Prepared for
Major Projects Canberra
ABN: 66 676 633 401

AECOM

Greenhouse Gas Assessment

28-Sep-2021
Raising London Circuit

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Delivering a better world

Greenhouse Gas Assessment

Client: Major Projects Canberra

ABN: 66 676 633 401

Prepared by

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Executive Summary

AECOM Australia Pty Ltd (AECOM) has been commissioned to undertake a greenhouse gas (GHG) assessment for the proposed works associated with the raising of London Circuit (RLC) (the Project). The Project includes the removal of existing infrastructure and services, earthworks and reintroducing the road network to a new design level.

A quantitative GHG assessment was undertaken to estimate Scope 1, Scope 2, and key Scope 3 emissions from construction of the Project. GHG emissions were estimated using the default method (Method 1) in accordance with the *National Greenhouse and Energy Reporting Act 2007* and the accompanying *National Greenhouse and Energy Reporting (Measurement) Determination 2008*. The total emissions generated by the Project are estimated to be 1,875 t CO_2-^{e} a relatively minor amount which equates to approximately 0.15% of ACT's total emissions 0.00035% of Australia's total annual emissions based on reported 2019 values.

Quantitative assessment of operational GHG emissions from the Project has not been undertaken but GHG emissions would include power consumption from the electrical grid for the proposed signalised intersection at London Circuit and Commonwealth Avenue and ancillary infrastructure such as street lighting. Grid electricity used in the ACT is sources from renewable energy and therefore GHG emissions from electrical consumption would be negligible[1]. Changes to the local road network from the Project are unlikely to result in a material difference to existing GHG emissions from the local network. The Project is also expected to include the addition of established trees as part of future landscaping works; with a Project objective of 30% canopy cover in accordance with Transport Canberra and City Service guidelines. In summary greenhouse gas emissions attributed to the Project are unlikely to have any significant impacts.

[1] Based on the *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity* (ACT Government 2017) document in the 2024-25 financial year renewables are expected to account for 99.6% of energy consumption in ACT. This equates to a weighted average emissions intensity of only 0.003 t/CO_2 per megawatt hour.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) has been commissioned to undertake a greenhouse gas assessment (GHG) for the proposed works associated with the raising of London Circuit (RLC) (the Project).

The following report assesses the greenhouse gas emissions as a result of the construction and operation of the Project, to identify the potential for impacts to occur.

1.1 Potential GHG emissions from the Project

Greenhouse gas emissions from the Project would largely be associated with construction activities. Construction activities that have the potential to generate GHG emissions include:

- Combustion of liquid fuels from stationary and mobile plant equipment and other vehicles.
- Power consumption from the electrical grid
- Embodied energy of construction materials and construction waste.

Quantitative assessment of operational GHG emissions from the Project has not been undertaken. Operational GHG impacts associated with the Project would include power consumption from the electrical grid for the proposed signalised intersection at London Circuit and Commonwealth Avenue and ancillary infrastructure such as street lighting. Grid electricity used in the ACT is sources from renewable energy and therefore GHG emissions from electrical consumption would be negligible[2]. Changes to the local road network from the Project are unlikely to result in a material difference to existing GHG emissions from the local network. The Project is also expected to include the addition of established trees as part of future landscaping works; with a Project objective of 30% canopy cover in accordance with Transport Canberra and City Service guidelines. Therefore, operational GHG impacts from the Project have not been assessed further.

1.2 Report scope

The scope of work for the report has been provided in **Table 1-1**.

Table 1-1 Project scope and corresponding report section

Project scope item	Report section
Project description	**Section 2.0**
Regulatory framework	**Section 3.0**
Assessment methodology – Greenhouse gas	**Section 4.0**
Impact assessment – Greenhouse gas	**Section 5.0**
Conclusion	**Section 6.0**

[2] Based on the *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity* (ACT Government 2017) document in the 2024-25 financial year renewables are expected to account for 99.6% of energy consumption in ACT. This equates to a weighted average emissions intensity of only 0.003 t/CO_2 per megawatt hour.

2.0 Project description

Raising London Circuit (the Project) would involve raising London Circuit between Edinburgh Avenue and Constitution Avenue on a gradual filled embankment to meet the current height of Commonwealth Avenue, and provision of a new signalised intersection between London Circuit and Commonwealth Avenue.

The completed Project, including its main features and elements, is shown in **Figure 2-1**. Key elements of the Project are summarised in **Table 2-1**. Further details of the Project are provided in Chapter 3.0 of the Environmental Assessment.

Table 2-1 Key elements of the Project

Key element	Description
Main embankment	A main embankment with associated retaining walls and batters between Edinburgh Avenue in the west and Constitution Avenue in the east, rising in the centre to around the current height of Commonwealth Avenue. The main embankment would have a slope of up to 3.5 per cent, tapering off to around 2.0 per cent towards the new London Circuit-Commonwealth Avenue intersection
London Circuit West	A modified and reconstructed London Circuit West between Edinburgh Avenue and Commonwealth Avenue: • London Circuit West would be generally one travel lane in each direction, widening to two lanes between the potential future intersection with the proposed West Road and the new Commonwealth Avenue intersection.
London Circuit East	A modified and reconstructed London Circuit East between Commonwealth Avenue and Constitution Avenue: • London Circuit East would be two travel lanes in each direction
New and modified intersections	New and modified intersections would be delivered at Edinburgh Avenue (modified) and Commonwealth Avenue (new), as well as making provision for a future potential intersection to tie into the potential future West Road (which would run south from London Circuit West to the future New Acton Waterfront Precinct, but which does not form part of this project). ***Modified London Circuit-Edinburgh Avenue intersection*** The modified London Circuit-Edinburgh Avenue intersection would include tie-in works with London Circuit to the west of the intersection. No changes to Edinburgh Avenue outside the intersection are proposed. The intersection would retain three travel lanes in each direction on Edinburgh Avenue and one travel lane in each direction on London Circuit. ***New London Circuit-Commonwealth Avenue intersection*** The new London Circuit-Commonwealth Avenue intersection would be signalised and would include tie-in works on Commonwealth Avenue to the north and south of the intersection. The intersection would be designed to integrate into the local landscape and to minimise intrusion into the significant vista along the Commonwealth Avenue corridor between City Hill and Capital Hill. On Commonwealth Avenue, the southern approach would provide one left turn lane, two through lanes and a right turn lane into London Circuit East. On London Circuit there would be two travel lanes in each direction on both the eastern and western approaches. This intersection configuration would be integrated through tie-in works to the existing configuration of Commonwealth Avenue north and south of this intersection.

