010 and February 2012.
- Haul route to spoil placement site at Swanbank – anticipated at 90 trucks per day to and from the Western Freeway and Toowong worksites between April 2010 and June 2011.

Potential for cumulative construction effects based upon currently available information is as follows.

- CLEM7: there would be no overlap in use of the common route for spoil haulage to the Port of Brisbane route as CLEM7 is expected to be complete prior to use of this route for Northern Link in July 2010.
- Gateway Motorway Upgrade: if Gateway Motorway Upgrade haulage continues on the Western Freeway-Centenary Motorway beyond April 2010, there would be an overlap with the Northern Link spoil haulage west-bound to Swanbank. However, the Northern Link haulage volumes would represent only 0.2% of traffic on this route, so cumulative effects would be minimal.
- Airport Link, Northern Busway and Gateway Roundabout Upgrade Project: The estimated peak combined haulage traffic associated with Airport Link and Northern Link (160 trucks per day) during 2010/11 would represent approximately 1.8% of the 2010 background truck traffic and approximately 0.3% of total traffic on this route. There are, however, several intersections along Kingsford Smith Drive operating at close to nominal capacity during peak periods. The impact on performance of key intersections during peak periods would need to be examined during the preparation of the Construction Traffic Management Plans, and haulage operations managed accordingly (eg: being restricted to outside peak hours if necessary).
- Hale Street Link: The proposed haulage routes associated with Northern Link would not be likely to have any direct effects on the Hale Street Link construction activities. The construction program associated with the Hale Street Link project incorporates a number of traffic management and diversion measures within the eastern end of the Coronation Drive and Milton Road corridors to facilitate the connection of Hale Street Link to Hale Street. Early works to upgrade the Milton Road/ Croydon Street intersection within the Northern Link construction program could further assist in the management of traffic on diversion routes related to Hale Street Link construction.
- Ipswich Motorway Upgrade: the haul route to Swanbank, used by 60 trucks per day to and from the Western Freeway and Toowong worksites between April 2010 and June 2011, would pass through several construction projects planned on the Ipswich Motorway. Cumulative effects of overlapping haulage activities would be minimal as Northern Link haulage volumes would represent only 0.2% of traffic on the route.
- Centenary Highway and Western Freeway transit lane project: this project is still in the planning phase by DMR, with construction program and details unknown.

Cumulative effects with projects emerging from contemporary studies have also been considered by considering the potential effect of a range of corridor options released for public comment in April 2008 from State Government's Western Brisbane Transport Network Investigation (WBTNI). Relevant WBNTI links were tested as tolled links operational in 2026[25], with the inclusion of several major tolled links branching from the Western Freeway (ie: Option 3 - Toowong to Everton Park, Option 5 – TransApex E-W Link and

25. Proposed toll rates for these other facilities have not been published to date, so preliminary assumptions only have been applied in traffic modelling.



Tunnel Boring Machine, CLEM7

Option 4 - Northern Link). It was assumed that the Western Freeway and Centenary Motorway, including the Centenary Bridge, would operate as three general purpose lanes in each direction for this assessment.

Key findings for the cumulative effects assessment are as follows.

- As there is some overlap of the cross-city (west-east, west-north and west-south) functions performed by the WBTNI options and Northern Link, a small reduction in traffic use of Northern Link is forecast. Preliminary modelling indicates that the average weekday traffic use of Northern Link volume would reduce by 12.4%, from 75,900 vehicles per day to 66,500 vehicles per day in 2026.
- Northern Link would continue to cater for similar east-west travel patterns between the Western Corridor and the ATC in the cumulative scenario. Overall the predominant cross-city function provided by Northern Link between the west, east and north would be maintained.
- Traffic reductions in the cumulative scenario would result with key roads such as the ICB, Gympie Road, and Gateway Motorway north likely to benefit from congestion relief. Increased traffic volumes are forecast for the Western Freeway and Centenary Highway (in line with the capacity upgrades that would be implemented on these corridors to feed a combination of Northern Link and WBTNI option 3).
- This preliminary testing of cumulative effects indicates minimal change to the local streets and city distributors in the Inner West with the combination of Northern Link and the WBTNI projects.

4.5 Conclusions – Traffic and Transport

From a traffic and transport viewpoint, Northern Link would fulfil a range of traffic and transport needs and support the Project objectives.

- Northern Link would provide a motorway standard link between the Western Freeway and the ICB that would remove the need to travel through the Brisbane CBD for cross-city movements between the west, north and east of Brisbane. Northern Link would predominantly cater for cross-city travel representing over 80% of all trips and 95% of commercial vehicles trips.
- Northern Link, in conjunction with the Centenary Highway, Western Freeway, ICB and Airport Link would provide a motorway standard corridor between the far south-west, the Western Corridor and the central city, the ATC, north Brisbane and the strategic road network to the north for long distance freight and regional freight distributors. This would provide an alternative freight route to the Brisbane Urban Corridor and the regional roads in the inner west and improve travel times and reliability for freight.
- By redistributing travel to motorway standard routes from the local road network Northern Link would reduce congestion and improve travel time reliability on the regional roads through the inner west. There would be an overall reduction in crashes on major roads in the inner west.
- Northern Link would relieve congestion on the existing major bus routes on Coronation Drive and Milton Road that would improve bus journey times and reliability and could assist in increasing public transport operations. Northern Link also provides the opportunity for express bus services from the Western Corridor and Brisbane's western suburbs to be routed through it to access the Inner Northern Busway and the CBD.
- Connectivity to the designated activity centres within the inner western suburbs such as Toowong, Indooroopilly and the University of Queensland at St Lucia would be improved. Forecast traffic reductions on the surface road network in the inner western suburbs would provide the opportunity for improvements to the active transport and public transport networks within the inner western suburbs.

While some adverse effects have identified and assessed, the traffic and transport study shows clear support for the projects objectives and in particular for providing for cross-city movement of people and freight.

Western Freeway at Toowong

5. Environmental Conditions and Impacts

Within the Northern Link study corridor and adjacent areas studies have been made of the existing environment to provide the baseline information upon which to base the assessment of potential environmental impacts and from which to develop the Project design. Environmental disciplines relevant to Northern Link include:

- geology and soils;
- hydrology (ground water, surface water and flood potential);
- air quality and green house gases;
- the acoustic environment, including vibration;
- flora and fauna;
- cultural heritage, including indigenous cultural heritage;
- social and community conditions;
- economic conditions;
- land use and planning and; and
- landscape and visual conditions, including urban design.

5.1 Geology and Soils

5.1.1 Existing Conditions

Elevations within the study corridor are up to 70m above the Australian Height Datum (AHD) on Musgrave Road and 50m above on other ridge lines such as the Frederick Street – Birdwood Terrace intersection. In general, the topography of the study corridor is undulating with several steep ridges radiating from Mt Coot-tha. The proposed portals are at elevations of approximately 25m AHD at the Western Freeway and Frederick Street, 50m AHD at Kelvin Grove Road and 35m AHD at the ICB.

Surface geological mapping of the study corridor identifies two low grade metamorphic rock units, namely the Bunya Phyllite and the Neranleigh-Fernvale Beds. The Bunya Phyllite occupies the area from the western end of the study corridor to approximately Musgrave Road at the Normanby Fiveways. Further east, the study corridor has been mapped as including the Neranleigh-Fernvale Beds.

A review of the *Acid Sulfate Soils Tweed Heads to Redcliffe Map 1* (NRW 2002) indicates that the area within the study corridor has been mapped as NA – Land not assessed for Acid Sulfate Soils (ASS).

While more detailed analysis has identified small areas with a low risk of ASS within or closely adjacent to the study corridor, none are likely to be excavated or otherwise disturbed during any Project construction.

The linear nature of Northern Link means that a large number of properties are either on the actual route or are in its vicinity. Furthermore, the study corridor traverses one of the older areas of Brisbane and has been subject to land use changes for more than 100 years. Consequently, there is a likelihood that activities causing contaminated land may have occurred in the study corridor. Contaminated sites may comprise either contaminated soils or groundwater.

There are no known significant mineral or energy resources in the study corridor and none have been noted in the core logs. Mt Coot-tha Quarry is a locally important extractive resource located with the study corridor.

5.1.2 Predicted Impacts and Mitigations – Geology and Soils

The soils in the study corridor are considered to be moderately dispersive with a potential for erosion if appropriate erosion and sediment control measures are not implemented and maintained during site works. Mitigation measures incorporated in the construction EMPs would be implemented throughout various stages of the Project to control and reduce the risk of erosion due to construction and operation activities.

Settlement resulting from tunnel construction activities may arise due to:

- elastic ground settlements caused by tunnel construction; and
- consolidation settlements caused by dewatering from groundwater drawdown into the tunnel.

Given the anticipated high strength rock conditions for much of the tunnel length, areas where some impacts on the surrounding infrastructure may occur are low cover or poorer quality rock such as areas in the vicinity of the tunnel portals and the connection between the mainline tunnels and the Kelvin Grove ramps. To minimise the risk associated with settlement, it is important to adhere to suitable engineering practices and ensure that effective management and monitoring approaches are implemented and reviewed from the onset of construction. A range of such measures are included in Chapter 19, Element 3 of the Draft Design and Construction EMP.

The nearest areas with a low possibility of encountering ASS are in the vicinity of Toowong Memorial Park on Sylvan Road, the eastern end of Baroona Road and Neal Macrossan Park. Mitigation measures for the project would implement management and monitoring practices to ensure potential environmental impacts associated with ASS, if any, are minimised and controlled.

Contaminated land or potentially-contaminated land located within a one kilometre radius of the study corridor may have a potential to impact Project construction. The disturbance of potentially contaminated soil is likely to occur at 17 sites in the study corridor.

Mitigation measures have been proposed for these 17 sites in accordance with the EPA *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland*. The draft guidelines provide for contaminated site investigations being assessed progressively and managed through a staged approach.

5.2 Hydrology

5.2.1 Groundwater

Existing environment

Groundwater potential in the basement rock (mainly Bunya Phyllite, west, and Neranleigh-Fernvale Beds, east of Musgrave Road) have negligible primary porosity with groundwater likely to be semi-confined or confined and limited to localised structural defects such as joints, fractures, or other structural voids.

Groundwater potential in the unconsolidated surface alluvium is limited. In general, these alluvial sediments form unconfined and perched aquifers overlying less permeable basement rocks.

Survey of DNRW's groundwater database (GWDB) identified 12 registered groundwater bores within 5km of the study corridor, with five of these facilities classified as 'abandoned and destroyed'. No detailed water quality, hydraulic testing or groundwater yield data were available for any of the registered existing bores.

In general, quality of groundwater resources within the Bunya Phyllite is variable and considered poor with reference to drinking quality, as total dissolved solids (TDS) concentrations range from fresh (300mg/l) to brackish (5000mg/l). Similar trends were noted in the Neranleigh-Fernvale beds with TDS values ranging from 300 to 30,000mg/l (AGE, 2006). For reference purposes the Australian Drinking water guidelines recommend values between 500mg/l and 1000mg/l for potable use.

Victoria Park Golf Course at Herston

Groundwater within the localised alluvial aquifer near the lowest point in the Botanic Gardens was brackish with a TDS of 1,494-2,508mg/l and a pH ranging from slightly acidic to neutral (pH 6.52 and 7.27).

Impacts

The predicted long term groundwater level drawdown as a consequence of tunnel construction and operation is illustrated for the alluvial/weathered material (Layer 1) in Figure 7-10, and for fractured rock aquifers (Layer 2) in Figure 7-11, in Chapter 7 of the EIS. The modelling indicates that the total long-term groundwater inflow to the tunnel is likely to be very low (in the order of 4 L/s over the length of the tunnel).

Settlement due to groundwater level lowering, along almost the entire tunnel route will be effectively negligible. The only possible exceptions are the occurrences of alluvium in proximity to the western portal cut and cover section and at the central section of the tunnel (close to Fernberg Road).

The level of groundwater dependency in the area is likely to be low with terrestrial vegetation, river base flow systems and aquifer systems potentially utilising groundwater in the saturated zone only during drought conditions when surface water flux is uncommon.

The numerical modelling undertaken indicates that the drawdown cone is unlikely to intercept the Brisbane River in the long term. The prospect of saline water migrating and discharging to the tunnel (and presenting corrosion or clogging issues) is therefore improbable.

5.2.2 Surface Water

Existing Environment

The study corridor does not directly intersect any major waterways due to the extensive channelling and underground piping of drainage lines in this area of the city.

Three upper tributaries of Toowong Creek cross the very western extent of the study corridor beneath the Western Freeway. At the eastern end of the study corridor a minor waterway intersects the study corridor in the vicinity of the ICB at Victoria Park Golf Course. 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.

The receiving waterways which could potentially be affected by construction activities and/or operation of

the Project are the Brisbane River, Breakfast/Enoggera Creek and Toowong Creek.

The water quality of the estuarine reach of Toowong Creek is poor, with nutrient concentrations (especially oxidised nitrogen) exceeding all guidelines. Dissolved oxygen concentrations also failed to meet desired water quality objectives. Low chlorophyll-a concentrations indicate minimal algal productivity within the system.

Although Breakfast Creek/Enoggera Creek does not directly intersect the study corridor, a major detention basin within Victoria Park discharges via an underground brick arch drain into Enoggera Creek. As a result, construction activities at 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) in Breakfast Creek.

Water quality of Enoggera Creek is poor. Overall nutrient concentrations of nitrogen and phosphorus exceeded all water quality guidelines. Median values for dissolved oxygen, chlorophyll-a, suspended solids, and pH, all met the relevant water quality criteria. Turbidity levels exceed guidelines.

Impacts and Mitigation

The main potential sources of surface water 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; and
- changes to surface water hydrology.

Generic 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.

Further generic potential impacts specific to the construction phase include:

- disturbance of acid sulphate soils (ASS) resulting in acidic runoff; and
- use of recycled water for construction activities.

During construction, potential impacts to water quality would be managed through the following measures and controls:

- maximise the areas of vegetation retained and progressively rehabilitate cleared sections where appropriate;
- diversion of stormwater from higher ground around disturbed areas where possible;
- 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;
- ensure dust suppression measures are implemented throughout the construction phase;
- 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; and
- waste storage facilities and spoil placement areas are to be located away from existing drainage lines and have appropriate bunding and drainage mechanisms.

A water quality monitoring program for the construction phase would be established to ensure compliance with water quality objectives and to enable potential impacts to water quality to be assessed and mitigated.

As runoff from road infrastructure has been identified as a significant contributor of heavy metals and other toxicants to local waterways, an appropriate operational monitoring program would be essential to the assessment and management of potential long-term and cumulative impacts to surface waters.

5.2.3 Flood Potential

The flood potential in and adjacent to the study corridor has been assessed, to understand how the project may alter the existing flooding regime of the area, to ensure that the Project design takes account of flooding risks and to identify how to avoid flood damage during the construction and life of the infrastructure.

Flood risk to property and infrastructure has been assessed for the one in 100 Average Exceedance Probability (AEP) flood event. Flood immunity of the tunnel has been assessed for the one in 10,000 AEP flood event.

During construction, both the transition and cut and cover sections at the Western Freeway connection would be exposed and need protection from local flooding. This would be achieved by sheet pile/ diaphragm walls along the two faces of construction exposed to flooding, or a combination of the two.

The construction area upstream of the Western Freeway, adjacent to the Botanical Gardens, would

also need to be protected from local flooding during construction. This would be achieved by construction of a bund, to provide immunity to the construction area in a one in 100 AEP event. The bund would be approximately 400-600m long and 2m high at its highest point. The existing 1650RCP culvert under the Western Freeway would be maintained during construction while the existing 900 RCP to the west would become redundant and be removed.

The adopted BCC one in 100 AEP flood level in the Brisbane River closest to the western connections is 4.5m AHD. This level is well below the terrain at the western connection with the Milton Road roundabout above 14m AHD. Therefore Brisbane River flooding would not impact on the Project in a one in 100 AEP event and the Project would not impact on flood levels developed by the Brisbane River in a one in 100 AEP flood event.

For the one in 10,000 AEP flood a recalculation of the maximum water level was undertaken for the purposes of the Project with an upper and lower bound as confidence levels of this estimate. After addressing several sensitivities, a level of 14.9m AHD has been adopted for the reference project with a freeboard of 300mm.

Between Victoria Street and Blamey Street, opposite McCaskie Park, is an area of low lying land containing existing residential properties. Any alteration of the storage volume or the drainage under Kelvin Grove Road has the potential to alter flood levels and impact the flood immunity of upstream properties. The existing catchment discharges under Kelvin Grove Road via pipes into an overland flow-path designed through the Kelvin Grove Urban Village development.

South of the proposed Kelvin Grove Road portals are two detention areas. The one upstream of the ICB overpass, which is proposed as a worksite for the project, discharges to the Kelvin Grove Road – Ithaca Street intersection through a 375mm diameter pipe, or via overland flow down Kelvin Grove Road. Overtopping onto Kelvin Grove Road is not predicted to occur during a one in 100 AEP event. Any reduction to available storage volume in the existing basin areas through construction or operation would need to be offset by basin reconfiguration to achieve zero external hydraulic impacts.

The Brisbane Grammar School sports fields, on the corner of the ICB and Victoria Park Road and bounded on the east by the Inner Northern Busway, functions during large to extreme flood events as a detention basin that stores water before passing it down an open channel that runs parallel to the ICB to York's Hollow. The Project includes realignment of the existing open drainage channel and the bikeway slightly to the north to allow the existing capacity of the channel to be maintained. Whilst there is no expected effect on residential properties, the detailed design would ensure no change to the storage capacity of the basin and maintaining the existing discharge capacity past the busway abutment.

5.3 Air quality

5.3.1 Existing Conditions

Data from four EPA air quality monitoring sites (Brisbane CBD, Rocklea, South Brisbane and Woolloongabba) and two road tunnel project monitoring sites (Bowen Hills and Kedron) have been assessed for the purposes of this study. In addition, two monitoring sites have been established for the Northern Link project, one at Toowong and another at Kelvin Grove. Monitoring at Toowong commenced in November 2007 and covers the southern end of the Project. The Kelvin Grove site covers the northern end of the Project and was established in July 2008.

Ambient air quality collected in the Brisbane area show the following:

- Carbon monoxide (CO) concentrations have been, and are likely to continue to be, below the EPA air quality goal (see **Table 11**). Compliance with the EPA goal has been exhibited near busy roads as well as in residential areas and parklands.
- Maximum nitrogen dioxide (NO_2) concentrations have been, and are likely to continue to be, below the EPA's short-term air quality goal (1hr maximum, **Table 11**)[26]. Annual average NO_2 concentrations at the monitoring sites, covering busy road as well as residential locations, have been below the EPA's goal.
- Lighter winds and less rain in the cooler months of the year generally lead to higher concentrations of the primary pollutants, CO and NO_2 in particular, at most monitoring locations.
- Ozone and SO_2 concentrations are below the EPA's air quality goals at all monitoring locations.
- Short-term (ie: 24hr maximum) PM_{10} concentrations have exceeded the NEPM standard (of 50ug/m3) at all monitoring locations on at least one occasion in recent years. These events generally coincide with widespread dust storms or bushfires which can influence large areas. Widespread dust storms or bushfires generally trigger elevated levels at all monitoring locations. There have been no exceedances of the EPA goal (of 150ug/m3), which is less stringent than the NEPM standard.
- Annual average PM_{10} concentrations are below the EPA's air quality goals at all monitoring locations.
- Short-term (daily) and annual average $PM_{2.5}$ concentrations have been above the NEPM 'Advisory Reporting Standards' **Table 11** on occasions at two of the three monitoring locations. As for PM_{10}, the highest $PM_{2.5}$ concentrations are usually influenced by widespread events.

26. The EPA has indicated during discussions that it would be appropriate to adopt the National Environmental Protection Measure (NEPM) air quality standards and goals either where there is no set EPA criteria or where the NEPM criteria are more stringent than the set EPA criteria.

5.3.2 Construction Impacts on Air Quality

Potential impacts on air quality during the construction phase may arise from:

- surface construction works (eg roadworks, cut and cover tunnelling worksite activities);
- movement or queuing of construction vehicles with diesel-powered motors adjacent to sensitive activities;
- long-term operation of diesel-powered plant and equipment;
- venting air from tunnel construction areas; and
- handling, removal and placement of construction spoil.

Construction air quality management plans will be required to incorporate measures to avoid, or mitigate and manage the potential adverse impacts from construction activities on air quality. The Draft Outline EMP provides construction air quality goals to be achieved during the construction works. Ventilated air from tunnel excavation is to be treated for the removal of dust prior to release from worksites. Regular air quality monitoring is to be undertaken to determine whether environmental requirements of the Construction EMP and Construction Air Quality Sub-Plan(s) are being met. Construction compliance reporting of monitoring records is to be maintained during construction and available for inspection at any time.

The Project proposes the use of ventilated acoustic enclosures at the worksites for the handling and loading of spoil as a primary means of controlling and managing the risk of dust-related impacts on air quality. The proposed spoil conveyor would be enclosed to ensure the construction air quality criteria applied to surrounding areas could be met by the facility.

The impact of heavy vehicle operations would be managed through implementation of relevant provisions within a construction vehicle management plan. The Draft Outline EMP included in the EIS provides typical measures required to manage the operation of the construction vehicle fleet to mitigate air quality impacts on surrounding areas.

5.3.3 Operational Impacts on Air Quality

The major contribution of air pollution in Brisbane comes from motor vehicles, with other activities such as power generation and industry also contributing pollution to the air. The surface road network, with high levels of traffic congestion on the radial arterial routes, contributes significantly to this pollution load.

Also of concern for road tunnel projects is the level of pollution within each of the tunnels, requiring ventilation for motorists' visibility and safety. Workforce safety is also a key consideration. For the management of in-tunnel air quality, the standards adopted were presented earlier in **Table 1,** Tunnel Ventilation Design Criteria. In circumstances where the in-tunnel standards might be approached, the range of mitigation measures would include:

- increased operation of the fans within the tunnel system and the ventilation station;
- limitations on the in-flow of traffic to the tunnel system; and
- other traffic management measures to relieve traffic congestion on the approach and departure routes from the tunnel system.

For the assessment of the potential impacts of Northern Link on the external ambient environment, the existing guidelines and regulatory measures for air quality were canvassed. To achieve a low-risk air quality outcome, the following combination of standards and goals was adopted:

- air quality goals for ambient air established in Queensland's Environmental Protection Policy (Air) 1997; and
- the National Environmental Protection Measures (NEPM) where there were no Queensland standards,

Table 11: Goals for Ambient Air Quality

Pollutant	Goal	Measuring Period
Carbon monoxide (CO)	10 mg/m^3	8 hour maximum
Nitrogen dioxide (NO_2)	246 µg/ m^3	1 hour maximum
	62 µg/ m^3	annual average
Particulate matter < 10µg (PM_{10})	50 µg/ m^3	24 hour maximum
	25 µg/ m^3	annual mean
Particulate matter < 2.5µg ($PM_{2.5}$)	25 µg/ m^3	24 hour maximum
	8 µg/ m^3	annual mean
Total suspended particulate matter	90 µg/ m^3	annual average

Table Note:
The $PM_{2.5}$ goals are referred to as Advisory Reporting Standards and are set for the purpose of gathering data to facilitate a review of these standards as part of the development of the $PM_{2.5}$ NEPM.

or where the measures would be more stringent than the Queensland standards.

