SIMTA Intermodal Terminal Facility- Stage 1

Greenhouse Gas and Climate Change Impact Assessment

SIMTA

SYDNEY INTERMODAL TERMINAL ALLIANCE

Part 4, Division 4.1, State Significant Development

April 2015

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SIMTA STAGE 1

Greenhouse Gas and Climate Change Impact Assessment

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Report No	1
Date	April 2015

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GLOSSARY

ALCAS	Australian Life Cycle Assessment Society
AR5	Fifth Assessment Report
BAU	Business as Usual
BoM	Bureau of Meterology
BPIC	Building Products Innovation Council
CBD	Central Business District
CCTV	Closed Circuit Television
CH_4	Methane
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalents
Concept Plan Approval	Concept Plan Approval (MP 10_0193) granted on 29 September 2014 for the development of the SIMTA Moorebank Intermodal Terminal Facility at Moorebank. This reference includes the associated Conditions of Approval (CoA) and Statement of Commitments (SoC) which form the approval documentation for the Concept Plan Approval.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	Development Application
DAP	Direct Action Plan
DNSDC	Defence National Storage and Distribution Centre
DoE	Department of the Environment
DP&E	Department of Planning and Environment
EA	Environmental Assessment
EEO	*Energy Efficiency Opportunities (Repeal) Bill 2014*
e.g.	For example
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC Approval	Approval (No. 2011/6229) granted under the EPBC Act on March 2014 by the Commonwealth Department of Environment for the development of the SIMTA Moorebank Intermodal Terminal Facility at Moorebank.
FFDI	McArthur Forest Fire Danger Index
GHG	Greenhouse gas
GWP	Global Warming Potential
ha	Hectares

GLOSSARY

IMT	Intermodal terminal
IPCC	Intergovernmental Panel on Climate Change
kg	Kilograms
km	Kilometres
Km/h	Kilometres per hour
LCA	Lice cycle assessment
LGA	Local Government Area
m^2	Square metres
m^3	Cubic metres
MAC	Marginal Abatement Cost
MIC Proposal	Moorebank Intermodal Terminal Project
Mpa	Megapascal
Mt	Mega tonnes
N_2O	Nitrous oxide
NGA	*National Greenhouse Accounts*
NGER Act	*National Greenhouse and Energy Reporting (NGER) Act 2007*
NSW	New South Wales
PAC	Planning Assessment Commission
PBP	*Planning for Bushfire Protection 2006*
PMF	Probable Maximum Flood
Proposal site	Includes the Stage 1 site and the Rail Corridor, i.e. the area for which approval (construction and operation) is sought within this EIS.
PPR	Preferred Project Report
Rail Corridor	Area defined as the 'Rail Corridor' within the Concept Plan Approval. The rail link is also included within this area (refer to Figure 1).
SIMTA	Sydney Intermodal Transport Alliance
SIMTA Project	The SIMTA Moorebank Intermodal Terminal Facility at Moorebank as approved by the Concept Plan (MP_10_0913).
SIMTA site	Includes the former Defence National Storage and Distribution Centre (DNSDC) site, the land owned by SIMTA which is subject to the Concept Plan Approval (refer to Figure 1).
SME	School of Military Engineering

GLOSSARY

Stage 1 site	The subject of this EIS, the western part of the SIMTA site which includes all areas to be disturbed by the Stage 1 Proposal (including the Operational area and Indicative Construction area) (refer to Figure 1). This area does not include the Rail Corridor.
SSD	State Significant Development
SSFL	Southern Sydney Freight Line
t	tonnes
TEU	twenty-foot equivalent units
The Proposal	Stage 1 of the SIMTA Moorebank Intermodal Terminal Facility including construction and operation of the intermodal terminal facility and rail link, i.e. all works and built form for which approval is sought in this EIS/Technical Report.
VKT	Vehicle kilometres travelled
WRI/WBCSD	World Resources Institute/World Business Council for Sustainable Development

EXECUTIVE SUMMARY

The SIMTA Project involves the development of an intermodal terminal facility, including warehouse and distribution facilities, freight village (ancillary site and operational services), stormwater, landscaping, servicing and associated works on the eastern side of Moorebank Avenue, Moorebank (the SIMTA site). The SIMTA Project also includes a Rail link, within an identified rail corridor (the Rail Corridor), which connects from the southern part of the SIMTA site to the Southern Sydney Freight Line (SSFL) (the entire area, SIMTA site and Rail Corridor referred to as the Project site)

The facility will be developed in three key stages including an Intermodal Terminal (IMT) facility and rail link (Stage 1), construction of warehouse and distribution facilities (Stage 2) and extension of the IMT facility and completion of warehouse and distribution facilities (Stage 3). This assessment will address Stage 1 of the facility (the Proposal) which includes the construction and operation of the intermodal terminal facility and rail link, connecting to the Southern Sydney Freight Line (SSFL). The Proposal will support a container freight volume of 250,000 TEU (twenty-foot equivalent units) throughput per annum.

Approval for the Proposal is being sought under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This report has been prepared as part of the environmental assessment process required under the EP&A Act, and includes greenhouse gas (GHG) emission projections, mitigation measures, a marginal abatement cost analysis and a climate change risk and adaptation assessment for the Proposal.

The total Greenhouse Gas (GHG) emissions associated with the construction of the Proposal are expected to be 4,262 tonnes of carbon dioxide equivalents (tCO_2-e) during the 18 month construction period, with the total embodied GHG emission within the construction materials generating an additional 44,668 tCO_2-e. The annual operational GHG emissions were assessed for two operational scenarios namely;

- Scenario One where trains and trucks would be loaded/unloaded using forklifts and reach stackers
- Scenario Two whereby gantry cranes would be operational.

Scenario One would generate fewer GHG emissions than Scenario Two, generating 7,723 tCO_2-e/year and 9,221 tCO_2-e/year respectively. Under the ‘worst case’ scenario (i.e. Scenario Two), the majority of operational GHG emission would be Scope 2 emissions generated from electricity consumption, amounting to 6,699 tCO_2-e/year or 73 per cent of the total operational GHG emissions.

Annual ‘worst case’ GHG emissions from the Proposal represent approximately 0.0017 per cent of Australia’s total annual GHG emissions (554.6 Mt CO_2-e). The transport sector contributes 90.2 Mt CO2-e each year to Australia’s GHG emissions (DoE 2014d). The Proposal is predicted to contribute 0.01 per cent to Australia’s transport sector inventory and 0.035 per cent to NSW inventory for the transport sector (of a total 26.4 Mt CO_2-e). Accordingly, the contribution of the Proposal to Australia’s GHG emissions is not considered to be significant, in terms of both the construction and operational phases of the Proposal.

Furthermore, the Proposal will have a net reduction in transportation emissions generated by transportation of freight when compared to a ‘Business as Usual’ (BAU) scenario where freight is transported directly from Port Botany to the freight catchment by truck. This is because the use of train to transport freight is more efficient than by truck, therefore generating fewer emissions. The net reduction in GHG emissions from the change in freight distribution would be a saving of 3,907 tCO_2-e/year, which is equivalent to approximately 42 per cent of the annual operational emissions generated by the Proposal. Furthermore, mitigation strategies have been identified to reduce the emissions associated with the construction and operational phases of the Proposal. Further reduction would be achieved through future stages of the SIMTA Project.

A Marginal Abatement Cost (MAC) analysis for the operation of the Proposal identified the theoretical costs associated with reducing GHG emissions generated. Marginal abatement means the cost to reduce or offset one unit of pollution; in this case one tonne of GHG emissions. An analysis of the GHG emissions reductions achievable by different energy efficiency projects for the Proposal identified theoretical costs associated with reducing emissions. This analysis then identified the theoretical cost per year to reduce GHG emissions by 5 or 15 per cent – to align with current and potential Federal Government reduction targets.

The MAC analysis for the operation of the Proposal indicates that, for the Scenario Two where gantry cranes would be operational – i.e. the worst case operational scenario - a total indicative cost of $32,000/year and $51,000/year would be required to reduce annual GHG emissions by 5 per cent and 15 per cent respectively. Conversely, the MAC analysis indicated that under operational Scenario One (Forklifts) the cost to abate GHG emissions by 5 and 15 per cent would be $50,000 and $279,000 respectively. This indicates that despite Scenario One generating fewer GHG emissions than Scenario Two, it would have a higher average marginal cost of abatement; $129/t$CO_2$-e compared to $70/t$CO_2$-e to abate five per cent respectively.

A climate change risk and adaptation assessment for the Proposal was undertaken to assess the risk posed by climate change and to identify adaptation strategies to mitigate these risks. The assessment identified a total of sixteen key climate change risks for the Proposal. If these risks are unmitigated the assessment found that there would be 4 high, 10 medium and 1 low uncontrolled risks by 2090 as a result of potential climate change impacts. A range of adaptive responses for treatment of the climate change risks identified will be incorporated into the design and operation of the Proposal to promote resilience to projected future climate change. Once implemented the engineering design and procedural responses for treatment of climate change risks would result in lowered residual risk rating; such that no high risks remained. The residual climate change risk assessment for the year 2090 identified seven moderate risks and eight low risks.

1 INTRODUCTION

Hyder Consulting has been commissioned by Sydney Intermodal Transport Alliance (SIMTA) to prepare a Greenhouse Gas (GHG) Assessment, Climate Change Risk and Adaptation Assessment and a Marginal Abatement Cost Analysis for Stage 1 of the SIMTA Intermodal Terminal Facility (the Proposal). The purpose of this reporting is to support a State Significant Development (SSD) Environmental Impact Statement (EIS) under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979*.

1.1 BACKGROUND

The SIMTA Project involves the development of an intermodal facility, including warehouse and distribution facilities, freight village (ancillary site and operational services), stormwater, landscaping, servicing and associated works on the eastern side of Moorebank Avenue, Moorebank (the SIMTA site). The SIMTA Project also includes a Rail link, within an identified rail corridor (the Rail Corridor), which connects from the southern part of the SIMTA site to the Southern Sydney Freight Line (SSFL) (the entire area, SIMTA site and Rail Corridor referred to as the Project site). The SIMTA Project is to be developed in three key stages:

- Stage 1- Construction of the Intermodal Terminal Facility and rail link
- Stage 2- Construction of warehouse and Distribution Facilities
- Stage 3- Extension of the Intermodal Terminal Facility and completion of Warehouse and Distribution Facilities.

A summary of the approvals undertaken to date for the SIMTA site, relating to the SIMTA Project, include:

- EPBC Approval (No. 2011/6229) granted in March 2014 for the impact of the SIMTA Project on listed threatened species and communities (sections 18 and 18A of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)) and Commonwealth land (sections 26 and 27A of the EPBC Act).
- Concept Approval (No. 10_0193) granted by the Planning Assessment Commission (PAC) on the 29 September 2014 for the 'Concept Approval' of the SIMTA Project under Part 3A of the EP&A Act.

Both of these approvals involved the preparation of design and environmental assessment documentation.

1.2 PROPOSAL OVERVIEW

The Proposal involves the construction and operation of the necessary infrastructure to support a container freight volume of 250,000 TEU (twenty-foot equivalent units) throughput per annum. Specifically, Stage 1 includes the following key components, which together comprise the intermodal terminal facility (IMT):

- Truck processing, holding and loading areas- entrance and exit from Moorebank Avenue.
- Rail loading and container storage areas – installation of four rail sidings with adjacent container storage area serviced by manual handling equipment initially and overhead gantry cranes progressively.
- Administration facility and associated car parking with light vehicle access from Moorebank Avenue.

- The rail link – located within the Rail Corridor, including a connection to the intermodal terminal facility, traversing Moorebank Avenue, Anzac Creek and Georges River and connecting to the SSFL.
- Ancillary works- vegetation clearing, remediation, earth works, utilities installation/connection, signage and landscaping.

1.3 SITE CONTEXT

The SIMTA site, including the Stage 1 site, is located approximately 27 kilometres south-west of the Sydney Central Business District (CBD) and approximately 26 kilometres west of Port Botany. The SIMTA site is situated within the Liverpool Local Government Area (LGA), in Sydney's South West Sub-Region, approximately 2.5 kilometres from the Liverpool City Centre.

The SIMTA site is located approximately 800 metres south of the intersection of Moorebank Avenue and the M5 Motorway. The M5 Motorway provides the main road link between the SIMTA site and the key employment and industrial areas within the West and South Western Sydney Sub-Regions. The M5 Motorway connects with the M7 Motorway to the west, providing access to the Greater Sydney Metropolitan Region and NSW road network. Similarly the M5 Motorway is the principal connection to Sydney's north and north-east via the Hume Highway.