Key element	Description
	The new intersection would allow full vehicle movements in all directions between London Circuit and Commonwealth Avenue, except for: • No right turn from London Circuit westbound into Commonwealth Avenue northbound • No right turn from Commonwealth Avenue southbound into London Circuit westbound. • No right turn from London Circuit eastbound into Commonwealth Avenue southbound
Modification and removal of existing cloverleaf ramps	Modification and removal of existing cloverleaf ramp connections between Commonwealth Avenue, London Circuit and Parkes Way: • The cloverleaf ramp connections to the north west and to the south west of the existing London Circuit-Commonwealth Avenue interchange would be removed, with affected land stabilised and rehabilitated. • The cloverleaf ramp connection to the south east of the existing London-Circuit-Commonwealth Avenue interchange would be modified. This would remove the connection from London Circuit (westbound) on to Commonwealth Avenue (southbound), but would retain the connection between Parkes Way (eastbound) and Commonwealth Avenue (southbound).
Bicycle infrastructure	Provision of bicycle facilities: • Dedicated, separated off-road bicycle paths would be provided on the verge on both sides of London Circuit West and London Circuit East, which would operate as one-way pairs in each direction. • Dedicated, separated off-road bicycle paths bicycle paths would be provided along both sides of the tie-in works on Commonwealth Avenue to the north and to the south of the new London Circuit-Commonwealth Avenue intersection.
Pedestrian infrastructure	Provision of pedestrian facilities: • Dedicated, separated pedestrian paths would be provided on both sides of London Circuit West and London Circuit East, and along both sides of the tie-in works on Commonwealth Avenue around the new London Circuit-Commonwealth Avenue intersection.
Ancillary infrastructure	Ancillary infrastructure and works, including utility connections, lighting, street furniture, landscaping and drainage are included in the project.

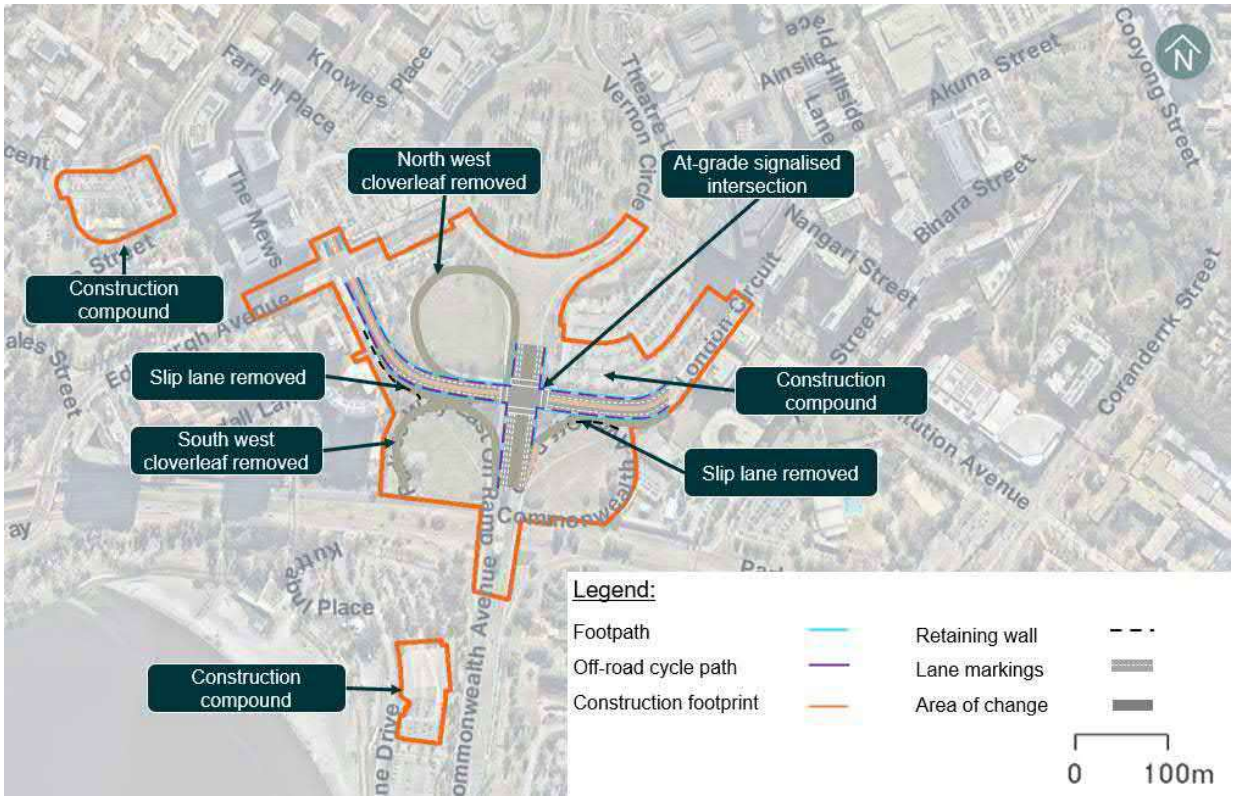


Figure 2-1 The Project and its key features

Subject to securing and complying with the conditions of environmental and planning approvals, construction of the Project would commence around April 2022 and would take approximately two years to complete. The construction footprint for the Project, and the areas affected by separate early works are show in **Figure 2-2**.

Construction of the Project would be preceded by a series of early works required to allow construction works to commence around April 2022. These early works are subject to separate assessment and approvals, and would include:

- Relocation of utilities currently located within the Project construction footprint
- Translocation of Golden Sun Moth (*Synemon plana*) larvae from areas affected by utility relocations
- Traffic management works at the London Circuit-Edinburgh Avenue intersection to allow closure of London Circuit during construction of the Project
- Traffic management works at the Commonwealth Avenue-Vernon Circle intersection, including signalisation, and at the London Circuit-Constitution Avenue intersection to allow closure of London Circuit and traffic management along Commonwealth Avenue during construction of the Project.

Further details of early works are provided in Chapter 4.0 of the Environmental Assessment.

Key construction activities for the Project are summarised in **Table 2-2**. Further details of the construction of the Project are provided in Chapter 4.0 of the Environmental Assessment.