For the purposes of this EIS, it is proposed to adopt the NEPM air quality standards and goals either where there is no set EPA criteria or where the NEPM criteria are more stringent than the set EPA criteria, in keeping with the approach taken by the Coordinator-General in relation to both CLEM7 and Airport Link. It is important to note that the standards established as part of the NEPM are designed to be measured to give an 'average' representation of general air quality. That is, the NEPM monitoring protocol was not designed to apply to monitoring peak concentrations from major emission sources. The goals for ambient air quality are set out in **Table 11**.

The primary air quality objective for the ventilation system for Northern Link is to ensure that the air quality goals listed in **Table 11** are not exceeded at any location where there is the possibility of human exposure for the time period relevant to the goal. The predicted, highest concentrations of pollutants at ground level for each of the ventilation outlets (North and West) are presented in **Table 12**.

The predicted impacts on ambient air quality from the operation of the ventilation outlets for Northern Link would be well below the goals adopted for the Project. Furthermore, the predicted impacts would represent a minor change from the predicted air quality should Northern Link not proceed.

With regard to air pollution impacts from the surface road network, consideration was given to the predicted changes in traffic as a consequence of the Project, as well as the separation distances to sensitive land uses, such as schools, child care centres, aged care facilities, hospitals and residential premises. Changes in ambient air quality for selected major roads were predicted at the kerb, 10m, 30m and 50m from the kerb.

The following observations are made from the surface road dispersion model predictions:

- predicted pollutant concentrations are highest at the kerb for each road section;
- predicted pollutant concentrations for 2007 as the base year, are highest near Hale Street;
- air quality would be better along sections of both Coronation Drive and Milton Road with the implementation of Northern Link than in the 'do minimum' scenario;
- air quality would be impacted close to the shoulder of some sections of the Western Freeway and ICB as a consequence of Northern Link;
- road sections where the differences between the 'with' and 'without' Northern Link cases are considered negligible include Hale Street, Waterworks Road, Boundary Street, Given Terrace, Miskin Road and Kelvin Grove Road;
- improvements in local air quality are observed with reductions in surface traffic that occur as a result of diverting traffic to the tunnel; and
- at distances appropriate for the nearest residences, the model predictions for all sections and future years are below the associated air quality goals.

Cumulative Impacts at Herston and Bowen Hills

The reference design for Northern Link includes a ventilation outlet immediately east of the INB and north of the ICB adjacent to Victoria Park golf course. The northern ventilation outlet for CLEM7 will be constructed in Sneyd Street, Bowen Hills approximately 1.6kms to the north-east. The southern ventilation outlet for Airport Link will be constructed on land adjacent to Mann Park off Byrne Street Windsor, approximately 2.1kms to the north north-east. The cumulative effects on ground-level concentrations of key pollutants were modelled for this EIS, with the findings summarised in **Table 13**.

Table 12: Highest ground-level concentrations due to ventilation outlet emissions

Pollutant and averaging time	Predicted maximum ground-level concentrations due to emissions from each ventilation outlet								Background Concentration	Air quality goal
	2014		2016		2021		2026			
	N	W	N	W	N	W	N	W		
Maximum 8-hour average CO (mg/m3)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.5	10
Maximum 1-hour average NO2 (µg/m3)	3.1	7.0	3.3	8.3	2.7	7.3	2.5	6.8	94.3	246
Annual average NO2 (µg/m3)	0.3	0.9	0.3	0.9	0.3	0.7	0.3	0.7	18.5	62
Maximum 24-hour average PM10 (µg/m3)	0.3	0.4	0.3	0.4	0.2	0.3	0.2	0.3	52.6	50
Annual average PM10 (µg/m3)	0.02	0.07	0.02	0.07	0.02	0.05	0.02	0.05	16.7	25

Table 13: Highest Ground Level Contributions due to Northern Link, Airport Link and CLEM7 Ventilation Outlets in 2014

Pollutant and averaging time	Concentrations due to NL northern ventilation outlet	Predicted maximum ground-level concentrations due to cumulative emissions from three ventilation outlets	Background Concentration	Air quality goal
Maximum 8-hour average CO (mg/m^3)	0.1	0.1	2.5	10
Maximum 1-hour average NO_2 ($\mu g/m^3$)	3.1	4.5	94.3	246
Annual average NO_2 ($\mu g/m^3$)	0.3	1.06	18.5	62
Maximum 24-hour average PM_{10} ($\mu g/m^3$)	0.3	0.4	52.6	50
Annual average PM_{10} ($\mu g/m^3$)	0.02	0.05	16.7	25

The cumulative contribution to ground-level concentrations of each of the key pollutants from the ventilation outlets for Northern Link, CLEM7 and Airport Link would be well below the goals for ambient air quality, and would not be the cause for any exceedance of the goals. The increase in the predicted maximum 24 hour average PM_{10} of 0.1µg/m3 is small compared with the goal of 50µg/m3. While the recorded maximum 24 hour average of 52.6µg/m3 for this locality is above the goal, it should be noted that the annual average of 16.7µg/m3 is well below the goal of 25µg/m3, suggesting that the Herston/Bowen Hills/ Windsor area is susceptible to the influence of external factors over short periods..

5.3.4 Air Filtration

The issue of filtration of air from the ventilation outlets is a matter of great community interest. The EIS presents a review of the implications of operating filtration within the ventilation system. The available, effective technologies for air filtration suitable for road tunnel applications include:

- filtration of particles through the operation of electrostatic precipitation; and
- denitrification for the removal of oxides of nitrogen either by chemical absorption or by catalytic conversion. Denitrification becomes more efficient with the prior removal of particles.

The air quality impact assessment included modelling of ground-level concentrations of particulate matter and nitrogen dioxide with and without filtration in the ventilation system. For this modelling, typical performance results were:

- 80 to 95% removal efficiency for total suspended particulates, with 90% removal assumed for the modelling; and
- 60% removal efficiency for total oxides of nitrogen.

The dispersion modelling results which compare ground-level pollutant concentrations for the Northern Link tunnel without and with emission treatment, indicate that the ground-level pollutant concentrations both without and with tunnel filtration are very similar. Differences to ambient air quality arising solely from emission treatment for the tunnel ventilation system would be difficult to detect. The model predictions demonstrate that pollutant concentrations in the study corridor are dominated by emissions from motor vehicles on the surface roads and that emissions treatment for each of the Northern Link tunnels would result in very similar ambient air quality implications to the Project without emissions treatment.

Provision has been made in the reference design to fit filtration systems should monitoring of ambient air quality indicate that Northern Link is causing adverse impacts above the goals. While this provision is made, it is expected that advances in engine technology and cleaner fuels would lead to greater reductions in pollutant loads in the air shed than would filtration of two ventilation outlets for a relatively short length of road tunnels.

5.4 Acoustic Environment

5.4.1 Existing

The noise environment in the study corridor is typical of many inner urban areas, in that it is largely road traffic noise. However, at some locations rail noise and/or mechanical plant noise are other significant sources.

Existing noise levels in the study corridor, as revealed from monitoring at 14 sites (eight adjacent to the western connection and six near the eastern connections), indicate a noise environment typical of inner suburban areas. The dominant noise source is road traffic, with some contribution from rail lines and mechanical plant. The levels of existing background noise at the monitored sites in the study corridor are presented in **Table 14**.

Table 14: Existing background noise levels - Average L90 parameter

Site	Monitoring Location	Description	Rating Background Levels, minLA90 (dBA)		
			Day 7am - 6pm	Evening 6 - 10pm	Night 10pm - 7am
1	22 Crag Road, Taringa	Front yard of detached single storey dwelling, facing Western Freeway	48	46	39
2	115 Elizabeth Street, Toowong	High side of front yard of detached highset	46	41	34
3	6 Wool Street, Toowong	Front yard of single-storey detached dwelling	47	41	37
4	128 Sylvan Road, Toowong	Front yard of block of units	49	44	35
5	29 Valentine Street, Toowong	Front yard (facing Milton Road) of detached highset	53	50	43
6	69 Frederick Street, Toowong	Front verandah of highset detached dwelling	61	48	35
7	9 Victoria Crescent, Toowong	Front yard of detached double-storey dwelling	48	43	35
8	5 Clyde Street, Brisbane City	Front patio of detached single-storey dwelling	54	51	43
9	26 Low Clifton Terrace, Red Hill	Front yard of detached double-storey dwelling	58	56	45
10	7 Westbury Street, Red Hill	Front yard of detached single-storey dwelling	49	44	34
11	INB, Normanby Station	Located on parcel of Translink land between Ithaca Street and INB east of Normanby Busway Station	56	51	40
12	43 Normanby Terrace, Kelvin Grove	Rear yard (overlooking ICB) of detached highset dwelling	53	52	39
13	9 Horrocks Street, Toowong	Low side yard of highest dwelling	51	48	37
14	QUT, Kelvin Grove Campus	Adjacent to south end of block Y1	47	45	43

On-ground measurements of vibration in the study corridor were below the lowest recognisable limit of the instrumentation and thus below the threshold of human perception.

5.4.2 Criteria

Construction Noise

To achieve the objective of preserving community values for noise during construction, where reasonable and practicable, construction activity above ground and outside an acoustically-lined work enclosure should be limited to the hours of 6.30am to 6.30pm Monday to Saturday, with no outside work on Sundays or public holidays.

The construction noise goals for Northern Link relate to goals for the avoidance of sleep disturbance for night time construction, (generally below ground or within an acoustic shed) and internal noise for day time construction. Internal noise design goals are recommended because they directly address the values to be protected, and provide the greatest opportunity for cost-effective noise control.

To preserve the function of adjacent developments during construction, it is proposed that noise controls should aim to achieve:

- the maximum recommended internal noise levels specified in AS/NZS 2107: 2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors* for steady (or quasi-steady) noise sources. Example criteria from this standard are shown in **Table 15**; and
- maximum (LAmax) internal noise levels specified in Brisbane City Council's Noise Impact Assessment Planning Scheme Policy (NIAPSP) to avoid sleep disturbance, being:
  - 45dBA for residences within R1 to R3 categories as defined in Appendix A of AS 1055.1;
  - 50dBA for residences in R4 to R6 categories as defined in Appendix A of AS 1055.1; and
  - Noise levels comparable to the existing noise environment.

Table 15: Construction Noise Design Goals from AS/NZS 2107:2000

Type of Building Occupancy	Average Noise Level Goal LAeq (dBA)
Residential buildings (sleeping areas)	40 (near major roads)/35 (near minor roads)
Residential buildings (living areas)	45 (near major roads)/40 (near minor roads)
Places of Worship	40 (with speech amplification)
School music rooms	45
School teaching areas	45
School libraries	50
School Gymnasia	55
Commercial buildings – office space	45
Commercial Buildings – retail space	50

Vibration during Construction

Vibration targets vary primarily according to whether the sources are continuous or intermittent and whether they occur during the day or night. The effects of vibration in buildings can be divided into three main categories.

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Those in which the integrity of the building structure may be prejudiced.
- Those where the building contents may be affected.

Vibration criteria which are relevant to the disturbance of building contents are more stringent than criteria relating to cosmetic building damage. However, vibration criteria relating to human comfort are the most stringent. This is because people are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building.

Australian Standard AS 2670.2-1990 provides 'human comfort' vibration velocity levels as shown in **Table 16**. These levels, below which the probability of reaction (commonly referred to as 'adverse comment') is low, are based on worldwide experience. A vibration guide level of 0.5mm/s (peak) has been estimated as the threshold at which sleep disturbance may occur.

The vibration velocity levels in **Table 16** are based on vibration velocity averaged within a defined time to recognise that humans register vertical vibration more readily than horizontal.

As no Australian Standards exist for vibration levels in relation to building or building contents damage the project adopts British and German standards for these considerations. Over the frequency range typical of vibration in buildings from excavation and construction equipment (approximately 8Hz to possibly 100Hz), the threshold for visible movement of susceptible building contents (eg: plants, hanging pictures, blinds, etc.) is approximately 0.5mm/s. Audible rattling of loose objects (eg: crockery) generally does not occur until levels of about 0.9mm/s are reached.

Operational Noise

For noise from activities described as 'beneficial assets' (particularly roads, railways and airports), the EPP Noise specifies 'planning levels' which may be used as a guide 'in assessing reasonable noise levels from an activity'. The planning levels for a public road (measured 1m in front of the most exposed facade of a noise sensitive building) are as follows.

- For a State controlled road - 68dBA LA10 (18hour).
- For another public road - 63dBA LA10 (18hour).
- The highest 1 hour equivalent continuous A-weighted sound pressure level between 10.00pm and 6.00am -60dBA LAeq (1hour).
- A single event maximum sound pressure level - 80dBA LAmax.

The applicable statutory requirement for noise emissions from fixed mechanical plant (such as the tunnel ventilation plant) is the EPP (Noise) which nominates qualitative characteristics of the noise environment that are to be protected, but does not specify any numerical limits.

5.4.3 Worksites

Western Freeway

Site preparation would involve installation of safety barriers, site clearance, delivery of worksite infrastructure and enclosure construction. Noise intensive activities for these works would be during the daytime only. The most noticeable source of noise during site preparation would be earthmoving and rockbreaking. Given the limited duration of this particular component of the work it is not likely to result in a significant impact. During daytime tunnelling operations, the dominant noise sources will be spoil removal via conveyor and deliveries of concrete and other materials. The noise from these sources are not expected to exceed the design goal at any residence south of Wool Street or north of Mt Coot-

Table 16: Recommended Vibration Velocity Levels for Human Comfort

Type of Space Occupancy	Time of Day	Vibration Velocities (mm/s) corresponding to a 'Low Probability of Adverse Comment'			
		Continuous Vibration (16h Day, 8h Night)		Transient Vibration Excitation with several Occurrences per Day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg: hospital operating theatres, some precision laboratories, etc)	Day	0.1	0.3	0.1	0.3
	Night	0.1	0.3	0.1	0.3
Residential	Day	0.2 to 0.4	0.6 to 1.1	3 to 9	9 to 26
	Night	0.14	0.40	0.14 to 2.0	0.4 to 6.0
Offices	Day	0.4	1.2	6 to 13	17 to 37
	Night	0.4	1.2	6 to 13	17 to 37
Workshops	Day	1.2	3.2	9 to 13	26 to 37
	Night	1.2	3.2	9 to 13	26 to 37

tha Road. During night-time tunnelling, most surface noise sources would be confined within an acoustic enclosure. Spoil removal would be via conveyor directly to Mt Coot-tha quarry. Construction noise sources would include intermittent dump-truck noise and continuous noise from the temporary tunnel ventilation system. No significant acoustical impacts would be expected although the spoil conveyor may marginally exceed the LAeq dBA external noise goal. This assessment has not included topographical considerations which would be expected to have ameliorating effect where ground slope or vegetation removes line of sight to such a noise source.

Toowong

Site preparation would involve removal of existing buildings, site hoarding and safety barrier installation, delivery of worksite infrastructure and enclosure construction. The noise intensive activities associated with these works would be carried out during the daytime only. It is anticipated that the most noticeable source of noise during site preparation would be heavy earthmoving machinery during demolition and material excavation. Exceedances of noise goals of this nature are common when construction works occur in such close proximity (minimum of 10m) to receivers. Mitigation of noise levels from several plant items anticipated to be used would be essential for residents of Valentine Street. It is important that the use of significant noise generating plant be minimised insofar as possible and that nearby residents are notified of the works in advance. In this position it would be necessary to erect permanent or temporary noise barriers between the worksite and the residences before site preparation begins. For the majority of the short duration construction works required for site preparation, construction noise levels at Milton Road residences would likely be similar in the level or below existing road traffic noise levels from Milton Road

During daytime tunnelling works, the dominant noise sources would be associated with spoil removal and material deliveries to site. Valentine Street residences would be expected to experience significant construction noise impacts associated with such daytime tunnelling activities. Construction of a high performance acoustic enclosure over the portal is recommended together with boundary construction noise barriers a minimum of 5m high as the adjacent buildings are double storeys.

During night-time tunnelling all surface noise sources would be confined within the tunnel portal enclosure. Spoil haul-out and stockpiling would be achieved by loaders and trucks within the enclosure. Night-time noise levels are still predicted to be up to 6dBA above the recommended goals with a high performance enclosure. This would generally be described as a 'noticeable' exceedance. However, when machinery is located further within the tunnel, noise levels would decrease. The temporary noise wall advocated for the worksite boundary would also diminish the impact through the night. A range of further mitigation measures would be applied in consultation with affected residents, including:

- building modifications (eg: upgrading the façade windows, provision of air-conditioning to the affected residences), where it proves effective and acceptable to the community;
- further assess and consult with property owners immediately adjoining the site as to the best form of noise barriers or the provision of architectural treatment (and ventilation) to impacted rooms facing the worksite to address noise during site preparation and/or rock-drilling at or near the access shaft; and
- attended noise monitoring at the commencement of and periodically during noise intensive activities.

Kelvin Grove

Residents of Upper Clifton Terrace and Westbury Street are adjacent to the worksite. Without adequate mitigation measures, these people would experience significant noise impacts during site preparation of a magnitude that would be audible within dwellings and likely to result in acoustic impacts.

The small work area would reduce the likely duration of site preparation works enablinig the acoustic barriers and enclosures would be established quickly. The extent of the likely impacts requires consideration of all practicable noise mitigation measures.

Due to the close proximity of Lower Clifton Terrace, Upper Clifton Terrace and Westbury Street residences, a high performance enclosure would be required to reduce the extent of the noise impact and to achieve the environmental objectives. However, tunnel construction may still lead to occasional exceedances of the night-time noise goal for Upper Clifton Terrace residences. In these circumstances, early and on-going consultation with the occupants and owners of affected properties would be required to determine the most effective means of mitigating construction impacts.

The noise control measures recommended above for the Western Freeway and Toowong worksites would be applicable at the Kelvin Grove worksites.

5.4.4 Surface Construction of Roadways

Equipment likely to be used in construction of surface roads at the four connections include excavators bulldozers, graders, loaders, bobcats, compaction equipment, dump trucks, water trucks, bored piling rig, hydraulic rockbreakers, rock ripping equipment, pneumatic jack hammer, shotcrete equipment, rock bolting equipment, compressors, cranes, concrete delivery trucks, paving machines, and line marking pumps. Indicative noise levels at the most exposed buildings associated with the use of typical construction equipment may exceed guidelines as identified in Chapter 9. A range of mitigation measures are proposed to achieve the environmental objectives for these places.

5.4.5 Tunnel Construction between Portals

It is proposed that two Tunnel Boring Machines (TBMs) would be used to construct the mainline tunnels between the Western Freeway and ICB. Roadheader and drill and blast construction methods are proposed for the Toowong and Kelvin Grove entry and exit ramps and for cross passages, low point sumps, substations, and other features not fitting with the TBM profile.

Potential vibration levels have been estimated along each of the tunnel sections, in relation to vibration-sensitive places such as residential properties, aged-care facilities, educational facilities, sensitive commercial facilities and buildings of stated heritage value.

Potential impacts of vibration on buildings and on people have been assessed by comparing the predicted vibration levels using the guide values for minimising the risk of cosmetic (superficial) building damage and/or appropriate statutory requirements and using the guideline values for subjective human disturbance response, respectively. Generally, tunnel construction could proceed with a low probability of exceeding the environmental objectives. Possible exceptions include places where tunnel construction and surface works would be in close proximity to vibration-sensitive places.

To address community concerns regarding potential vibration impacts in a pro-active manner, a range of response management measures would be implemented prior to and/or during tunnel construction. The specific management response measures are dependent on the predicted levels of possible impacts on buildings and their occupants and are described in **Table 17**.

Table 17 Potential Vibration Impact Response Management Measures[1]

Predicted Effect of Tunnelling Vibration Emissions	Pre Notification to Building Occupants	Building Condition Survey	Building Sensitivity Study [1]	Vibration Monitoring
Not felt				
Threshold of perception				
Barely noticeable	✓		✓	✓
Sleep disturbance[2]	✓		✓	✓
Noticeable	✓		✓	✓
Easily noticeable	✓	✓	✓	✓
Strongly noticeable	✓	✓	✓	✓
Very strongly noticeable	✓	✓	✓	✓

Table Notes:
1) This applies to specific sensitive buildings identified in Technical Report No. 9 - Noise and Vibration in Volume 3 of the EIS.
2) This category is defined to be 0.5mm/s.

5.4.6 Construction Traffic

Truck deliveries of materials and machinery would utilise the same site access arrangements as for the spoil removal. These movements would occur during daytime working hours only, except where over-size regulations require transit at other times. All employee access to Northern Link worksites is directly from major roads.

Noise effects from construction-related heavy vehicle traffic has been assessed through the LA10 (12hour) measure using the CoRTN prediction algorithms. The result is that spoil traffic would not increase average traffic noise levels at any residential sites by more than 0.2dBA. Changes in noise levels of 2dBA or less are considered undetectable to the human ear and therefore negligible. Spoil traffic would not be expected to impact significantly on the noise environment of residential locations.

5.4.7 Operational Impacts and Mitigation Measures

Assessments of road traffic noise impacts have been undertaken on a 'with Northern Link' and 'without Northern Link' basis to identify the potential increases in traffic noise in a number of key locations within the study corridor.

Modelling has been undertaken for predicted levels of road traffic noise with and without Northern Link proceeding. The following situations have been modelled in accordance with the ToR.

- Do minimum (2014) - includes all future traffic utilising the existing road corridor in the proposed year of opening (ie: 2014), excluding Northern Link, for example, future traffic that would have arisen in the absence of Northern Link. It represents the baseline noise projections against which some of the other scenarios are compared.
- With Northern Link (2014) - traffic flows including Northern Link in the proposed year of opening (ie: 2014). This scenario represents the change in traffic noise, attributable directly to Northern Link.
- Do minimum (2026) - the predictions include all future traffic utilising the existing road corridor in the design year (ie: 2026), excluding Northern Link. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared.
- With Northern Link (2026) - traffic flows including Northern Link in the design year (ie: 2026). This scenario represents the change in traffic noise, attributable directly to Northern Link. Noise barrier design has been undertaken for this scenario.

Output from this modelling is a series of maps for the connection areas with predicted sound contours that are used to guide proposals for noise barriers within each scenario modelled.

The only state controlled road where there are exceedances of the 68dBA L_{A10} (18 hour) planning level for this project is Frederick Street. It is not feasible to build noise barriers to protect these homes due to access requirements. Therefore, in accordance with Main Roads' Code of Practice, property treatments outside the road reserve should be undertaken to achieve an equivalent indoor noise amenity.

