SINCLAIR KNIGHT MERZ

Northern Link

TECHNICAL REPORT NO. 7B

GREENHOUSE GAS EMISSIONS IMPACT ASSESSMENT

-
- 24 September 2008

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1. Introduction

1.1. Project Overview

The Northern Link Project ("the Project") is a significant element in an overall strategy to alleviate congestion on Brisbane's road network. The Project will link the Western Freeway at Toowong with the Inner City Bypass (ICB) at Kelvin Grove. Northern Link would be constructed mostly in parallel tunnels.

Following the declaration by the Coordinator-General that the Project is a "project of State significance for which an EIS is required", Brisbane City Council has commissioned the Joint Venture (JV) between Sinclair Knight Merz (SKM) and Connell Wagner (CW) to prepare an Environmental Impact Statement (EIS) for the Project.

1.2. Terms of Reference

The Terms of Reference (ToR) for the Project are in accordance with the requirements of the State Development and Public Works Organisation Act 1971 (SDPWO Act). The ToR identifies matters that should be addressed in the EIS. With regard to Greenhouse Gas (GHG) impacts the following work elements are required:

> *The impacts of the project on greenhouse gas emission levels are to be assessed for the construction and operational phases. This assessment should include the calculation and presentation of changes in volume of greenhouse emissions resulting from the predicted changes in traffic volumes, haulage of excavated material from construction and also the greenhouse gas emissions associated with energy used to operate ventilation, lighting, ITS and other electrical equipment used in the operation of the project . The methodology for the assessment should be briefly outlined in this section and should be based on the Commonwealth Department of Climate Change's publication titled "Australian Methodology for the Estimation of Greenhouse Gas emissions and sinks".*

> *The implications of the project in relation to national, state and local government greenhouse, or climate change strategies should be discussed.*

2. Background

2.1. Science of Climate Change

The greenhouse effect is a natural phenomenon that makes the Earth warmer due to gases found in the atmosphere known as greenhouse gases. Since the start of the Industrial Revolution (c1750-1800) the emission of greenhouse gases has risen substantially due to increased industrial and agricultural production, and the use of fossil fuels. The Fourth Assessment Report produced by the Intergovernmental Panel on Climate Change (IPCC, 2007) concluded that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations". In addition, changes in rainfall frequency and intensity have been experienced.

2.1.1. Greenhouse Gases

Major greenhouse gases produced or influenced by human activities include the following:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Synthetic halocarbons;
- Sulphur hexafluoride (SF_6); and
- Other important gases.

A brief discussion on each of these gases is presented below.

Carbon Dioxide

Carbon dioxide is the main anthropogenic gas contributing to climate change and concentrations of this gas in the atmosphere have increased by 30% during the past 200 years (CSIRO, 2000). The major anthropogenic sources of CO_2 emissions are fossil fuel combustion and land clearing associated with agriculture.

Methane

Atmospheric methane concentrations have increased by 150% during the past 200 years (CSIRO, 2000) and although there is less methane in the atmosphere than CO_2, it is a significantly stronger greenhouse gas. The major anthropogenic sources of methane are cattle, rice growing and leakages during natural gas production, distribution and use. At present natural processes remove methane from the atmosphere at almost the same rate as methane is being added to it. Over the next 100 years, however, methane concentrations are likely to rise.

Nitrous Oxide

Atmospheric nitrous oxide concentration has increased by 15% during the past 200 years and it can persist in the atmosphere for up to 100 years. Major sources of nitrous oxide include industrial processes, fertiliser use and land clearing associated with agricultural activities.

Halocarbons and Sulphur Hexafluoride

Hydrofluorocarbons (HFC) are chlorofluorocarbons (CFC) with the chlorine atom removed, and were introduced to replace CFCs in the refrigerant industry since they do not deplete ozone. HFCs can be over 11,000 times stronger greenhouse gases than CO_2.

HFCs, PFCs (perfluorocarbons, another CFC substitute) and sulphur hexafluoride (a gas used for electrical insulation) are powerful greenhouse gases.

Other important Gases

The hydroxyl radical (OH) is a highly reactive agent that helps cleanse the atmosphere of pollutants such as methane. OH will also react with carbon monoxide which, although not a greenhouse gas, reduces the amount of OH in the atmosphere, thereby increasing the length of time greenhouse gases such as methane stay in the atmosphere. Carbon monoxide, hydrocarbons and oxides of nitrogen can react to form ozone, another greenhouse gas.