The Southern Sydney Freight Line (SSFL) is located one kilometre to the west of the proposed SIMTA site. The SSFL is a 36 kilometre dedicated freight line between Macarthur and Chullora.

The SIMTA site was recently operating as the Defence National Storage and Distribution Centre (DNSDC) however Defence has recently relocated this operation and vacated the SIMTA site. The majority of land immediately surrounding the SIMTA site is owned and operated by the Commonwealth and comprises:

- School of Military Engineering (SME), on the western side of Moorebank Avenue directly adjacent to the SIMTA site.
- Holsworthy Military Reserve, to the south of the site on the southern side of the East Hills Passenger Railway Line.
- Commonwealth Residual Land, to the east between the SIMTA site and the Wattle Grove residential area.
- Defence National Storage and Distribution Centre (DNSDC), to the north and north east of the SIMTA site.

The site to immediate west of the SIMTA site which currently includes the SME is the subject of a Development Application (DA) (SSD-5066), under Part 4, Division 4.1 of the EP&A Act, for the development of an intermodal facility known as the Moorebank Intermodal Terminal Project (MIC Proposal). The EIS for the MIC Proposal has recently been prepared and publically exhibited on 8 October 2014 to 8 December 2014. A Preferred Project Report (PPR) is currently under preparation to respond to submissions received during public exhibition. The MIC Proposal has yet to be determined by the Department of Planning and Environment (DP&E).

A number of residential suburbs are located in proximity to the Stage 1 site, including:

- Wattle Grove, located approximately 600 metres from the Stage 1 site and 750 metres from the rail link to the east.
- Moorebank, located approximately 1,700 metres from the Stage 1 site and more than 2,700 metres from the rail link to the north.
- Casula, located approximately 1,100 metres from the Stage 1 site and 250 metres from the rail link to the west.

- Glenfield, located over 1,700 metres from the Stage 1 site and 750 metres from the rail link to the south-west.

The footprint and operational layout of the Stage 1 Proposal is shown on Figure 1-1.

Figure 1-1 Stage 1 Site layout

1.4 PURPOSE AND SCOPE OF THIS ASSESSMENT

This report has been prepared for approval of the initial stage of the SIMTA Project, known as the Stage 1 Proposal. A summary of the works included in the Stage 1 Proposal is provided below. This report has been prepared to support a SSD Application for which approval is sought under Part 4, Division 4.1 of the EP&A Act.

This report has been prepared in accordance with the Statement of Commitments (SoCs) provided in the Concept Plan Environmental Assessment (EA). Table 1-1 provides a summary of the commitments and the section where they have been addressed in this report.

Table 1-1 Conditions of Approval compliance table

Section/number	SoCs	Where addressed
Concept Plan Conditions of Approval	The Proponent commits to the preparation of a Greenhouse Gas Management Plan for the three major stages of the development in accordance with the provisions of the Greenhouse Gas Assessment.	The contents of this Report provide the context and analysis supporting the development of the Greenhouse Gas Management Plan. Mitigation and adaptation measures for GHG emissions and climate change risks are outlined in Sections 9 and 11.7 respectively. A summary of the proposed management strategies for the Proposal is provided in Appendix A.
	The Proponent will where applicable implement the controls and mitigation measures summarised in the *Climate Risk Assessment* report and including: ▪ Incorporate climate change sensitivity analyses for 20 per cent increase in peak rainfall and storm volumes into flood modelling assessment to determine system performance	Climate change risks have been assessed in Section 11 and Appendix B of this Report. Recommended controls identified in the Concept Plan Climate Change Risk Assessment have been incorporated into the design of the Stage 1 Proposal. These measures have also been incorporated within the management strategy for Stage 1 (Appendix A). Adaptation measures to promote resilience to projected climate change are presented in Section 11.
	▪ Incorporate appropriate flood mitigation measures, where practical within the design to limit the risk to acceptable levels	
	▪ Consider the impacts of climate change on system performance, and where practical incorporate adaptive capacity measures within the design to limit the risk to acceptable levels	
	▪ Use of appropriate materials and engineering design capable of withstanding potential impacts posed by storm damage	

Section/number	SoCs	Where addressed
	▪ Incorporate appropriate strategic protection zones, including asset protection zones into design to limit bushfire risk to acceptable levels, where required	
	▪ Control of performance of hotworks on total fire ban days during construction and operation, particularly within any defined asset protection zones	
	▪ Maintain track stability through regular maintenance, use concrete sleepers in place of wooden ones and use preventative measures in the event of heatwaves (e.g speed restrictions, warehouse ventilation for improved heat removal)	
	▪ Consider further assessment of Marginal Abatement Cost Curves to assess commercial opportunities of reducing reliance on single energy source.	A Marginal Abatement Cost (MAC) analysis for the Stage 1 Proposal is presented in Section 10.

1.5 STRUCTURE OF REPORT

This report is structured according to the following:

- Section 2 documents the GHG emission estimation approach
- Section 3 provides a summary of the existing environment including an emissions profile for Australia and NSW within the transport sector
- Section 4 assesses the expected emissions from construction activities for the Proposal
- Section 5 assesses the expected emissions due to the Proposal's operational activities
- Section 6 assesses the expected emission from embodied energy within construction materials
- Section 7 provides a summary of the expected total emissions for the Proposal
- Section 8 documents the expected reduction in freight transport emissions within the Sydney freight catchment associated with a freight modal shift from trucks to train as a result of the Proposal
- Section 9 documents a number of mitigation strategies to alleviate GHG emissions at the Proposal site
- Section 10 describes MAC analysis and results undertaken for the operational phase of the Proposal
- Section 11 outlines the climate change risks and adaptation strategies for the Proposal
- Section 12 concludes the assessment.

2 GHG EMISSIONS ESTIMATION APPROACH

This section outlines the GHG emission estimation approach; policy framework; methodology and assessment boundary for the Proposal.

2.1 POLICY FRAMEWORK

In September 2013, the Intergovernmental Panel on Climate Change (IPCC) Working Group I released its Fifth Assessment Report (AR5) on climate change. During 2014, working groups 2 and 3 released further reports with the culminating synthesis report released in November 2014. The AR5 stated that warming of the climate system is unequivocal and, since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Furthermore, the AR5 stated that it is extremely likely (95 to 100 per cent confidence) that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2014).

In Australia, there are a number of regulations, policies and targets which have been developed to manage and reduce GHG emissions. These include the following:

Table 2-1 Greenhouse gas emissions and climate change regulatory and policy context

Level	Type	Name	Description
Commonwealth Government	Regulation	*The National Greenhouse and Energy Reporting Act 2007*	Introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year.
	Target	Australia's emissions reduction targets under the Kyoto Protocol	The Australian Government has committed to reduce its emissions between 5 and 25 per cent below 2000 levels by 2020. It has also committed to a long term emissions reduction target of 80 per cent below 2000 levels by 2050.
	Inventory	State and Territory Greenhouse Gas Inventories for 2012/13.	This document provides an overview of the latest available estimates of GHG emissions for the Australian States and Territories based on a Kyoto accounting basis.
NSW Government	Target	*NSW Greenhouse Plan 2005*	The Plan sets emission reduction targets for NSW, including a 60% reduction in greenhouse gas emissions by 2050 and a return to year 2000 levels by 2025.
	Legislation	*Environmental Planning & Assessment Act 1979*	The EP&A Act contains a general requirement to address environmentally sustainable principles, including climate change, within development applications.
	Target	NSW State Plan 2021	The NSW Plan 2021 has goals and targets towards climate change including: ▪ 20% renewable energy by 2020 ▪ assistance for businesses and households to realise annual energy savings of 16,000

Level	Type	Name	Description
			gigawatt-hours by 2020 compared with 'business as usual' trends ▪ support for 220,000 low-income households to reduce their energy use by up to 20% by June 2014 ▪ an increase in the share of commuter trips made by public transport, including increasing the proportion of total journeys to work by public transport in the Sydney Metropolitan Region to 28% by 2016 ▪ targets to increase walking and cycling ▪ planning policy to encourage job growth in centres close to where people live and to provide access by public transport.

2.1.1 REGULATORY CHANGES

The regulatory and policy framework in Australia has recently undergone significant changes. On 11 September 2014, the *Energy Efficiency Opportunities (Repeal) Bill 2014* (EEO) received Royal Assent. The repeal has a retrospective commencement clause and is effective from 29 June 2014. Accordingly, all obligations and activities under the EEO Program have ceased.

Similarly, the Australian Government has abolished the Carbon Pricing Mechanism as of 1 July 2014, and commenced implementation of the Direct Action Plan (DAP). As a result, no new carbon tax liabilities will be incurred. The DAP will primarily seek to reduce GHG emissions through an Emissions Reduction Fund which will aim to incentivise emission reduction activities.

It should be noted that during the lifetime of the Proposal legislation and policies are likely to change and may result in future requirements for GHG management and/or abatement.

2.2 ASSESSMENT METHODOLOGY

The scoping processes used for the assessment of GHG emissions for the Proposal are based on the following guidelines and regulations:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* (WRI/WBCSD, 2004)
- *National Greenhouse and Energy Reporting* (Measurement) *Determination 2008* (DoEa)
- The Department of Environment (DoE) *National Greenhouse and Energy Reporting System Measurement: Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia* (NGER Technical Guidelines) (2014b).
- DoE *National Greenhouse Accounts* (NGA) *Factors* (2014c).

Under 'the Greenhouse Gas Protocol' (WRI/WBCSD, 2004), a Proposal's direct and indirect emissions sources can be delineated into three 'scopes' (Scope 1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. These scopes are associated within an organisations operational boundaries (refer to Figure 2-1)

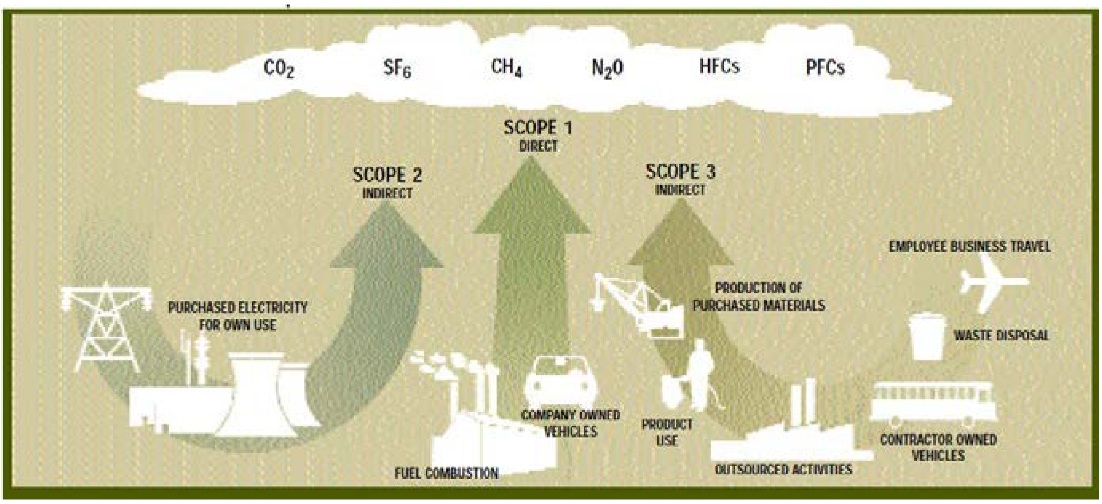

Figure 2-1 Overview of scopes and GHG emissions sources (WRI/WBCSD, 2004)

Further details of GHG operational scopes are outlined below:

Scope 1: Direct Greenhouse Gas Emissions – Scope 1 emissions are direct GHG emissions from sources that are owned or controlled by SIMTA. Scope 1 can include direct emissions sources such as fuel consumption within machinery used during construction and operation.

Scope 2: Electricity Indirect Greenhouse Gas Emissions –These account for GHG emissions arising from purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated. Scope 2 emissions associated with the Proposal include the electricity that will be consumed within the SIMTA buildings, facilities and the Rail Link.

Scope 3: Other Indirect Greenhouse Gas Emissions – Scope 3 emissions are those that are a consequence of SIMTA, but occur outside the site operational boundary and are not under SIMTA's control, such as construction vehicles and delivery materials to the Proposal site. Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions.