Along roads that are not State controlled in both the Toowong area and the Kelvin Grove area, there are significant numbers of properties that exceed the 'Planning Level' goals with full 8m high barriers. At 8m high, noise barriers would also have significant visual and shading issues. 'Status Quo' noise levels [ie to maintain noise levels anticipated without the project] can be achieved at almost every location in both areas with somewhat lower barriers. Where the 'Status Quo' noise level cannot be achieved, predicted increases in noise levels between the 'Do Minimum' and 'With Northern Link' are within 2dBA and are considered insignificant. Therefore, it is recommended that the 'Status Quo' goals be adopted for all non-state controlled roads.

5.5 Flora and Fauna

5.5.1 Existing Environment

The study corridor includes a highly urbanised area of Brisbane with significantly disturbed terrestrial and aquatic ecosystems. Original vegetation cover has been substantially cleared for development and urban land uses and surface drainages have mostly been confined to concrete stormwater drains.

The western end of the study corridor traverses the edge of a large bushland system on the slopes of Mt Coot-tha, the Botanic Gardens and isolated fragments of vegetation that exist in urban parks, private properties and along watercourses. A small wetland

View of Paddington towards Mt Coot-tha

is mapped in the eastern portion of the study corridor within the Victoria Park Golf Course.

Database searches indicate 286 fauna species recorded from, or are likely occurrences within the study corridor. These include 11 species of frogs, 32 species of reptiles, 216 species of birds, 10 species of bats and 14 other species of mammals.

Threatened species previously sighted on Mt Coot-tha are the Swift Parrot (*Lathamus discolor*), Powerful Owl (*Ninox strenua*) and the Black-breasted Button-quail (*Turnix melanogaster*). The Swift Parrot is a seasonal migrant to south-east Queensland and is a semi-regular visitor to the outer western suburbs of Brisbane including Bardon, Kenmore and Chapel Hill, and was last recorded from Mt Coot-tha in 2002. The Powerful Owl is regularly recorded in the Mt Coot-tha area occurring in tall open forest and woodlands, preferring to roost by day in dense vegetation within gullies. The Black-breasted Button-quail was recorded in 1993 within microphyll vine scrub along Ithaca Creek and is generally restricted to south-east Queensland within semi-evergreen vine thickets, dry sclerophyll forests and occasionally thickets of Lantana. A permanent population is known from the Enoggera Creek catchment where good quality habitat occurs. From investigations conducted for this EIS, it is suspected that there are no permanent populations in the Mt Coot-tha area and that the record from 1993 may have been birds dispersing from the Enoggera population.

Database searches indicate freshwater turtles in the study corridor, namely, the Broad-shelled River Turtle (*Macrochelodina expansa*), Brisbane Short-necked Turtle (*Emydura macquarii signata*) and the Saw-shelled Turtle (*Wollumbinia latisternum*). All species are listed as of least concern under the Nature Conservation Act.

The study corridor occurs at the periphery of the large habitat and movement system incorporating Mt Coot-tha and Brisbane Forest Park. Excluding this corridor, well vegetated connections do not occur within the study corridor due to the highly fragmented nature of existing vegetation. This limits movement opportunities for fauna and restricts the types of species potentially using such fragmented corridors. Some fauna species are likely to utilise waterway corridors in the western part of the study corridor that have sufficient vegetation cover.

5.5.2 Potential Impacts and Mitigation Measures

In total, the surface construction works would affect approximately 4.8ha of the identified vegetation communities. Approximately 1.6ha of this includes remnant regional ecosystems identified under the State RE mapping as remnant vegetation (12.11.5 / 12.12.5) and scheduled under the *Vegetation Management Act* as Not of Concern. All of the affected remnant vegetation communities are in the area of the Western Freeway connection and the south-western corner of the construction worksite associated with the construction of the ramps, surface road connections, the conveyor and the ventilation station.

The majority of the 4.8ha of affected vegetation communities is mapped as non-remnant vegetation as well as "unconfirmed remnant" in the area of Victoria Park Golf Course for the ventilation outlet. Approximately 3.2ha of these communities may be cleared as a result of the Project construction. These areas include the majority of the Western Freeway worksite and the associated spoil conveyor, the western freeway entry ramp and surface road connection, small areas to be cleared for surface road works on the northern and southern ends of Kelvin Grove Road, and some within the northern area of the Kelvin Grove worksite. The areas affected by the permanent road works are small. Significant landscape works would be applied to the Project design to compensate for the loss of these non-remnant communities.

Several street and landscape trees require removal at portal areas. The short term impacts (pre-construction to up to three years) on vegetation are proposed to be mitigated by the following measures.

- Identify vegetation to be removed and that to be retained on construction drawings and on site to minimise loss of habitat and vegetation.
- Give high priority to the retention of mature trees during the planning and layout of the Western Freeway worksite.
- Avoid damage to the root zones of adjacent trees during construction - locate vehicle access, material storage and the cleaning of plant and equipment away from adjacent trees.
- Prepare a weed management plan prior to any construction or clearing activities occurring to prevent the spread of declared and other weeds.
- Revegetate disturbed areas with local native species (or landscape species depending upon location of revegetation area), as soon as possible after disturbance.
- Monitor revegetation plantings for up to two years post-construction to ensure success and that long-term impacts on native wildlife are minimised through restoration of habitat to at or beyond pre-construction condition.

The aim of the rehabilitation program within remnant and non-remnant communities is to restore the ecological values of cleared and impacted areas in the long term (three to five years plus) by replanting with a suite of locally endemic species. Non native species would only be used where the use of these species is consistent with existing landscaping.

No flora species listed as EVR under State or Commonwealth legislation would be impacted by construction. Two flora species of conservation significance under State legislation were identified within the study corridor during field survey. Neither plant is likely to be impacted by the proposed construction.

A single Crows Ash (*Flindersia australis*), currently protected by a VPO and located at 575 Milton Road, Toowong, would be impacted. This individual is judged to be in poor condition so that translocation is not recommended. This species is included in the planting palette for streetscape and landscape amenity revegetation zones. It is probable that many individuals of this species would be planted throughout the revegetation zones.

Weed species are common throughout the study corridor comprising approximately 36% of the floral diversity. Weed control procedures would aim to prevent the introduction and spread of weeds throughout the project area. Weed control procedures would be detailed in the *Design and Construction Environmental Management Plan* (EMP) and would include such strategies as dedicated vehicle wash-down facilities, minimisation of topsoil disturbance and minimising the time between disturbance and rehabilitation.

Remnant vegetation within the study corridor is characterised by mature eucalypts and a high structural complexity of vegetation beneath the canopy. The loss of any of this vegetation translates to an effective loss of food, nesting and shelter resources for wildlife. The potential loss of remnant vegetation is not considered to have a significant adverse impact upon fauna in the area as the proposed areas for clearing are in close proximity to large areas of remnant vegetation which are not proposed to be disturbed. It is considered that any species which are disturbed would migrate to the undisturbed areas. Non-remnant vegetation within the study corridor comprises small patches of mature and regrowth vegetation and landscaped areas. Fauna that utilise this vegetation are generally adapted to the urban environment and can tolerate a level of disturbance. The potential loss of this type of vegetation is not expected to result in a significant impact on any urban fauna species.

Five species listed as Endangered, Vulnerable or Rare (EVR) under Queensland and/or Commonwealth legislation are known, likely or possible occurrences within the study corridor. The majority of suitable habitat for these species occurs at the western end of the study corridor and is associated with adjacent remnant vegetation. The minimal amount of remnant vegetation to be cleared compared with adjacent patches is not considered to significantly impact on any of these EVR species. Nevertheless, some small potential exists for impacts on these species from vegetation clearance works or in the unlikely event of changes occurring to hydrology or water quality.

Potential impacts on aquatic flora and fauna may occur at the western end of the study corridor, specifically on the gully within Anzac Park, several creeks which cross the Western Freeway and York's Hollow. Works associated with the construction of tunnel entrances and widening of roads may have localised impacts on aquatic flora and fauna, although no significant ecological impacts are expected after the project is completed. Stormwater runoff would be treated prior to release into drainage systems. Stormwater related issues such as erosion and sedimentation and proposed mitigation are discussed.

St Brigid's Church, Red Hill

5.6 Land Use and Planning

5.6.1 Existing Environment

Land Use Planning

The land use and planning context for Northern Link is considered in terms of planning at the regional level and the local level. At the regional level, land use is directed by the SEQ Regional Plan and State Planning Policies, whereas at the local level, land use is directed by City Plan and its component parts, including local growth management strategies and local plans. At the regional planning level, the SEQ Regional Plan advances nine strategic directions, of which two are directly relevant to the assessment of Northern Link. These are:

- providing infrastructure and services; and
- integrating land use, transport and economic activity.

Northern Link provides necessary transport infrastructure in time to meet increasing travel demand arising as a consequence of sustained population growth and economic development in Brisbane and the SEQ Region. Northern Link also supports the integration of land use change with transport infrastructure and economic development, by supporting the designated activity centres and employment centres in the inner western suburbs, the Brisbane CBD and beyond to the Australia TradeCoast.

City Plan similarly advances the concepts of integrated land use and transport planning and establishes a road hierarchy within its planning scheme policies. The Brisbane City Council's strategic vision, *Living in Brisbane 2026*[27], anticipates that in 2026, Brisbane's road network will be safe, timely and efficient for

27. Brisbane City Council, 2006, *Our Shared Vision – Living in Brisbane 2026*, Council, Brisbane

all users and will deliver economic benefits to the community and business.

In addition to these statutory instruments, there are a number of planning initiatives of relevance to land use and development in the Northern Link study corridor and adjacent areas. These initiatives[28] include:

- Smart Cities: Rethinking the City Centre;
- City West Strategy; and
- Draft Brisbane CityShape 2026.

The community-based planning initiative, *CityShape*, has as one of its core elements an integrated Transport Strategy, the purpose of which is to achieve better integration of transport and land use planning to support urban infill in centres on the existing public transport network and to provide a safe and efficient road network, that minimises traffic impact on neighbourhoods and the environment; facilitates economic growth by minimising commuter travel and preventing congestion delays for high value freight and commercial vehicles; and promote public transport use, walking and cycling.

Local planning, expressed in City Plan, is provided for in:

- Ithaca Local Plan;
- Mt Coot-tha Local Plan;
- Toowong – Indooroopilly Local Plan;
- Kelvin Grove Urban Village Local Plan;
- Latrobe and Given Terraces Local Plan;
- Toowong Centre Local Plan;
- Toowong Major Centre Local Plan; and
- Draft Milton Railway Station Precinct Plan.

The planning framework at both the regional and local levels anticipate the development of necessary transport infrastructure to meet the needs of the rapidly growing population.

Land Use Pattern

Generally, the land use survey conducted for the EIS confirmed that the City Plan Area designations closely reflected the existing land use pattern. The 'tin and timber' housing stock was generally contained within the 'Character Residential Area', multiple unit dwellings were generally found within the 'Low-Medium Residential Area', and the commercial and retail uses were generally found within the 'Convenience Centre' or 'Suburban Centre' area designations.

The predominant land uses at the western end of the corridor, in terms of size, are the Toowong Cemetery, the Botanical Gardens, Mt Coot-tha Park/Brisbane Forest Park, ANZAC Park and Brisbane City Council's Toowong bus depot. Apart from commercial uses along

Toowong Cemetery

Milton Road, 'tin and timber' character housing is the predominant land use type in this vicinity.

Detached residential dwellings are the dominant land use within the central section of the study corridor. Although many of these properties do represent the 'tin and timber' housing style, the area is also well represented by modern, recently developed properties. Another common land use within this central section is multiple-unit dwellings, which are situated in various locations throughout the study corridor.

The predominant land uses at the northern connection are Victoria Park and Victoria Park Golf Course. These open spaces, combined with the two Grammar Schools and the BGS playing fields, dominate the landscape on either side of the ICB.

Near the Kelvin Grove connection, between Kelvin Grove Road and Victoria Park, the Kelvin Grove Urban Village is the predominant single land use in terms of size. However, land uses within the Kelvin Grove Urban Village are diverse and include multiple unit dwellings, food and convenience shops, speciality shops, restaurants and cafes, entertainment facilities and some basic health services. Also situated between Kelvin Grove Road and Victoria Park are a number of residential dwellings and the Hilltop Gardens Retirement Home.

Other significant land uses within this section of the study corridor include Brisbane Grammar and Brisbane Girls Grammar Schools on Gregory Terrace, St Brigid's Church on Musgrave Road, commercial buildings around the Normanby five-ways intersection and on Kelvin Grove Road, and a number of green spaces such as Marshall and McCaskie Parks.

There are several development applications for large projects in the Kelvin Grove Urban Village precinct for a mix of uses, in buildings ranging in height from six storeys to 12 storeys.

There are also a number of significant land uses within or adjacent to the study corridor, including the Milton Brewery, former Milton Tennis Courts, Milton Office park, Kelvin Grove Urban Village/QUT campus at Kelvin

28. Dept of Premier and Cabinet, 2007, *Smart Cities: rethinking the city centre*, Queensland Government, Brisbane
CityWest Taskforce, 2004, *The City West Strategy*, joint initiative of the Queensland Government and Brisbane City Council, Brisbane
Brisbane City Council, 2006, *The Draft Brisbane CityShape 2026*, Council, Brisbane

'Tin and Timber' character housing

Grove, former Sunny Queen Eggs site, former Police Barracks at Petrie Terrace, Suncorp Stadium formerly known as Lang Park, the Wesley Hospital, Toowong bus depot, the University of Queensland at St Lucia and the Long Pocket Research Centres.

5.6.2 Land Use Impacts

Northern Link would impact on land use during both the construction and operation phases. During the construction phase, the Project would impact directly on land use for properties within the worksites. There would be limited potential for indirect impact on land use of nearby properties due to changes in access during construction.

Changes in Land Use at the Western Freeway

The Project works at the Western Freeway would cause the temporary change in use of part of the Botanic Gardens through the temporary establishment and operation of the spoil conveyor from the worksite to the Mt Coot-tha Quarry. Mitigation measures for construction effects such as noise and dust would be required to maintain the recreational, scientific and landscape values of those areas within the Botanic Gardens adjacent to the Project works, including the construction worksite.

Similarly, a narrow sliver of Anzac Park would be required along the margin of the Western Freeway for the operation of the out-bound ramp and the realignment of the pedestrian and cycle way. This area is adjacent to the existing Freeway and apart from its use for pedestrian and cycle access, does not form part of the primary recreational areas of the Park.

Changes in Land Use at Toowong

Northern Link would impact on land use for that area bounded by Frederick Street, Valentine Street and Milton Road for the establishment of the Toowong worksite. This area is characterised by a mix of commercial, residential and other uses. Residential properties to the north of Milton Road, including those to be acquired, are predominantly 'timber and tin' character housing common to the Toowong area.

The Project would also impact on land use on the southern side of Milton Road between Sylvan Road and Croydon Street, and on the western side of Croydon Street between Milton Road and Sylvan Road. The land required for Project works in these areas is mostly used for residential purposes. Part of Quinn Park would be taken to accommodate the widening of Milton Road for the tunnel connecting ramps.

Despite the acquisitions, the land use balance of the locality would not be significantly affected by the reduction in residential land area.

Upon completion of the Project works, the Toowong worksite is proposed to be retained as a landscaped buffer to the elevated road infrastructure to be owned and maintained by PPP Co and then returned to Council upon completion of the franchise period. The land along the southern side of Milton Road and the western side of Croydon Street would be used for open space and landscaped buffer respectively. The land used for open space would be rehabilitated and returned to Council upon completion of the works, whereas the landscaped buffer would be maintained and returned to the Council upon completion of the franchise period.

Changes in Land Use at Kelvin Grove

Northern Link would impact on land use for the area bounded by Kelvin Grove Road, between Lower Clifton Terrace and Victoria Street, for the establishment of the Kelvin Grove worksite. At present this area is used for residential purposes. Land on the eastern side of Kelvin Grove Road is occupied by the Kelvin Grove Urban Village and the Kelvin Grove campus of the Queensland University of Technology.

Upon completion of the Project works, the Kelvin Grove worksite would be used as follows:

- Southern section along Lower Clifton Terrace – landscaped buffer, with a potential alternative use being for a depot for Project maintenance and safety vehicles, with an active frontage to Lower Clifton Terrace, which subject to City Plan could comprise dining and leisure activities.
- Central section near the Kelvin Grove portals – landscaped buffer.
- Northern section near Victoria Street – either landscaped buffer or residential at an appropriate scale and intensity, subject to the requirements of City Plan.

Northern Link would require the acquisition of small areas within the Brisbane Grammar School playing fields for Project connections, and within Victoria Park golf course for the ventilation station and ventilation outlet. These acquisitions would accompany a permanent change in use of the areas involved.

Changes in land use within the study corridor

Northern Link would reduce traffic congestion on key arterials, such as Milton Road and Coronation Drive, creating opportunities for enhanced public

transport (bus), particularly along Coronation Drive. The enhanced accessibility within the inner western corridor bounded generally by Coronation Drive, Hale Street, Milton Road and Croydon Street/Jephson Street, is expected to facilitate land use changes to achieve the intentions of local plans covering the area.

Reductions in traffic on the key arterials through the inner western corridor would be likely to reduce rat-running pressures on other routes through residential and commercial areas. Consequently, Northern Link is expected to lead to indirect benefits in terms of urban amenity, enhanced pedestrian and cycle conditions, accessibility and congestion relief for the inner western suburbs. There would be no surface property impacts in the study corridor between the connections at Toowong and Kelvin Grove.

Northern Link would not impede the implementation of other strategies still in development, such as the City West strategies, and the completion of the Kelvin Grove Urban Village master plan. Other planning intentions with regards the designated activity centres within and nearby the study corridor are expected to be more readily achieved as a consequence of the enhanced accessibility and connectivity provided by Northern Link and through on-going development of public transport.

5.7 Landscape and Visual Conditions

5.7.1 Landscape and Visual Context

The study area is a diverse urban landscape, with distinctive landmarks and built features in an urban setting where the natural features of topography and vegetation vary considerably. All of the study corridor lies on undulating to hilly terrain, providing opportunities for commanding views and vistas to large parts of Brisbane. In most cases the urban fabric has responded to the landform, with roads following ridges in places, and in some cases creating difficult environments for pedestrians and cyclists. The study corridor includes established inner suburbs and near-CBD neighbourhoods with a rich mix of housing styles, commercial buildings, heritage buildings and places, and open spaces.

The overall urban character of the study corridor changes seamlessly from suburb to suburb in a consistent and coherent pattern. The main elements supporting this consistency are the dominant presence of subtropical architectural elements regularity of topographic features, familiar and recognisable landscape features such as characteristic tree species, and local open spaces. The predominant form of residential buildings is characterised by single detached dwellings in the vernacular 'tin and timber' architectural typologies.

The study corridor's landscape context is largely defined and confined by prominent physical landscape elements of the Brisbane River to the south-east, Mt Coot-tha and the Taylor Range to the west, and a prominent system of ridges extending from Bardon through Paddington to Red Hill and Kelvin Grove. Mt Coot-tha, to the south-west of the corridor, is the highest point in Brisbane at over 280m above sea level and forms a backdrop to the study corridor and the city. The Brisbane River defines a distinct physical boundary to the immediate south-eastern context of the study corridor. Its broad expanse along the Milton Reach provides visual amenity and a significant visual relief to the heavily urbanised landscapes on both banks of the river.

Vegetation is concentrated in reserves, parks and other green spaces such school grounds, around playing fields and other sites such as Government House in Paddington and Toowong Cemetery. It is also a significant element of the urban landscape, particularly in low density residential areas and streetscapes. This character dissipates towards areas of urban activity and the CBD. In these areas, vegetation character approaches a more urban character with grouped or individual trees seen more as fragments retained in the face of development.

5.7.2 Landscape and Visual Impacts

The EIS presents a suite of landscape and visual objectives and supporting guidelines for the impact assessment. These objectives would contribute to the environmental objectives in the Draft Outline EMP provided in Chapter 19, Environmental Management Plan of the EIS.

Western Connection

The main impact at the Western Connection during operation would be the 800m long transition lanes, which would extend along either side of the Western Freeway and require the construction of embankments approximately 20m wide into the existing vegetated foothills of Brisbane Forest Park. This would be mitigated by planting appropriate species on the cuttings and medians to retain the integrity of this gateway experience.

The ventilation outlet would impact on landscape amenity because it would be visible to motorists along the Western Freeway, particularly for outbound traffic, on Mt Coot-tha Road, and from some parts of the Botanic Gardens. The ventilation outlet would be contrasted against the existing bushland and timbered ridge within the Botanic Gardens. From Mt Coot-tha Road and other vantage points, the western ventilation outlet would therefore have a high visual impact. The ventilation station would be partially buried within the landscape setting around the Western Freeway worksite.

The architectural and urban design treatment of the ventilation outlet and ventilation station would have a mitigating effect on the visual impact of the facility.

Figure 15 Urban Design and Landscape Mitigations – Western Connection

MITIGATION MEASURES

Revegetation

1. Protect exisiting significant vegetation, in particular along Mt Coot-tha Road.
2. Revegetate, rehabilitate and enhance areas damaged during construction, in particular areas disturbed due to the spoil conveyor.
3. Provide the planting component in consultation with the Botanic Gardens to rehabilitate the worksite.

Landscape Open Space

4. Urban Forest Treatment - Provide significant tree plantings to medians with sight line considerations.

Recreational Opportunities

5. Provide opportunities for active and passive recreation within discrete areas of open space at Anzac Park.

   Develop a preferred expansion option in consultation with the Botanic Gardens.

Connectivity

6. Provide improved pedestrian/cycle connections to and from the western suburbs, the CBD, Mt Coot-tha, the Botanic Gardens, Toowong Park & Ride, Anzac Park, Cemetery Toowong & surrounding suburbs.

Boulevard Treatments

7. Provide enhanced streetscape amenity with under planting & accessible footpaths to Mt Coot-tha Road to the Quarry turn off, and between Frederick Street and the Mt Coot-tha turn off.

Public Art

Provide opportunities for public art and character elements within the transport network at locations such as the Toowong-Mt Coot-tha roundabout, the Toowong Park & Ride, Anzac Park and the Botanic Gardens interface with the Western Freeway.

1. Landscape treatments to assist in visual mitigation and integration of proposed infrastructure into surroundings.
2. Ventilation Outlet & Ventilation Outlet Station with a screening buffer of Indigenous plantings

   Note: Refer Engineers drawings for infrastructure detail.

During construction, the establishment of a worksite adjacent to the Botanic Gardens, would have a temporary impact on the landscape setting for the gardens. The construction period would be approximately 3.5 years. Following construction, it is possible that this land, when rehabilitated and revegetated, may be incorporated into the Botanic Gardens.

For construction of the reference project, an enclosed conveyor system is proposed to remove construction spoil from the Western Freeway construction site to the Mt Coot-tha Quarry. The conveyor system would ideally follow the shortest, most direct route and would be as low to the ground as possible. However, the shortest practicable route encroaches on the Botanic Gardens. This structure would be inconsistent with the landscape setting within the gardens and would therefore have an impact on visual amenity for the duration of construction.