2.2. Global Warming Potential

Global Warming Potentials (GWP) are used to compare the abilities of different greenhouse gases to trap heat in the atmosphere. GWPs are based on the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide (CO_2), as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of CO_2. The GWP provides a common measure to aggregate the radiative impacts of various greenhouse gases into a uniform measure denominated in carbon dioxide equivalents ($CO_{2\text{-}e}$).

In 2007, the IPCC updated its estimates of global warming potential for key greenhouse gases. **Table 2-1** compares the GWPs published in 1996 in the IPCC's Second Assessment Report with those published in 2001 in the IPCC's Third Assessment Report and 2007 in the Fourth Assessment Report.

- **Table 2-1: Comparison of 100-Year Global Warming Potential Estimates from the IPCC's Second (1996), Third (2001) and Fourth (2007) Assessment Reports**

	Global Warming Potential		
Greenhouse Gas	**IPCC1996**	**IPCC 2001**	**IPCC 2007**
Carbon dioxide	1	1	1
Methane	21	23	25
Nitrous oxide	310	296	298
HFC-23	11,700	12,000	14,800
HFC-125	2,800	3,400	3,500
HFC-134a	1,300	1,300	1,430
HFC-143a	3,800	4,300	4,470
HFC-152a	140	120	124
HFC-227ea	2,900	3,500	3,220
HFC-236fa	6,300	9,400	9,810
Perfluoromethane (CF4)	6,500	5,700	7,390
Perfluoroethane (C2F6)	9,200	11,900	12,200
Sulphur hexafluoride (SF6)	23,900	22,200	28,800

In assessing the greenhouse impact from a collection of different gases it is typical to report the collective impact as carbon dioxide equivalents (CO_2-e), which is based on the gases global warming potentials. For example, the Global Warming Potentials for methane and nitrous oxide are 25 and 298 respectively, meaning an emission of 1 tonne of methane and nitrous oxide is equivalent to emissions of 25 and 298 tonnes respectively of CO_2.

2.3. Greenhouse Gas Response and Management

2.4. International Response

The international response to climate change has involved the development of an international treaty designed to limit the emissions of GHG and ozone depleting substances: the *Kyoto Protocol to the Framework Convention on Climate.*

The Kyoto Protocol establishes provisions to limit emissions of specified greenhouse gases. Most signatories to the *Kyoto Protocol* would be required to reduce greenhouse gas emissions by at least five per cent below 1990 levels by 2008–2012.

The Kyoto Protocol sets a framework for the control of the emission of six greenhouse gases. These are:

- Carbon dioxide (CO_2);

- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and
- Sulphur hexafluoride.

2.5. National Response

Australia ratified the Kyoto Protocol in December 2007, with the completion of legalities associated with ratifying the agreement currently underway. Once the ratification process has been completed, Australia will be bound to control its GHG emissions to 108% of 1990 levels by 2008-12. Australia will participate actively and constructively in the negotiations working towards a post-2012 agreement that is equitable and effective.

There is a range of Federal government legislation and programs aiming to reduce Australia's greenhouse gas emissions. The relevant greenhouse gas programs are described below.

2.5.1. National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes a national framework for Australian corporations to report GHG emissions, reductions, removals and offsets, and energy consumption and production. The purpose of the NGER Act is to provide for a single, national system for the reporting of greenhouse gas emissions, abatements and energy consumption and production activities by corporations. The NGER Act applies to corporation activities from 1 July 2008, with the first reporting period ending on 30 June 2009.

Under the Act, reporting is compulsory if a corporation triggers any one of the reporting thresholds during the reporting period (specified as one financial year). A corporation will trigger the reporting threshold if a facility(s) under its control emits greenhouse gases, produces energy or consumes energy at, or above, the level specified by the NGER Act. It is noted that there will be a phase-in period for reporting thresholds during the first three years, during which time reporting thresholds will be reduced. Defined reporting thresholds are provided in **Table 2-2**.