Table 2-2 Key construction activities

Key construction activity	Description
Site establishment and preparation	Site establishment and preparatory works would involve: • Mobilisation and establishment of construction compound sites. Construction compounds approved for use as part of the utility relocation early works would continue to be used for construction of the Project (refer to **Figure 2-2**) • Implementation of temporary surface water and drainage management infrastructure, including temporary grass swales, along around areas of London Circuit to be filled and raised with bulk earthworks • Decommissioning and removal of utilities from within the Project construction footprint. Some decommissioning and removal works may also be carried out as part of construction works along London Circuit and around the new London Circuit-Commonwealth Avenue intersection • Implementation of traffic management measures, including reliance on early works carried out at the London Circuit-Edinburgh Avenue, Commonwealth Avenue-Vernon Circle and London Circuit-Constitution Avenue intersections, and closure of London Circuit to traffic between Edinburgh Avenue and Constitution Avenue.
Closure and raising of London Circuit	Closure and raising of London Circuit would involve: • Removal of existing street furniture, road pavement and vegetation along London Circuit and within the Project construction footprint • Removal of existing street furniture and road pavement along the north west and south west cloverleaf ramp connections between Commonwealth Avenue, London Circuit and Parkes Way, and stabilisation and rehabilitation of land in those areas • Removal of existing street furniture and road pavement for the connection between London Circuit East and the south east clover leaf ramp connection between London Circuit, Commonwealth Avenue and Parkes Way. Only the connection with London Circuit would be affected, with the remainder of the ramp connection retained with potential minor modification to accommodate the embankment batter for London Circuit East. Land affected by removal of the London Circuit connection would be stabilised and rehabilitated • Construction of retaining walls and batters, and staged filling of the London Circuit road corridor between Edinburgh Avenue and Constitution Avenue. The infilling along London Avenue would continue concurrently and in coordination with demolition and infilling beneath the Commonwealth Avenue northbound and southbound bridges (refer below)
Demolition and infilling of Commonwealth Avenue bridges	Demolition and infilling of the Commonwealth Avenue bridges would be carried out in stages to allow continued passage of traffic during the works. Indicative staging would be as follows: • A temporary sidetrack would be constructed to the east of the existing Commonwealth Avenue southbound bridge and associated temporary pavement of the existing Commonwealth Avenue median to allow traffic diversion around the Commonwealth Avenue bridges during demolition works. The sidetrack would provide two traffic lanes as shown in **Figure 2-3** • Implementation of traffic management measures, including reliance on early works carried out at the Commonwealth Avenue-Vernon Circle intersection, to divert traffic on Commonwealth Avenue so that:

Key construction activity	Description
	- Southbound traffic travels via the temporary sidetrack - Northbound traffic crosses onto the existing southbound carriageway - The Commonwealth Avenue northbound bridge is free of traffic • Demolition of the Commonwealth Avenue northbound bridge • Infilling and stabilisation of the area beneath the demolished Commonwealth Avenue northbound bridge as part of the staged program to infill along London Circuit • Construction of the western part of the new London Circuit-Commonwealth Avenue intersection, including a new northbound carriageway • Implementation of traffic management measures following completion of the demolition and infilling of the Commonwealth Avenue northbound bridge so that: - Southbound traffic continues to travel via the temporary sidetrack - Northbound traffic travels via the new northbound traffic lanes and western part of the London Circuit-Commonwealth Avenue intersection - The Commonwealth Avenue southbound bridge is free of traffic • Demolition of the Commonwealth Avenue southbound bridge • Infilling and stabilisation of the area beneath the demolished Commonwealth Avenue southbound bridge as part of the staged program to infill along London Circuit • Construction of the eastern part of the new London Circuit-Commonwealth Avenue intersection, including a new southbound carriageway • Implementation of traffic management measures to return southbound traffic on Commonwealth Avenue to the new southbound traffic lanes and eastern part of the London Circuit-Commonwealth Avenue intersection • Demolition of the temporary sidetrack and infilling the area beneath it as part of the staged program to infill along London Circuit.
Permanent road works	Permanent road pavement, median works and kerb and guttering would be constructed in coordination with the completion of infilling London Circuit to provide the permanent reconstructed London Circuit. Road works would include intersection works at Edinburgh Avenue and Commonwealth Avenue, and tie-in works at Constitution Avenue and around the modified and new intersections with Edinburgh and Commonwealth Avenues.
Ancillary infrastructure and finishing works	Ancillary infrastructure and finishing works would be completed prior to commissioning and opening London Circuit to traffic, including: • Construction of active transport infrastructure, permanent drainage and utilities works • Installation of lighting and street furniture, and road line marking • Landscaping • Demobilisation, and stabilisation and rehabilitation of disturbed areas, including construction compound sites.

Figure 2-2 The Project construction footprint

Figure 2-3 Temporary Commonwealth Avenue sidetrack configuration

3.0 Regulatory framework

3.1 Greenhouse gas legislation and strategic context

3.1.1 International policies and commitments

3.1.1.1 United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) aims to stabilise greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. It was entered in to force in 1994, and currently has 197 countries (including Australia) that are parties to the convention. The convention also puts the onus on developed (Annex I) countries to lead the way in greenhouse gas emissions reduction, requiring them to report regularly on their climate change policies and measures. Annex I countries are also required to submit an annual inventory of their greenhouse gas emissions.

3.1.1.2 Kyoto Protocol

The Kyoto Protocol was adopted in 1997, entered in to force in 2005 and currently has 192 countries, including Australia, that are parties to the protocol. The aim of the protocol is to implement the objective of the UNFCCC, covering the six greenhouse gases: carbon dioxide (CO_2), methane (CH_4), N_2O, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The protocol only binds Annex I countries as they are largely responsible for the current high levels of greenhouse gases. Primarily countries must meet emission reduction targets nationally, however there are flexibility mechanisms available including international emissions trading.

3.1.1.3 The Paris Agreement

The Paris Agreement is an international treaty on climate change, was adopted by 196 parties, including Australia, in 2015 and entered in to force in 2016. The aim of the agreement is to limit global warming to below 2°C, and preferably 1.5°C compared to pre-industrial levels. The main driver to limit warming is reducing greenhouse gas emissions, and the countries partied to the agreement are required to submit plans on a five-year cycle outlining the actions they will take to reduce emissions. The agreement also puts a focus on best practice technologies for reducing greenhouse gas emissions but also adapting to climate change.