On completion of the works, the conveyor would be removed and the corridor rehabilitated and revegetated with a species palette reflecting the biodiversity of this area of the gardens. The worksite itself would be rehabilitated in consultation with the gardens curatorial staff, so as to accommodate long-term plans for possible expansion of the Botanic Gardens at this location.

The proposed urban design and landscape masterplan for the Western Freeway connection is illustrated in **Figure 15**.

Toowong Connection

The most significant visual impacts on the Toowong connection would be the two proposed elevated structures over Milton Road adjoining the Frederick Street roundabout, combined with the widening of Milton Road to accommodate additional traffic lanes for through traffic from Frederick Street and Mt Coot-tha Road. The landscape character of the gateway experience to the Western Freeway at the Frederick Street roundabout would become further 'cluttered' visually by the elevated ramp structures for the Toowong connections. The Milton Road corridor both in-bound and out-bound would be changed in its visual character through the introduction of the elevated ramps structures and the provision of additional traffic lanes. This would compound the existing barrier perception of Milton Road in this location.

The elevated road structures would be of a similar height to the existing ramp from Frederick Street to Mt Coot-tha Road. The on ramps would impact on the visual amenity and aspect of properties on the southern side of the widened Milton Road corridor. While the ramps would be provided with urban design treatments, it is unlikely that their visual impact on the Milton Road corridor or adjacent properties would be mitigated effectively by such treatments. An enhanced urban mitigation option has been proposed as a landscaped corridor extension of Quinn Park, which could provide an effective mitigation for the areas south of Milton Road between Sylvan Road and Croydon Street (Chapter 20). For the properties west of Sylvan Road, the impact would remain largely unmitigated.

The off ramps would impact on the visual amenity and aspect of properties fronting the northern side of Milton Road and the remaining properties in Valentine Street. The visual impacts would be mitigated effectively for the properties in Valentine Street, over time, through the retention and development of the Toowong worksite as a landscaped buffer.

The Project would require the closure of approximately half of Quinn Park, to accommodate the proposed widening of Milton Road. This would leave a flat open area which is currently used as a neighbourhood park. The opportunity exists to strengthen the existing design of the park in consultation with stakeholders. The park's interface with the Project would be mitigated through the planting of suitable species on the southern side of the walled edge to the park. However, despite the design treatments and landscaping, the landscape setting and intimate character of Quinn Park would be changed, with adverse consequences for the park's utility and amenity, should the Project be constructed in its present form. Further treatments of Quinn Park would be required, including possible expansion and landscaping, if the Project impacts were to be addressed effectively.

The widening of Croydon Street would also change the local visual setting. Croydon Street presently has a low visual amenity as a consequence of the wide variety and condition of building forms and land uses, with little if any street plantings to soften the effect. The proposed widening of Croydon Street, supported by comprehensive landscape treatments, would lead to an improved although quite different urban streetscape.

The inclusion of other mitigation measures to address Project impacts, such as noise barriers, potentially would lead to visual impacts and diminished amenity, particularly for those properties closest to the roadways and elevated ramp structures.

The proposed urban design and landscape masterplan for the Toowong connection is illustrated in **Figure 16**.

Kelvin Grove Connection

The major impacts associated with the Kelvin Grove connection would be the widening of Kelvin Grove Road, the scale and form of Project infrastructure opposite Musk Avenue, and the removal of two large fig trees from Marshall Park. At the completion of the works, residual land would be available for landscape and urban design treatments, presenting an opportunity to provide areas of high landscape amenity, for example by planting mature trees over the spaces created.

Figure 16: Urban Design and Landscape Mitigations – Toowong Connection

MITIGATION MEASURES

Revegetation
Replacement planting for the vegetation removed in Valentine Street, Morley Street, Quinn Street, Croydon Street and Milton Road.

Landscape Open Space
1 Urban Forest Treatment - Provide significant tree plantings to open space and medians.

Recreational Opportunities
2 Quinn Park - Provide opportunities for active and passive recreation. Enhance existing community park facilities and provide new facilities in consultation with stakeholders.

Relocate commemorative items to an appropriate setting within Quinn Park.

Relocate John Oxley memorial to appropriate setting eg Anzac Park.

Connectivity
3 Provide improved ped/cycle connections for recreational users along Milton Road to Toowong Park and Ride running through Quinn Park.

4 Link the community north of Milton Road to the principal cycle route at Sylvan Road.

5 Investigate new ped/cycle opportunities.

6 Relocate bus stops & provide new shelters

Boulevard Treatments
7 Provide significant tree planting, public art, street furniture and accessible pathways to Milton Road and Croydon Street.

8 Provide enhanced streetscape amenity to these Streets. Retain trees in centre of Valentine Street.

Suburban Centre Improvement Schemes
9 Strengthen the viability of the convenience precinct at the Milton Road intersection.

Public Art
1 Provide opportunities for public art and character elements.

2 Landscape treatments to assist in scale reduction and visual mitigation of impacts of infrastructure

Landscape treatments to assist in visual mitigation and integration of proposed infrastructure into surroundings.

Additional plantings of signature trees, such as the Moreton Bay figs, would be proposed in strategic locations to retain and enhance the landscape character of Kelvin Grove Road.

That part of the worksite between Kelvin Grove Road and Lower Clifton Terrace would become a green edge to the busy Hale Street and Kelvin Grove Road. A comprehensive landscaping approach on this area would reduce the visual impact of Kelvin Grove Road, the new infrastructure including the Hale Street connections and the tunnel portal, and the proposed noise barriers.

Further north along Kelvin Grove Road above and beside the proposed exit portal, opposite Musk Avenue, a new space would be created albeit with topographical challenges. This presents opportunities for local pedestrian/cycle connections, and also to create a dramatic and sculptural series of landscaped terraces on the western side of Kelvin Grove Road. The space above the portal exit would also provide a pedestrian link around the portal structure, along Kelvin Grove Road to Westbury Street, Victoria Street and Marshall Park.

Two portals for westbound entry from the north and south would be situated in Kelvin Grove Road, increasing the scale of the road. Recommended mitigation measures would reduce the perceived width of the road infrastructure through appropriate landscaping and tree planting.

The Kelvin Grove connection presents an opportunity to provide an entrance to both Northern Link and Kelvin Grove Urban Village at the intersection with Musk Avenue. Detailed design studies would be required to address and achieve this potential during the project delivery stage.

The proposed urban design and landscape masterplan for the Kelvin Grove Road connection is illustrated in **Figure 17**.

Inner City Bypass Connection

The major landscape and visual impacts at the northern connection with the ICB would be within the existing, adjacent landscaped open space between Victoria Park Road and Normanby Terrace, to accommodate the proposed eastbound tunnel portal. There would also be some reconfiguration required for the redesign of the Victoria Park Road – ICB intersection, which would impact on the existing access into the Brisbane Grammar playing field adjacent to Victoria Park Road. The impacts at the portal would be mitigated by extensive replanting of suitable species to provide landscape for both the residents of Normanby Terrace and the users of the ICB. Access to the playing field would be maintained during construction, and would be reinstated after construction in a similar configuration to the existing.

Another impact would be the widening of the ICB to accommodate a (westbound) portal entrance to Northern Link. The widened roadway would reduce the open space on the northern edge of the ICB. At present this edge contains a pedestrian/cycle pathway and a stormwater gully draining to York's Hollow further to the east, both of which would remain functional during operation. Overall, the mitigation opportunities at this connection centre around connecting pedestrians and cyclists into new and existing routes, and providing high amenity landscape planting to the edge of the ICB.

The ventilation station would be partially buried in the low ridge to the east of the Inner Northern Busway and north of the ICB. The ventilation outlet would be positioned further north and higher along that same ridge, adjacent to the golf course. The potential visual impact of the ventilation station would be reduced by positioning the structure partly within the rising ground of the ridge, and partly by the elevated infrastructure of the Inner Northern Busway.

The ventilation outlet is proposed to stand at least 15m high on its site. This structure would be evident when standing in either Normanby Terrace or from the front of properties along Victoria Park Road, south of Maidstone Street. Views from a wide viewshed to the north, south and east would be less evident, although still available, due to topographical variations, existing buildings and vegetation. A combination of architectural treatments, colour and landscaping will aid in mitigating the visual impact of the ventilation outlet. Should more detailed modelling show a taller structure is required to achieve the stringent air quality goals, a detailed design study would be required to mitigate visual impacts of the northern ventilation outlet.

The proposed urban design and landscape masterplan for the ICB connection is illustrated in **Figure 18**.

Figure 17: Urban Design and Landscape Mitigations: Kelvin Grove Connection

MITIGATION MEASURES

Revegetation

1. Protect exisiting significant vegetation, in particular the Fig Trees along Kelvin Grove Road.
2. Rehabilitate damage to waterways to area below Lower Clifton Terrace where appropriate.

Landscape Open Space

3. Urban Forest Treatment - Provide significant tree plantings to open space and medians.
4. Create opportunities to enhance critical views and vistas including views to the Kelvin Grove Urban Village "Artspace" billboard and new greenspaces.

Recreational Opportunities

5. Provide opportunities for active and passive recreation within Marshall Park and the land between Westbury Street and Victoria Street

Connectivity

6. Provide safe, legible & comfortable ped/cycle connections, in particular to and from the ICB ped/cycle over/underpass to Lower Clifton Terrace, between Kelvin Grove Urban Village and Upper and Lower Clifton Terrace.

Neighbourhoods

7. Retain and enhance characteristics of local neighbourhoods and strengthen neighbourhood precincts through the implementation of well connected community park/s.

Boulevard Treatments

8. Provide significant tree planting in particular to the medians in the middle of Kelvin Grove Road.
9. Provide enhanced streetscape amenity to these streets.

Public Art

Provide opportunities for public art and character elements within the transport network and existing and new greenspace areas. Landscape treatments to assist in visual mitigation of impacts on built form from lot resumptions.

1. Landscape treatments to assist in visual mitigation and integration of proposed infrastructure into surroundings.
2. Note: Refer Engineers drawings for infrastructure detail.

Figure 18: Urban Design and Landscape Mitigations – ICB Connections

MITIGATION MEASURES

Revegetation

Protect exisiting significant vegetation.

1 Revegetate and enhance areas damaged during construction.

Landscape Open Space

2 Urban Forest Treatment - Provide significant tree plantings to open space and medians.

Connectivity

3 Provide safe, legible & comfortable ped/cycle connections, in particular to and from Kelvin Grove Urban Village to the CBD, between Victoria Park Road and the ICB ped/cycle overpass, and to and from York's Hollow and the Land Bridge.

Neighbourhoods

4 Retain and enhance characteristics of local neighbourhoods, in particular Normanby Terrace and Victoria Park Road.

Provide vegetative screening to sound barriers &/or provide access to views & vistas of the surrounding areas using transparent materials.

Boulevard Treatments

5 Provide significant tree planting to the rear of the portal of the west bound tunnel & ICB edge.

6 Provide enhanced streetscape amenity to Normanby Terrace and the southern part of Victoria Park Road.

Public Art

Provide opportunities for public art and character elements within the transport network at locations such as the new open space adjacent to the ICB.

1 Landscape treatments to assist in visual mitigation and integration of proposed infrastructure into surroundings.

2 Ventilation Outlet and Ventiation Outlet Station, provide indigenous plantings to base

Note: Refer to Egineers drawings for Infrasturcure detail.

5.8 Cultural Heritage

The potential for Northern Link to impact on aspects of cultural heritage has been assessed in accordance with the guiding principles of relevant Queensland and Commonwealth legislation. The National Heritage List, the Register of the National Estate, the Commonwealth Heritage List, the Queensland Heritage Register, Brisbane City Council's City Plan Heritage Register and other relevant sources have been searched to identify places or items of local, State or national significance, Indigenous and non-Indigenous, and to determine whether the Project presents any risk that heritage values may be affected.

The Project would pass through some of Brisbane's older established suburbs. It would pass beneath the Toowong Cemetery, which contains the graves of past Queensland Governors, decorated soldiers, political, religious and community leaders, and thousands more citizens buried since the early 19th century. It would surface in Toowong near the house where Alfred Ormand's Blacksmith shop still stands, and where the 'Condamine Bell' was manufactured for nearly 90 years. It would also pass deep beneath St Brigid's Church and the (former) St Brigid's Convent in Red Hill, and a number of other prominent, historic houses and public buildings in Paddington, Milton and Auchenflower.

5.8.1 Indigenous Cultural Heritage

The Project would be constructed within the traditional lands of the Jagera and the Turrbal People, the traditional owners with current (overlapping) claims over all land within the study corridor under the Native Title Act 1993. The western end of the study corridor has been heavily developed and disturbed, and is therefore likely to yield little about the traditional owners that is not already known. However, the eastern end of Northern Link would surface in close proximity to York's Hollow, the most important known Aboriginal cultural heritage site within the study corridor. Although a re-created landscape, the vicinity of York's Hollow was a food gathering place. There are suggestions that it also held religious significance. Groups of up to 800 gathered in the vicinity of York's Hollow from as far away as the Blackall Ranges, for ceremonial and trading purposes.

Should Aboriginal archaeological places or artefacts be identified during construction, under State legislation they must not be harmed. The site must be reported to the EPA, and assessed by a qualified archaeologist. Monitoring of earthworks and vegetation removal at the worksites would be carried out in the presence of representatives of the relevant Aboriginal Parties, in accordance with a Cultural Heritage Management Plan to be prepared prior to construction.

5.8.2 Toowong Cemetery

Toowong Cemetery, Brisbane's main burial ground from 1875 until recently, is listed in its entirety on the Queensland Heritage Register. Three individual items within the cemetery are also listed separately. Many of the graves and monuments on terraced areas of the cemetery are in a badly deteriorated and highly unstable condition. Vibration in these areas may adversely impact on already unstable and deteriorating retaining walls, grave surrounds and headstones.

Vibration levels in Toowong Cemetery during TBM construction would vary from approximately 0.7mm/sec to 13.9mm/sec. The wide discrepancy between the upper and lower figures is a function of the steep terrain in the cemetery, and the varying depth from surface to tunnel crown. The highest figure corresponds only to that portion of the cemetery nearest to Mt Coot-tha Road, where the driven tunnel would be at its shallowest. However, the predictions also show vibration levels above the guide value, around the mid-point of that section of tunnel passing beneath the cemetery.

Through the cemetery, the depth of cover over the two tunnels ranges between 8.4m and 43.3m. At the cemetery's high points, vibration would be almost imperceptible, while on lower ground it would be more noticeable. The vibration assessment suggests a 'Guide Value' for cosmetic damage of 2mm/sec (for heritage structures), and also suggests that the higher levels of predicted vibration in Toowong Cemetery would be 'strongly noticeable'. Given the poor structural condition of many of the graves and monuments in the cemetery (**Figure 19**) there is potential for (further) structural damage to occur during tunnel construction. Vibration in areas of shallower cover is likely to adversely impact on already unstable and deteriorating retaining walls, grave surrounds and headstones.

There are a range of possible mitigation measures that could be applied to prevent further damage to vulnerable grave sites from vibration-induced damage. The actual strategies used would depend on the results of the structural audit and detail design vibration modelling, but may include any or all of the following.

- Construction of pier supports beneath endangered structures.

Figure 19: Badly cracked monumental masonry in Toowong Cemetery

- Erection of permanent support structures or temporary shoring.
- Stabilisation, reconstruction and/or restoration of susceptible monumental masonry (ie: those already impacted by vault distortion or collapse, differential compaction of soil or the localised movement of soil. A number of the obelisks, columns and pedestal memorials were originally erected with minimal reinforcement and mortar that has disintegrated over time making them vulnerable to collapse).

Continuous vibration monitoring devices would be located at numerous points within the cemetery during construction, to confirm the predictions and to provide accurate data on which to base decisions regarding any changes to mitigation strategies, while tunnel construction is under way.

5.8.3 Other Cultural Heritage Items

Road widening works would impact on two items at Toowong, namely the John Oxley memorial on the corner of Sylvan Road and Milton Road, and the Toowong Baptist Church on the corner of Sylvan Road and Jephson Street. Both of these items are listed on Council's Heritage Register. The partial acquisition of church property on this corner would require the removal of a retaining wall and a 1938 commemorative plaque. While the John Oxley memorial (Crows Ash) is in poor condition and unlikely to survive relocation, it is recommended that the memorial plaques for both these items be relocated as near as practicable to their current locations.

The Project would pass beneath a number of other listed heritage items in the study corridor, including 'Baroona'[29] and Forester's Hall, Paddington, St Brigid's Church and Convent, Red Hill, and the Blacksmith's shop at Toowong mentioned above. Northern Link would pass to the south of the former Gona Barracks which was established for military training, and which now is included on the Queensland Heritage Register.

In all cases, the vibration assessment has shown a low risk of cosmetic or structural damage from tunnel construction, although precautionary measures such as pre-construction building condition surveys, early notification of scheduled works, and vibration monitoring are recommended, to confirm the predictions and to allay community concerns.

5.8.4 Character Places

In addition to the listed heritage items, Northern Link would pass beneath 296 residential and commercial 'character places' as identified under Brisbane City Plan 2000. On-going monitoring of vibration and settlement would be undertaken on a sample of these places, to confirm the accuracy of the predicted vibration levels and to allay community concerns. A number of character places would also be acquired and demolished for the surface connections at Toowong and Kelvin Grove.

5.8.5 Kelvin Grove Fig Trees

Surface works in Kelvin Grove Road would require the removal of two State heritage-listed fig trees in Marshall Park. Application would therefore be required under the *Queensland Heritage Act 1992* to the Chief Executive of the Environmental Protection Agency in relation to these trees. It is recommended that advice be sought regarding the possibility of relocating the affected trees, possibly to nearby McCaskie Park, which also contains a stand of significant fig trees, some of which have been relocated from other places along Kelvin Grove Road.

5.9 Social and Community Conditions

5.9.1 Existing Social Context

The Northern Link study corridor is associated with the suburbs of Mt Coot-tha, Toowong, Bardon, Auchenflower, Paddington, Milton, Red Hill, Kelvin Grove, Brisbane City , Spring Hill and Herston. These suburbs are home to nearly 60,000 people. The suburbs associated with the study corridor are typical inner city suburbs comprising a mosaic of old and new land uses encompassing "tin and timber" character housing, areas of medium and high density unit development, health and education facilities, open space and recreation and commercial and entertainment precincts.

Population

At the time of the census in 2006, the study corridor suburbs had an estimated residential population (ERP) of 57,291. The population is expected to grow to about 68,000 people by 2026, with an increase of 18.7%. Between 2001 and 2006, the estimated residential population with the suburbs associated with the study corridor grew at an annual average rate of 4.4%, more than double the overall growth rate for the City of Brisbane. This high population growth was driven in part by the growth of medium and high density residential development in the City and Spring Hill. This growth in the inner city resident population is expected to continue.

Age Profile

The population of the study corridor suburbs had a relatively homogeneous age profile, which differed from the Brisbane LGA. At the 2006 Census, relative to Brisbane, the study corridor had a lower proportion of children (ie: aged 0-14 years), higher proportions of people aged 15-24 years and 25-44 years, and a lower proportion of people aged over 45 years. The exception to this was Bardon, which generally aligned more closely with the age profile for the Brisbane LGA.

29. Baroona Hall was constructed between 1883 and 1884 by the United Brothers Lodge, Manchester Unity Independent Order of Oddfellows, Qld EPA.

Household and Family Type

In 2006, the population of the study corridor suburbs generally had a lower proportion of family households and higher proportions of lone person and group households compared to the Brisbane LGA. At the 2006 Census, 53.3% of households in the study corridor comprised family households, compared to 68.2% and 25.1% in Brisbane and Queensland respectively. At the 2006 Census, couple only families comprised 47.8% of families in the study corridor suburbs, compared to 37.8% in the Brisbane LGA. Over 30% of households in the study corridor suburbs had only one occupant, compared to the Brisbane and Queensland averages of 25.1% and 22.8% respectively.

Cultural Diversity

Compared to the Brisbane average, the study corridor suburbs had a lower proportion of people who spoke a language other than English at home and who spoke English not well or not at all. Approximately 25% of the study corridor's population was born overseas, which was similar to the Brisbane average. These people represent a stakeholder group with particular communication needs and which may be more vulnerable to changes in the social environment than some other members of the community.

Socio-Economic Disadvantage

The Australian Bureau of Statistics (ABS) produces four Socio-Economic Indices for Areas (SEIFA) based on census data for local areas. These indices identify areas of relative advantage and disadvantage.

Each of the statistical local areas (SLAs) or suburbs, rank highly on the SEIFA Index, indicating higher proportions of people on high incomes, qualified people, and professionals than residing in other suburbs in Brisbane. The average SEIFA Index value for the study corridor suburbs (1,125) was higher than the Brisbane LGA average (1,063) with value ranges for each SLA also above those for Brisbane LGA, and amongst the highest in Queensland. The study corridor SLAs also ranked highly on the Index of Economic Resources indicating higher proportions of high-income families, a lower proportion of low-income families and more households living in large houses.

Social Infrastructure

The study corridor suburbs include a wide range of community services and facilities to service the needs of local communities, including community support, education and training, sport and recreation, cultural, health, and emergency facilities and services. In addition there is a range of social infrastructure servicing the needs of the broader community at a regional, interstate and international level, including health and medical, open space, sport and recreation, and education facilities. The study corridor suburbs also includes a range of commercial and retail centres that cater for local and regional communities in terms of entertainment and leisure, employment and other high-order services.

Community Values

Community values are those tangible (physical) and intangible (social) elements held as being important to quality of life and well-being. They include parks, buildings, and landscape; a sense of belonging and community diversity. Social infrastructure is a major contributor to the development of community values, as are demographic characteristics, and the natural and built features of the landscape.

Interactions between social and physical values contribute to qualities such as accessibility, amenity, sense of place and safety, and also to social capital. The tangible and intangible elements that make up a community, and which communities identify with, could be affected as result of changes to the physical and social environment. Some of these elements that contribute to community values in the suburbs associated with Northern Link include:

- connectivity, provided by major transport corridors and good connection to other areas of Brisbane by road, bus, rail and bicycle;
- diverse housing options;
- access to residential neighbourhoods within easy reach of the city's services and amenity;
- contribution of heritage places and 'tin and timber' character housing to the study corridor's local character and sense of place;
- district and local open space areas including the Brisbane River, Botanic Gardens and Brisbane Forest Park, Anzac Park and Victoria Park;
- social, cultural, historical, recreational and landscape values of heritage listed facilities such as Toowong Cemetery and St Brigid's Church Red Hill;
- good access to community facilities of state and regional significance, including education, health care, public transport, community facilities and employment opportunities; and
- strong community networks and levels of volunteering.