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- **Table 2-2: NGER Corporation Reporting Thresholds**

Variable	Reporting Year		
	2008-9	2009-10	2010-11 (onwards)
CO_2-e emission (kt)	125	87.5	50
Energy production /consumption (TJ)	500	350	200

It should be noted that a facility based reporting threshold will also apply from July 2008. Unlike the corporation level reporting requirement, however, there will be no phase-in period. Under the NGER Act, the annual reporting thresholds for an individual facility is set at 25 kt $CO_{2\text{-}e}$ emitted or 100 TJ energy produced or consumed.

The data collected through the reporting system will be used to help formulate and evaluate the Australian Emissions Trading Scheme (the Scheme). The Scheme is projected to be a ‘cap and trade’ system and should be operational no later than 2010. The detailed design of the Scheme is due to be finalised by the end of 2008.

2.5.2. Energy Efficiency Opportunities Regulations 2006

The *Energy Efficiency Opportunities* program is a national energy efficiency program for large energy using (>0.5 PJ or 139GWh per year) corporations established by the *Energy Efficiency Opportunities Act 2006*, administered by the Department of Industry, Tourism and Resources (DITR). This requires corporations to register and report greenhouse gas emissions, reductions, offsets and energy consumption.

2.5.3. Greenhouse Challenge Plus

Greenhouse Challenge Plus enables Australian companies to form working partnerships with the Australian Government to improve energy efficiency and reduce greenhouse gas emissions.

Greenhouse Challenge Plus is part of the Australian Government’s comprehensive Climate Change Strategy, announced in 2004. The programme is managed by the Department of Climate Change as part of the Australian Government’s Department of the Environment, Water, Heritage and the Arts. The programme builds on the success of Greenhouse Challenge (established in 1995), integrating the Generator Efficiency Standards and the Greenhouse Friendly™ initiative into a single industry programme:

2.5.4. National Greenhouse Strategy

The *National Greenhouse Strategy* was developed to provide the strategic framework for an effective greenhouse response and for meeting current and future international commitments

(Commonwealth of Australia 1998). The Strategy was endorsed by the Commonwealth and all State and Territory governments in 1998. The three goals of the *National Greenhouse Strategy* are to:

1) Limit net greenhouse gas emissions, in particular to meet our international commitments;
2) Foster knowledge and understanding of greenhouse issues; and
3) Lay the foundations for adaptation to climate change.

2.6. Queensland State Response

To address the diversity of factors influencing Queensland's greenhouse gas emissions, the Queensland Greenhouse Strategy incorporates a range of policy responses including financial incentives, co-operative/partnership-based programs, business and community information, climate modelling, research and technology development and regulation.

The *Queensland 13% Gas Scheme* is a key initiative in the energy sector that was announced as part of the *Queensland Energy Policy — A Cleaner Energy Strategy* in May 2000. Significantly, this scheme, in combination with the *Townsville Power Station and Gas Delivery Project*, is expected to result in savings in greenhouse gas emissions of 24 million tonnes CO_2-e over its 15-year life. The scheme will also promote diversification of Queensland's energy mix and assist the gas industry to develop new gas supplies and infrastructure.

Transport sector initiatives focus on integrated transport planning and smarter, more greenhouse-friendly transport choices.

The Queensland Government supports a number of programs and projects aimed at identifying and addressing barriers such as financial, legislative and educational barriers to emission reduction and sequestration of carbon. The Queensland Government through the *Queensland Sustainable Energy Innovation Fund* helps industry develop sustainable energy products and technologies. A range of education and partnership programs have been developed to increase awareness of greenhouse and climate change issues and are helping to facilitate the adoption of sustainable response actions, such as more efficient energy use.

On the residential side, the Government's solar hot water rebate is an example of a program that assists householders overcome the higher initial costs of installing this renewable energy technology.

2.7. Brisbane City Council Response

In August 2006, Brisbane City Council (BCC) set up an independent taskforce to advise it on issues relating to climate change. The Climate Change and Energy Taskforce presented its findings in their report titled, *Climate Change and Energy Taskforce Final Report: A Call for Action.* The report was presented to cabinet on the 12th March 2007.

The top actions identified that Council can take in the short to medium term to respond to climate change and peak oil are to:

- Take concerted and active leadership at all levels
- Work towards zero net greenhouse emissions from Brisbane by 2050
- Educate the community about climate change, peak oil and sustainability and the positive actions people can take
- Develop a new way of thinking about planning for our future, especially in relation to public transport, walking and cycling infrastructure
- Further drought-proof the city.