3.1.2 National Policies

3.1.2.1 The Climate Active Carbon Standards

The Climate Active Carbon Standards set out the minimum requirements for calculating, reducing, offsetting, auditing, and reporting on emissions based on international standards and tailored to Australia. The climate active carbon standards include standards for business operations, products and services, events, precincts, and buildings.

3.1.2.2 Zero Emissions Government Fund

The Zero Emissions Government Fund is the key mechanism for supporting cost effective emission reduction projects in Government operation. The fund is designed to support emission reduction projects by providing interest free loans to Government agencies for projects that cut emissions from natural gas and transport. Energy bill savings are used to repay loans, continually replenishing the fund.

The Zero Emissions Government fund supports the ACT Government under the Environment, Planning and Sustainable Development Directorate (EPSDD) objective to move towards a zero emissions government by perusing rapid emission reduction targets of greater than 33% reduction in emissions from government operations by 2025 (from 2020 levels) and zero emissions by 2040. Additional GHG ACT policy information is discussed in **Section 3.1.3**.

3.1.2.3 Low emissions technology focuses

The Australian government has a current focus of investing and encouraging low emissions technologies. Of relevance to this project is the future fuels strategy and encouraging electric vehicle use.

3.1.2.4 National Greenhouse and Energy Reporting Scheme

The National Greenhouse and Energy Reporting Scheme (NGER) is the national framework used for reporting company information about greenhouse gas emissions, energy production and energy consumption. If a facility or corporate groups reach the applicable threshold, they have an obligation under the *National Greenhouse and Energy Reporting Act 2007* (Cth) to report CO_2 equivalent emissions.

Under section 10 of the *National Greenhouse and Energy Reporting Act 2007* allows for the provision of the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (amended 1 July 2021) legislative instrument. This determination provides for the measurement of:

a. Greenhouse gas emissions arising from the operation of facilities

b. The production of energy arising from the operation of facilities

c. The consumption of energy arising from the operation of facilities.

The determination provides four methods and criteria for the measurement of Scope 1 and Scope 2 GHG emissions (refer to **Section 4.3** for a description of Scope 1 and Scope 2 emissions). The four methods used for estimation include:

- **Method 1** (default method) - derived from the National Greenhouse Accounts methods and is based on national average estimates
- **Method 2** - facility specific method using industry practices for sampling and Australian or equivalent standards for analysis
- **Method 3** - same as Method 2 but is based on Australian or equivalent standards for both sampling and analysis
- **Method 4** - facility specific measurement of emissions by continuous or periodic emissions monitoring.

Scope 1 emissions for the construction of the Project have been estimated using Method 1. Emissions estimation methodology for both Scope 1 and Scope 2 emissions from the Project are discussed in more detail in **Section 4.0**, **Appendix A** and **Appendix B**.

3.1.3 Territory Policy

3.1.3.1 ACT Climate Change Strategy 2019-2025

The ACT Climate Change Strategy has set a goal of net zero emissions for the entire territory by 2045. 100% supply of electricity from renewable sources was the target for 2020, with the focus moving on to reducing emissions from transport and gas, which are not as easily controlled by the government as electricity supply. The strategy sees the government providing the services, incentives, and regulatory framework to support change amongst the community and businesses.

4.0 Greenhouse gas assessment methodology

4.1 Greenhouse gas accounting

The calculation methodology utilised to assess the greenhouse gas contribution of the Project is as outlined in the *National Greenhouse and Energy Reporting Act 2007* and the accompanying *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (amended 1 July 2021).

Scope 1 emissions have been estimated using the default method (Method 1) using GHG emission factors listed in *The National Greenhouse Accounts Factors, Australian National Greenhouse Accounts* (Commonwealth of Australia 2021) (NGA) to assess the GHG contribution of the project.

Calculation of Scope 2 emissions has incorporated an ACT specific emission factor for electricity consumption as published within the ACT 2017 document *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity*. This accounts for the increased reliance on renewable energy within the ACT as opposed to the NGA emission factor for ACT/NSW which is considerably higher to reflect the higher reliance on fossil fuels within the state of NSW.

The Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2013) was consulted to supplement actual project data where assumptions for material quantities or qualities were required[3].

4.2 Greenhouse gases assessed

All expected activities were analysed to determine emission sources and likely greenhouse pollutants. The project is likely to have both direct and indirect emissions. Direct emissions are produced from sources within the boundary of the project, such as construction activity. Indirect emissions are generated in the wider economy as a consequence of the project, such as goods and services required to facilitate the project, with electricity the most significant category of indirect emissions. CO_2 is considered to be the most significant greenhouse gas emission for the project, however the emission factors from NGA also take into account methane, NOx, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

GHG emissions have been reported as carbon dioxide equivalent (CO_2-^{e}) a metric measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential by converting amounts of other gases (e.g. NOx) to the equivalent amount of CO_2 with the same global warming potential.

The main emission sources for this project are expected to be:

- Energy including fuel (ULP and diesel) used for stationary and transport purposes;
- Electricity; and
- Waste generated in demolition and construction.

4.3 Scope of emissions

Emissions due to the Project are reported under different scopes, and are determined by the origin of the emission, that is, whether the activity causing the emission occurred within the projects boundary (direct), or outside it (indirect).

Scope 1

Scope 1 emissions are direct GHG emissions that are produced by activities that are controlled by the proponent. Scope 1 are calculated from direct emission factors which give the carbon dioxide equivalent at the point of release within the boundary of the Project.

Examples of Scope 1 emissions include combustion of solid, gaseous, and liquid fuels and the combustion of liquid or gaseous fuels.

[3] The National Greenhouse and Energy Reporting (Measurement) Determination 2008 deals with Scope 1 emissions and Scope 2 emissions. Supplementary Material in TAGG 2013 has been used for estimating Scope 3 emissions for the Project.

Scope 1 emissions also includes the clearing of vegetation (resulting in a lost carbon sink) however this would be limited. It is estimated as part of the Project Landscaping and Tree Management Plan that approximately 118 trees would be removed, most of which are in fair to poor condition as discussed in the Biodiversity chapter for the Project. Additional established trees are also expected to be planted as part of future landscaping works; with a Project objective of 30% canopy cover in accordance with Transport Canberra and City Service (TCCS) guidelines. Therefore, vegetation clearing is not considered a significant source of GHG emissions for the Project.