Quantification of potential emissions from the Proposal has been undertaken in relation to carbon dioxide (CO_2) and other non-CO_2 GHG emissions, including methane (CH_4) and nitrous oxide (N_2O). To report these emissions, they are converted to carbon dioxide equivalents (CO_2-e) as specified under the Kyoto Protocol. The Global Warming Potential (GWP) adopted for each GHG is as follows: carbon dioxide GWP of 1; methane GWP of 21; and nitrous oxide GWP of 310, as detailed in the *NGA Factors* (DoE, 2014c).

This assessment has been undertaken using the best available current and historical data. Assumptions have been outlined, where appropriate to maintain transparency.

2.3 ASSESSMENT BOUNDARY

A number of potential Scope 1, Scope 2 and Scope 3 emissions sources have been identified for the Proposal during the construction and operational phases. GHG emissions that would be generated during the construction and operation phases are summarised in Section 4 and Section 5 respectively. The key sources of GHG emissions from construction and operation are provided below.

2.3.1 CONSTRUCTION

Construction would be undertaken in five works periods over an 18 month period, shown in Figure 2-2. Works periods have been identified to group construction activities that would likely be undertaken together for assessment purposes only, and are indicative of the timing of construction.

The key activities and potential sources of GHG emissions from each works period are summarised in Table 2-2.

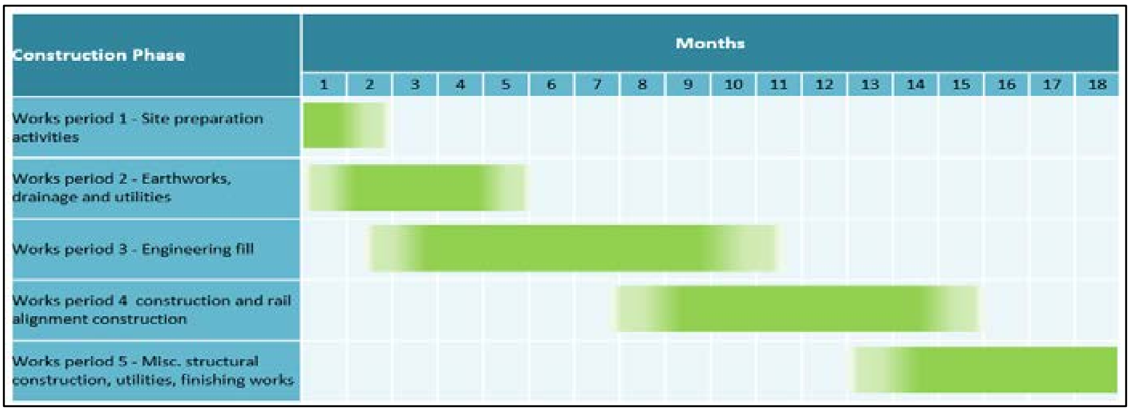

Figure 2-2 Construction Works periods

Table 2-2 Potential sources of GHG emissions during the construction of the Proposal

Works period	Activity
Works period 1 - Site Preparation Activities	▪ Demolition ▪ Clearing vegetation ▪ Temporary Works ▪ Enabling Works
Works period 2 - Earthworks, Drainage and utilities	▪ Bulk Earthworks
Works period 3 - Engineering Fill	▪ Engineering fill under slab
	▪ Rail formation
	▪ Bridge Construction/Modifications
Works period 4 -pavement construction and rail alignment construction	▪ Pavement construction
	▪ Permanent ways and rail systems
	▪ Bridge construction (continued)
Works period 5 - Misc. structural construction, utilities, finishing works	▪ Misc. structural construction, utilities, finishing works ▪ Commissioning ▪ Decommissioning/Demobilisation of site

2.3.2 OPERATION

The operation of the Proposal, which would be 24 hours a day, 7 days a week, would generate emissions from:

- Transport of freight by rail and road
- Energy use and fuel consumption from facilities, machinery and locomotives within the intermodal terminal facility and rail link.

Details of the assessment boundary for this assessment are illustrated below in Figure 2-3. The assumptions considered for the quantum of GHG emissions of the Proposal are explained in the following sections.

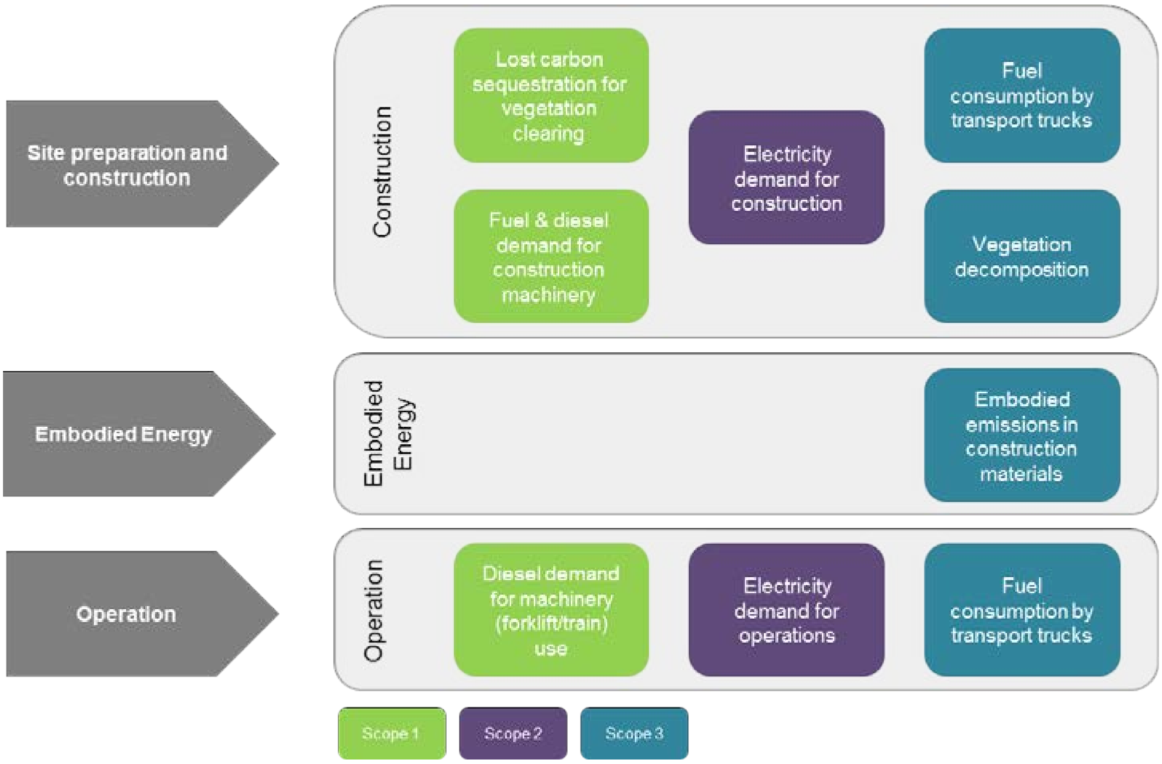

Figure 2-3 Assessment boundary for construction and operation of the Proposal.

2.3.3 ASSUMPTIONS FOR THE ASSESSMENT

This assessment has been undertaken using the best available data at the time of writing. Assumptions have been outlined, where appropriate, to maintain transparency.

Where specific assumptions have been made for the calculation of GHG emissions arising from an individual activity, they have been identified within the corresponding section of this report. The following provides a list of the general assumptions used throughout this report on the whole:

- Construction work hours were assumed to be 9 hours per day and 5.5 days per week
- The closest building material suppliers and, recyclers and waste disposal facilities were identified by desktop search, and associated distances used in report calculations
- Only plant and machinery that would significantly contributed to CO_2-e emissions were considered in this assessment
- All cleared vegetation will be composted.

3 EXISTING ENVIRONMENT

Existing accounts of greenhouse gases provided by the Commonwealth Department of the Environment (DoE) estimate that approximately 554.6 Mega tonnes (Mt) CO_2-e were emitted in Australia during the 2011–12 financial year (DoE, 2014d). Table 3-1 presents a breakdown of the individual State and Territory GHG emissions contribution.

Table 3-1 Australian State and Territory GHG emissions 2011/2012 (DoE, 2014c)

State or Territory	Total Emissions (Mt CO_2-e)	Percentage of Total Australian Emissions
New South Wales	154.7	27.9
Victoria	124.5	22.4
Queensland	152.4	27.5
Western Australia	70.5	12.7
South Australia	28.2	5.1
Tasmania	7.0	1.3
Australian Capital Territory	1.3	0.2
Northern Territory	15.0	2.7
External Territories	0.04	<0.01
Total	**554.6***	100

*The difference between the national and the sum of the State and Territory emissions reflects the inclusion of military transport in the national inventory and a small balancing item.

As per the Intergovernmental Panel on Climate Change (IPCC), and reported within Australia's *Greenhouse Gas Inventory*, fuel combustion in transportation forms a sub-sector of the energy sector. The combined energy subsectors (including transport) were the largest source of GHG emissions in Australia in 2012, comprising 75 per cent of Australia's total emissions (413.4 Mt) (DoE, 2014d). The energy sector has also experienced the greatest sectoral increase in GHG emissions over the 1990 to 2012 period, increasing by 45.5 per cent, which was notably partly attributable to an increase in diesel consumption in heavy vehicles (DoE, 2014e).

The transport sector accounted for around 16.3 per cent (90.2 Mt CO_2-e) of Australia's GHG emissions in 2011-12 and 17 per cent of total GHG emissions in NSW (DoE, 2014d). Approximately 3.1 per cent of emissions produced by the transport sector are attributable to the railways subsector, while road transportation comprises 85 per cent and 87 per cent of the Australian and NSW transport sectors respectively (DoE, 2014d).

4 CONSTRUCTION BASED GHG EMISSIONS

Construction of the Proposal will be undertaken in five key works periods over an 18 month period. Primarily, construction will include the transport of materials on and off the Proposal site, civil works and construction of buildings and structures, and the rail link. These activities require the use of fuels and electricity which will result in the release of associated GHG emissions.

Emissions were calculated by estimating fuel use and electricity consumption using available data. Emissions in tonnes CO_2 equivalent were calculated using factors and methods from the *Australian Government National Greenhouse Accounts Factors - December 2014*. Specific assumptions were made with regard to fuel use, electricity consumption, construction schedules, material quantities, material transport and waste decomposition.

A range of plant and equipment would be required for the construction of the Proposal. A summary of the plant and equipment that may be utilised is provided in Table 4-1 and Table 4-2 for the Stage 1 site and the Rail Corridor respectively. These machinery types have formed the basis of all fuel consumption estimations associated with machinery use throughout this Section of the report. Assumptions have been made having regard to the number of each machinery type used and the duration it would be used within each works period included in the construction.

Table 4-1 Indicative construction plant and equipment – Stage 1 Site

Equipment	Construction Works period				
	Works period 1: Site preparation	Works period 2: Earthworks, drainage and utilities	Works period 3: Granular base construction	Works period 4: Pavement construction	Works period 5: Buildings and finishing works
Loaders	✓	✓	✓		✓
Static and vibratory rollers	✓		✓		
Mobile cranes	✓			✓	✓
Excavators	✓		✓	✓	✓
Excavators with hammers	✓	✓		✓	
Backhoes	✓	✓		✓	
Crushing plant	✓				
Batch plant				✓	
Concrete agitators (or similar)				✓	
Concrete pumps				✓	
Concrete saws				✓	
Air compressors	✓	✓		✓	✓
Jackhammers	✓	✓			
Dozers	✓	✓	✓	✓	
Mulchers	✓				
20-40 tonne articulated tipper trucks	✓	✓	✓	✓	
Scrapers		✓			
Graders	✓	✓	✓		
Water trucks	✓	✓	✓	✓	
Piling rigs				✓	
Forklifts	✓	✓	✓	✓	✓

Table 4-2 Indicative construction plant and equipment – rail link

Equipment	Construction Works period				
	Works period 1: Site preparation	Works period 2: Earthworks, drainage and utilities	Works period 3: Granular base construction	Works period 4: Pavement construction	Works period 5: Buildings and finishing works
Loaders	✓	✓	✓		
Static and vibratory rollers	✓	✓			
Mobile cranes	✓			✓	✓
Excavators	✓	✓			
Backhoes	✓	✓			✓
Concrete agitator		✓		✓	
Concrete pumps		✓		✓	
Air compressor	✓	✓			
Dozers	✓		✓		
Mulcher	✓				
Scrapers	✓	✓	✓		
Graders	✓	✓			
Water truck	✓	✓	✓		
Piling rig		✓		✓	
River work boat (barge and lift pontoon)				✓	
Rail tamper					✓
Forklift					
Welder				✓	✓

4.1 WORKS PERIOD 1 -SITE PREPARATION ACTIVITIES

Works period 1 of construction will include site preparation activities; such as vegetation clearing, demolition of existing structures, establishment of a compound with portable offices, and amenities and connection to utilities.