Cabinet adopted 22 out of the 31 recommendations made by the taskforce. The adopted recommendations were incorporated into *Brisbane's Plan for Action on Climate Change and Energy* (BCC, 2007). The 22 recommendations adopted by in *Brisbane's Plan for Action* are categorised into the following eight strategic areas:

- Leadership and partnering;
- Decision making;
- Communication and education;
- Strategic and land use planning;
- Sustainable transport;
- Preparedness for change, emergencies and surprises;
- Natural resource management; and
- Research.

With regard to sustainable transport the report, some of the recommendations include further integration of transport systems, investment in public transport, investment in cycle and walkways, promotion of alternative fuels and travel demand management.

3. Greenhouse Gas Emissions Estimates

3.1. Overview

This section of the report provides a summary of estimated fuel and energy consumption during the construction and operation of the Project. These estimates are based on preliminary design information relating to the works and on typical diesel consumption rates in the construction vehicle fleet, electricity consumption from tunnel excavation and ventilation equipment, and site services.

3.2. Methodology

The Department of Climate Change has prepared a document called *National Greenhouse Accounts (NGA) Factors* (DCC, 2008), updating and replacing the *AGO Factors and Methods Workbook* (AGO, 2006), which provides a single source of current greenhouse gas emission factors for Australian organisations to estimate their emissions and abatement.

This document provides three types of greenhouse gas emission categories –

1) **Scope 1** – covers direct (or point source) emissions per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.).
2) **Scope 2** – covers indirect emissions from the combustion of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station or facility.
3) **Scope 3** – includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation. Scope 3 emission factors should be used for organisations that:
   - burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
   - consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the T&D network.

This assessment uses the emission factors as set out by DCC (2008) to estimate potential greenhouse gas emissions associated with the construction and operation of the Project. Emission factors relevant to the Project are detailed in **Table 3-1**.

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Table 3-1: Relevant GHG Emission Factors (DCC, 2008)

Activity	Emission Factor (Full Fuel Cycle)	Units
Scope 1		
Diesel	2.9	t CO_{2-e}/ kL
Blasting (ANFO)	0.17	t CO_2 / t explosive
Scope 2		
Purchased electricity (full fuel cycle)	1.04	kg CO_{2-e} / kWh

3.3. Construction Emission Estimates

Greenhouse gas emissions during construction would be associated with fuel use, electricity consumption and blasting.

Fuel consumed during for the construction of the Project would be associated with:

- Construction vehicles moving on and between sites; and
- Haulage of construction materials to and from site.

Fuel consumption estimates during the 3.5 years of construction of the Project are presented in **Table 3-2**. Over the 3.5 years of construction it is estimated that 2,579,240 litres of diesel would be consumed, resulting in 7,480 tonnes CO_{2-e}. This equates to an average of 736,926 litres per annum i.e. 2,137 tonnes CO_{2-e}. A breakdown of the fuel calculations can be found in **Appendix A**.

Table 3-2: Estimated Construction Fuel Consumption

Location	Total Construction (3.5 years)	Annual Average
Fuel Consumption (litres)		
Western Freeway Worksite	1,696,318	484,662
Frederick Street Worksite (Milton Road)	119,988	34,282
Kelvin Grove Road Worksite	545,098	155,742
ICB Worksite	217,836	62,239
Total Fuel Consumption	**2,579,240**	**736,926**
Greenhouse Gas Emission (t CO_{2-e})	**7,480**	**2,137**

Electricity consumption would be associated with the following:

- Site offices;
- Tunnel boring machine;
- Road headers;

- Lighting;
- Tunnel ventilation;
- Electrical equipment; and
- Mobile plant and equipment.

An estimate of electricity consumption for the three worksites is presented in **Table 3-3**. A total of 40.0 million kWh is estimated to be consumed during the construction phase of the Project. This equates to 41,600 tonnes $CO_{2\text{-}e}$.

Table 3-3: Estimated Construction Electricity Consumption

Site	Total Construction (3.5 years)	Annual Average
Electricity Consumption (million kWh)		
Western Freeway	16.8	4.8
Kelvin Grove Road	13.9	4.0
Frederick Street	9.3	2.7
Total	**40.0**	**11.5**
Greenhouse Gas Emission (t $CO_{2\text{-}e}$)	**41,600**	**11,960**

Note: Rounding errors may occur

It is envisaged that blasting will be required during the construction process. It is estimated that 850 tonnes of ammonium nitrate / fuel oil (ANFO) would be required for the Project. This equates to 145 tonnes $CO_{2\text{-}e}$ over the construction period, or 41 tonnes $CO_{2\text{-}e}$ per annum.