5.9.2 Social and Community Impacts

Northern Link would resolve a significant 'missing link' in Brisbane's motorway network, and would result in a net social benefit to the city and to the Brisbane metropolitan region. Without the Project, traffic congestion in the inner western suburbs would continue to increase, with further loss of local amenity, increased travel times, and increased rat-running in local streets. With Northern Link, substantial volumes of traffic, including heavy vehicle freight traffic, would be removed from surface roads between Toowong and the ICB, including Milton Road, Coronation Drive and other routes providing benefits for local and regional communities. By facilitating more efficient movement of people and goods between the growth suburbs of the Western Corridor and the Australia TradeCoast, Northern Link would contribute to economic development of Brisbane's western suburbs,

with benefits flowing to employment, housing and the provision of social services.

At the local level, Northern Link would involve changes to those neighbourhoods situated around the surface connections at Toowong and Kelvin Grove. The Project would result in some adverse impacts on those communities in close proximity to the proposed surface connections at Toowong and Kelvin Grove. In particular, the infrastructure proposed for the Toowong connection would transform the precinct of Frederick Street/Milton Road/Croydon Street. Initially this change would occur through land acquisitions and establishment of a construction site. In the longer term, the widening of Milton Road and the construction of the access ramps and flyovers would change the character of the Milton Road corridor between Sylvan Road and Croydon Street. Half of Quinn Park, on the south side of Milton Road, would be required for the widening of Milton Road. Acquisition and demolition of private property would displace residents, some of whom are long-term residents and for whom relocation would be socially disruptive and potentially stressful.

The Kelvin Grove connection would have a similar impact on the community in the immediate vicinity of the tunnel portals. Property acquisitions, changes to access, changes to the character of the urban landscape, traffic and traffic noise, and the general disturbances associated with construction activities over a prolonged period, would have a long term effect on local community values and amenity.

While the Project would alter the local environments around the Western Freeway and ICB connections, these locations are not as built-up as the Toowong and Kelvin Grove connections, and social impacts would not be a major issue for the Project. However, the Western Freeway worksite would be located in public open space adjoining the Botanic Gardens, with the proposed temporary spoil conveyor passing through the Gardens to the Mt Coot-tha Quarry. This would have a temporary impact on the visual and recreational values of the Gardens. Construction works would also encroach into the north-western edge of Anzac Park, but the affected land is currently densely vegetated and holds little recreational value or utility. Similarly, construction works for the ICB connection would encroach on the edge of Victoria Park, and although there would be a small loss of open space, the impact on recreational values would be minimal. On completion of works, these areas would be rehabilitated within overall landscape masterplans.

A total of 85 individual residential properties would be directly affected by the Project of which 57 would be at Toowong and the remainder at Kelvin Grove. In addition, 11 commercial properties would be affected at these connections, comprising 24 individual businesses including restaurants, car dealers, real estate agents and service stations.

One of the major concerns of the community, raised during consultation, was the Project's potential impacts on property values in the study corridor, particularly in proximity to the surface works or the tunnel alignment. Those properties above the tunnel alignment would be subject to acquisition of a volumetric subdivision, for which their owners would be compensated based on a 'before and after' valuation method in accordance with relevant legislation. Based on experience from recent urban tunnel projects in Brisbane and other Australian capital cities, improvements to local amenity and accessibility within the study corridor are likely to support property values in the longer term. This is already evident in suburbs directly affected by the CLEM7 and Airport Link/Northern Busway Projects, such as Woolloongabba and Windsor, where house prices over the 12 months to December 2007 grew faster than the Brisbane average (REIQ, Autumn 2008).

There is also concern in the community regarding operational air quality. The community perceives a risk to health from the emissions from tunnel portals and from the Project ventilation system. Air quality modelling undertaken for Northern Link found that air quality would not change substantially as a result of the Project, and that local air quality improvements would be achieved in some areas of the study corridor, particularly where traffic volumes are reduced.

A key issue in the assessment and management of social impacts is the issue of equity and sustainability. While the benefits of the Project would be widely distributed, many of the Project's construction and operation impacts, including property acquisition and impacts on amenity, would be experienced by those residents closest to the Project works.

Should it proceed, it would be important that social impacts are managed during construction and operation, and that where possible those impacts are offset through the provision of local mitigations or benefits. Issues such as noise, vibration and dust would be managed directly within the required standards.

A number of urban mitigation measures are proposed in Chapter 20 of the EIS. A number of these measures are incorporated in the EIS Reference Design for the Project, through integration of the engineering infrastructure with, for example, improvements to pedestrian and cycle connections and enhancement of local open space areas near surface connections. Such initiatives would help to improve amenity, access and connectivity for local residents.

During construction, community concerns relating to the impacts of construction activities can be partially alleviated through continued, clear, timely communication regarding the scheduling of those activities and their likely impacts. The community would be kept regularly informed in relation to progress, current issues, and results of monitoring (eg: noise, air quality). There would also be a 24-hour project information line where comments, feedback and complaints would be received. If required (for example,

due to construction vibration), residents in affected properties would be temporarily relocated for the duration of that activity.

5.10 Economic Conditions

5.10.1 Existing Environment

Northern Link is being proposed at a time of unprecedented growth in Queensland and SEQ in particular. In 2006-2007 Queensland's economic growth was at an eight-year high of 6.8%, well above the growth of 2.5% in the rest of Australia. Queensland's average annual growth rate for the past 10 years is 5.1% compared with 3.2% for the rest of Australia.

Queensland's prosperous economy has also created significant employment opportunities across the state and in particular in SEQ. Over the past year, employment in Queensland increased by 4.6% and accounted for more than 92,000 persons or about one-third of all jobs created in Australia. Queensland's unemployment rate is at an all time low of 4%.

The success of major economic centres (eg: the CBD, Brisbane Airport, Toowong/Milton, Indooroopilly, the ATC and the Western Corridor) that have been identified as within the catchment of Northern Link, depends on high capacity transport access and connectivity. The performance and projected future of each centre are integral to the broader improvements to regional prosperity that may be able to be supported by the project.

5.10.2 Development

Brisbane City Council's 2026 vision for Brisbane is to be "prosperous and sustainable with cohesive healthy communities…a leader in technology, driving a strong economy that provides job opportunities for all." The key themes that are articulated in this vision include an accessible city, a smart and prosperous city, an active and healthy city and a regional and world city.

A number of key socio-economic aggregates have been forecast to 2026 in the Brisbane Economic Development Plan (BEDP) that would need to be supported by economic infrastructure such as road investment. These forecasts include:

- the population of the greater metropolitan area defined by the Brisbane Statistical Division will grow from 1.8 million in 2006 to 2.4 million;
- the residential population of the Brisbane Local Government Area (LGA) will grow from 980,000 in 2006 to 1.19 million;
- employment in the Brisbane LGA will increase from 585,000 to 850,000;
- 80% of the Brisbane LGA growth in employment (ie: 212,000 persons) will be concentrated in 20% of the city's suburbs;
- suburbs or areas within the Northern Link catchment, namely the CBD, ATC, Milton and the inner west of Herston figure prominently in the top 10 centres of future employment growth. For example, employment in the CBD will increase from 120,000 to 190,000, while the ATC will increase from 34,000 to 80,000; and
- connectivity and accessibility to the CBD and ATC resulting from Northern Link will be a major factor in reducing journey time between the outer western suburbs of Brisbane and the CBD and ATC.

The BEDP has a key theme that Brisbane needs to have world class roads and other economic infrastructure to ensure the efficiency and competitiveness of the city's economic activity. This high quality infrastructure is required to attract and support high levels of productivity and export based private investment. The BEDP has set an annual export growth rate of 4% that will grow the city's value of exports from a current $32 billion in 2004 to $79 billion by 2026.

Freight

The existing freight network and demands as well as the region's future challenges that have significance for the Project are listed below:

- The SEQ region represents about 62% of the Queensland economy and has potential to assume an even greater role based on regional population growth forecast of one million persons over the next 20 years.
- Assuming household consumption grows by 4.5%, existing freight volume will almost triple by 2026. Industrial production will grow and the volume of freight will increase to approximately 80 million tonnes in 2026.
- Growth in inter and intra urban freight movements is likely to significantly impact on the SEQ's priority freight costs and the local road network with the following key locations recognised as likely increases in freight activity.
  - Brisbane CBD.
  - ATC driven by expansion of the Brisbane Airport's passenger throughput and other commercial developments on airport land.
  - existing and new industrial precincts within the region and requiring cross city travel including Acacia Ridge, Ipswich, Virginia and Brendale.

The ability of the metropolitan road network to meet demand for cross city movement of people and freight will be critical to the long term development of Brisbane. Brisbane is the key location for interregional, interstate and international economic activity in Queensland and accounts for over 11% of national Gross Domestic Product (GDP). In Queensland, Brisbane accounts for around 60% of GDP.

Strategic Property Impact Assessment

The potential and actual impact of the Project on commercial and residential property values, investment and development within the project corridor has been considered. Consultation processes relating to tunnel

projects in Australia have generally identified the following issues of concern to property owners.

- The psychological impact of the 'feeling' of the tunnel below.
- The potential impact on resale value resulting from volumetric title or proximity to infrastructure.
- A reduction in passing traffic and therefore business.
- Traffic congestion as a result of traffic seeking to avoid the tolls.

All property acquisitions would be conducted under the *Acquisition of Land Act 1967*, which entitles an affected landowner (residential or commercial) to be compensated for the full market value of a property that is acquired. In the case of commercial property, the business proprietor is entitled to compensation under the Act for the cost of relocating the business, or for the value of the business, whichever is the lower. Where the proprietor is also the owner of the freehold title to the premises, the proprietor is also entitled to be compensated for the full market value of the property.

It is generally expected that most of the businesses affected by the Project would find suitable alternative premises, notwithstanding that the motor vehicle dealership and the service station on Milton Road have specific location and land footprint requirements, which may impact on their capacity to find a suitable alternative site in the locality.

Indirect impacts on local property may include reduced market value and reduced property appeal, although it would be difficult to directly attribute this to the Project. To date, there is limited evidence that the CLEM7 or the Airport Link Tunnel have negatively impacted property values, other than for those properties directly affected by resumption.

For comparison of market acceptance, the impact of the Airport Link project on property values over the last 10 years has been analysed in Chapter 15 because it represents a current project, with many similar issues as for Northern Link. In conclusion, it could be said that the Airport Link project has had no evident impact on house or unit prices in the suburbs affected by that project. The announcement of the project has had no evident impact on the property values for houses or units in the affected suburbs.

There is little market evidence to guide the determination of the monetary value effect that a volumetric lot title may cause. Anecdotal evidence has been tendered that property owners perceive a loss in property value and property appeal, compared with similar properties that are not subject to a volumetric title. The volumetric lot may discourage some buyers from bidding for a property containing a permanent subterranean title in a market where there are other properties available with no such title. In addition, it is likely that prospective purchasers of a property with a volumetric title in place would expect some form of price reduction. Acquisition of volumetric title under the *Acquisition of Land Act 1967* entitles the affected landowner to compensation based on a 'before and after' valuation of the land in accordance with the legislation. The monetary impact of a subterranean volumetric title would differ for each property depending on location, quality of the property and other specific factors directly attributable to the property.

5.10.3 Cost Benefit Analysis

The economic assessment uses a Cost Benefit Analysis (CBA) model that has been specifically developed for the Project. The CBA Model provides investment results to assess the economic viability of the Project in terms of travel time savings, vehicle operating costs savings, road safety savings, environmental and externality benefits. An allocation of resources increases economic efficiency if the sum of the benefits accruing to those who gain by that allocation exceeds the sum of costs borne by those who lose.

The benefits and costs included in this CBA model have been monetised using data from actual markets where available (ie: capital costs (CAPEX), labour prices, vehicle operating prices, etc). Austroads/DMR have provided road user costs while CAPEX project costs have been sourced from recent project cost schedules in 2008 prices. The CBA modelling is not the sole determining factor of the worthiness of the project. It should be considered alongside other major social, environmental and planning related project impacts that have been identified in other Project studies.

The most significant data inputs that impact on the CBA modelling include:

- CAPEX (construction) and OPEX (operation and maintenance) cost estimates;
- network traffic data for the 'With' and 'Without' Northern Link;
- discount rate with a rate of 6% assumed for the reference Project reporting; and
- sensitivity testing using 4% and 8% discount rates for risk adjusted P10 (best case) and P90 (worst case) estimates of CAPEX.

CBA model results

The Northern Link CBA with a risk adjusted (P50) indicates CAPEX of approximately $2,039 million and OPEX of around $1,627 million over 45 years at a discount rate of 6% are shown in **Table 18**.

The Net Present Value (NPV) is the value of the discounted total future benefits minus discounted total future costs over the 45 year assessment period. On the basis of the assumptions that have been adopted, the CBA model returns a NPV of $710 million over the life of the Project and represents a strong economic justification for proceeding with the Project.

The Benefit Cost Ratio (BCR) is equal to the discounted total benefits over the concession period divided by the discounted total costs (ie: CAPEX and OPEX). A

Table 18 Northern Link P50 CBA findings (6% discount rate)

Output	Value
Present Value of Costs (PVC)	$2,311.1 m
Present Value of Benefits (PVB)	$2,861.0 m
Net Present Value (NPV)	$549.9 m
Benefit Cost Ratio (BCR)	1.2

ratio >1 indicates that Northern Link is economically viable in the context of the CBA although there maybe other non CBA factors (eg: available program funding, social and environmental) which may also be pertinent to the assessment of the project. A higher BCR indicates greater economic merit for the Project.

The BCR for the Project as calculated from the CBA model is 1.2. The BCR of 1.2 indicates that the Project provides a 20% return over the discounted value of the investment for the 45 year assessment period.

5.11 Waste Management

5.11.1 Waste Streams

The Northern Link Project has the potential to generate a range of liquid and non-liquid waste materials, primarily in the construction phase of the project. The key waste streams include:

- demolition waste (building and structure materials, kerbs and pavements);
- building waste (packaging materials, scrap metal, timber formwork, pallets, plastic wrapping, cardboard);
- general waste from construction compounds; and
- liquid wastes from construction (dust control water, vehicle maintenance wastes, spillage from chemical or oil storage, groundwater inflow) and operation (groundwater inflow, pavement run-off, wash down water) of the tunnel.

5.11.2 Waste Management Strategies

The principles of reduce, re-use and recycle determine measures for waste minimisation and management.

Reduce

The construction contractors for the project will be required to identify opportunities for reducing waste generation on site. Strategies for reducing waste would be detailed in the detailed waste management plan and may include:

- use of materials and products with recycled content wherever cost-and-performance competitive, and where they are environmentally preferable to the non-recycled alternative; and
- encouraging employees and sub-contractors to avoid and reduce waste wherever possible.

Re-use

Construction waste re-use during the project may include:

- waste concrete and pavements to be used as hard stand areas in construction compounds;
- broken tiles to be used in fill or transferred to a building supply company;
- bricks to be used in fill or to be recycled;
- asphalt to be re-used by transferring to batching plants or use as a select/earthworks coarse layer; and
- topsoil to be stockpiled and stored for reuse, if possible.

Recycle

Recycling during construction may involve or include:

- kerb and pavement materials (concrete, asphalt) to be collected and transported to crushing and recycling plants;
- provision of recycle facilities for general rubbish, ie glass, plastic, waste paper and metals, using colour-coded bins;
- transport of demolition materials to a recycling depot;
- collection and transport of steel scraps to a recycling facility;
- use of the available groundwater whereever possible (eg: spraying roadworks to reduce dust generation or for watering progressive landscape works);
- incorporation of a closed water recycling system for worksite buildings;
- use of recycled materials, particularly spoil which may be processed to requirements in the adjacent quarry treatment works, to the limits of design in concrete, road base, asphalt and other construction materials;
- empty oil and fuel drums being collected or returned to recycling facilities; and
- training of all employees in the waste management plan and recycling opportunities.

5.12 Hazards and Risk

The environmental and social values that have been identified in the EIS that are subject to potentially hazardous events include:

- the residential communities and other sensitive land uses adjacent to the tunnel portals, work sites and transport routes and above the tunnels;

- the waterways of Toowong Creek, Anzac Park and York's Hollow;
- culturally significant community assets in the vicinity of the project works (eg: the Botanic Gardens, Toowong Cemetery, Victoria Park Golf Course, St Brigid's Church);
- the motorists who would use the tunnel;
- the motorists, pedestrians and cyclists who would use the road network and footpaths near the portals and roads which result from the tunnel; and
- remnant terrestrial vegetation areas protected by Council VPOs.

5.12.1 Construction

Hazardous activities associated with the construction of the tunnel include:

- operation of vehicles and construction equipment in the tunnel – especially fire or leakage or spillage of oils, fuels and other dangerous goods including explosives;
- operation of vehicles and construction equipment and storage of dangerous goods in the compound areas – fire or leakage or spillage of oils, fuels or other dangerous goods;
- transport of dangerous goods to the compound areas – spillage and accidents;
- transport of spoil to spoil placement areas – accidents leading to spillage;
- tunnel collapse or subsidence;
- flooding and inundation during construction; and
- related community action or protest.

A variety of safety management measures would be put in place during construction.

- Containment and Hazardous Goods Management Plan in the event of spillage of fuels and other dangerous goods within either the tunnel or the surface construction sites during transport or storage. The detailed Construction Environmental Management Plan to be developed during the detailed design phase would contain the Hazardous Goods Management Plan as well as the Incident Management Plans (Chapter 19, Environment Management Plan) and these would include provision for access and egress of emergency vehicles, particularly inside the tunnels.
- Containment and clean up procedures dealing with prevention of and management of spillage of spoil during transport to spoil placement areas. These would be included in sedimentation and erosion control plans developed as part of the Construction Environmental Management Plan.
- Construction of portal entrances to minimise the time the tunnel is exposed to inundation from flooding.
- Structural analyses and risk assessment prior to blasting within the confines of the tunnel. A Blast Management Plan and an Emergency Response Plan would be developed that would contain information relating to blast design configuration.
- Community consultation and information sessions to help mitigate any action or protest that may take place during the construction of the tunnel.

5.12.2 Operation

Hazardous activities associated with the operation of the tunnel include:

- transportation of Dangerous Goods, both in the tunnel and on surface routes;
- minor vehicles accidents and incidents in the tunnel leading to fuel spillage or small fires;
- major vehicle accidents in the tunnel or acts of 'terrorism' leading to major fires and explosions;
- tunnel collapse or subsidence; and
- flooding and inundation during operation.

A risk rating including assessment of likelihood and nature of consequences, was undertaken (**Table 19**) as a guide to areas of risk that require attention during the detailed design phase.

Measures would be incorporated into the design and operation of the tunnels to manage accidents and hazardous incidents during tunnel operation. The Tunnel Control Centre would monitor and control operation of the tunnel to ensure its safe and effective operation. In-tunnel monitoring systems would collect and process data and ensure that all services are controlled. Water tankers for the tunnel wash down operations, the pressure booster for use by the fire brigade, and parking and marshalling areas for maintenance and emergency vehicles equipped with spill kits are to be provided most probably adjacent to the Tunnel Control Centre.

Recent events have highlighted the vulnerability of public transportation to acts of violence from terrorists. Risk assessment involves prioritisation of surface transportation or tunnel assets, determination of vulnerabilities and identification of cost-effective operational security measures and engineering design standards to reduce its vulnerability.

5.13 Health and Safety

5.13.1 Health Risk due to Changed Air Quality

Regional air pollution as a result of Northern Link is not expected to have a measurable impact on community health. The EIS provides 'worst case' forecast changes in regional ambient carbon monoxide, nitrogen dioxide, coarse and fine particulate matter, and the air toxics including 1,3 butadiene, benzene, formaldehyde, toluene and xylene. The worst case changes in ambient air pollutants were forecast to be very small and were equivalent to 0.001% to 1.1% of the National Environmental Protection Measures (NEPM).

Table 19: Risk Assessment Matrix - Community

Hazard	Potential community impact	Frequency of occurrence	Impact or consequence	Risk Level	Proposed mitigation measures
Construction					
Spillage from storage of dangerous goods in tunnel or adjacent areas	Contamination of soil and ground- or surface water from leakage. Emission of fumes. Injury to community	L	M	L	Implement appropriate clean up procedures.
Spillage from transport of dangerous goods en route to compound areas	Contamination of soil and ground- or surface water by chemicals. Injury to community	L	M	L	Transport in accordance with dangerous goods standards. Implement clean up procedures. Train workforce in handling of hazardous goods and spill containment procedures. Ensure adequate spill kits are available. Prepare Emergency Response Plan.
Infrastructure collapse due to uncontrolled blasting	Dust emission Death or injury to community members Vibration damage to nearby houses	L	H	M	Conduct structural analysis and risk assessment prior to blasting; Appropriate blast design configuration to suit locality of blast; Prepare an Emergency Response Plan.
Explosion/fire from build up of heavy vehicle fumes in the tunnel or use of hazardous materials.	Fume emissions. Contamination of soil and surface or ground water. Air contamination Injury to community	L	H	M	Control volume of vehicles inside the tunnel; Provide appropriate ventilation; Monitor fume levels at work.
Flood and inundation	Water pollution Property damage to nearby residences	L	H	M	Tunnel design and construction to appropriate standards.

The models used for estimating the health effects were based on published: epidemiological studies in Brisbane, other Australian cities or overseas cities, long term studies of mortality and lung function growth from the United States; challenge chamber studies and panel studies. Where more than one health effect estimate was available the most conservative estimate, that is, the one that gave the largest adverse health impact, was used.

Worst case emissions for the northern and western ventilation outlets of Northern Link and the cumulative emission from the ventilation outlets of Northern Link, Airport Link and CLEM7 were forecast to be very small. The forecast health effects, such as hospital admissions or mortality were correspondingly small, in the order of one in 3 million to one in 200 million on the day and at the location where the forecast worst case occurs. The long term impact on lung function growth in adolescents may be a very small increase in the number of children with reduced lung function if exposed to the worst case annual increase over an 8 year period. The size of the effect is difficult to quantify, however previous studies, with 67 times higher changes in NO_2, have found an impact on lung development in children.

5.13.2 Health Effects from Changes in Regional Air Quality

A conservative approach was used to model the health impacts of ambient regional air pollutants from the proposed Northern Link. Three regional sites were considered: Bowen Hills, Brisbane Grammar School and Toowong. Bowen Hills and Toowong were selected so that a comparison could be made between model predictions and monitoring data. Brisbane Grammar School was selected as a sensitive place in an area where the regional changes were predicted to be amongst the highest, although still very low. It should be noted that other locations, such as sites close to roadways, are predicted to experience greater changes in air quality than the regional sites. The health effects at these near road locations have also been considered.

The worst case increases in air pollutants were used for assessing the potential worst case health impact. Where improvements in air quality were forecast, they were not used to offset the worst case estimates of adverse health effects.