Scope 1 emissions have been quantified in **Section 5.0** to assess the potential GHG emissions from construction of the Project.

Scope 2

Scope 2 are indirect GHG emissions are a result of activities associated with the Project from the consumption of electricity, heating cooling or steam that is produced offsite. Scope 2 emissions are calculated from electricity consumed during construction and operation.

These emissions are dependent on the origin of the electricity and based on burning fossil fuels at the power station, outside of the Project boundary. In the ACT is sourced from 100% renewables and therefore Scope 2 emissions have a low CO_2 equivalent intensity (ACT Government 2017) based on the rate of electrical consumption.

The most significant source of Scope 2 emissions for the Project would be from electricity from the grid at site compounds. Scope 2 emissions have been quantified in **Section 5.0** to assess the potential GHG emissions from construction of the Project.

Scope 3

Scope 3 emissions are indirect emissions that have not been accounted for in Scope 2. Scope 3 emissions are generally referred to as embodied emissions and refers to the emissions created over the entire lifecycle of a material from creation to disposal, not including direct emissions from usage.

Scope 3 emissions are not reported under the NGER scheme, however primary Scope 3 emissions for the Project including transport of construction materials (such as concrete, steel, asphalt, aggregate and sand), embodied energy within key construction materials and disposal of waste generated by the Project have been included in this assessment.

4.4 Assumptions and limitations

A bill of quantities was supplied for the purpose of this assessment, based on best estimates from the current Project design. It is assumed that these quantities will not be 100% accurate due to variations in the Project over the construction period. If any quantities are changed significantly, especially concrete and steel estimates, then this assessment should be revisited and verified for accuracy.

Where quantities of fuel were not able to be supplied, calculations were made from volume estimates.

The Project is planned to have a construction duration of two years. Emission estimates for the Project have been compared to both ACT and National GHG emissions for the 2019 reporting year and are therefore considered conservative.

NGA Scope 2 reporting factors for ACT includes electrical consumption from NSW which is heavily reliant on fossil fuels and is not considered representative of ACT emission factors which currently rely on 100% renewable electricity. As such an emission factor for 2019-20 estimated within the *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity* (ACT Government 2017) report has been adopted.

Some emissions from the Project have been omitted as they are considered immaterial. In accordance with Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2013) emissions are not required to be calculated if they are likely to be less than 5% of the total project emissions. On this basis, due to the CBD setting of the Project, the amount of vegetation to be removed is minimal, and has not been quantified. Scope 3 emissions have been limited to transport and embodied energy of key construction materials and disposal of waste generated by the Project.

Additional information regarding assumptions made for the GHG inventory for the Project are detailed in **Appendix A**.

5.0 Greenhouse gas impact assessment

5.1 Impact assessment

In the construction phase of the Project, the following are expected to be the significant sources of emissions as relevant to the CO_2-e calculation. In accordance with the ACT Climate Change Strategy 2019-2025, the Project aims to achieve net zero emissions.

Scope 1 - Direct emissions:

- Earthwork plant, diesel combustion emissions
- Stationary engines, petrol or diesel combustion emissions
- Fleet vehicles of contractors, petrol or diesel combustion emissions

Scope 2 - Indirect emissions from electricity:

- Electricity use in construction, such as electricity supply for temporary compounds, tools and lights

Scope 3 - Indirect emission not included in scope 2:

- Embodied energy of key materials used in the project:
    - concrete, asphalt, cement, aggregate, steel, bitumen, sand, water, lime and imported fill
- Transportation of materials, supplies and waste outside of the Project bounds by trucks, diesel combustion emissions

The data sources used to estimate GHG emissions from the Project have largely been based on the Bill of Quantities from the Project. Data inputs and assumptions for individual emission sources are itemised in **Appendix A.**

5.1.1 Calculations

This section details the estimated quantities of greenhouse gas generating materials and activities for the Project for construction. GHG estimates for the Project have been calculated using emission factors using the following documentation:

- The National Greenhouse Accounts Factors, Australian National Greenhouse Accounts (Commonwealth of Australia 2021)
- Past and projected future components of electricity supply to the ACT, and resultant emissions intensity (ACT Government 2017)
- Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2013).

A detailed description of adopted emission factors and key inputs and assumptions are provided in **Appendix A. Table 5-1** provides a summary of the estimated GHG emissions from the project, categorised by scope, source group and activity type. A more detailed emissions inventory for individual emission sources is provided in **Appendix B**.

The total emissions generated from construction by the Project are estimated to be 1,875 t CO_2-e, inclusive of Scopes 1, 2 and 3. The majority of the emissions are Scope 3, which are emissions that are generated off site, however are directly related to the project in terms of offsite transport or greenhouse gas generation during the manufacture of materials and supplies. Diesel fuel used in stationary machinery on site during the project accounts for almost 23% of the emissions; while Scope 2 emissions are negligible, due to the uptake of 100% renewable energy by ACT.

The Project is assumed to emit roughly half of the above emissions per year, during the two-year duration of the construction. Realistically due to the staging of construction activities this will not be completely accurate, however for the purposes of determining Project life emissions it is not deemed significant.

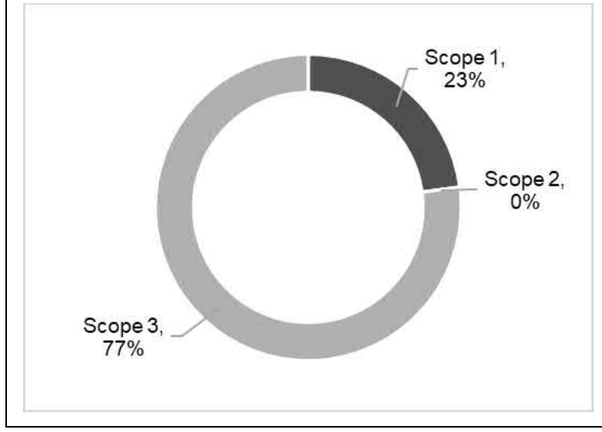
In 2019 Australia's total greenhouse gas emissions were 529.3 megatonne (Mt) CO_2-e, with ACT contributing 1.28 Mt CO_2-e (DISER, 2021). In comparison, the Project is expected to represent