A summary of greenhouse gas emission estimates during construction is provided in **Table 3-4**. Over the construction period of the Project greenhouse gas emissions would be in the order of 49,225 tonnes $CO_{2\text{-}e}$. This equates to an annual average of 14,138 tonnes $CO_{2\text{-}e}$.

Table 3-4: Estimated GHG Emissions Due to Project Construction

Construction Activity	Estimated $CO_{2\text{-}e}$ Emissions (tonnes)	
	Total Construction	Annual Average
Scope 1		
Diesel	7,480	2,137
Blasting (ANFO)	145	41
Scope 2		
Electricity	41,600	11,960
Total	**49,225**	**14,138**

3.4. Operational Emission Estimates

Once operational, greenhouse gas emissions will be associated with the consumption of electricity and through changes to road network performance. The Northern Link assumes a concession period of 45 years. The operating period is assumed to commence after construction completion which is 3.5 years from financial close. Electricity will be required to run ventilation fans, pumps, lighting, pressurisation fans, and portal buildings and control cubicles.

The operations power consumption breakdown is presented in **Table 3-5**. The two dominant power consumption systems are the tunnel ventilation and lighting systems. The ventilation system consumes the majority of the power and it tends to vary with:

- The level of pollution of the motor vehicles;
- The speed at which the vehicles are moving through the tunnel and hence the piston effect they create; and
- The location of the extraction points.

Table 3-5: Average Operational Power Consumption Breakdown

Unit	Consumption (%)
Ventilation	64.6%
Pumps	1.0%
Lighting	29.6%
Pressurisation Fans	4.8%

Analysis of energy consumption during operation shows that energy demand increases in a linear fashion from the year of opening for the 41 years on analysis. This assessment presents years 2014, 2016, 2021 and 2026 in **Table 3-6** to be consistent with VKT data presented below. Electricity consumption has been estimated for 41 years of operation. Over this time period annual average electricity consumption is 22,872,890Wh, which equates to 23,788 tonnes $CO_{2\text{-}e}$ (assuming today's greenhouse intensity for electricity consumption).

A full summary of electricity consumption and greenhouse gas emissions during the life of the Project is presented in **Appendix B**

- **Table 3-6: Operational Energy Consumption and Associated Greenhouse Gas Emissions Estimate**

Description	2014	2016	2021	2026
Energy Consumption (kWh)	20,685,390	21,102,057	22,143,723	23,185,390
Greenhouse Gas Emissions Estimate (tonnes (CO_{2-e})	21,513	21,946	23,029	24,113

Changes to Road Network Performance

The delivery of the Project may affect road network performance and therefore greenhouse gas emissions from Brisbane's vehicle fleet. Aside from engine fuel efficiency modifications, greenhouse gas emissions could arise by either changing vehicle kilometres travelled (VKT) for the network or improving the flow of traffic, which improves the fuel efficiency of vehicles.

For the purposes of this assessment, the efficiency of the road network was assumed to be reflected in a comparison of projected VKT with and without the Project. This is considered a conservative assumption as it does not account for any improvements in traffic flow or potential future improvements in energy efficiency from alternative fuels.

The projected VKT on the Brisbane road network with and without the Project is summarised in **Table 3-7**. The delivery of the Project will result in a small increase (approximately 0.1%) in VKT compared to the "Do Minimum" Scenario i.e. projected traffic increases without the Northern Link tunnel. Further detail on the traffic projections for the Project is provided in *Technical Paper Number 1 Traffic and Transport Volume Three* of the EIS.