Vegetation clearing would generate emissions from a number of potential sources; including the loss of carbon sequestration, diesel consumption in machinery used for clearing and mulching, transportation of vegetation waste, and vegetation decomposition.

Approximately 24 hectares (ha) of vegetation would need to be cleared to prepare the site for construction.

The loss of carbon sequestration, while not a true GHG emission, would result in less carbon dioxide being removed from the atmosphere. The net effect would therefore be that a greater amount of carbon dioxide would remain. Consequently the loss of sequestration has been assessed as a Scope 1 source of emissions. Different vegetation types characteristically sequester carbon at different rates and to a different extent. Based on the vegetation types listed above, the likely tonnes of dry vegetation per hectare, and the average emissions factor have been used to determine the loss of sequestration (TAGG, 2013). Loss of sequestration has included all carbon pools including woody, non-woody, debris and soil. To provide a conservative estimate it has been assumed that all carbon removed is converted to carbon dioxide and released to the atmosphere.

The use of machinery to undertake clearing and grubbing activities would represent a source of Scope 1 emissions. Vegetation decomposition and transportation of vegetation waste to a nearby composting facility, however, have been assessed as Scope 3 emissions as they would occur offsite. The total GHG emissions that would be generated as a result of vegetation clearing are summarised in Table 4-3.

Table 4-3 Vegetation clearing GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Cleared Sequestration Loss	1,149.65	-	-
Cleared Vegetation Decomposition	-	-	267.88
Clearing and scrubbing activities	71.47	-	-
Mulching	5.16	-	-
Removal of vegetation (transportation)	-	-	1.33
TOTAL	**1,226.28**	**-**	**269.21**

Other site preparation activities would generate only Scope 1 emissions from fuel combustion in machinery. Based on the machinery listed in Table 4-1 and Table 4-2, the emissions generated from the above would be:

Table 4-4 Works period 1 construction activities (Excluding vegetation clearing)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Demolition of existing buildings	119.43	-	-
Site establishment/mobilisation	14.18	-	-
Materials handling	25.38	-	-
Materials treatment for re-use	148.99	-	-
Removal/remediation of contamination	11.27	-	-
TOTAL	**319.24**	**-**	**-**

Works period 1 construction would generate approximately 1,816 tCO_2-e, including 1,546 tCO_2-e of Scope 1 emissions and 270 tCO_2-e of Scope 3 emissions. Figure 4-1 shows the total GHG emissions produced by Works period 1 as attributable to the key activities to be undertaken during this Works period of construction.

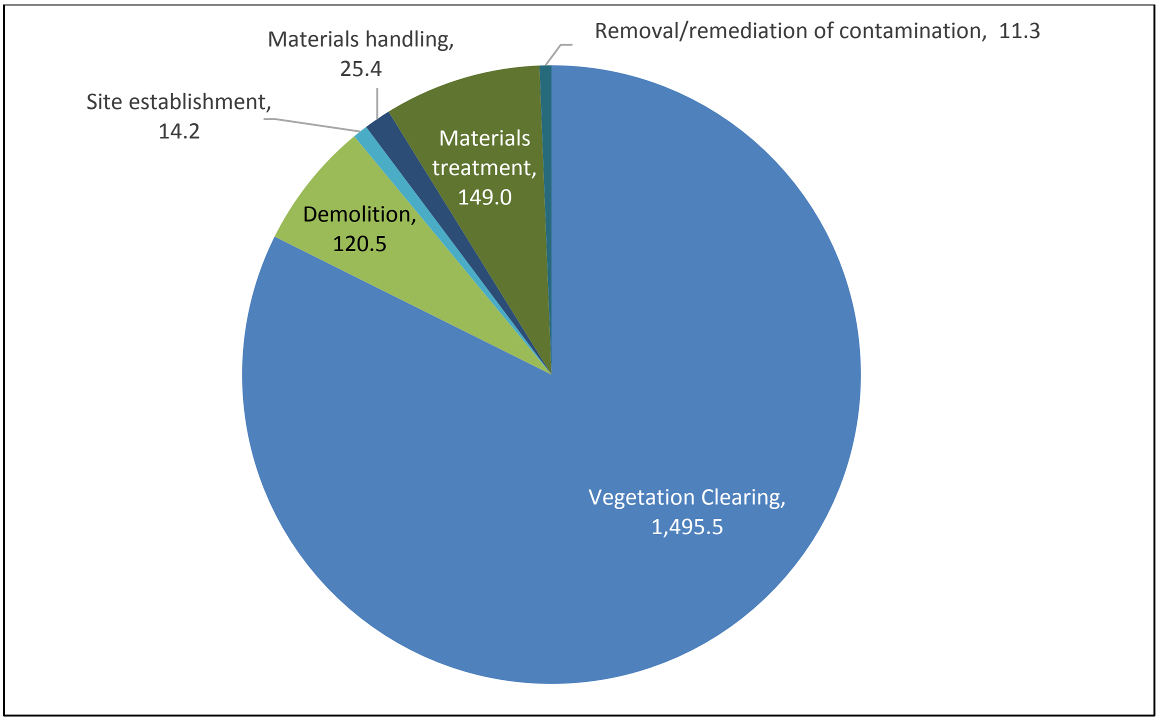

Figure 4-1 Summary of Construction Works period 1 GHG Emissions (tCO_2-e)

4.2 WORKS PERIOD 2 - EARTHWORKS, DRAINAGE AND UTILITIES

Works period 2 of construction would involve earthworks, drainage and utilities connection within both the Stage 1 site and Rail Corridor and would involve:

- Excavation and filling
- Construction and installation of stormwater drainage structures and utilities services infrastructure
- Backfilling

Where possible and subject to its suitability, excavated soil would be reused on-site for foundation preparation, levelling works or access track maintenance. Excavated soil which is not considered suitable for re-use onsite may be temporarily stockpiled within the construction compound and then transferred offsite.

A source of general fill material within the Proposal site would be used for the Proposal. It is also assumed (for the purpose of this assessment) that a portion of material will need to be exported from the Proposal site.

Generally, the work to supply the utilities to the Stage 1 site would involve trenching and the installation of water, sewer and gas pipes, and electricity and telecommunications conduits. Trenches would then be backfilled and the area made good.

New drainage infrastructure for the Stage 1 site would include:

- Pits and pipes throughout the site as required
- Construction of bio-swales and detention areas on the northern, southern and western, eastern perimeters of the Stage 1 site

New drainage infrastructure for the rail link would include:

- Construction of a culvert over Anzac Creek
- Construction of infrastructure such as diversion drains and the like along the rail link
- Alterations to existing drainage infrastructure within the SSFL and East Hills rail corridors

The main source of emissions in Works period 2 of construction would be from fuel combustion within machinery, and would consequently be characterised as Scope 1. Scope 1 emissions would also be generated by articulated haulers moving fill within the Proposal site. The emissions associated with the removal of additional fill offsite would be considered to be Scope 3 as they would occur offsite.

Works period 2 of the Proposal would generate approximately 473 tCO_2-e which would predominantly be comprised of Scope 1 emissions from fuel combustion within machinery (refer Table 4-5).

Table 4-5 Summary Works period 2 GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Transportation of fill materials and excavation	0.01	-	-
Transportation of fill offsite	-	-	2.47
Machinery use	470.87	-	-
TOTAL	**470.88**	**-**	**2.47**

4.3 WORKS PERIOD 3 -ENGINEERING FILL

Works period 3 of construction works involves placement of engineered fill on the Stage 1 site, importing and laying rail formation for the rail link, and bridge construction/modification. Activities have been concentrated separately within the Stage 1 site and the Rail Corridor during this works period.

Within the Stage 1 site the key activities to be undertaken would include construction of formation and foundations for pavement, buildings, structures, permanent ways and rail systems and drainage preparation and construction.

These works would include machinery use resulting in the majority of emissions being generated as a result of fuel combustion, producing Scope 1 emissions.

Within the Rail Corridor, construction activities would also include:

- Placing rail formation for the rail link, including laying protection of significant existing infrastructure including Ethane gas line and 750 rising main.
- Bridge construction and modifications including Georges River crossing and Anzac Creek culvert crossing.

Transportation of material to the Stage 1 site would generate Scope 3 emissions.

Table 4-6 summarises the emissions that would be generated during these activities, demonstrating that approximately 1,180 $tCO2$-e would be produced. Laying and construction of the rail cap and ballast would contribute the largest portion of total GHG emissions produced in Works period 3 of construction (refer Figure 4-2).

Table 4-6 Summary of Works period 3 GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Engineering fill under slab	347.78	-	-
Rail formation	707.14	-	-
Bridge construction/modifications	118.39	-	-
Transportation	-	-	6.43
TOTAL	**1,1732.32**	**-**	**6.43**

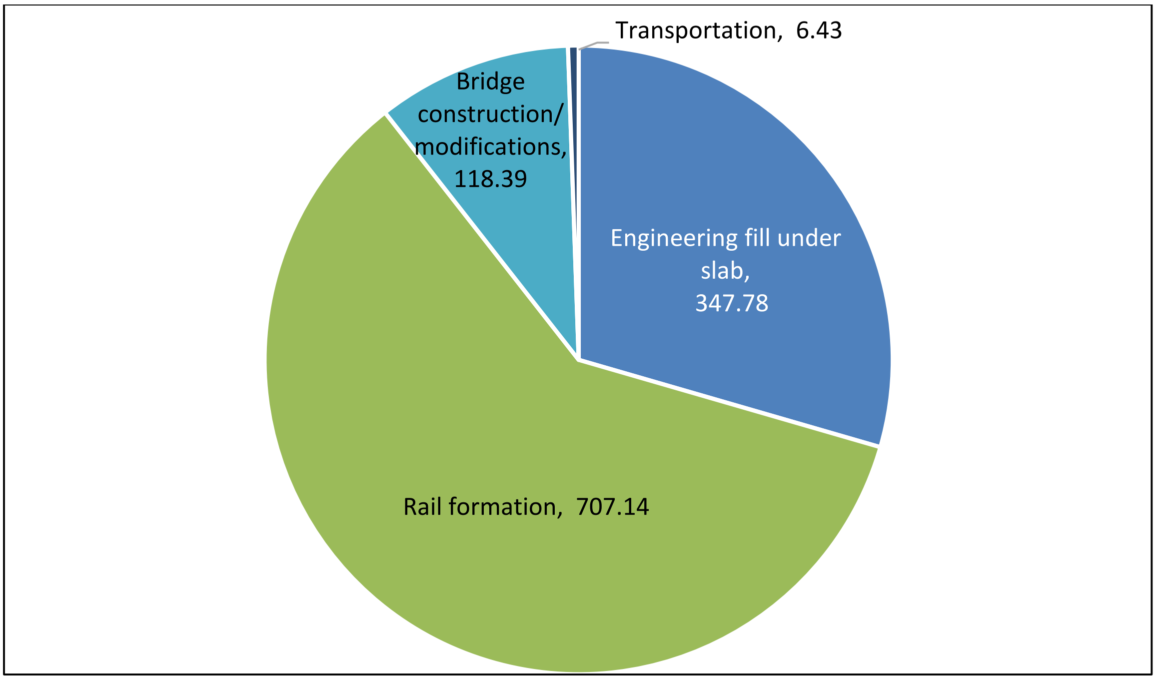

Figure 4-2 Summary of Construction Works period 3 GHG Emissions (tCO_2-e)

4.4 WORKS PERIOD 4 - PAVEMENT CONSTRUCTION AND RAIL ALIGNMENT CONSTRUCTION

Works period 4 of construction would involve construction of the pavement structures within the Stage 1 site. Works within the Rail Corridor would include permanent ways, rail systems and bridge construction activities.

The pavement would require construction of various hardstand areas, including internal roads, car parking areas, container storage and handling areas, and the rail sidings. A range of construction equipment would be required to undertake these works.

While the majority of equipment used in pavement construction would be diesel operated, a possible batching plant has been assumed in this assessment and is envisaged to be electrically powered. Due to the electricity demand of batching equipment it would be connected to the grid, and would therefore generate Scope 2 emissions.

Bridge construction activities, permanent ways construction and installation of rail systems would require the use of various machinery all of which would be diesel powered and generate Scope 1 emissions.