Carbon Monoxide (CO)

No increases in 8 hour ambient CO in 2014, 2016, 2021 and 2026 are predicted, therefore no adverse health

events are expected at these sites due to changes in ambient CO as a result of Northern Link

Nitrogen Dioxide (NO_2)

The maximum increase regional 1-hour NO_2 as a result of the proposed Northern Link is forecast to be 2.7 $\mu g/m^3$ at Brisbane Grammar School. The incremental increase in hospital admissions for cardiovascular diseases, respiratory admissions and asthma are forecast to be 1 in 13.7 million, 1 in 5 million and 1 in 16 million, respectively, people exposed to the maximum increase per day on the days when the maximum increases in NO_2 occurs. The incremental increase in mortality is forecast to be 1 in 29.2 million people. These are very small increases in health risk.

The maximum forecast increase in annual NO_2 at Brisbane Grammar School resulting from the proposed Northern Link is 0.5 $\mu g/m^3$, which is likely to have a very small impact on lung function growth in adolescents. The long term health impact of increased near roadway annual average NO_2 is difficult to quantify, however previous studies, with 143 times higher changes in NO_2, have found an impact on lung development in children.

Particulate Matter (PM_{10})

The maximum forecast increase in 24 hour PM_{10} is predicted to be to 0.1 $\mu g/m^3$ and would result in very small increases in hospital admissions and total mortality on the days when this maximum increase actually occurs. The background daily rate of these health events is small; therefore small increases in these events are forecast one in 103 million - 281 million people.

The forecast increase in regional PM_{10} from Northern Link is forecast to result in a 0.04% increase in cough for adults and 0.01% increase in lower respiratory symptoms in children with chronic respiratory conditions. A very small increase in the daily rate of GP attendances for asthma is also forecast to occur as a result of the proposed Northern Link. This is an increased risk of one in 2.45 million children, when the forecast maximum increase in 24 hour PM_{10} actually occurs.

The forecast increase in regional annual PM_{10} resulting from Northern Link is 0.1 $\mu g/m^3$, which is forecast to have a very minor effect on lung function growth in children, equivalent to an additional 0.01% of adolescent with reduced lung function at age 18.

Particulate Matter ($PM_{2.5}$)

The maximum forecast increase in regional $PM_{2.5}$ from Northern Link is predicted to result in a 0.05% increase in hospital admissions for cardiovascular diseases. This worst case community health outcome is equivalent to an increased risk of one in 91.6 million. The long-term effect of a 0.1 $\mu g/m^3$ in annual average $PM_{2.5}$ is a 0.04% increase in long term total mortality.

The 'worst case' forecast changes in concentration of the air toxics are very small, leading to a negligible increase in health risk.

5.13.3 Health Effects from Changes to Roadside Air Pollutants.

Numerous studies have demonstrated that living near a busy road is detrimental to the health of adults and children. The EIS examines the additional health risk due to increases in roadside pollutants associated with Northern Link at distances of 10m, 30m and 50m from the kerb of the roads. To estimate the likely health impact the proximity of child care centres, schools, aged care facilities and hospitals to the major roads was also considered. Both acute and long term health effects were examined.

It should be noted that the roadway with the largest predicted increase in near- road concentrations, in this case the Western Freeway, has been used as a worst-case benchmark. Although other roads, for example Jephson Street and Croydon Street, are predicted to experience a greater percentage increase in traffic than the Western freeway, the increase in traffic numbers is less and so increase in near-road pollution levels would also be less.

Carbon Monoxide (CO)

The maximum increase in near road CO was 0.3 mg/m^3 10m from the Western Freeway, south of Mt Coot-tha Road and was forecast to result in very small increases in hospital admissions for asthma, all respiratory diseases, cardiovascular diseases and mortality. The size of the increases ranged from 0.005-0.015 persons per 100,000 people exposed to the forecast worst case increase in CO. Given the relatively localised increase in the roadside pollutants and the absence of residences within 10m of the Western Freeway, this increase is extremely unlikely to have measurable impact on community health.

Nitrogen Dioxide (NO2)

The predicted maximum increase in near road 1-hour maximum NO_2 was 11.74 $\mu g/m^3$ at a distance of 10m from the Western Freeway, south of Mt Coot-tha Road. This increase is not expected to have a significant impact on health. Hospital admissions for all respiratory diseases, asthma, cardiovascular diseases and mortality were predicted to increase, however the magnitude of the increases were extremely small and ranged from 0.015-0.032 person per 100,000 people exposed to the forecast worst case increase in NO_2.

The long term health impact of increased near roadway annual average NO_2 is difficult to quantify, however previous studies, with 10 times higher changes in NO_2, have found an impact on lung development in children. There are no residences within 10m of the Western Freeway.

Particulate Matter (PM_{10})

The predicted maximum increase in near road 24-hour PM_{10} was 2.26 $\mu g/m^3$ at a distance of 10m from the Western Freeway, south of Mt Coot-tha Road is not expected to have a significant impact on health. Hospital admissions for all respiratory diseases, cardiovascular diseases and mortality were predicted to increase, however the magnitude of the increases were extremely

small and ranged from 0.008-0.022 person per 100,000 people exposed to the forecast worst case increase in PM_{10}.

The forecast impact on acute symptoms in adults and children with asthma were also negligible. The worst case increase in annual average PM_{10} was 0.83 µg/m^3 and is not likely to have a significant impact on lung growth or mortality, since it represents a small increase in comparison to levels known to have a long term impact on health. There are no residences within 10m of the Western Freeway.

Particulate Matter ($PM_{2.5}$)

For the assessment of $PM_{2.5}$, it was assumed conservatively that all the near road PM_{10} was $PM_{2.5}$, therefore the size and location of forecast increases was as per PM_{10}. The magnitude of increases in hospital admission for asthma, other respiratory diseases and cardiovascular diseases as result of the worst case increase in $PM_{2.5}$ was very small. Increases of between 0.012-0.025 persons per 100,000 people exposed to the worst case increase were forecast. The long term increase in $PM_{2.5}$ impact was also forecast to be negligible.

5.14 Cumulative Impacts

Cumulative impacts are normally associated with the compounding and synergistic interactions on the environment arising from other developments, occurring in the same area or over similar time frames to the project being assessed. Many of the cumulative environmental effects associated with the Project are derived from traffic and transport interactions that can be measured using established traffic and transport models.

Details of planned or potential future traffic and transport projects and their timing were compiled from anticipated capital works programs. This included the South East Queensland Infrastructure Plan and Program (SEQIPP), and an agreed list for network modelling projects for forecasting years of 2014, 2016, 2021 and 2026 developed in consultation with DMR and BCC (*Appendix C of Technical Paper No 1 – Traffic and Transport in Volume 3 of the EIS*).

5.14.1 Interrelationships of Overall Impacts Within the Project

The Terms of Reference has requested information on the overall impacts of the Project and a discussion of the interrelationships of these impacts. An indication of the potential for interaction between the environmental aspects of the Project, as identified in individual chapters of this EIS, is identified in **Table 20** below. The potential for cumulative impacts associated with interaction between and amongst these elements includes the potential for mitigation measures, identified to manage individual measures, having a cumulative impact on other aspects of the project.

5.14.2 Cumulative Construction Impacts

Existing infrastructure projects specifically identified in the ToR or otherwise overlapping in time or location within which cumulative construction impacts with Northern Link may arise are identified in **Table 21** and discussed below. The assessment includes:

- identification of construction impacts of the projects on the regional, arterial and local road networks;
- identification of the construction of the projects on the community (including through community consultation); and
- identification of the construction of the projects on local and state labour markets.

An indicative program for each of the major infrastructure constructions is presented in **Table 21**.

Table 20: Environmental Impact Interaction Matrix

	Traffic and Transport	Topography, Geology, Soils	Hydrology	Air Quality	Noise	Flora and Fauna	Land Use	Cultural Heritage	Social	Landscape and Urban Design	Hazard
Traffic and Transport	■			■	■		■		■	■	■
Topography, Geology and Soils		■	■		■	■	■				
Hydrology			■			■	■				
Air Quality				■	■		■		■		
Noise					■		■	■	■	■	
Flora and Fauna						■				■	
Land Use							■	■	■	■	■
Cultural Heritage								■	■	■	
Social									■		
Landscape and Urban Design										■	
Hazard											■

As identified in Section 5.7.3 of the EIS, during construction, the impact on traffic flow, journey times and public transport due to worksite construction activities for Northern Link would be minimal. Any cumulative impact with other projects overlapping in construction timeframes, and sharing the same local or regional road network with Northern Link would consequently be minimal. Details of the routes to be used by delivery vehicles to the Western Freeway, Toowong connection, Kelvin Grove Road connection work sites and ICB work area are unknown at this stage of the planning process, however they would be confined to major roads. For general delivery, truck numbers are anticipated to be lower than that required for spoil haulage. The two proposed spoil haulage routes that have the potential to overlap with construction activities of other projects are summarised below.

- Western Freeway and Toowong worksites – westwards to Swanbank via the Western Freeway, Centenary Highway and Ipswich Motorway..
- Kelvin Grove and ICB worksites – eastwards to the ATC via the ICB and Kingsford Smith Drive.

It is not intended to permit the movement of spoil eastwards from either the Toowong or Western Freeway worksites. The two proposed spoil haulage routes that have the potential to overlap with construction activities of other projects are summarised as follows.

- Haul route to spoil placement site(s) at Port of Brisbane - anticipated at 50 trucks per day to and from the Kelvin Grove Road connection worksite and the ICB work area between July 2010 and February 2012.
- Haul route to spoil placement site at Swanbank – anticipated at 90 trucks per day to and from the Western Freeway and Toowong connection work sites between April 2010 and June 2011.

5.14.3 Conclusion

The assessment of cumulative impacts in Chapter 21 of the EIS has considered the combined effects and interactions of all of the different issues and impacts that have arisen in the development of the Northern Link EIS Reference Design. The assessment has taken into account not only the predicted impacts as identified through the technical investigations for the EIS, but also the views and concerns of the community as communicated to the study team during the consultation process for the Project. Further, the cumulative impact assessment has considered the wider implications for Brisbane of the combined effects of Northern Link and the other transport projects, either in construction or planning, that are underway across SEQ.

The overall cumulative effect can be summarised as follows:

- A clear pattern has emerged wherein there is currently a large number of major road infrastructure projects in various stages of development in the Brisbane metropolitan area, either coinciding with each other or with overlapping design and construction schedules. This is reflective of the actions being taken at all levels of government, to respond to the demands being placed on all forms of urban infrastructure by the sustained population growth in SEQ.
- This wave of development places pressure on the urban environment that is eventually manifested in a sense of 'construction fatigue' experienced by Brisbane's population at large. Large projects such as Northern Link are therefore subjected to high levels of political, environmental, economic and social scrutiny, and there are growing expectations in terms of impact assessment and mitigation.
- Notwithstanding the combined impacts of these projects, there is an underlying justification, measured and expressed in this EIS as the economic benefit to Brisbane and the SEQ region. The economic benefits have been assessed as outweighing the overall economic costs, and this assessment of costs and benefits has taken into account not only dollar costs, but also social, environmental and time costs and benefits.

With implementation of the various mitigation measures recommended in this EIS, it is considered that the Project can proceed without a significant long term detrimental impact on the environment, and without any significant additional cumulative effects with other projects, either proposed or under construction.

Table 21: Known or Anticipated Infrastructure Projects and Timing

	Timing During Construction of Northern Link					
Project	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Northern Link						
CLEM7						
Gateway M'way Upgrade						
Hale Street Link						
Airport Link						
Northern Busway						
Airport R'about Upgrade						
Ipswich M'way Upgrade						
Tank St Bridge						

Brisbane City Council Queensland Government

6. Environmental Management

Careful management of Northern Link is required during both the construction and the operational phases to maintain if not enhance the environmental conditions in the study corridor. Detailed environmental management plans (EMPs) will need to be prepared for each phase of the Project. Some aspects of the EMPs will need to be approved by the Queensland Government and Brisbane City Council, and others will need to be approved by Brisbane City Council prior to the commencement of construction and operation of Northern Link. Existing laws, regulations, codes and the like determine the approval roles and responsibilities of both the Queensland Government and Brisbane City Council.

This EIS provides draft Outline EMPs for the project delivery or construction phase, and the operation phase, drawing upon the findings of the EIS studies, consultation processes, detailed design, more detailed predictive modelling and baseline monitoring.

The draft Outline EMPs provide a performance-based approach to environmental management. This approach seeks to identify the key objectives for environmental management, having regard to the technical studies and investigations, and community and stakeholder consultation. While the environmental objectives are important and must be achieved, the effectiveness of either the Contractor or the Operator in achieving them is to be measured against a range of performance criteria set out in the draft Outline EMPs.

The mitigation measures set out in the draft Outline EMPs are intended to provide direction as to how the environmental objectives might be achieved, but do not preclude other means or measures which are equally or more effective. They are intended to be achieved, together with the performance criteria being met. Flexibility in the method of achieving the environmental objectives allows the construction contractor to respond to specific community concerns or specific design issues.

It is anticipated that the principles of these draft Outline EMPs will form the basis for conditions imposed by the Coordinator-General and subsequently, for the detailed management plans drawn up by the Contractor and Operator of the Northern Link Project. Desirably, the environmental objectives would be incorporated and addressed with the commencement of detailed design, and followed through the construction and operational phases of Northern Link.

The environmental objectives would be implemented through further development of the draft Outline EMP, preferably in response to conditions the Coordinator-General might set, should Northern Link be approved to proceed.

7. Urban Regeneration and Urban Mitigations

7.1 Overview

Northern Link would lead to a range of transport and other benefits for communities living both within and beyond the study corridor. However, the impacts of Project delivery are contained mostly within the study corridor, and specifically in those areas proximate to the surface connections. Furthermore, Northern Link would provide a catalyst for indirect changes in community activity, economic activity, land use and transport patterns in the inner western suburbs and the catchment areas of the Project.

If these changes are managed within an over-arching framework, Northern Link would provide the opportunity to deliver lasting transport, economic, community and environmental benefits to the City. An over-arching framework would seek to manage land use change, integrate land use and transport planning, and as a consequence, facilitate opportunities for beneficial community and economic activity. An integrated approach to planning is required, and would need to be consistent with or complementary to planning initiatives at both the State and local levels of government.

The urban regeneration initiatives for Northern Link should:

- build on previous integrated planning measures for the inner western suburbs, such as the CityShape initiative and the local growth management strategy, local plans, and corridor plans;
- build capacity in the communities of the study corridor for engaging in the planning of their urban environment;
- deliver enduring urban design of Project works and adjacent streets;
- deliver community benefits in the short term; and
- stimulate opportunities for sustainable economic development, consistent with desired urban planning outcomes.

7.2 Community Expectations

From the preliminary rounds of community consultation undertaken to support preparation of this EIS, there is broad community support for Northern Link in terms of its high level benefits. There is local concern and anxiety over the local level impacts. Preliminary community consultation for Northern Link has identified the following community concerns and expectations.

- Recognition that traffic congestion in the inner western suburbs is 'a problem', and the need for traffic management and reduction in the inner western suburbs.
- Concerns over construction and operational aspects of the Project, particularly for communities near the surface connections at Toowong and Kelvin Grove (eg: traffic congestion on approach roads, and project justification, visual impacts of surface infrastructure, noise, vibration, air quality, vent location and appearance).
- Concerns that surface infrastructure and road widenings associated with connections at Toowong and Kelvin Grove will create physical barriers between neighbourhoods and to community facilities.
- Expectation that local residents should benefit from the Project equally, if not more so, with the people who presently drive through their suburbs to access employment in the CBD.

7.3 Implementing Urban Regeneration

Program initiatives for urban regeneration should be developed within a consultative framework involving agencies, stakeholders and local communities. Potential urban regeneration initiatives in the inner western suburbs are identified below.

- Queensland Government – further development of the 'City West' master plan to determine the feasibility of implementing the Normanby action plan for improved urban amenity along Kelvin Grove Road and Musgrave Road in the vicinity of the ICB.
- Brisbane City Council – investigation of local planning at Toowong and continuation of local planning at Milton and at Kelvin Grove to manage land use change and to achieve a high level of integration in land use and transport planning, consistent with the growth management strategy developed under the SEQ Regional Plan.
- Proponent - investigation of employment schemes for youth, disabled people, indigenous people and prematurely retired or long-term unemployed people, in conjunction with employment initiatives of the delivery vehicles.
- Proponent - investigation of possible participation in Project construction or in community-based, project-related activities building community capacity for people who don't speak English as their first language, people with low education levels and people with special needs.

While the government programs are presently operating, the intention is for their delivery in the study corridor to be integrated and coordinated, in order to optimise the potential for community benefit, and to optimise the benefits from each of the programs.

7.4 Urban Mitigation Initiatives

In conjunction with the implementation of urban regeneration measures, a range of urban mitigation initiatives are required to address the Project impacts, in addition to the environmental management measures recommended in the draft Outline EMPs.

These mitigation initiatives are outlined in **Table 22** and are recommended as works to be undertaken as part of the Project to optimise the potential benefits of Northern Link and to address potential issues with social equity.

The overall scheme of urban mitigations proposed for the western connections (Mt Coot-tha and Toowong) and the northern connections (Kelvin Grove and ICB) are presented in **Figure 20** and **Figure 21**. A range of mitigation measures could be brought to bear on the impacts of the Toowong ramps, should Northern Link be delivered strictly in accordance with the reference design. While innovation in detailed design and tendering would be encouraged, one possible means of mitigating the impacts of the Toowong connections is presented in **Figure 22**. This proposal would entail the acquisition of residential properties likely to be impacted adversely by the elevated ramps and structures, enabling Quinn Park to be extended as a linear open space between Sylvan Road and Croydon Street.

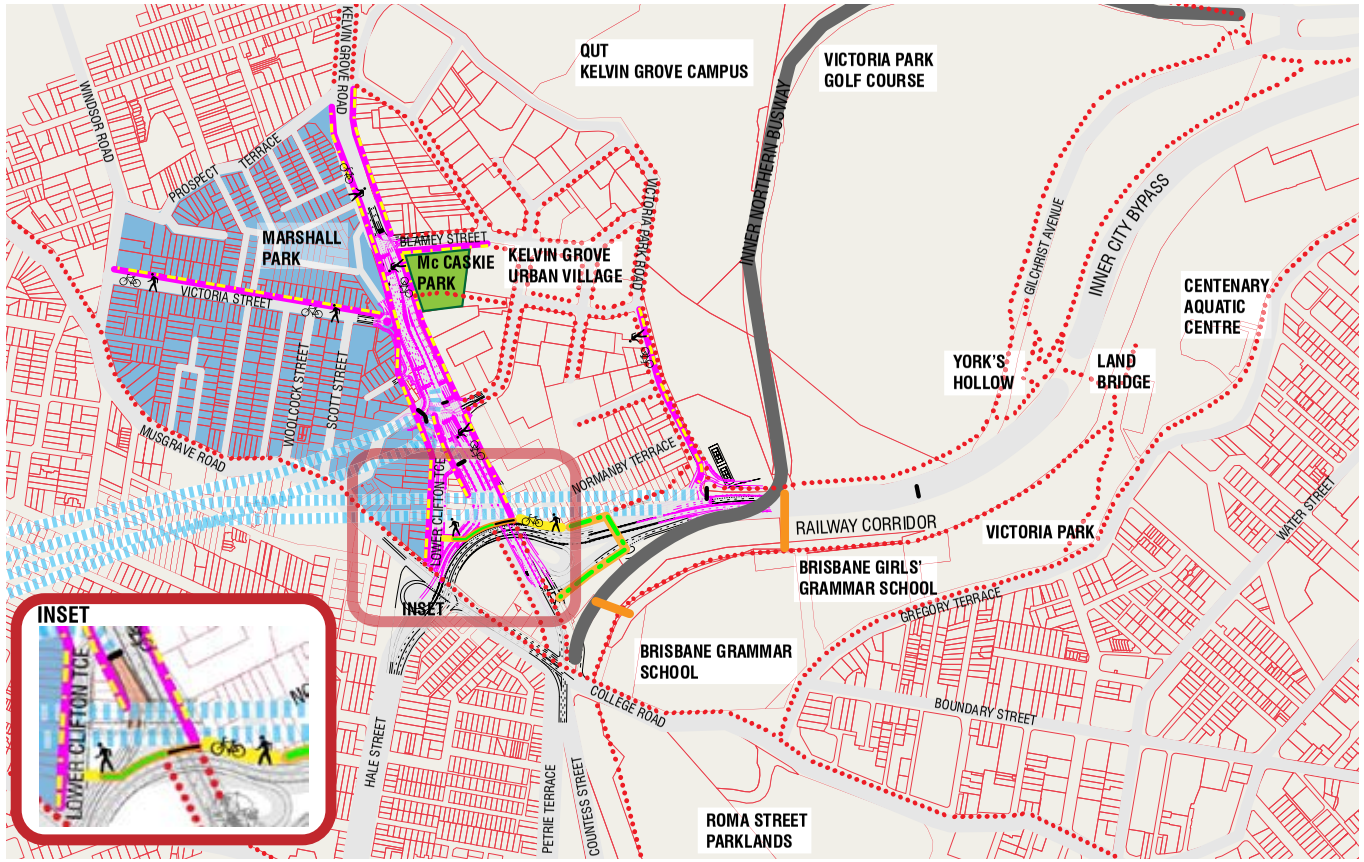
7.5 Public Art Strategy

Public art is proposed in the suite of urban mitigations as an effective measure which would link communities with activity centres via pedestrian and cycle links. Public art is also proposed as part of an integrated approach to mitigating the effects of Project infrastructure (eg: elevated road structures, ventilation outlets and ventilation stations, retaining walls for road connections).