- **Table 3-7: Total Current and Predicted Future VKT With and Without the Project**

Year	Total VKT		Increase in VKT
	Do Minimum Scenario (AWDT)	Northern Link Scenario (AWDT)	
2014	62,114,786	62,182,347	(67,561 AWDT) (22,970,625 Annual)
2016	64,640,294	64,697,490	(57,196 AWDT) (19,446,606 Annual)
2021	70,965,411	71,006,133	(40,722 AWDT) (13,845,522 Annual)
2026	76,634,450	76,690,882	(56,432 AWDT) (19,186,899 Annual)

Table notes:
AWDT = average weekday travelled
Annual = AWDT x 330

The greenhouse gas emissions associated with changes in road network performance have been determined using the following assumptions:

- The vehicle fleet is made up of 93% light passenger vehicles, 7% heavy vehicles;

- Fuel consumption rates per kilometre travelled are derived using the AGO (2006) conversion factors as set out in **Table 3-8** (note that the updated NGA (DCC, 2008) workbook did not provide conversions factors. Discussion with the DCC indicated that the AGO (2006) conversion factors should be used);
- All passenger vehicles use petrol, and all heavy vehicles use diesel.

Table 3-8: Fuel Consumption (AGO, 2006)

Fuel Type	Fuel Consumption (L/km)
Unleaded petrol passenger cars	0.113
Diesel heavy trucks	0.546

The difference in greenhouse gases emissions as a result of changed road network performance due to the implementation of the Project is presented in **Error! Reference source not found.**.

Table 3-9: Difference in GHG Emissions from Network Performance

Year	Increase in GHG Emissions (tonnes $CO_{2\text{-}e}$)
2014	5,541
2016	4,516
2021	2,419
2026	3,255

The greenhouse inventory for the implementation of the Project indicates that there will be a small increase in greenhouse gas emissions due to an increase in VKT. However, as noted in **Section 0** these calculations do not take into account the difference in fuel consumption associated with traffic congestion compared to free flow. A study conducted by the Royal Automotive Club of Queensland (RACQ, 2008) showed that Brisbane's morning peak hour increases vehicle fuel consumption and greenhouse emissions by around 30 per cent. The survey also found the trip to work took almost twice as long as travelling the same routes between the morning and evening peaks.

3.5. Reporting Implications

The body with operational control over the tunnel would be required to report greenhouse gas emissions should these emissions exceed the relevant NGER thresholds (refer to **Section 2.5.1**). It is expected that the Project would be considered a "facility" under the NGER, with an ANZSIC code 529 – other transport support services. In 2014 electricity consumption would be in the order 18,810,390 kWh, which equates to 68 tera joules, and 19,563 tonnes $CO_{2\text{-}e}$. This does not trigger the reporting threshold for a facility. Over time energy consumption and associated greenhouse gas emissions for tunnel operation are expected to increase, and in 2040 greenhouse gas emissions will exceed the facility reporting level of 25,000 tonnes CO_{2-e}. When this occurs the body with operational control of the tunnel will be required to report these emissions.

Reporting may be required at an earlier stage if the body with operational control of the facility also has operational control over other facility(s) whose aggregate emissions exceed the criteria set out for corporations by the NGER (refer to **Table 2-2**).

3.6. Comparison with National and State Emissions

The Department of Climate Change has published National and State GHG inventories for 2005. In 2005 Australia's net GHG emissions across all sectors totalled 559.1 million tonnes CO_{2-e} (DCC, 2007a). Of this total, 28% of emissions were from Queensland (i.e.157 million tonnes CO_{2-e}) (DCC, 2007b).

It is expected that the Project will produce 49,225 tonnes of CO_{2-e} over the construction period. This equates to 0.009% of National emissions in 2005, and 0.03% of Queensland's emissions in 2005. On an average annual basis emissions are expected to be in the order 14,138 tonnes of CO_{2-e}, this equates to 0.003% of national emissions in 2005, and 0.009% of state emissions.

Once operational, the annual average electricity consumption would result in 23,788 tonnes CO_{2-e}. This equates to 0.004% of National emissions and 0.015% of state emissions.

4. Mitigation Measures

4.1. Construction

In order to minimise GHG emissions due to construction of the project a variety of mitigation and management measures are available, including:

- Designing a construction works program to minimise haul distances from construction sites to spoil placement locations;
- Maintaining construction equipment and haul trucks in good working order so fuel efficiency of equipment is maximised;
- Using of appropriately sized equipment for construction activities;
- Minimising waste from construction; and
- Using low intensity lighting throughout the length of the tunnel. More powerful lighting is used at the portals for safety reasons.

These measure will be documented the EMP.