Transportation of materials required in Works period 4 would generate Scope 3 emissions.

Table 4-7 summarises the GHG emissions that would be generated as a result of the construction activities within Works period 4. Works period 4 would produce approximately 492 tCO2-e, of which 53 per cent would be attributable to the construction of the base slab (refer Figure 4-3).

Table 4-7 Summary of Works period 4 GHG emissions (tCO_2-e)

Emissions source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Pavement construction	202.07	58.97	-
Transportation	-	-	8.44
Permanent ways and rail systems	66.23	-	-
Bridge construction	156.71	-	-
TOTAL	**425.01**	**58.97**	**8.44**

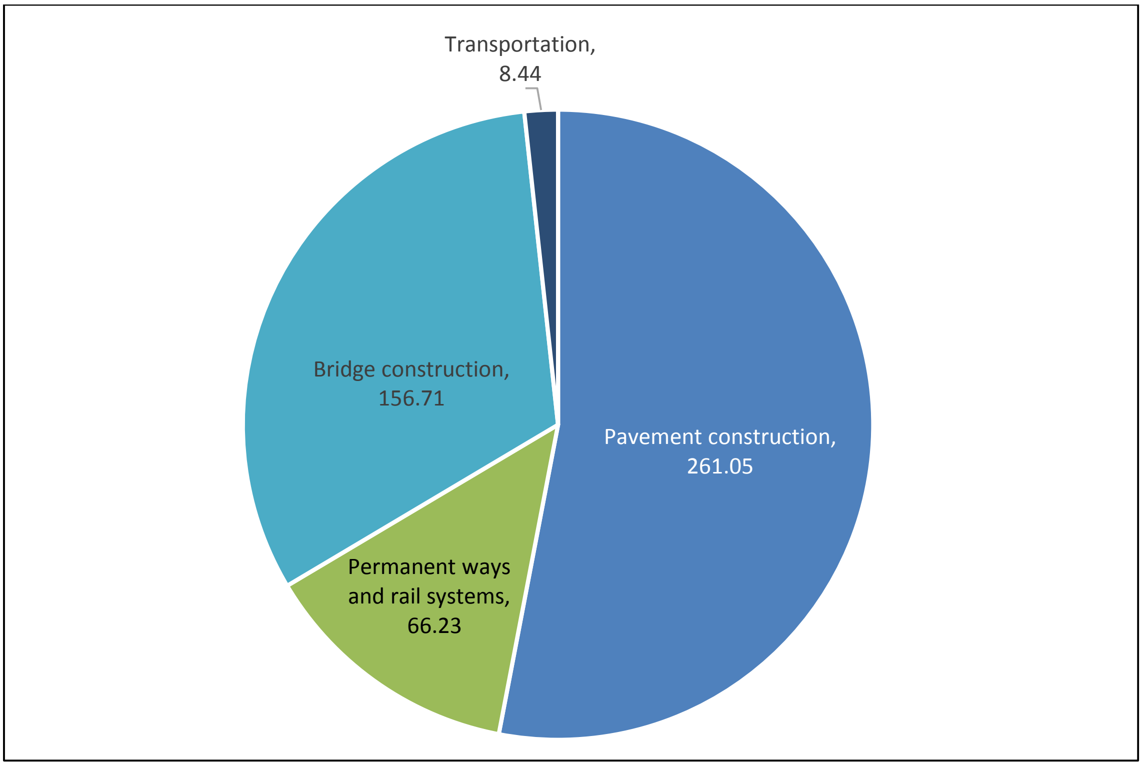

Figure 4-3 Summary of Construction Works period 4 GHG Emissions (tCO_2-e)

4.5 WORKS PERIOD 5 - MISC. STRUCTURAL CONSTRUCTION, UTILITIES, FINISHING WORKS AND COMMISSIONING

Works period 5 of construction involves finishing works, commissioning, demobilisation and miscellaneous construction activities not undertaken during Works period 1-4 or described above. An assumption has been made with regard to the likely activities and machinery types required. Fuel combustion from machinery use during Works period 5 would generate approximately 76 tCO_2-e of Scope 1 GHG emissions.

Transportation of miscellaneous materials would generate approximately 1.12 tCO_2-e of Scope 3 GHG emissions, resulting in the total GHG emissions generated equating to 77 tCO_2-e.

4.6 SITE OFFICES

Site offices would be required during the duration of construction activities. Construction compounds would be located within the Proposal site, containing varying numbers and sizes of site offices. An approximate average floor area of 1,400 m^2 has been estimated for the site offices that would be operational during construction. This would generate approximately 223 tCO_2-e across the 18 month construction period.

4.7 SUMMARY OF CONSTRUCTION BASED GHG EMISSIONS

Construction of the Proposal would generate approximately 4,262 tCO_2-e over the 18 month construction period. Scope 1 emissions would generate over 87 per cent of total emissions, with Works period 1 generating the greatest proportion of emissions (refer Figure 4-4 and Figure 4-5). Table 4-8 provides a summary of total GHG emissions generated by the construction of the Proposal.

Table 4-8 Total Construction GHG emission by Scope

Construction Works period	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Works period 1	1,545.52	-	270.24
Works period 2	470.88	-	2.47
Works period 3	1,173.32	-	6.43
Works period 4	425.01	58.97	8.44
Works period 5	76.09	-	1.12
Site Office	-	223.59	-
TOTAL	**3,690.82**	**282.56**	**288.70**

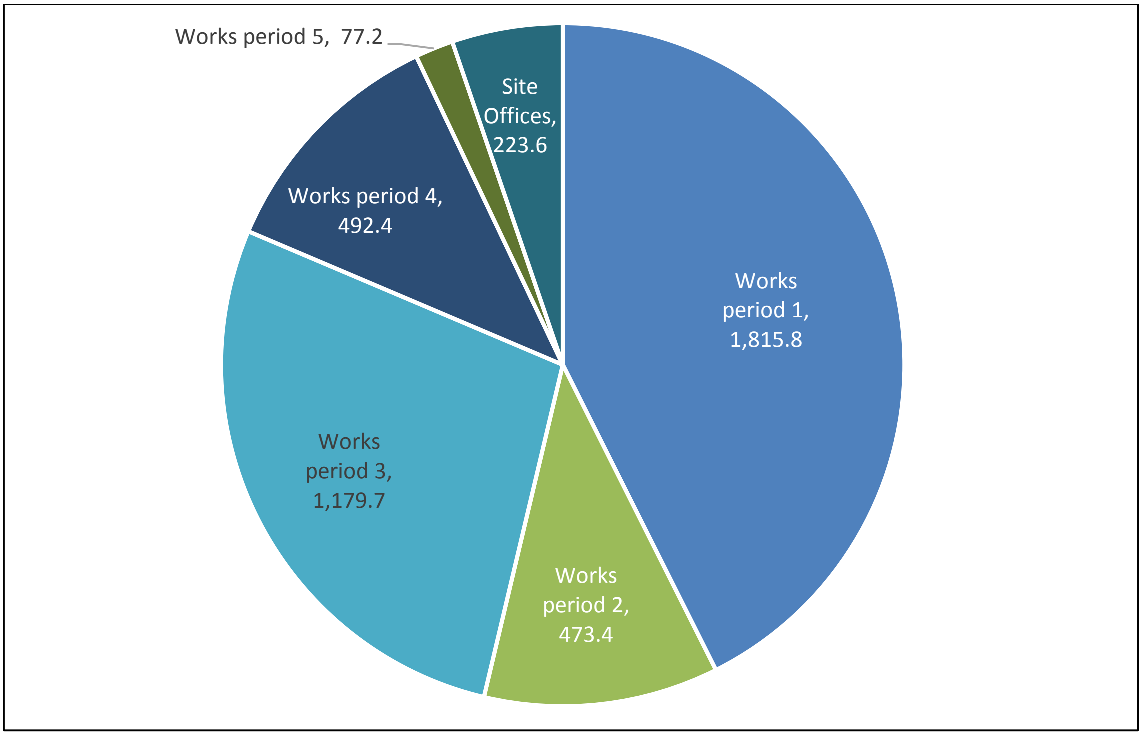

Figure 4-4 Summary of Construction GHG Emissions by Works period (tCO_2-e)

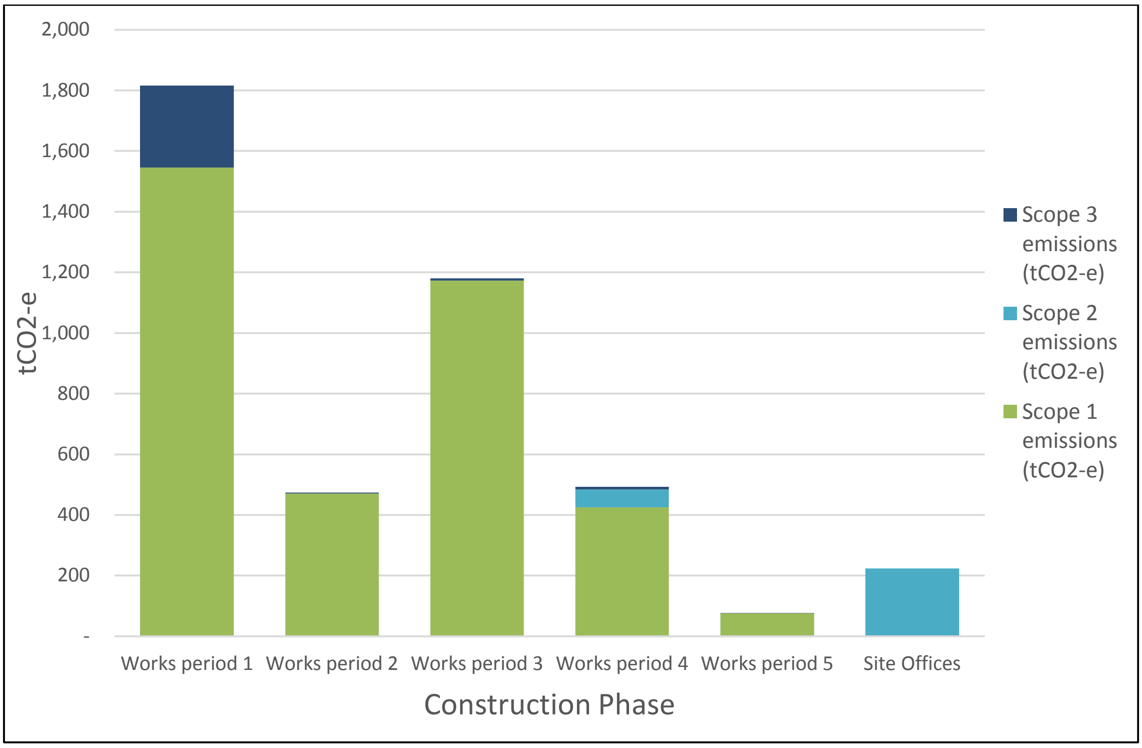

Figure 4-5 Summary of Construction GHG Emissions by Scope (tCO_2-e)

5 OPERATION BASED GHG ASSESSMENT

This section outlines the GHG emissions associated with the operation of the Proposal. The Proposal would involve the operation of the rail link and the intermodal terminal facility (including the administration facility). The Stage 1 site and rail link would operate 24 hours per day and seven days per week. Once operational, Stage 1 is expected to have a capacity of up to 250,000 TEU throughput per annum.

Trains would operate as a shuttle service between the intermodal terminal facility and Port Botany. Trains would access the intermodal terminal facility site from the SSFL using the rail link. The rail link would branch near the SSFL to enable freight trains to travel to and from either the north or the south. It is anticipated that the Proposal would generate up to 10 train movements per day (5 in and 5 out).

The intermodal terminal facility would comprise four rail sidings capable of storing trains of up to 650m in length with container loading / unloading and storage areas located either side of the sidings. Three of the rail sidings would be ordinarily used for operations and one would provide an locomotive relief road.

Trains would enter the intermodal terminal facility from the south on one of the rail sidings, with trucks entering the intermodal terminal site at the northern end from Moorebank Avenue. Trucks would be processed within the site before proceeding to the designated loading / unloading area. It is anticipated that around 670 truck movements would be generated per day. Freight transported via road would typically be serviced within the designated catchment area of the intermodal terminal facility.

Initially the unloading and loading process would be undertaken using large forklifts and reach stackers. On average, approximately three reach stackers would be required to strip a train. Progressively, overhead gantry cranes would be installed to undertake the unloading and loading process.