Table 22: Urban Mitigation Initiatives

Category	Location	Priority
Urban design	Milton Road (Croydon Street to Markwell Street)	High (undertaken as project works)
	Milton Road (Markwell Street to Torwood Street)	
	Sylvan Road (Milton Road to Coronation Drive)	
	Jephson Street (Croydon Street to Sherwood Street)	
	Valentine Street	
	Frederick Street (Valentine Street to Sleath Street	
	Kelvin Grove Road (ICB on ramp to Prospect Terrace)	
	Victoria Street Precinct (bounded by Prospect Terrace, Windsor Road, Musgrave Road, Lower Clifton Terrace and Kelvin Grove Road)	
	Red Hill (Scott Street, Woolcock Street)	
	Kelvin Grove (Blamey Street)	
	Normanby Terrace	
	Lower Clifton Terrace	
	Victoria Park Road (Maidstone Street to ICB)	
Pedestrian and cycle ways	Mt Coot-tha Road (Western Freeway to Botanic Gardens gate)	High
	Sylvan Road (Milton Road to Coronation Drive)	
	Sylvan Road to Western Freeway bikeway (Anzac Park, adjacent Dean Street)	
	Milton Road (Croydon Street to Dean Street)	
	Milton Road (intersection with Croydon Street)	
	Kelvin Grove – contribute to additional pedestrian/cycle link over ICB to Normanby busway station	
	Lower Clifton Terrace – enhance connection	
Open space	Brisbane Botanic Gardens at Mt Coot-tha	High
	Quinn Park, Toowong	
	Anzac Park, Toowong	
	MacCaskie Park, Kelvin Grove	
	Marshall Park, Kelvin Grove	
Public art	Toowong connection	Medium term
	Sylvan Road to Coronation Drive	
	Kelvin Grove connection – north and south	

URBAN MITIGATIONS
NORTHERN & KELVIN GROVE ROAD CONNECTION



EXISTING ELEMENTS

- Brisbane Grammar's private pedestrian bridge across ICB
- Overpass from ICB cycle bridge to Lower Clifton Terrace
- Existing pedestrian/cycle connections

PROJECT INFRASTRUCTURE

- Portals
- Tunnel Alignment

Not to scale

URBAN MITIGATION WORKS

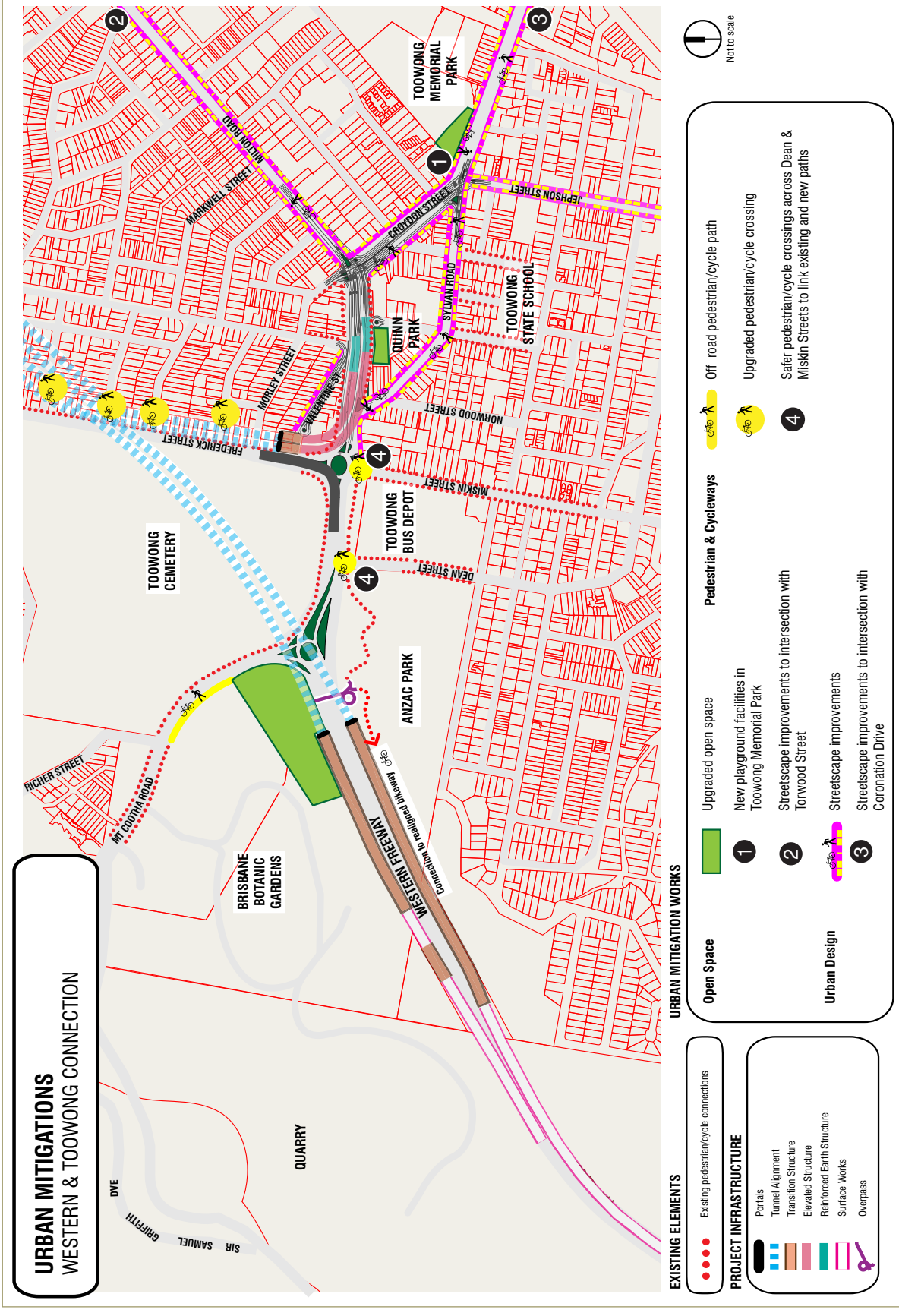
Open Space
- Upgraded open space
- Neighbourhood enhancement

Urban Design
- Streetscape improvements

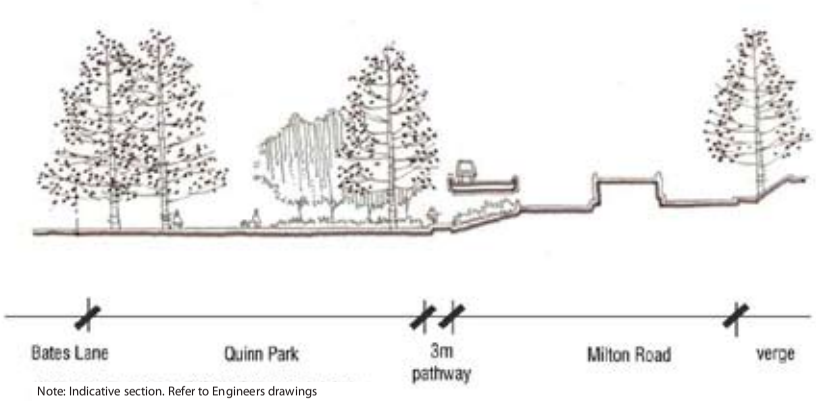
Pedestrian & Cycleways
- Overpass connecting existing ICB overpass to Lower Clifton Tce
- Potential Bridge overpass landing at ICB pathways north & south
- Upgraded existing pedestrian/cycle path

Figure 20: Urban Mitigations – Northern Connections

Figure 21: Urban Mitigations – Western Connections



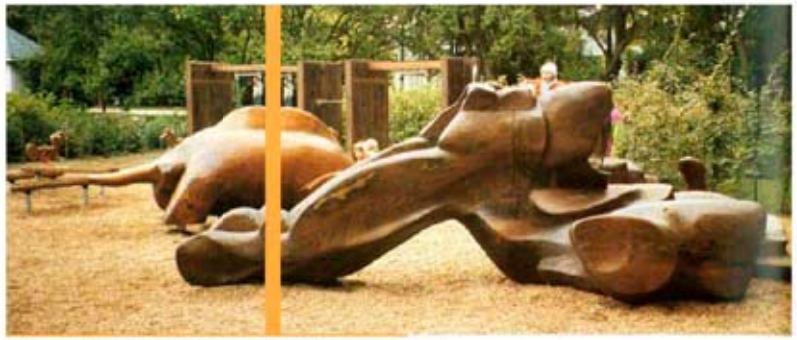
Open Space



Typical section A-A - Quinn Park and Milton Road

Note: Indicative section. Refer to Engineers drawings for details & location of infrastructure.

Bicylette Ensevelie, Claes Oldenburg & Coosje van Bruggen - Parc de la Villette, Paris, France



Playground by Artelier de Launey - Parc de Sceaux, Paris, France

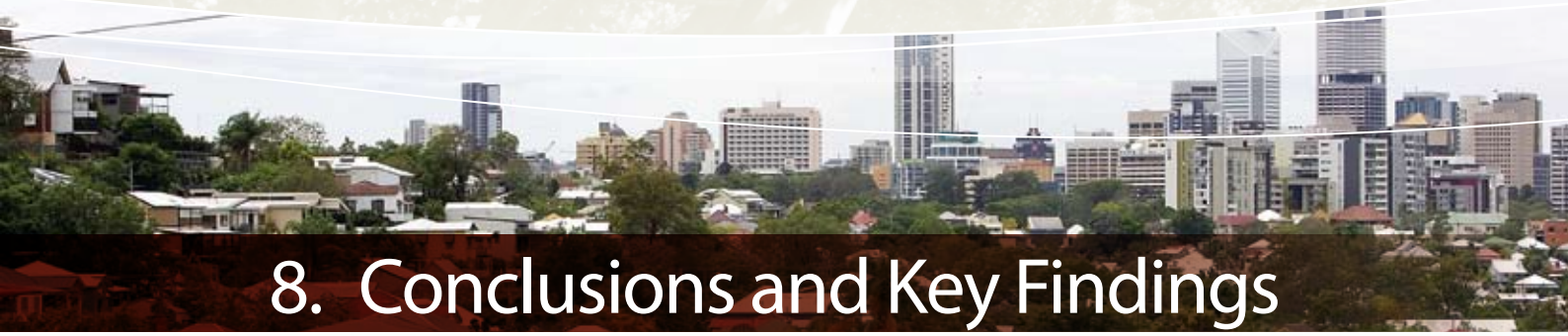
Playground Example

QUINN PARK

1 Quinn Park - enhancements include extension of park to Croydon Street with Playground for all ages, Public Art, pedestrian lighting and park amenities.

typical plan - not to scale

Figure 22: Urban Mitigations – Quinn Park



8. Conclusions and Key Findings

With the designation of Northern Link as a project of State significance, the Coordinator-General determined that an EIS was required to describe the scope of the Project, to identify the potential benefits and impacts, and to describe the mitigation measures required to address such impacts. The Coordinator-General established and released Terms of Reference for the assessment of Northern Link in April 2008.

The investigations for the development of the Northern Link design and for the preparation of the EIS, have extended beyond the matters raised in the Terms of Reference to include matters raised during the preliminary consultation process and during the design development phase.

The conclusions drawn from the design studies and the EIS relate to:

- the strategic need, or rationale, for Northern Link within Brisbane's road network;
- the potential benefits and impacts of Northern Link upon the environment of the study corridor, and beyond in some circumstances, in both its construction or delivery and its operation;
- the scope of community and stakeholder interests in Northern Link; and
- the range of mitigation measures available to address community issues.

8.1 Rationale for Northern Link

Sustained population growth and economic development in SEQ over the last two decades or more has led to a strengthening of the SEQ Regional Plan from an advisory document to a statutory instrument. The Queensland Government has implemented this change in approach to planning for and managing the effects of growth and demand for infrastructure and essential services.

One outcome of this growth is the continued increase in travel demand across the SEQ Region, and within key local government areas. Brisbane will accommodate nearly 18% of regional population growth, or in the period 2006 – 2026. As Brisbane is and will remain the principal centre for business activities, high-level services and employment in the region, it will continue to be the focus for this growth in travel demand. Such significant growth in population and employment would lead to a sustained growth rate in trip making at an average of 1.6% per annum through to 2026. This would be an increase in over 2,000,000 total weekday person trips compared to 2007.

Over the past 15 years there has been a concerted effort to increase significantly the use of public and active transport. The current rate of patronage growth for weekday trips in the region is around 7.7% per annum[30]. Despite this substantial growth in public transport usage the majority of trips in the Brisbane Metropolitan Area are made by private and commercial vehicles.

The SEQ Regional Plan, and the South East Infrastructure Plan and Program present the Queensland Government's framework for sustainable growth management. A key aspect of the suite of infrastructure identified is the on-going augmentation of the road transport network.

The key deficiencies of the current road network are related to gaps in the strategic network, system performance, the ability to cater for growth in travel, low and unreliable travel times and a lack of route choice and flexibility. The gaps in the strategic transport network principally affect east-west transport efficiency, safety and reliability. There are network gaps between the western and northern approaches to Brisbane, and a direct, high quality connection between the west and the ATC (North), which includes Brisbane Airport, is missing from the current network structure.

The traffic congestion that currently exists on the road network is forecast to deteriorate further over time. This will have a range of consequences such as:

- congested arterial roads resulting in excessive and unreliable travel times;
- increased and unreliable bus journey times;
- increased time for the road network to recover from an incident;
- constrained local accessibility such as banned turns and one-way systems, to cater for regional radial traffic;
- the diversion of through-traffic to the local road network;
- inappropriate vehicles types (freight) using inner urban roads;
- a lack of road space for local functions such as parking, loading, public transport; and
- increased reliance on signalised intersections resulting in significant delay during congested times, in particularly for local traffic.

Increased travel demands in future years will create significant additional pressure in the metropolitan area transport network. The consequences of the road network deficiencies will worsen such that peak

30. Queensland Government, 2007, TransLink Network Plan, Brisbane.

period journey travel times are forecast to increase compared to the current level. For example, without Northern Link, but with enhanced mode share to public transport, traffic conditions on the Milton Road, Coronation Drive and Moggill Road corridors are forecast to deteriorate over time. Traffic volume growth to 2026 is forecast to be almost 30% on Milton Road and 15% on Coronation Drive.

Northern Link would address strategic transport needs by:

- supporting the preferred future development pattern, population and employment growth of SEQ in accordance with the SEQ Regional Plan by improving connectivity and transport system capacity to cater for major growth areas (eg: Western Corridor) and economic activity centres (eg: CBD, Toowong and Indooroopilly, ATC;
- improving east-west transport efficiency (eg: Western Corridor and western suburbs to ATC, the CBD and the regional roads in northern suburbs);
- improving freight distribution by completing an alternative, motorway-standard corridor for long distance freight from the south-west to the CBD, ATC and north Brisbane; and
- providing additional public transport capacity, and facilitating enhanced public transport capacity within existing corridors such as Coronation Drive and Milton Road.

Northern Link would address local transport needs by:

- providing a high quality route for express bus services between the western suburbs and the CBD, and improving public transport efficiency on major surface bus routes;
- removing through-traffic from Coronation Drive, Milton Road and Moggill Road which pass through major commercial and residential areas, and consequently relieving rat-running pressures from local roads; and
- providing an alternative higher order freight route to inappropriate routes through local areas, and so removing freight movements from surface traffic routes.

8.2 Project Objectives

The objectives for Northern Link, consistent with transport planning at the Commonwealth, State and local levels, are:

- Transport network
  - To improve east-west cross-city movement of people and freight.
  - To address deficiencies in the national freight network to improve freight distribution in and around Brisbane.
  - To provide opportunities for additional public transport capacity.
- Environment
  - To protect and, where possible, enhance the environment.
- Social
  - To assist development of a sustainable urban environment for inner-western suburbs.
- Value for money
  - To deliver value-for-money over whole of project life.
- Timeliness
  - To deliver Northern Link by June 2013.

8.3 Sustainability

In addition to these functional objectives, development of the Northern Link concept has been influenced by community inputs, technical inputs and a commitment to pursuing sustainability in all feasible aspects of Project construction and operations. Brisbane City Council has established a Corporate Vision for the future of Brisbane through *Our Shared Vision – Living in Brisbane 2026*[31]. The vision is supported by a Sustainability Policy which provides Brisbane-specific guidance for achieving sustainability outcomes through the implementation of Northern Link. The four focus areas identified in this policy are listed below:

- Resource efficiency: saving energy and water and reducing waste;
- Sustainable places and urban form: improving Brisbane's built environment, especially the interactions between land use, transport and the environment;
- Biodiversity conservation: protecting and enhancing biodiversity, natural areas and waterways; and
- Health and wellbeing: developing a city where our people and communities enjoy physical, mental and social well-being.

8.3.1 Sustainability Framework for Northern Link

Table 23 provides a sustainability framework for identifying relevant strategic and project specific areas for the development of sustainability measures. The framework provides the basis for a structured approach for integrating Council's Vision and Sustainability Policy into the proposed Northern Link Project, as well measuring the achievement of sustainability outcomes.

8.3.2 Sustainability Measures

Specific sustainability measures that have been applied in the development and refinement of the Reference Project have included:

- how the design process is undertaken:
  - minimise paper use and only use recycled paper;
  - coordinate and manage site visits and travel by Project Team to minimise emissions;

31. Brisbane City Council, 2006, *Our Shared Vision – Living in Brisbane 2026*, Council, Brisbane

Table 23: Sustainability Framework and Northern Link

KEY INDICATORS	SUB-CATEGORIES	PROJECT PHASE#			
		Plan	Design	Const.	Ops.
STRATEGIC (how the project contributes to)					
Resource efficiency	Regional/city freight movement	✓	✓		✓
	Regional/city transport network	✓	✓		✓
Sustainable places and urban form	Urban form, design, mixed use/TOD, connectivity	✓	✓		✓
	Public transport movement	✓	✓	✓	✓
Biodiversity conservation	Regional/city green corridors/spaces/waterways	✓	✓	✓	✓
Health and well-being	Amenity and community character	✓	✓	✓	✓
	Public spaces/facilities	✓	✓	✓	✓
PROJECT SPECIFIC (how the project addresses)					
Economic					
Direct Cost	Construction, life cycle	✓	✓		✓
Indirect cost	Community, natural environment	✓	✓		✓
Environmental					
Land use	Project footprint	✓	✓	✓	✓
	Adjoining properties	✓	✓	✓	✓
Water	Impact/mitigation – water cycle	✓	✓	✓	✓
	Water capture/reuse	✓	✓	✓	✓
Air	Quality impact/mitigation	✓	✓	✓	✓
	Ventilation outlet	✓	✓	✓	✓
Noise	Impact/mitigation	✓	✓	✓	✓
Ecology	Impact/mitigation	✓	✓	✓	
	Replacement/enhancement of habitat	✓	✓	✓	
Visual	Impact/mitigation/enhancement	✓	✓	✓	
Waste management	Extent of waste created		✓	✓	
	Reuse		✓	✓	
Social					
Social uses	Impact/mitigation/enhanced access or protection	✓	✓		
Public access and physical activity	Connectivity to employment, services and PT options changed access to open space and parks	✓	✓		✓
Public engagement	Perception	✓	✓	✓	✓
	Involvement and satisfaction with outcomes	✓	✓		
Resource utilisation					
Site access	Construction equipment, workforce, waste, material	✓	✓	✓	
Resource availability	Material, equipment, workforce	✓	✓	✓	
Material type		✓	✓	✓	
Reusability	Reusability of moulds, formwork	✓	✓	✓	
Quality assurance	Ease of quality control	✓	✓	✓	
Health and safety					
Occupational		✓	✓	✓	✓
Public	Pedestrian, vehicular and open space safety	✓	✓	✓	✓
Project administration					
Project requirements (EIS, contract)	Inclusion of sustainability-related clauses	✓	✓		
Procurement method	Assessment against sustainability	✓	✓		

Table Notes:
This table has been created from a range of sources including BCC Corporate Sustainability Policy, Kumaraswamy, 2004, Wong, 2003 and SKM 2007.
Project Planning and Feasibility Assessment have been combined into 'Planning' and 'Decommissioning' has not been included at this time.

- achieving efficient transport network and traffic movement outcomes through the location and design of connections to surface roads;
- options for accommodating express bus movements;
- the capture of stormwater for use during construction;
- the reuse of tunnel spoil; and
- sustainable urban regeneration and mitigation initiatives.

It is the Proponent's intention to include sustainability measures in the Project procurement phase and throughout the detailed design, construction and operation of the Project. Specific sustainability measures that have been currently identified for inclusion into the next phase of project design and delivery following the evaluation of the EIS would include:

- maintaining construction equipment and haul trucks in good working order so fuel efficiency of equipment is maximised;
- vehicle management systems to reduce waiting e.g. spoil haulage;
- use of appropriately sized equipment for construction activities;
- minimising waste from construction, including reuse of tunnel spoil as a valuable resource;
- using low intensity lighting throughout the length of the tunnel without compromising user safety;
- energy efficient and effective lighting, fans and traffic management systems;
- automatic control of light intensity in the portal region as varying with ambient light conditions on the surface;
- a ventilation system design which utilises the piston effect of traffic movement through the tunnels and with demand management of the ventilation system where ventilation (and associated electricity use) can be increased or decreased as necessary based on in-tunnel concentrations of air pollutants or in the event of fire or emergency situations;
- low energy design of project buildings;
- water sensitive construction practices; and
- sustainability objectives in urban design, landscape treatments and urban mitigation.

8.4 Project Impacts and Mitigations – Construction Phase

Northern Link would have a range of environmental and community impacts during its construction phase. Such impacts would vary in their duration and intensity along the study corridor, but mostly would be confined to the immediate locality of the Project works. Most construction impacts would be of a temporary nature, even though some of them may be present for the duration of the 3.5 year construction period. Other impacts, mostly relating to land use and property aspects, would be long-term.

8.4.1 Construction and Worksites

Northern Link is a major infrastructure project involving a scale of construction activity not previously encountered in the study corridor. Construction impacts could include:

- diminished air quality due to exposed earth surfaces in the worksites, the operation of earth-moving equipment, and the loading and haulage of spoil;
- noise and vibration due to both surface and sub-surface construction techniques such as drilling and blasting, rock-breaking, cut and cover works, or tunnelling either by roadheader or tunnel boring machine;
- reduced surface water quality due to the escape of drainage waters contaminated with sediments or other entrained material, and possible drawdown of groundwater in some areas of alluvium;
- loss of vegetation, including some significant trees in Kelvin Grove; and
- possible risk of impacts on places of cultural heritage significance, such as Toowong Cemetery.

To respond to and manage effectively these and the other potential impacts arising from construction of Northern Link, a draft outline Environmental Management Plan for the construction phase has been proposed in this EIS. The Outline EMP presents a performance-based approach in which environmental objectives are proposed. These objectives, supported by recommended performance criteria, are relevant to maintaining reasonable conditions and quality of life for nearby residents and businesses.

The construction of Northern Link would entail the establishment of worksites at the Western Freeway, Toowong, Kelvin Grove and a temporary work area within the ICB corridor. While the worksite at the Western Freeway and the area in the ICB corridor are within public land, the worksites at Toowong and Kelvin Grove would require the acquisition of private land. These latter sites would be situated in close proximity to residential dwellings and would require a high standard of site management to avoid, or to mitigate and manage construction impacts.

Acoustically-lined and ventilated enclosures or sheds would be erected over the portals to each of the tunnels at the Western Freeway, Toowong and Kelvin Grove to manage noise and dust impacts from tunnel construction and spoil handling and loading. All spoil handling and loading into trucks or the conveyor system at the Western Freeway would occur within these enclosures or sheds. The worksheds would be large and bulky in character, and would impact a temporary impact on the visual amenity of near neighbours. Night lighting on these sheds and the worksites would need to be directional and would need

to comply with the requirements for managing light spill intrusion on near neighbours.

The movement of vehicles, including spoil haulage trucks, and other construction plant and equipment would need to be managed effectively to achieve the environmental objectives for construction noise and air quality. The haulage routes for the removal of spoil would generally follow the motorway network and the arterial road network where there is no ready access to a motorway. To reduce the impact of spoil haulage by up to 65,000 loads, a spoil conveyor system servicing the TBMs at the Western Freeway worksite is proposed, discharging spoil to the adjacent Mt Coot-tha Quarry for stockpiling and re-use, both in Project works and other applications.