4.2. Operation

In order to minimise greenhouse gas emissions during operation of the Project a variety of mitigation and management measures are available, including:

- Automatic control of light intensity in the portal region as varying with ambient light conditions on the surface; and
- It is proposed to use a ventilation system which utilises the piston effect of traffic movement through the tunnels and utilises demand management of the ventilation system. Demand management of the ventilation system means that 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.

5. References

AGO (2006) *Factors and Methods Workbook for use in Australian Greenhouse Emissions Reporting*, Australian Greenhouse Office, Canberra, Act

CSIRO (2000) CSIRO Atmospheric Research Greenhouse Information Paper, http://www.dar.csiro.au/publications/greenhouse_2000f.htm

DCC (2007a) *National Greenhouse Gas Inventory 2005 Australia's National Greenhouse Accounts: Accounting for the 108% Target*, *Department of Climate Change*, Canberra, ACT, ISBN: 978-1-921297-22-9

DCC (2007b) *State and Territory Greenhouse Gas Inventories 2005*, Department of Climate Change, ISBN: 978-1-921297-21-2

DCC (2008) *National Greenhouse Accounts (NGA) Factors*, Department of Climate Change, Canberra, ACT, ISBN: 978-1-921298-00-4

Royal Automobile Club of Queensland (2008) *RACQ Congested Road Report: The Effects of Fuuel Consumption and Vehicle Emissions – A Field Test Comparing the Effects of Travelling in Peak Hour Traffic Compared to Normal Running Conditions*, RACQ Vehicle Technologies Department, May 2008.

Appendix A Construction Fuel Consumption Estimates

Location	Vehicle Type	Total trips (each site/type)	Fuel Consumption (Litres/100km)	Travel Distance (one Way) (Km)	Travel Distance (Return) (Km)	Estimated Total fuel consumption (Litres)	GHG Emissions Estimate (CO_{2-e})	Comments
Western Freeway Worksite	Spoil trucks to Port per day (assume 10hrs)	16,920	30	38.3	76.6	388,822	1,128	Travek to SwanBank Soil Placement Site
	Concrete trucks per day (assume 10hrs)	25,584	25	7.6	15.2	972,192	2,819	Travel from Jindalee Hanson
	Site workers parking and transport to other sites (incl mini-van)	53,280	12.5	20	40	266,400	773	
	Miscellaneous movements	12,240	22.5	10	20	55,080	160	
	Shotcrete trucks per day (24hrs)	4,608	25	6	12	13,824	40	Travel to Fredrick St & Kelvin Grove work sites
	Total Fuel consumption					**1,696,318**	**4,919**	
Fredrick Street Worksite (Milton Road)	Spoil trucks to Port per day (assume 10hrs)	1,344	30	38.8	77.6	31,288	91	Travel to SwanBank Soil Placement Site
	Spoil trucks to Quarry per day (assume 10hrs)	15,624	30	1	2	9,374	27	
	Concrete trucks per day (assume 10hrs)	4,368	25	5.6	11.2	12,230	35	Travel from West End Hanson
	Miscellaneous deliveries	12,240	22.5	10	20	55,080	160	
	Shotcrete trucks per day (24hrs)	2,016	25	1	2	1,008	3	Travel from Western Freeway worksite
	2 x Dump Trucks per day(assume 10hrs)	28,224	30	0.65	1.3	11,007	32	Travel within site
	Total Fuel consumption					**119,988**	**348**	
Kelvin Grove Road Worksite (Lower Clifton Tce)	Spoil trucks to Port per day (assume 10hrs)	25,920	30	27	54	419,904	1,218	Travel to Fisherman Islands
	Concrete trucks per day (assume 10hrs)	7,200	25	3.6	7.2	12,960	38	Travel from West End Hanson
	Miscellaneous deliveries	15,840	22.5	10	20	71,280	207	
	Shotcrete trucks per day (24hrs)	2,592	25	5	10	6,480	19	Travel from Western Freeway worksite
	2 x Dump Trucks per day(assume 10hrs)	38,304	30	1.5	3	34,474	100	Travel within site
	Total Fuel consumption					**545,098**	**1,581**	
ICB Worksite	Spoil trucks to Port per day (assume 10hrs)	9,600	30	25.6	51.2	147,456	428	Travel to Fisherman Islands
	Concrete trucks per day (assume 10hrs)	6,000	25	5.1	10.2	15,300	44	Travel from West End Hanson
	Miscellaneous deliveries	12,240	22.5	10	20	55,080	160	
	Total Fuel consumption					**217,836**	**632**	
Total Project						**2,579,240**	**7,480**	