The main operational source of emissions from the Proposal would be from electricity use and fuel combustion in machinery at the intermodal terminal facility. The transportation of TEU by train to the site and then by truck from the Stage 1 site to the consumer will also generate emissions as a result of fuel combustion. The assessment has been based on full operational capacity of the intermodal terminal facility and therefore provides an approximate maximum for energy use.

An assessment has been undertaken to assess the two potential operating scenarios:

- **Scenario One (Forklifts)**: Forklifts and reach stackers would be used to load and unload containers in the interim period until the gantry cranes are installed and become operational
- **Scenario Two (Gantry Cranes)**: Gantry cranes would be used to load and unload containers. It has been assumed that one reach stacker would remain operational in this scenario for occasional use if required, albeit unlikely.

It is important to note that one and/or a combination of the above-mentioned scenarios could be implemented over the operational timeframe for the Proposal.

In both scenarios emissions from the use of electricity for the site office, weighbridge, lighting, and CCTV would be generated. Similarly transportation emissions and emissions from the use of fuel onsite in the locomotive shifter would be generated equally in both scenarios.

5.1 ELECTRICITY DEMAND

The Proposal will have an on-site electricity demand associated with the site office (including lighting, heating and air conditioning), operations of the intermodal terminal facility (including weighbridge, lighting, and CCTV). A loco-shifter would be located at the northern end of the rail sidings. As trains enter the facility the locomotive would be uncoupled from the remainder of the train and driven onto the loco-shifter. The loco-shifter would traverse the locomotive to the relief siding to enable the loco to return to the southern end of the intermodal terminal facility.

Electricity use represents a source of Scope 2 emissions. In Scenario Two (Gantry Cranes) the use of gantry cranes to unload and load containers would represent an additional source of electricity demand compared with Scenario One (Forklifts). It has been assumed that all gantry cranes would be operational for the full 24 hour period per day, however this is considered a conservative estimate and unlikely to be completely reflective of the operations of the Proposal. Furthermore each crane has been assessed based on a maximum power usage rate with all functions of the crane undertaken simultaneously. In reality, each operation of the crane (e.g. lifting, manouevring or horizontal movement) would use only a fraction of the total maximum power. Consequently this assessment is likely to have overestimated the electricity consumption associated with the operation of gantry cranes in order to assess a 'worst case', albeit unlikely, operational scenario.

Based on the above it has been estimated that Scenario Two would generate an additional 6,177.55 t CO_2-e of Scope 2 emissions per year compared to Scenario One (refer Table 5-1).

Electricity demand represents the key source of GHG emissions for the operation of the Proposal, particularly in Scenario Two when the gantry cranes would be operational.

Table 5-1 Annual Scope 2 GHG Emissions (tCo_2-e)

Scope 2 Emission Source	Scenario One (tCo_2-e/year)	Scenario Two (tCo_2-e/year)
Site Office	277.55	277.55
Container hardstand area (lighting)	62.03	62.03
Green Space/Landscape areas (lighting)	467.08	467.08
Weighbridges	150.67	150.67
CCTV	1.19	1.19
Loco Shifter	30.39	30.9
Gantry Cranes	-	6,177.55
TOTAL GHG emissions	**521.82**	**6,699.38**

5.2 ONSITE FUEL CONSUMPTION

The use of machinery onsite will generate GHG emissions as a result of fuel combustion. In Scenario One (Forklifts), reach stackers and large forklifts would be used to load and unload containers, generating Scope 1 emissions. In Scenario Two (Gantry Cranes) these would be replaced by gantry cranes, assessed above.

The Scope 1 emissions that would be generated from the use of machinery are summarised in Table 5-2. Scenario One would generate an additional 4,680 tCO_2-e per year from machinery use onsite compared with Scenario Two.

Table 5-2 Annual Scope 1 emissions (tCo_2-e) generated by Stage 1 from machinery use

Scope 1 Emissions Source	Scenario One (tCo_2-e p/a)	Scenario Two (tCo_2-e p/a)
Reach Stacker/s	2,552.66	425.44
Forklifts	2,552.66	-
TOTAL GHG emissions	**5,105.31**	**425.44**

5.2.1 TRANSPORTATION

The transportation of freight from the Stage 1 site and distribution from the intermodal terminal facility would result in GHG emissions arising from fuel combustion. Freight will be transported to/from the Stage 1 site by rail, with diesel consumption within the locomotives. Articulated trucks will then transport the freight to/from the Stage 1 site to/from the end customers. To assess a 'worst-case' scenario it has been assumed that all trucks will travel to the furthest extremity of the freight catchment area, however in practice this is unlikely.

Transportation will predominantly represent a source of Scope 3 emissions as it will occur outside the Proposal site operational boundary and will primarily be outside SIMTAs' control. Trains will be potentially operated by a variety of rail operators, and consequently represent an indirect (Scope 3) emissions source for SIMTA. The majority of the truck fleet will be operated by third party operators, however a small proportion of the fleet is expected to be owned and operated by SIMTA. Consequently 10 per cent of emissions arising from fuel combustion in trucks has been assessed as Scope 1, with the remaining fleet generating Scope 3 emissions.

Transportation emissions would be the same for both Scenario One and Scenario Two. The GHG emissions generated by the movement of freight as a result of the Proposal operating at full capacity are summarised in Table 5-3.

Table 5-3 Annual Transportation Emissions Generated by the Proposal (tCO_2-e)

Emissions Source	Scope 1 emissions (t CO_2-e)	Scope 2 emissions (t CO_2-e)	Scope 3 emissions (t CO_2-e)
Transportation of freight to the Stage 1 site by rail	-	-	271.71
Transportation of freight from the Stage 1 site by truck	1,083.92	-	740.61
TOTAL GHG emissions	**1,083.92**		**1,012.33**

The Proposal will have a net reduction in transportation emissions generated by transportation of freight when compared to a 'Business as Usual' (BAU) scenario where freight is transported directly from Port Botany to the freight catchment by truck. This is because the use of train to transport freight is more efficient than by truck, therefore generating fewer emissions. An assessment of the net impact of the Proposal on GHG emissions generated by the movement of freight has been undertaken for the entire Sydney catchment, and is summarised in Section 8.

5.3 SUMMARY OF OPERATIONAL BASED GHG EMISSIONS

A comparative assessment between Scenario One (Forklifts) and Scenario Two (Gantry Cranes) is presented in Table 5-4. While Scenario Two generates significantly fewer Scope 1 emissions (4,680 tCO2-e fewer than Scenario One) these are offset by the increase in Scope 2 emissions generated from the increase in electricity demand (an additional 6,178 tCO_2-e). The use of gantry cranes instead of forklifts would therefore generate an additional 1,498 tCO_2-e per year.

Table 5-4 Scenario One and Scenario Two Annual Operational GHG emissions (tCO_2-e)

Scenario	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)	TOTAL (tCO_2-e)
Scenario One	6,189.23	521.82	1,012.33	**7,723.38**
Scenario Two	1,509.36	6,699.38	1,012.33	**9,221.06**
Difference	**-4,679.87**	**6,177.55**	**-**	**1,497.68**

A detailed summary of the GHG emissions from the onsite electricity demand, machinery fuel use and freight transportation generated by the Proposal is provided in Table 5-5. The total emissions have been documented for Scenario Two to represent a 'worst-case' operational scenario. The total operational emissions from the facility per year are therefore expected to be approximately 9,221 tCO_2-e/year.

At full operational capacity for the worst case scenario, the Proposal would therefore generate only 0.0017 per cent of Australia's total GHG emissions, and 0.0079 per cent of NSW total emissions. This would equate to 0.01 per cent of the transport sector across Australia.

Table 5-5 Expected GHG emissions from the Stage 1 SIMTA Proposal

Emission Source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Electricity Demand			
Administration facility	-	277.55	-
Container hardstand area (lighting)	-	62.03	-
Weighbridges	-	150.67	-
CCTV	-	1.19	-
Loco Shifter		30.39	
Gantry Cranes	-	6177.55	-
Machinery Use			
Reach Stacker/s	425.44	-	-

Emission Source	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Transportation			
Transportation of freight to the Stage 1 site by rail	-	-	271.71
Transportation of freight from the Stage 1 site by truck	1,083.92	-	740.61
TOTAL	**1,509.36**	**6,699.38**	**1,012.33**

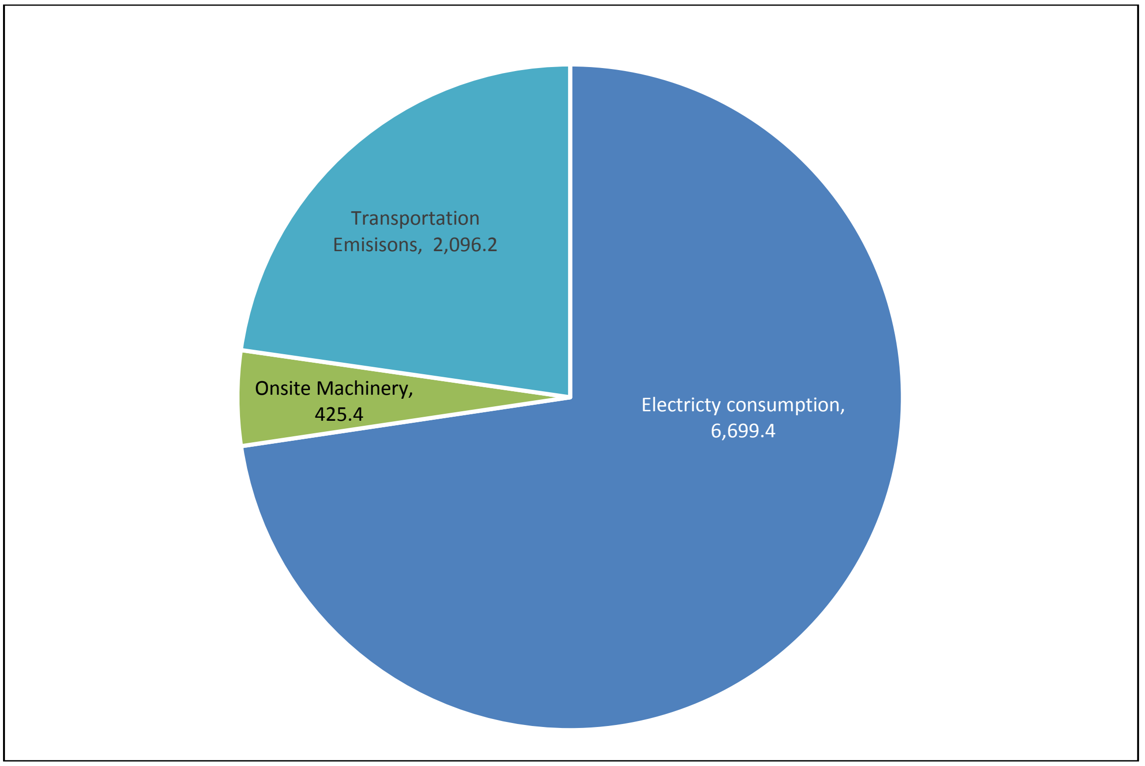

Figure 5-1 Annual Operational GHG emissions (tCO_2-e/year) – 'Worst Case'

Corporate emissions over 50,000 tCO_2-e/year will trigger reporting requirements under the *National Greenhouse and Energy Reporting (NGER) Act 2007.* In 2012/13 both Qube Holdings Ltd and Aurizon Holdings Ltd were recorded as reporting under the NGER Act.

Obligations under the NGER Act are based on which members have operational control over facilities, that meet a facility threshold or that contribute to meeting a corporate-level threshold. The potential liabilities under the NGER Act will be identified by the proponent to determine any requirement's for monitoring and reporting. If required, monitoring and reporting of GHG emissions will be carried out for the operation of the Proposal on an annual operational basis for incorporation into NGER reporting for the operationally controlling corporation.

6 MATERIALS EMISSIONS

To fully assess the potential environmental impacts of the Proposal throughout its lifecylce, consideration must be given to the materials used and their potential environmental, social and economic impacts. Internationally, life cycle (environmental) assessment (LCA) is acknowledged as the most complete and appropriate way to assess the environmental impacts of material and resource use. LCA considers the processes used to win raw materials, transport them, process them into usable materials and products, construct or assemble them and operate, maintain and refurbish them (ISCA, 2014).