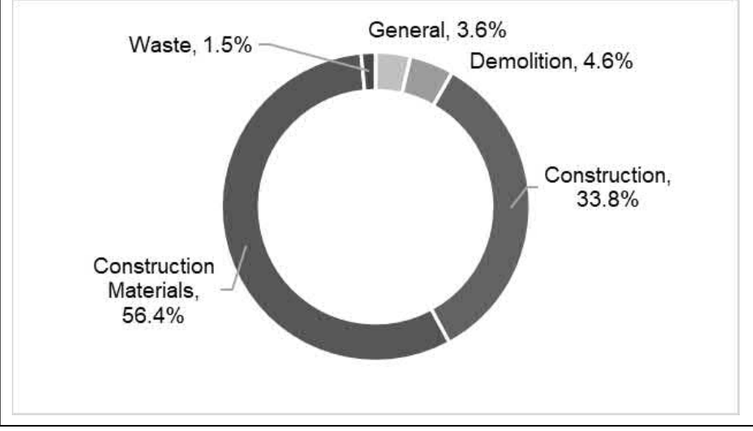
approximately 0.00035% of Australia's total emissions and 0.15% of ACT's total emissions. This is a conservative comparison noting the Projects GHG contribution of 1,875 t CO_2-e would be distributed over a period of approximately two years.

Table 5-1 Summary of Scope 1, 2 and 3 Construction GHG emissions for the Project as CO_2 equivalent.

Scope Type	Emission Source	Activity category	Qty	Unit	EF	Unit	GHG emissions (t CO_2-e)	Total (t CO_2-e)	Contribution (%)
Scope 1	Fuel Combustion (Diesel)	General Site Activities	5.2	kL	70.2	kg CO_2-e/GJ	14.1	429.0	22.9%
		Demolition Activities	69.1	kL	70.2	kg CO_2-e/GJ	69.1		
		Construction Activities	345.8	kL	70.2	kg CO_2-e/GJ	345.8		
Scope 2	Electricity	General Site Activities	71,280	kh	0	kWh	0	0	0%
Scope 3	Fuel Combustion (Diesel)	Demolition Activities	7.4	kL	70.2	kg CO_2-e/GJ	20.0	1446.1	77.1%
		Construction Activities	113.5	kL	70.2	kg CO_2-e/GJ	307.4		
		Waste Materials & Removal	0.42	kL	70.2	kg CO_2-e/GJ	1.1		
	Embodied Energy	Construction Materials (concrete)	1909	t	0.11175	kg CO_2-e/t	213.3		
		Construction Materials (aggregate)	804	t	0.005	kg CO_2-e/t	4.0		
		Construction Materials (steel)	109	t	1.05	kg CO_2-e/t	114.5		
		Construction Materials (general fill)	124,200	t	0.004	kg CO_2-e/t	496.8		
		Construction Materials (asphalt)	4,499	t	0.058	kg CO_2-e/t	260.9		
	Waste	Waste Materials (concrete)	250	t	0.11175	kg CO_2-e/t	27.9		
							Total	**1875.1**	**100.0%**
							ACT Contribution (2019) (Mt CO^2-e)	**1.28**	**0.14649%**
							Australian Contribution (2019) (Mt CO^2-e)	**529.3**	**0.00035%**

kL represents kilolitre
kg represented kilogram
kWh represents kilowatt hour





6.0 Conclusion

A GHG assessment was undertaken to estimate Scope 1, Scope 2 and key Scope 3 emissions associated with the Project. GHG emissions were estimated using the default method (Method 1) in accordance with the *National Greenhouse and Energy Reporting Act 2007* and the accompanying *National Greenhouse and Energy Reporting (Measurement) Determination 2008.*The total emissions generated by the Project are estimated to be 1,875 t CO_2-^{e} a relatively minor amount which equates to approximately 0.15% of ACT's total emissions, and 0.00036% of Australia's total emissions based on reported 2019 values. There are also potential opportunities for offsetting emissions with landscaping opportunities which are likely to include the planting of established trees.

In summary potential greenhouse gas emissions attributed to the construction and operation of the Project are unlikely to have any significant impacts.

7.0 References

ACT Government (2017) *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity*. Australian Capital Territory Government, Environment and Planning Directorate, Climate Change, ACT, Canberra

Commonwealth of Australia (2021) National Greenhouse Accounts Factors, Australian National Greenhouse Accounts (August 2021), Australian Government, Department of Industry, Science, Energy and Resources

DEC (2007), *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.

DECC (June 2009), *Load Calculation Protocol*

Department of Industry, Science, Energy and Resources (DISER) (2021), *National Greenhouse Accounts 2019.*

EPA (2017), *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

ERM, (2018), *Evaluation distances for effective air quality and noise management*.

NEPC (2021), *National Environment Protection (Ambient Air Quality) Measure (Clth)*

NSW Government, (1997), *Protection of the Environment Operations Act 1997 (NSW)*

NSW Government, (2010), *POEO (Clean Air) Regulation 2010*

Transport Authorities Greenhouse Group (TAGG) (2013); Greenhouse Gas Assessment Workbook for Road Projects.

UK Institute of Air Quality Management (IAQM), (2014), *Guidance on the assessment of dust from demolition and construction*

Appendix A

Data sources for GHG emissions inventory calculation

Appendix A Data sources and equations for GHG emissions inventory calculation

Data sources

The data sources used to estimate GHG emissions from the project have been summarised below in **Table A-1**.

Table A-1 Summary of source data used in emissions calculations

Emission	Source
Site compounds, fuel consumption	Bill of quantities
Site compounds, electricity use[1]	Note 1
Site vehicles, fuel consumption	Bill of quantities
Asphalt & bitumen – site works	Bill of quantities
Asphalt & bitumen – disposal transport	Bill of quantities
Stormwater – site works	Bill of quantities
Stormwater – disposal transport	Bill of quantities
Bridge – site works	Bill of quantities
Bridge – disposal transport	Bill of quantities
Asphalt & bitumen – site works	Bill of quantities
Asphalt & bitumen - deliveries	Bill of quantities
Paths – site works	Bill of quantities
Paths - deliveries	Bill of quantities
Kerbs – site works	Bill of quantities
Kerbs - deliveries	Bill of quantities
Retaining walls – site works	Bill of quantities
Retaining walls - deliveries	Bill of quantities
Subsoil install	Bill of quantities
Structured walls	Bill of quantities
Traffic signals – site works	Bill of quantities
Traffic signals – deliveries	Bill of quantities
Power services – site works	Bill of quantities
Power services - deliveries	Bill of quantities
Stormwater – site works	Bill of quantities
Stormwater drainage – delivery	Bill of quantities
Trenching	Bill of quantities
Street lighting – site works	Bill of quantities
Street lighting - deliveries	Bill of quantities
Earthworks – site works	Bill of quantities
Earthworks – delivery	Bill of quantities