Appendix B Electricity Consumption and GHG Emissions during Operation

Year	Electricity Consumption (kWh)					GHG Emission (tonnes CO2-e)
	Ventilation Fans	Pumps	Lighting	Pressurisation Fans	Total	
2013	10,500,000	236,544	6,761,753	1,103,760	18,602,057	19,346
2014	10,708,333	236,544	6,761,753	1,103,760	18,810,390	19,563
2015	10,916,667	236,544	6,761,753	1,103,760	19,018,723	19,779
2016	11,125,000	236,544	6,761,753	1,103,760	19,227,057	19,996
2017	11,333,333	236,544	6,761,753	1,103,760	19,435,390	20,213
2018	11,541,667	236,544	6,761,753	1,103,760	19,643,723	20,429
2019	11,750,000	236,544	6,761,753	1,103,760	19,852,057	20,646
2020	11,958,333	236,544	6,761,753	1,103,760	20,060,390	20,863
2021	12,166,667	236,544	6,761,753	1,103,760	20,268,723	21,079
2022	12,375,000	236,544	6,761,753	1,103,760	20,477,057	21,296
2023	12,583,333	236,544	6,761,753	1,103,760	20,685,390	21,513
2024	12,791,667	236,544	6,761,753	1,103,760	20,893,723	21,729
2025	13,000,000	236,544	6,761,753	1,103,760	21,102,057	21,946
2026	13,208,333	236,544	6,761,753	1,103,760	21,310,390	22,163
2027	13,416,667	236,544	6,761,753	1,103,760	21,518,723	22,379
2028	13,625,000	236,544	6,761,753	1,103,760	21,727,057	22,596
2029	13,833,333	236,544	6,761,753	1,103,760	21,935,390	22,813
2030	14,041,667	236,544	6,761,753	1,103,760	22,143,723	23,029
2031	14,250,000	236,544	6,761,753	1,103,760	22,352,057	23,246
2032	14,458,333	236,544	6,761,753	1,103,760	22,560,390	23,463
2033	14,666,667	236,544	6,761,753	1,103,760	22,768,723	23,679
2034	14,875,000	236,544	6,761,753	1,103,760	22,977,057	23,896
2035	15,083,333	236,544	6,761,753	1,103,760	23,185,390	24,113
2036	15,291,667	236,544	6,761,753	1,103,760	23,393,723	24,329
2037	15,500,000	236,544	6,761,753	1,103,760	23,602,057	24,546
2038	15,708,333	236,544	6,761,753	1,103,760	23,810,390	24,763
2039	15,916,667	236,544	6,761,753	1,103,760	24,018,723	24,979
2040	16,125,000	236,544	6,761,753	1,103,760	24,227,057	25,196
2041	16,333,333	236,544	6,761,753	1,103,760	24,435,390	25,413
2042	16,541,667	236,544	6,761,753	1,103,760	24,643,723	25,629
2043	16,750,000	236,544	6,761,753	1,103,760	24,852,057	25,846
2044	16,958,333	236,544	6,761,753	1,103,760	25,060,390	26,063
2045	17,166,667	236,544	6,761,753	1,103,760	25,268,723	26,279
2046	17,375,000	236,544	6,761,753	1,103,760	25,477,057	26,496
2047	17,583,333	236,544	6,761,753	1,103,760	25,685,390	26,713
2048	17,791,667	236,544	6,761,753	1,103,760	25,893,723	26,929
2049	18,000,000	236,544	6,761,753	1,103,760	26,102,057	27,146
2050	18,208,333	236,544	6,761,753	1,103,760	26,310,390	27,363
2051	18,416,667	236,544	6,761,753	1,103,760	26,518,723	27,579

2052	18,625,000	236,544	6,761,753	1,103,760	26,727,057	27,796
2053	18,833,333	236,544	6,761,753	1,103,760	26,935,390	28,013
2054	19,041,667	236,544	6,761,753	1,103,760	27,143,723	28,229
Total	620,375,000	9,934,836	283,993,626	46,357,920	960,661,382	999,088
Average	14,770,833	236,544	6,761,753	1,103,760	22,872,890	23,788