Since 2006, the Australian Life Cycle Assessment Society (ALCAS) has been working with industry to compile Guidelines and a national database of life cycle inventory data (AusLCI) for every sector of the Australian economy. Further, the building and construction materials and products sector, represented by the Building Products Innovation Council (BPIC) have engaged the AusLCI to compile Life Cycle Inventory data for all the major structural materials and products used in buildings and infrastructure. The method used to facilitate this outcome is based on a whole of life or full LCA methodology, as guided by international standards, and enables access to Life Cycle Inventory (LCI) data for the purposes of conducting LCAs.

Embodied energy in the construction materials used for the Proposal have been modelled in accordance with the *BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*[1]. The assessment has focused on key materials that will be used in the construction process, including those that will represent the greatest volume and proportion of materials.

Embodied emissions are considered to be Scope 3 emissions as they would occur offsite and are not under the operational control of SIMTA.

6.1 EMBODIED GHG EMISSIONS

A number of key pieces of infrastructure associated with the Proposal have been identified as likely to embody the majority of emissions associated with materials used for the Proposal; these are:

- **Stage 1 site:** Including pavements, imported fill, stormwater pipes, stabilised granula fill, densely graded base, bio-retention media
- **Rail link:** including capping material, ballast material, rail sleepers, retaining walls
- **Bridges:** including bridge decking, reinforcement steel, super T's, abutments and piers, piling, can culvert structures

The materials that would be used for the construction of the above would be confirmed by the Contractor prior to construction commencing. However indicative construction materials have been identified for the purpose of this assessment. Where more than one material could potentially be used during construction, the material that would embody the greatest quantity of GHG emissions have been assessed in order to determine a 'worst case' scenario. Most notably, it has been assumed that the pavement used within the Stage 1 site would be concrete (40MPa) with reinforced steel.

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[1] GHG emissions from end of life of the Proposal have been excluded from the assessment due to large uncertainties in terms of degree of reuse of facilities and infrastructure, as well as degree of reuse, recycling and disposal of construction materials.

Based on the above, the following key material types have been identified for use in construction of the Proposal:

- Steel
- Aggregate
- Concrete (40MPa)
- Structural Steel

The total GHG emissions in construction materials were calculated to be 44,668 tCO_2-e, or approximately 10 times the estimated GHG emissions from the construction phase (excluding material impacts). However, the embodied construction materials amount to the equivalent of less than four years of operation. Embodied GHG emissions are presented in Table 6-1.

Table 6-1 Embodied GHG emissions (tCO_2-e) from key construction materials

Proposal Component	Unit	Steel	Aggregate	Concrete	Structural Steel
Stage 1 Site	Volume (m^3)	1,218	212,000	55,600	50
	Emissions (tCO_2-e)	15,046	997	24,297	457
Rail link	Volume (m^3)	540	19,000	944	-
	Emissions (tCO_2-e)	740	89	413	-
Bridges	Volume (m^3)	69	-	4,060	-
	Emissions (tCO_2-e)	856	-	1,774	-
TOTAL	**Volume (m^3)**	**1,827**	**231,000**	**60,604**	**50**
	Emissions (tCO_2-e)	**16,641**	**1,087**	**26,484**	**457**

As evidenced by Table 6-1, concrete represents the greatest source of embodied GHG emissions, generating 26,484 tCO2-e under the worst case scenario (refer Figure 6-1). As a result of the high volume of concrete that could be used during the construction of the Stage 1 site, this component of the Proposal would contribute 91 per cent of the embodied GHG emissions (refer Figure 6-2).

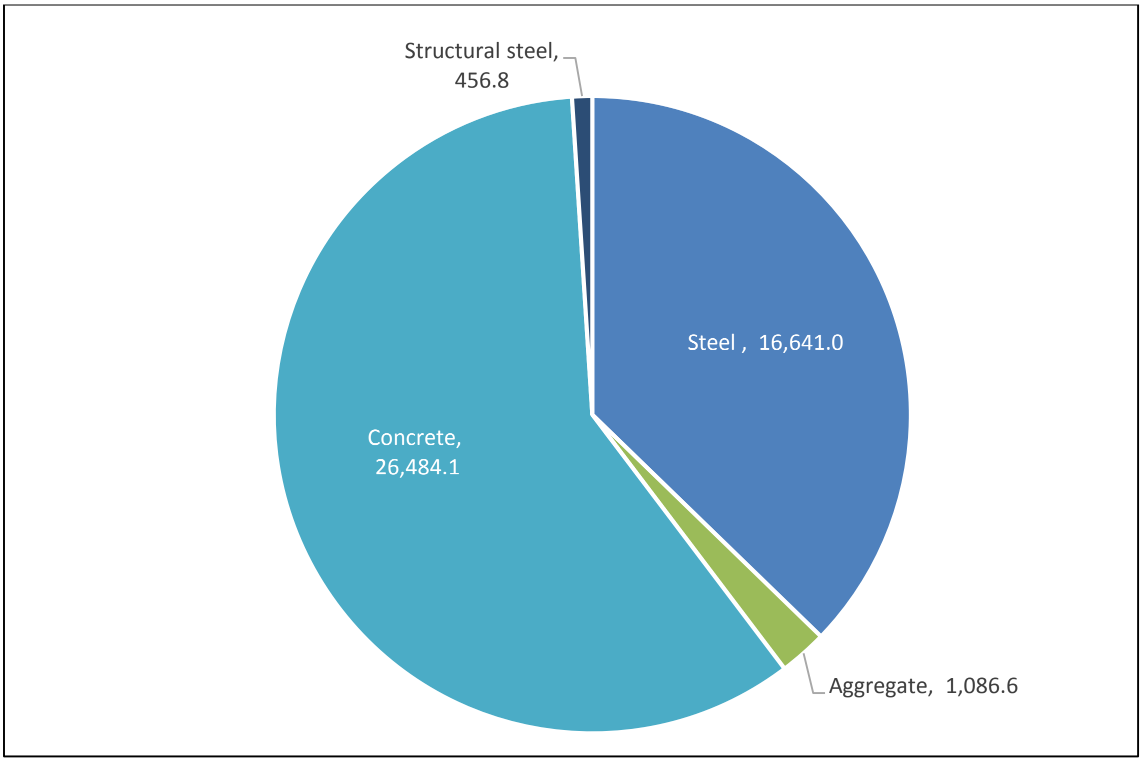

Figure 6-1 Embodied GHG emissions (tCO_2-e) from key construction15 materials

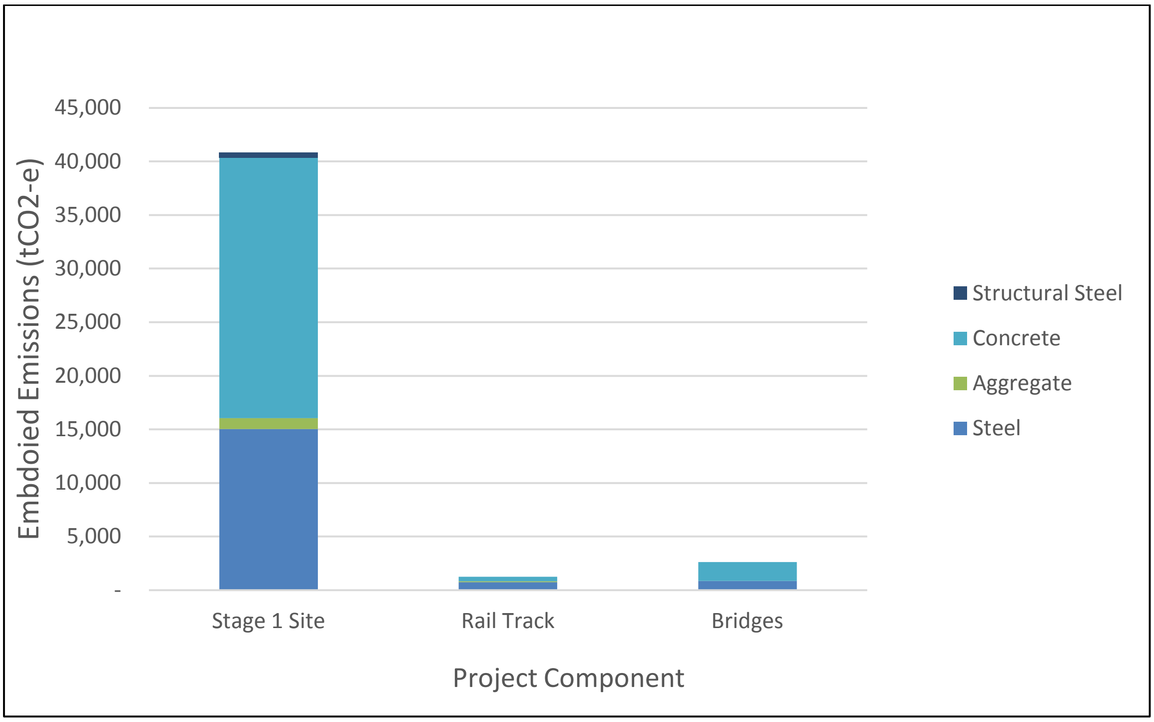

Figure 6-2 Embodied GHG emissions (tCO_2-e) from key Proposal components

6.2 CONCRETE SUBSTITUTIONS

As shown above, under a worst case scenario concrete contributes 26,484 tCO_2-e from embodied energy, amounting to 59 per cent of the total embodied emissions from the key construction materials associated with the Proposal. Consequently a review has been undertaken to identify potential opportunities to minimise GHG emissions embodied within concrete.

As noted above, a number of alternate materials may be used as substitutes to conventional concrete, such as asphalt, pavers or post-tension concrete. The use of any of these materials would reduce the embodied emissions associated with the pavement construction of the Stage 1 site. As concrete represents the worst case scenario further ways to potentially reduce embodied energy associated with the use of concrete are discussed below.

A significant opportunity to minimize GHG emissions from concrete consumption is to substitute Portland cement with materials such as local fly ash and blast furnace slag. In Portland cement manufacturing, almost one tonne of CO_2-e is released for every tonne of cement produced. The cement industry has reduced CO_2-e emissions significantly since the early 1980's and continues to develop methods that minimise the release of greenhouse gases, largely through the utilisation of supplementary cementituous materials such as fly ash, silica fume, ground granulated blast furnace slag and development of alternative binders to Portland cement (SCA, 2013).

Due to the large quantity of concrete possibly required, the Proposal will generate approximately 24,297 tCO_2-e from embodied GHG emissions, predominantly within the use of concrete within the Stage 1 site. This, however has been determined for a 40Mpa concrete with a 1:1.5:3 mix of cement, sand and aggregates. It has been assumed that a 'business as usual' cement mix would utilise 100 per cent Portland cement. Given the large volume of concrete required, and the high contribution to embodied GHG emissions, cementituous substitutions therefore may present an opportunity to significantly reduce embodied emissions.

Two cementituous substitution materials have been considered as appropriate for possible use in concrete for the Proposal, should this material be used; slag and fly ash. Slag is produced in a blast furnace during the reduction of iron ore to iron. By processing blast furnace slag into slag cement or slag aggregate, the material is diverted from landfills. Consequently utilisation of slag cement in concrete not only lessens the burden on landfill, it also conserves virgin manufactured produced. In addition, slag cement requires nearly 90 per cent less energy to produce than an equivalent amount of Portland cement, and consequently reduces the embodied emissions (SCA, 2013).

Fly ash is a by-product of coal combustion in power stations. The use of fly ash in concrete can lead to many improvements in both environmental and overall concrete performance.

The level of substitution of fly ash and/or slag is largely governed by the concrete specifications including compressive strength required for a particular purpose. Two indicative concrete mix types have been identified as being suitable for substitutions with a 40Mpa (1:1.5:3) for the Proposal, as follows:

- Mix One: 320 kg/m^3 of General Purpose Cement (Portland) and 60 kg/m^3 of slag
- Mix Two: 255 kg/m^3 of General Purpose Cement, 90 kg/m^3 and 135 kg/m^3 of slag

Based on the possible volume of concrete required as part of the Proposal the use of Mix One would generate approximately 22,017 tCO_2-e and Mix Two would generate 18,604.76 tCO_2-e, resulting in a 17 per cent and 30 per cent reduction in the concrete embodied emissions compared to the BAU scenario respectively, where concrete is used for hardstand areas across the entirety of the Stage 1 site. Figure 6-3 shows the total embodied GHG emissions for the volume of possible concrete required for the Proposal using alternate concrete mixes. It is noted that despite making up the majority of the embodied GHG emissions within concrete, cement comprises only a portion of the total materials used to make concrete. Little variance has been demonstrated within the other inputs into concrete (e.g. aggregate, sand and water) between the different concrete mixes.