Following construction, each of the worksites would be rehabilitated and landscaped to complement the locality. The Western Freeway worksite would complement the Botanic Gardens. The Toowong worksite would be developed as an attractive landscaped buffer to mitigate the visual impacts of the elevated road structures above Milton Road and the road traffic noise from the ramps into and out of the Toowong connections. The Kelvin Grove worksite lends itself to re-use for some form of active use, combined with an area adjacent to the Kelvin Grove Road and Hale Street connections being more suitable for landscaped buffer. The ICB connection would be provided with architectural treatments which complement or are consistent with the transport infrastructure theme in this corridor. The ICB landscaped area on the corner of Kelvin Grove Road would be reinstated with landscaping and urban design treatments.

8.4.2 Construction Traffic and Access

The movement of construction traffic in and around worksites is of concern to people living in the vicinity of each worksite. The indicative access arrangement for each worksite is intended to reduce the potential for conflict with both local traffic and general traffic using the arterial road network. The EIS recommends the preparation of detailed construction traffic management plans and construction vehicle management plans to address and manage the likely implications of construction traffic.

A key consideration will be the maintenance of traffic flows past each of the worksites during construction and during peak traffic periods. Staging of works at all sites would allow the existing number of through lanes to be provided past the sites at most times, though temporary alignment changes would be required. As a result, the level of through traffic intrusion into adjacent areas is expected to be small. Occasional short duration partial closures would be likely, for example for intersection works. Further, the management of construction traffic to nominated routes for spoil haulage would aid in reducing haulage impacts upon the road network as well as near neighbours. A key management measure would be to limit the use of these nominated spoil haulage routes to nominated hours – typically 6.30am Monday until 6.30pm Saturday, with there being no haulage on Sundays or public holidays.

Considering the location of each of the worksites within the arterial road network, the movement of construction traffic is within the function and the capacity of these roads.

8.4.3 Construction Air Quality

The potential for dust nuisance during construction would arise with the establishment of each worksite, through the clearing and reforming land, removing or demolishing buildings, the operation of plant and equipment for earthworks, and the handling and loading of construction spoil. The draft Outline EMP proposes criteria for managing dustfall at nearby locations, as well as proposing mitigation measures to avoid, or minimise or manage dust nuisance. Considering the proximity of dwellings to both the Toowong and Kelvin Grove worksites, there is an increased awareness of the importance of effective site management for dust control.

While dust management practices are well developed and understood, the avoidance of dust nuisance requires on-going, careful management, supported by a monitoring program and a reporting program. Where monitoring, or complaints, indicated the environmental objectives was not be achieved, the expectation would be that the construction entity would prepare an incident report and a corrective action report as part of a process to avoid further exceedances.

There would be two ventilation outlets constructed for Northern Link. One would be situated within the Western Freeway worksite on land adjacent to the Botanic Gardens. It would stand as part of the structure for the ventilation station. The other would be constructed on land within the Victoria Park golf course. The ventilation station for the northern ventilation outlet would be constructed on land adjacent to the ICB and the Inner Northern Busway. Each of these facilities would be designed and constructed to achieve their function of dispersing vitiated air from the tunnel system. Due to their scale, each facility would also require design and siting treatments to mitigate their potential visual impact.

8.4.4 Construction Noise and Vibration

The construction of the Northern Link tunnels would entail the removal of large quantities of hard rock by a variety of methods, each of which has the potential to generate noise and vibration. As the depth of each tunnel to the surface increases, the potential for noise or vibration to be detected by people on the surface diminishes. Surface works likely to generate noise or vibration, such as construction of the transitions and cut and cover tunnels, would require some form of physical

intervention, such as noise barriers, to reduce the impact upon people nearby.

The study corridor is characterised mostly by residential buildings in the 'timber and tin' architectural vernacular. While these buildings are more flexible than some other structures and therefore less affected by vibrations, they are also more susceptible to noise from surface works. Also, the presence of some places of cultural heritage significance, such as the Toowong Cemetery, above the tunnels, would require careful management to either avoid, or minimise the risk of damage.

The draft Outline EMP (Construction) proposes a range of guides for noise and vibration for works to achieve the environmental objectives, which would enable people to maintain a reasonable daily pattern of life within an acceptable acoustic environment. Other guides are provided to reduce the risk of damage to buildings and the disruption to the operation of sensitive equipment, such as computers and medical equipment. The draft Outline EMP also proposes a monitoring regime in combination with early and on-going consultation with people as construction progresses. An effective and accessible complaints and reporting system would also be established as part of the construction method.

Finally, the draft Outline EMP requires a building condition survey to be conducted, in advance of and following construction works along the route to identify the extent of damage caused by construction due to vibration, or settlement. The construction contractor would be obliged to repair and make good all damage caused.

8.4.5 Groundwater Movement and Settlement

The environmental studies undertaken for Northern Link indicate the likely presence of groundwater in a number of locations and at different depths. It is likely that groundwater would be intercepted by construction works establishing the western transition structures in shallow aquifers adjacent to the Botanic Gardens and the Toowong Cemetery. There may also be a potential to intercept groundwater in the mid-sections near Paddington, where the tunnel alignments come close to the surface drainage lines. Grondwater may be intercepted in other locations along the route, where faulting or fractures in the rock. Generally, the construction depths between the tunnel portals would reduce the potential for groundwater drawdown.

The drawdown of groundwater into Northern Link has been modelled and is predicted to occur slowly over more than 100 years. The rate of flow into the Northern Link tunnels through the hard bedrock conditions is slow to very slow, allowing consideration of construction without the need for waterproof lining, or 'tanking'. Drainage systems to minimise and manage groundwater inflow would be required for the sections of tunnel through the shallow aquifer at Mt Coot-tha.

The environmental studies did not detect any groundwater-dependent ecosystems. Considering the depth of the tunnel construction in hard competent rock, the potential to intercept surface aquifers supporting groundwater-dependent ecosystems was determined to be very low.

The extent of settlement likely to be caused by tunnel construction, either through groundwater drawdown or construction activity, is predicted to be small and unlikely to affect structures, including swimming pools, on the surface. As this is an issue of some concern to the communities living above the tunnel routes, monitoring and management of groundwater drawdown and settlement would be required through implementation of the construction EMP.

8.4.6 Cultural Heritage

The indigenous cultural heritage values of the study corridor have been identified by studies undertaken by representatives of the traditional owners with an interest in the area, namely the Jagera People and the Turrbal People. The traditional owners have an interest in maintaining the heritage values of places of significance to them and would welcome the opportunity to become involved in the construction phase of Northern Link, both to ensure such values are not impacted, but also as advisors to facilitate better recognition of their heritage in Northern Link.

Northern Link would pass beneath some of the older, more established suburbs in Brisbane in which are located places of cultural heritage significance on either the State or local level. Some places of State cultural heritage include Brisbane Forest Park and the Toowong Cemetery at the western end of the study corridor, and St Brigid's Church at Red Hill and Gona Barracks at the northern end of the study corridor. There are also areas of character housing and demolition control within the study corridor. While the reference project has minimised the extent of land required for the worksites, some buildings within these precincts would be removed or demolished.

While this EIS has identified places of cultural heritage significance, the construction of Northern Link would need to be planned and implemented carefully to avoid, or minimise and mitigate the effects on such places. Detailed design in combination with predictive modelling of the potential vibration and settlement effects would be required in advance of the works, to enable the environmental objectives to be achieved.

Approval of the detailed works would be required, in some circumstances, to meet the requirements of legislation (Integrated Planning Act) before the commencement of such works. Such approvals would be sought once detailed design has provided sufficient information to support an application.

8.4.7 Social Impacts

Northern Link would bring about a range of social impacts, both beneficial and adverse. The beneficial impacts would derive from improved accessibility across the city and within the study corridor as traffic congestion is relieved on the key arterials. Rat-running through suburbs to avoid these presently-congested routes would be relieved somewhat as a consequence of the Project. Other beneficial impacts would flow from enhanced access to employment and the opportunity for enhanced public transport in the inner western suburbs.

The potential adverse social impacts of construction would derive from the establishment and operation of worksites, particularly the Toowong worksite and the Kelvin Grove worksite, due to their location in proximity to residential areas. The Western Freeway worksite, if not carefully managed, has the potential to impact on the recreational and scientific values of Botanic Gardens. Management of each of the worksites, including the hours of work for outside or above-ground construction activities and the movement of construction vehicles, would need to achieve the environmental objectives and would need to be supported by an effective and accessible complaints and reporting system.

Community feedback received during preliminary consultation for this EIS has indicated a high level of concern for some residents living near the Toowong and Kevin Grove worksites. Such concerns include the scale and proximity of the works to residences, as well as noise, dust, construction traffic and general disruption to community life.

The construction of Northern Link must be planned and delivered in such a way that people can maintain a reasonable quality of life for the duration of the works. This objective might drive a requirement for innovative construction techniques to be employed. Such techniques must be developed in consultation with near-neighbours to address their reasonable and specific concerns about construction impacts.

8.4.8 Land Use and Planning

Construction of Northern Link would bring about some land use changes due to the establishment of the worksites. Such changes are likely to be long-term at Toowong and Kelvin Grove, and temporary in part, at the Western Freeway and the ICB corridor for the ventilation outlets and ventilation stations. It is proposed that the Toowong worksite be developed as a landscaped buffer, whereas it is possible a combination of landscaped buffer and re-use of the Kelvin Grove worksite is possible and a more desirable outcome.

Changes in traffic movements during construction would affect local access to some properties. Careful management and on-going consultation with affected owners and occupants would be required to avoid or minimise and mitigate the impacts of changed access.

8.4.9 Flora and Fauna

The construction of Northern Link would require the clearing of vegetation from the Western Freeway worksite and the approach lanes along the sides of the Western Freeway. There would also be some clearing of vegetation within the Botanic Gardens to allow for the construction of the temporary spoil conveyor from the worksite to the Mt Coot-tha Quarry. The extent of clearing is not significant in terms of habitat loss, nor would it result in the displacement of species endemic to those small local areas. There would be no impact on any rare or threatened species of plant or animal.

Construction activities would require the removal of two fig trees beside Kelvin Grove Road. These trees are of State cultural heritage significance and, as part of a stand of such trees, provide a notable landscape element to the locality and to the Kelvin Grove Road corridor. These trees do not possess any botanical or scientific value. It is proposed that an urban landscaping program be implemented as part of the construction works to compensate for the loss of these fig trees.

8.4.10 Landscape and Visual

Due to the surrounding topography, the construction works for Northern Link would not impact on the urban landscape or visual amenity much beyond the immediate vicinity of each of the worksites. The construction works would not be visible from many distant vantage points. However, the scale of the works would impact on the urban landscape and the visual amenity in the localities of each of the worksites. The visual impact of the works at the Western Freeway would be contained within the freeway corridor, however, the extent of cutting to provide the additional lanes on either side would be extensive and would require landscape mitigation. Any stabilising works or structures on these roadside cuttings would need to provide for landscaping and urban design treatments if the visual impact is to be mitigated.

The construction works in the ICB corridor would not impact on the landscape values of the corridor. However, care would be required to ensure the landscape values of York's Hollow and Victoria Park were maintained. Site rehabilitation and landscaping would be required to mitigate the visual impact of the northern ventilation station in the ICB corridor, and the construction of the ventilation tunnel to the outlet further north along the ridge.

8.5 Project Impacts and Mitigations – Operations Phase

The operational effects of Northern Link would have both beneficial and adverse outcomes. While on balance the Project would have a strong net benefit for the city, there would be some potential adverse impacts arising from road traffic noise, or, from the barriers required to mitigate road traffic noise to status quo levels.

8.5.1 Urban Design

The widening of Milton Road and of Croydon Street is of concern to many Toowong residents. The future scale of each of these roads would be considerably different to the four-lane roads at present. The combination of the elevated roads, ramp structures and additional traffic lanes in Milton Road between Sylvan Road and Croydon Street is a matter of great concern to local residents and local businesses. The visual impact of the infrastructure in this location would be significant and long-term. While noting that Milton Road is an arterial road with a regional transport function, it is unlikely that the landscaping and urban design treatments proposed for the reference project would succeed in reducing the visual impact on the locality. The visual impact of the infrastructure in this location is exacerbated by the loss of part of Quinn Park and also the proximity of the structures to residences and commercial properties along the southern alignment. Innovation in detailed design would be required to redress these impacts, if at all.

Northern Link would also entail the widening of Kelvin Grove Road between the ICB overpass and Blamey Avenue to accommodate the Kelvin Grove ramps and the Musk Avenue connection. While Kelvin Grove is presently configured to accommodate seven traffic lanes, the Project would require its widening to include an additional three lanes. The proposed widening is more in context with the setting at Kelvin Grove than the proposed widening of Milton Road. Despite that comparison, Kelvin Grove Road would require careful urban design treatments and landscaping measures to mitigate the visual effects of the additional traffic lanes, the infrastructure connections within the road reserve, the Musk Avenue portal and the noise barriers required to address road traffic noise.

The detailed design process should take into account the proximity of sensitive places, such as residential and some commercial places, adjacent to both Milton Road and Kelvin Grove Road.

The detailed design process should also seek to mitigate the visual impact of the ventilation stations at the Western Freeway and the ICB, through a combination of architectural, urban design and landscape measures.

8.5.2 Local Traffic

From the analysis presented earlier in this summary, Northern Link would achieve its objective of providing a motorway-standard route for cross-city trips. This would relieve traffic congestion on the key arterial roads, such as Milton Road and Coronation Drive, so that presently-congested intersections, such as the Mt Coot-tha roundabout, the Toowong roundabout and the Hale Street – Coronation Drive intersection would operate more freely. A consequential benefit of this redistribution of traffic to the motorway network would be the relief of congestion pressures leading to rat-running in the inner western suburbs.

There would be increases on the road network connecting with Northern Link. For example there would be increases in daily traffic flows on the Western Freeway, Croydon Street and Milton Road west of Croydon Street, and on the ICB. Other roads likely to experience an increase in traffic flows would be Jephson Street in Toowong and Kelvin Grove Road north of the connections in Kelvin Grove. The traffic analysis indicates that many roads in the inner western suburbs would benefit from a reduction in traffic as a consequence of Northern Link. Examples include:

- Milton Road east of Croydon Street, Coronation Drive, High Street, Sherwood Road, Miskin Street, Frederick Street, Jubilee Terrace, Caxton Street, Haigh Road, Stuartholme Road and Morley Street.

The reductions on Coronation Drive and Milton Road would provide opportunities for enhanced levels of

service for public transport (bus). Combined with the opportunity to operate express bus services through Northern Link to connect with the Inner Northern Busway at the Normanby busway station, Northern Link would contribute to an overall network and transport improvement in the inner western suburbs.

8.5.3 Traffic Noise

Road traffic noise is one of several adverse outcomes arising from congested or heavily trafficked roads. Increased traffic flows on the motorways and arterial roads connecting with Northern Link would also lead to an increase in traffic noise. However, a doubling in traffic flows usually would lead to an increase in traffic noise of about 3dBA or less. Considering that increases in noise of 2dBA or less are generally not detected by people, the potential impacts for traffic noise intrusion are confined to a number of specific locations.

The traffic noise assessment modelled noise levels and predicted the noise barriers required to mitigate noise to a 'status quo' level[32], as well as to meet the planning guides for local roads established by the Queensland Department of Main Roads. Barrier heights ranging from 5.0m to 8.0m were predicted for some locations (eg: on ICB adjacent to Normanby Terrace, on Valentine Street facing Milton Road). Noise barriers of this scale would present both visual and amenity impacts on nearby properties. Consequently, innovation in detailed design is required to find less intrusive measures to mitigate road traffic noise impacts on these exposed locations.

The noise modelling found there would be a minor reduction in traffic noise levels on those streets experiencing a reduction in daily traffic flows.

8.5.4 Air Quality

Motor vehicle emissions from Brisbane's congested road network are a major source of air pollution in Brisbane. The air quality implications of motor vehicle emissions generally, and from tunnel ventilation systems specifically, are a matter of community concern. The goals for ambient air quality adopted for Northern Link are more stringent than the standards set in the Environmental Protection Policy (Air), except for carbon monoxide which has been adopted as the Project goal.

The predicted impacts on ambient air quality from the operation of the ventilation outlets for Northern Link would be well below the stringent goals adopted for the Project. Furthermore, the predicted impacts would represent a minor change from the predicted air quality should Northern Link not proceed.

With regards pollution deriving from the surface road network, the predicted changes in traffic as a consequence of the Project, would not lead to significantly increased risk of adverse community health outcomes. Northern Link would lead to more efficient traffic movements in the inner western suburbs, with potential benefits for reduced motor vehicle emissions.

The assessment of potential impacts on air quality included an assessment of the benefits of filtration in the ventilation system. While the filtration system efficiency was found to be high, the beneficial effects of filtering air from the tunnels were overtaken in the dispersion of the outlet emissions in the airshed. There were few discernible changes in ground level concentrations of particulate matter and nitrogen dioxide, for which filtration processes are available.

8.5.5 Social and Economic Implications

Social Implications

Northern Link would have a positive socio-economic effect on Brisbane through improvements it would bring to the city's transport system and consequential benefits in productivity, road safety, vehicle operating costs and travel time reliability. Northern Link would have a positive economic impact when comparing project costs to project benefits over the 45 year life of the franchise period. Less tangible but still important local benefits would include improved accessibility in the inner western suburbs, improved access to employment and improved public transport in the corridors linking to the CBD.

There would be localised, adverse social consequences arising from the implementation of Northern Link. These would derive primarily from property impacts and the loss of housing in Toowong and Kelvin Grove. Also the impact of local open space at Quinn Park would be significant and long-term. It is unlikely that urban design and landscaping measures on the balance area of Quinn Park would compensate fully for the loss of area. Local residents also are concerned about reduced accessibility across Milton Road to the Toowong State School and to public transport. Pedestrian connections would remain available at the signalised intersection of Croydon Street and Milton Road. While access is already constrained, the widening of Milton Road lends to the perception of diminished accessibility.

It is noted that a number of options to provide grade-separated pedestrian and cycle connections across Milton Road were not pursued due to technical and feasibility issues, including the exacerbation of impacts on near neighbours.

The impacts on the communities of Kelvin Grove would derive from changed access arrangements for residents west of Kelvin Grove Road, due to the closure of access from Victoria Street and the redirection of Westbury Street. This community would become contained by Kelvin Grove Road, Prospect Terrace and Musgrave Road. The Kelvin Grove community east of Kelvin Grove Road would remain largely unaffected by Northern Link with the retention of access to Victoria Park Road from the ICB. Some residents had

32. 'Status quo' traffic noise is defined in Chapter 10 as being the traffic noise levels that would exist in a location in 2024, without Northern Link.

hoped Victoria Park Road would be closed at the ICB. Pedestrian connectivity southwards towards the Inner Northern Busway would be improved with the widening of the footpath on the eastern side of Kelvin Grove Road.

Economic Implications

The economic benefits of Northern Link can be quantified in terms of travel time benefits, reductions in vehicle operating costs, improved road safety both within the Project and on benefiting surface roads, and improved environmental conditions (eg: reduced air pollution and traffic noise, reduced greenhouse gases, enhanced urban amenity). With a risk-adjusted capital cost of $2,755 million and an operating cost of $1,627 million over the 45 year period of the franchise, Northern Link would have a net present value of approximately $550 million or a benefit cost ratio of 1.2, based on a discount rate of 6.0%. **Table 24** presents a summary of the benefit cost assessment for Northern Link.

Northern Link is estimated to generate in excess of $11 billion worth of undiscounted economic benefits over the life of the Project in terms of travel time savings, vehicle operating costs, road safety savings and environmental savings. Other non-monetised benefits include some public transport travel time and waiting savings, some bus fleet operational efficiencies, land value capture along the corridor and a number of other secondary benefits that would serve to improve the benefits of the Project. Under the modelling assumptions that have been adopted, there is an acceptable economic justification to proceed with Northern Link.

Table 24: Northern Link Benefit Cost Assessment

Output	Value
Present Value of Costs (PVC)	$2,311.1 m
Present Value of Benefits (PVB)	$2,861.0 m
Net Present Value (NPV)	$549.9 m
Benefit Cost Ratio (BCR)	1.2

Table Note: BCR derived from discount rate of 6% with risk-adjusted (P50) CAPEX and OPEX.

York's Hollow at Victoria Park

9. Recommendations

Northern Link as described in this EIS meets the needs of the project objectives, particularly in providing for east-west transport efficiency for vehicles and freight with the best balance of environmental impacts. Northern Link would lead to a wide range of transport, socio-economic and community benefits for the City, however, there would also be some likely adverse impacts for local communities residing in close proximity to the Toowong and Kelvin Grove connections.

Having regard to the comprehensive findings of the EIS with regards the benefits and impacts of Northern Link, the following recommendations are made to the Coordinator-General.

Recommendation 1

That Northern Link be approved to proceed subject to:

i project development adopting and implementing a sustainability framework consistent with the Brisbane City Council's sustainability policy and with the framework presented in this EIS;

ii detailed design embracing an innovative approach in seeking to resolve, to the extent feasible, the potential or predicted impacts of the reference project, particularly with regards the configuration of the local connections at Toowong and Kelvin Grove;

iii developing and implementing detailed environmental management plans for the construction and operational phases of the Project, where such plans adopt the environmental objectives and performance criteria where relevant, set out in the draft Outline EMPs presented in this EIS; and

iv developing and implementing a scheme of effective urban mitigation measures, such as those set out in Chapter 20 of this EIS, intended to address and mitigate the impacts of the Project upon the local communities and to enhance where reasonable and practicable within the scope of the Project, the locality of each of the connections to the surface road network.

Recommendation 2

It is further recommended to the Coordinator-General that:

i all necessary approvals and permits be obtained for the Project, including, but not limited to, those required under *City Plan 2000*, the *Integrated Planning Act 1997*, the *Transport Infrastructure Act 1994*, the *Queensland Heritage Act 1992*, and the *Environmental Protection Act 1994*;

ii Brisbane City Council commence an integrated land use and transport planning study for the inner western suburbs, coordinated with current local planning and local growth management strategies, with the purpose of managing land use changes anticipated as a consequence of the implementation of Northern Link; and

iii the Queensland Government and the Brisbane City Council investigate measures to coordinate the construction and delivery of Northern Link at the same time as a number of other major projects, including the Hale Street Link, the Western Freeway upgrade, Airport Link, Northern Busway and the Airport Roundabout Upgrade projects.

The Coordinator-General is requested to assess this EIS, and in preparing his evaluation report:

i recommend that Northern Link proceed;

ii state the conditions for the Project under section 39(1)(a) of the *State Development and Public Works Organisation Act 1971*;

iii recommend under section 43 of the *State Development and Public Works Organisation Act 1971*, the requirements for inclusion in the designation of the Project corridor or land required for parts of the Project as 'community infrastructure' under section 2.6.8 of the *Integrated Planning Act 1997*; and

iv where there is no other relevant approval, impose conditions on the Project where identified as relevant environmental mitigation and management measures identified in this EIS, under Division 8, section 54B of the *State Development and Public Works Organisation Act 1971*.