Emission	Source
Steel - delivery	Bill of quantities
Concrete- disposal transport	Bill of quantities
Asphalt	Bill of quantities
Concrete – roads/paths	Bill of quantities
Concrete - retaining walls	Bill of quantities
Aggregate	Bill of quantities
Steel	Bill of quantities
General Fill	Bill of quantities
General waste	Bill of quantities
General waste - transportation	Bill of quantities
Asphalt/pavement	Bill of quantities
Bridge	Bill of quantities
Stormwater	Bill of quantities

Notes for quantities:

1. 21 months of connection to grid following disconnection from diesel powered site generators. Site power usage assumed same as rating of site generator, 12 kilovolt-ampere (kva), at a factor of 0.8, equivalent to 115 kWh/day, based on a 12 hour day, 6.5 days per week.

Emission equations and assumptions

The following provides a summary of the equations used to estimate GHG emissions from Project construction and assumptions regarding data inputs noted above.

Scope 1: fuel combustion

Scope 1 emissions for fuels used for transport energy purpose were estimated using the following equation listed in Section 2.2 of the *National Greenhouse Accounts Factors* (2021)

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of gas type (j) (CO_2, CH_4 or NO_x form fuel type in CO_2^{e-} tonnes
Q_i	=	Qi is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes
EC_i	=	ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4. If Qi is specified in gigajoules, then ECi is 1
EF_{ijoxec}	=	EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO_2^{-e} per gigajoule) used for transport energy purposes.

All GHG emissions for Scope 1 emissions from vehicles was estimated using the emission factors for general transport using diesel oil listed under Table 4 of the *National Greenhouse Accounts Factors* (2021). An emission factor of 70.2 CO_2^{-e}/Gigajoules (GJ) was used based on the combined emission factors for diesel oil for CO_2, CH_4 and N_2O. An energy content factor for diesel oil of 38.6 GJ/kL was adopted in accordance with Table 4 of the *National Greenhouse Accounts Factors* (2021).

Estimated fuel quantities for each source were estimated using the bill of quantities for the Project and are provided in **Appendix B**.

Scope 2: fuel combustion

Scope 2 emissions for fuels used for transport energy purpose were estimated using the following equation listed in Section 2.3 of the *National Greenhouse Accounts Factors* (2021)

$$Y = Q \times \frac{EF}{1000}$$

Where:

Y	=	Scope 2 emissions measured in CO_2-e tonnes
Q	=	Quantity of electricity purchased (kilowatt hours)
EF	=	Emission factor, for the State, Territory or electricity grid in which the consumption occurs (kg CO_2-e per kilowatt hour)

All GHG emissions for Scope 2 emissions from electricity usage were estimated using the emission factor of 0.79 kg CO_2-e/kWh for NSW and ACT listed under Table 5 of the *National Greenhouse Accounts Factors* (2021). It is noted that in 2020 ACT achieved its goal to source 100% of its electricity from renewable generators in accordance with its Sustainable Energy Policy. The adopted emission factor for the project of 0.79 kg CO_2-e/kWh is therefore considered highly conservative.

The Scope 2 emission factor for electricity usage for NSW and ACT listed under Table 5 of the *National Greenhouse Accounts Factors* (2021) is 0.79 kg CO_2-e/kWh. In 2020, ACT achieved its goal to source 100% of its electricity from renewable generators in accordance with its Sustainable Energy Policy. The NGA emission factor for the project of 0.79 kg CO_2-e/kWh is considered overly conservative for ACT given NSW's high dependence on fossil fuels. The ACT Government (2017) *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity* report estimated in 2017 that the emission factor for ACT's electrical consumption would be 0 kg CO_2-e/MWh for the 2020-2021 financial year. This is based on an estimated renewable energy share for electrical consumption of 101.5%. Given the ACT achieved its goal to source 100% of its electricity from renewable generators in 2020 this value is considered more representative emission factor to estimate potential construction impacts from the Project.

Electricity usage estimated using the bill of quantities for the project and are provided in **Appendix B**. Electricity consumption has been estimated using electricity consumption from construction compound electrical consumption only and has not included energy usage of supporting infrastructure. Operational GHG emissions associated with electricity consumption from the RLC project have not been quantified. Based on the *Past and projected future components of electricity supply to the ACT, and resultant emissions intensity* (ACT Government 2017) document in the 2024-25 financial year renewables are expected to account for 99.6% of energy consumption in ACT. This equates to a weighted average emissions intensity of only 0.003 t/CO_2 per megawatt hour as such Scope 2 emissions from operation of the Project would be considered negligible.

Scope 3: fuel combustion

Scope 3 emissions for fuels used for transport energy purpose were estimated using the following equation listed in Section 2.2 of the *National Greenhouse Accounts Factors* (2021)

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of gas type (j) (CO_2, CH_4 or NO_x form fuel type in CO_2-e tonnes
Q_i	=	Qi is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes
EC_i	=	ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4. If Qi is specified in gigajoules, then ECi is 1
EF_{ijoxec}	=	EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO_2-e per gigajoule) used for transport energy purposes.

All GHG emissions for Scope 3 emissions from vehicles was estimated using the emission factors for general transport using diesel oil listed under Table 4 of the *National Greenhouse Accounts Factors* (2021). An emission factor of 70.2 CO_2^{-e}/GJ was used based on the combined emission factors for diesel oil for CO_2, CH_4 and N_2O. An energy content factor for diesel oil of 38.6 GJ/kL was adopted in accordance with Table 4 of the *National Greenhouse Accounts Factors* (2021).

Estimated fuel quantities for Scope 3 emissions were limited to the delivery of key construction materials and transport of waste. Estimated fuel quantities for each source were estimated using the bill of quantities for the project and are provided in **Appendix B**.

Scope 3: embodied energy

Scope 3 emissions for construction material (embodied energy) has been calculated using the construction material emission factors from Table D4 of the Greenhouse Gas Assessment Workbook for Road Projects (TAGG 2013). GHG emissions from the embodied energy of contraction materials was estimated using the following equation

$$Y = Q \times EF$$

Where:

Y	=	Scope 3 emissions measured in CO_2^{-e} tonnes
Q_i	=	Quantity of conduction material in tonnes
EF	=	Emission factor of construction material in t/CO_2^{-e}

GHG emission factors from Table D4 of the Greenhouse Gas Assessment Workbook for Road Projects (TAGG 2013) have been replicated below in **Table A-2.** GHG emission factors for concrete have been based on the average mine to end production emission factors for concrete and the emission factor for general fill was estimated to be the average of both sand and aggregate emission factors. For simplicity and given that exact quantities of sub material categories are unknown at the time of writing, for steel the emission factor for structural steel has been assumed and for asphalt an emission factor based on asphalt hot mix has been adopted. Construction material estimates were made using the bill of quantities for the Project and are provided in **Appendix B**.

Table A-2 Assumed emission factors for embodied energy in construction materials

Material	Emission factor
Concrete	0.11175
Steel	1.05
Asphalt	0.058
Aggregate	0.005
Sand	0.003
General Fill	0.004

Scope 3: waste

Scope 3 emissions from construction material (embodied energy) has been calculated using the construction material emission factors published in the Greenhouse Gas Assessment Workbook for Road Projects (TAGG 2013). GHG emissions from waste was estimated using the following equation

$$Y = Q \times EF$$

Where:

Y	=	Scope 3 emissions measured in CO_2^{-e} tonnes
Q_i	=	Quantity of waste material in tonnes
EF	=	Emission factor of waste material in t/CO_2^{-e} /t

It should be noted that inert waste material from the Project in accordance with the TAGG 2013 methodology was assumed to have an emission factor of 0 t $CO_{2}{}^{-e}$ but have been provided for transparency; noting that scope 3 combustion emissions from the transport of waste has also been included using the methodology described above. Waste material estimates were made using the bill of quantities for the Project and are provided in **Appendix B**.

Appendix B

Detailed GHG emissions inventory

Appendix B Detailed GHG emissions inventory

Table B-1 provides a detailed breakdown of the GHG emissions inventory used in **Section 5.0** of the report.

Table B-1 Quantities for calculation of Scope 1, 2 and 3 emissions

Emission	Source	Qty	Unit	GHG emissions, t CO_2-e				% Total
				Scope 1	Scope 2	Scope 3	Total	
General								
Site compounds, fuel consumption	Diesel	2.3	kL	6.2			6.2	0.3%
Site compounds, electricity use	Grid electricity	71,280	kwh		0		0	0.0%
Site vehicles, fuel consumption	Diesel	2.9	kL	7.9			7.9	0.4%
Demolition								
Asphalt & bitumen – site works	Diesel	6.7	kL	18.2			18.2	1.0%
Asphalt & bitumen – disposal transport	Diesel	6.6	kL			17.9	17.9	1.0%
Stormwater – site works	Diesel	7.2	kL	19.5			19.5	1.0%
Stormwater – disposal transport	Diesel	0.34	kL			0.9	0.9	0.0%
Bridge – site works	Diesel	11.6	kL	31.4			31.4	1.7%
Bridge – disposal transport	Diesel	0.45	kL			1.2	1.2	0.1%
Construction								
Asphalt & bitumen – site works	Diesel	8.4	kL	22.8			22.8	1.2%
Asphalt & bitumen - deliveries	Diesel	41.8	kL			113.3	113.3	6.0%
Paths – site works	Diesel	2.6	kL	7.0			7.0	0.4%
Paths - deliveries	Diesel	4.7	kL			12.7	12.7	0.7%
Kerbs – site works	Diesel	0.35	kL	0.9			0.9	0.1%
Kerbs - deliveries	Diesel	0.35	kL			0.9	0.9	0.1%
Retaining walls – site works	Diesel	1.2	kL	3.3			3.3	0.2%
Retaining walls - deliveries	Diesel	1.6	kL			4.3	4.3	0.2%
Subsoil install	Diesel	4.6	kL	12.5			12.5	0.7%
Structured walls	Diesel	1.78	kL	4.8			4.8	0.3%
Traffic signals – site works	Diesel	2.4	kL	6.5			6.5	0.3%
Traffic signals – deliveries	Diesel	0.35	kL			0.9	0.9	0.4%
Power services – site works	Diesel	3.1	kL	8.4			8.4	0.4%
Power services - deliveries	Diesel	0.24	kL			0.7	0.7	0.0%
Stormwater – site works	Diesel	45.7	kL	123.8			123.8	6.6%
Stormwater drainage – delivery	Diesel	11.8	kL			32.0	32.0	1.7%

Emission	Source	Qty	Unit	GHG emissions, t CO_2-e				% Total
				Scope 1	Scope 2	Scope 3	Total	
Trenching	Diesel	3.3	kL	8.9			8.9	0.5%
Street lighting – site works	Diesel	6.4	kL	17.3			17.3	0.9%
Street lighting - deliveries	Diesel	0.63	kL			1.7	1.7	0.1%
Earthworks – site works	Diesel	47.8	kL	129.5			129.5	6.9%
Earthworks – delivery	Diesel	50.9	kL			137.9	137.9	7.4%
Steel - delivery	Diesel	1	kL			2.7	2.7	0.1%
Concrete- disposal transport	Diesel	0.083	kL			0.2	0.2	0.0%
Construction materials								
Asphalt	Embodied	4499	tonnes			260.9	260.9	13.9%
Concrete – roads/paths	Embodied	1277	tonnes			142.7	142.7	7.6%
Concrete - retaining walls	Embodied	632	tonnes			70.6	70.6	3.8%
Aggregate	Embodied	804	tonnes			4.0	4.0	0.2%
Steel	Embodied	109	tonnes			114.5	114.5	6.1%
General Fill	Embodied	124,200	tonnes			496.8	496.8	26.5%
Waste								
General waste	Skip bin	720	tonnes			0.0	0.0	0.0%
General waste - transportation	Diesel	0.42	kL			1.1	1.1	0.1%
Concrete	Solid Waste	250	tonnes			27.9	27.9	1.5%
Asphalt/pavement	Solid Waste	11800	tonnes			0.0	0.0	0.0%
Bridge	Solid Waste	1372	tonnes			0.0	0.0	0.0%
Stormwater	Solid Waste	649	tonnes			0.0	0.0	0.0%
Totals				429	0	1446	1875	100%
% of total				23%	0%	77%		