In a worst case scenario, where concrete is selected for pavements, the application of measures such as fly ash and/or slag mixes would result in a reduction of embodied GHG emissions. The final pavement type, when selected, would consider alternate mixes/types which may reduce the embodied energy of that application, where appropriate.

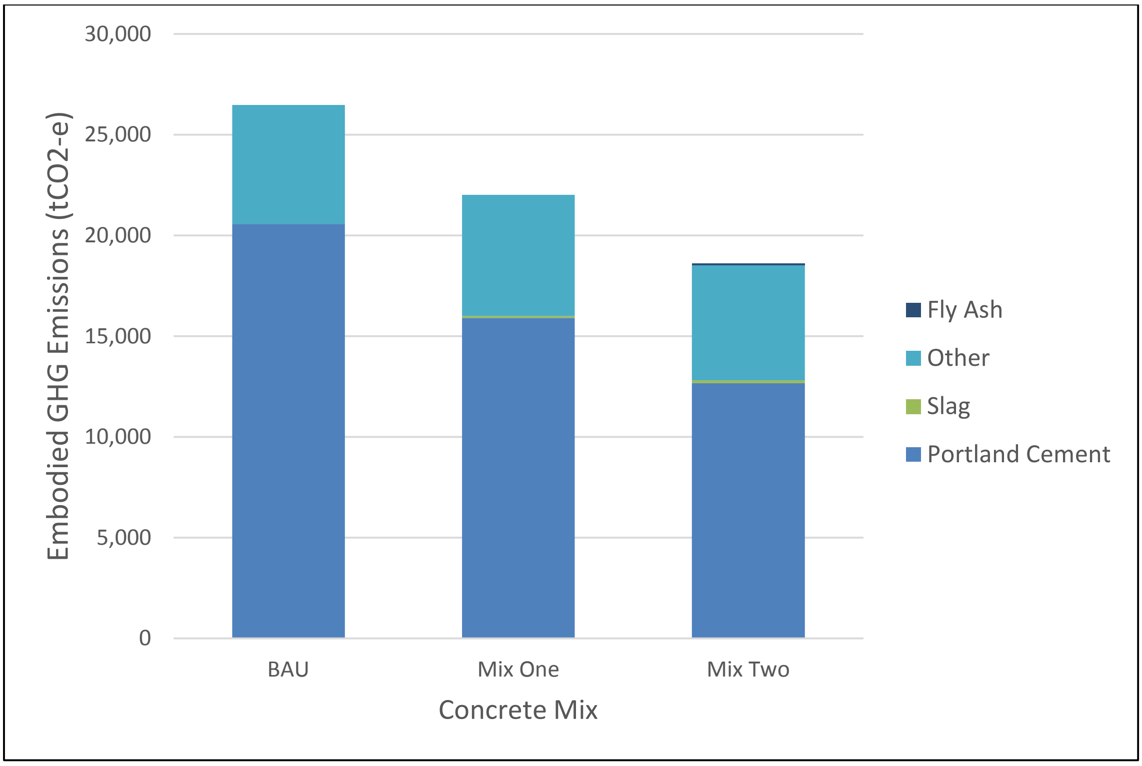

Figure 6-3 Embodied GHG Emissions associated with different concrete mix types

7 SUMMARY OF GHG EMISSIONS FROM THE PROPOSAL

This section summarises the total GHG emissions that will be generated by the Proposal. The construction phase of the Proposal will generate approximately 4,262 tCO_2-e over an 18 month period, including 3,691 tCO_2-e of Scope 1 GHG emissions. Embodied GHG emission from the key construction materials will generate 44,668 tCO_2-e under a worst case scenario (use of concrete for pavement construction within Stage 1 site), or more than ten times the emissions generated during the construction phase. Embodied GHG emissions, however, represent a full life cycle emission generation across the entire operational life of the Proposal. Operational GHG emissions with a throughput of 250,000 TEU per annum, based on the worst case scenario (where gantry cranes would be in operation) would equate to approximately 9,221 tCO_2-e, including 1,509 tCO_2-e Scope 1 GHG emissions and 6,669 tCO_2-e Scope 2 emissions (refer Table 7-1).

Table 7-1 Total GHG emissions from the Proposal

Proposal stage	Proposal component	Scope 1 emissions (tCO_2-e)	Scope 2 emissions (tCO_2-e)	Scope 3 emissions (tCO_2-e)
Construction (total)	Works period 1	1,545.52	-	270.24
	Works period 2	470.88	-	2.47
	Works period 3	1,173.32	-	6.43
	Works period 4	425.01	58.97	8.44
	Works period 5	76.09	-	1.12
	Site Offices (Works period 1-5)		223.59	-
Total Construction GHG emissions		**3,690.82**	**282.56**	**288.70**
Embodied GHG emissions (total)		-	-	44,668.4
Operational GHG emissions (annual)	Electricity consumption		6,669.38	
	Onsite Machinery	425.44		
	Transportation GHG emissions	1,083.92		1,012.33
Total Operational		**1,509.36**	**6,669.38**	**1,012.33**

To provide a comparison of GHG emissions produced as a result of construction, materials and operation, total GHG emissions have been accumulated over a 20 year period[2]. Figure 7-1 shows the comparison of cumulative tCO2-e generated as a result of construction, materials and operation. As evidenced by Figure 7-1 the construction phase will contribute a negligible amount when compared to the operational GHG emissions over the 20 year period. Similarly, operational GHG emissions will accumulate to over four times the total embodied GHG emissions over the period. This assessment is likely to overstate the materials cumulative impact, as it has apportioned the total embodied GHG emissions for the Proposal over the 20 year period, however it is likely that the materials will be in use for a longer period than this. It is also noted that, as discussed in Section 6.2, use of a alternatives to concrete (such as asphalt, pavers of post-tension slabs), or alternate concrete mixes (such as slag and/or fly ash) may result in significantly lower embodied GHG emissions within materials.

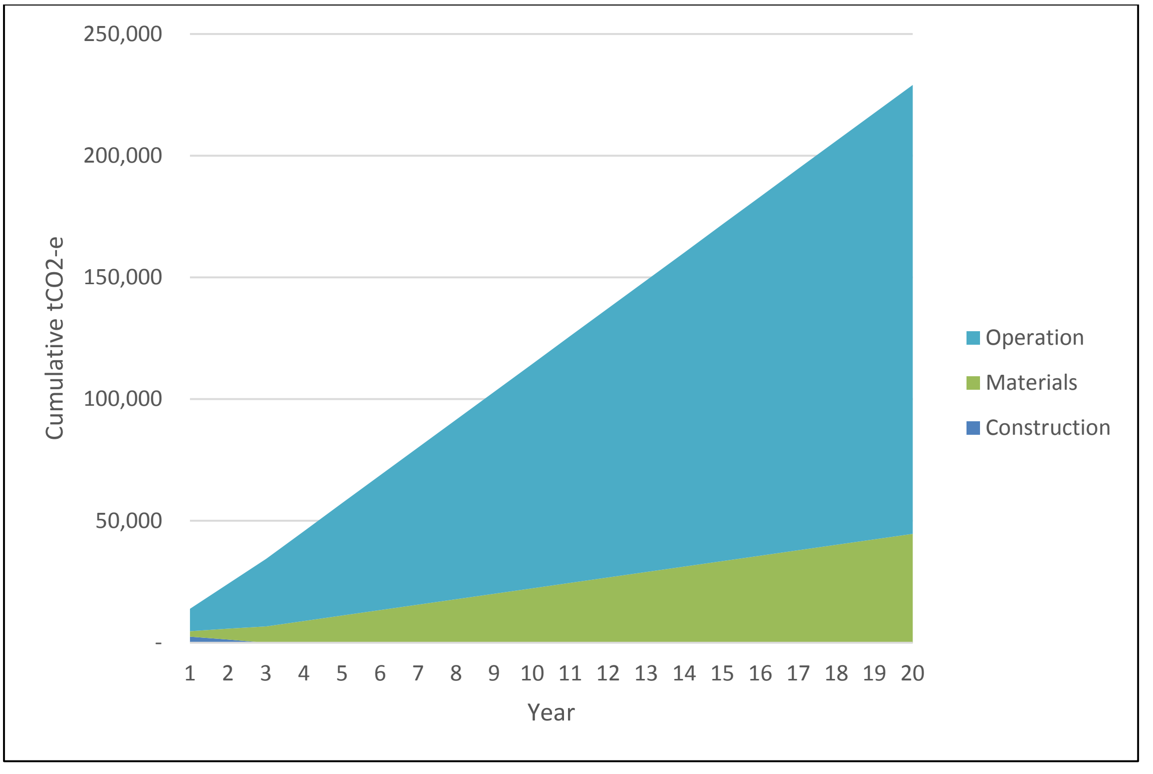

Figure 7-1 Cumulative total GHG emissions (tCO_2-e)

[2] A 20 year period has been selected to conservatively apportion embodied energy across a period of time. That is, if total construction emissions, annual operation emissions and embodied emissions were directly compared embodied energy would appear significantly higher than either construction or operation. This would be inconsistent with the whole of life assessment undertaken for materials. Instead this period aims to demonstrate conservative whole of life embodied energy compared with operational and construction emissions over a single period. It is likely that the comparative 20 year period will overstate the materials cumulative impact, as materials would last for a longer period than this, however it provides indicative context for identifying GHG contributions as a result of the Proposal.

8 FREIGHT TRANSPORT GHG EMISSIONS

The Proposal is intended to improve freight transport efficiency within the Moorebank freight catchment. Transporting freight by rail from Port Botany to the intermodal terminal facility will result in a significant reduction in road transport from Port Botany to the freight catchment area. One train can accommodate transport of up to 81 TEU to/from Port Botany to/from the Proposal site, whereas one truck will accommodate 2.08 TEU of freight per trip. The consolidation of freight distribution facilities within the freight catchment area will also result in a central distribution point where freight can be efficiently delivered to/from end destinations within the catchment area. The benefits of this consolidation are expected to be twofold:

- A significant reduction in road traffic
- A significant reduction in transport related GHG emissions associated with the transfer of road transport to more efficient rail transport

To determine the reduction in GHG emissions associated with freight transport, a comparison of the total vehicle kilometres travelled (VKT) for road and rail freight has been undertaken for a scenario with, and without, the SIMTA Project. As noted in Section 5.2.1, transport of freight to and from the Proposal site would generate Scope 3 emissions as they are not under the direct ownership, or operational control of SIMTA and occur offsite. However, the proportion of GHG emissions attributed directly to SIMTA associated with transport have been calculated as Scope 1 and are incorporated in the operational assessment of the Proposal (refer Section 5).

The purpose of the assessment of freight transport GHG emissions is to provide an indication of the net reduction in GHG emissions associated with the Proposal from the change in freight distribution methods and locations. This section, consequently, describes the total GHG emissions associated with freight transport without apportioning the relevant responsibility for these GHG emissions (e.g. between the freight distribution company, manufacturers, SIMTA etc.). As a result freight distribution GHG emissions have been assessed, and calculated, as Scope 1 emissions.

8.1 ASSESSMENT OF FREIGHT TRANSPORT GHG EMISSIONS

The vehicle kilometres travelled (VKT) for road and rail freight were projected, as part of the Concept Plan Approval for 2031, with the SIMTA Project providing port related freight distribution to/ from the catchment area. These projections have been made based on expected increases in freight demand by 2031. The ‘without SIMTA’ projection uses freight demand projections for the entire Sydney catchment to estimate the VKT required using unconsolidated distribution facilities. The ‘with SIMTA’ projections use the same freight demand but estimate VKT required using the consolidated distribution centre proposed in this Proposal. The VKT attributable to the Proposal have been determined in proportion to the freight attributable to this phase of the SIMTA Project (i.e. 250,000 TEU).

Table 8-1 Comparison of VKT required to meet freight demands in the Moorebank catchment with and without the SIMTA Project

Freight Transport Type	Projected annual vehicle kilometres (VKT) required to meet freight demands in 2031		Difference
	Without SIMTA proposal	With Stage 1 SIMTA Proposal	
Road	1,979,579,000	1,976,329,000	3,250,000
Rail	0	83,000	83,000

The traffic projections suggest that freight road transport from Port Botany will be reduced by approximately 3,250,000 VKT per annum regionally by 2031. The resulting increase in rail transport as a result of the Proposal is projected to be approximately 332,000 VKT.

While the VKT attributable to the Proposal outlined above have been determined in direct proportion attributable to this phase of the SIMTA Project, GHG emissions associated with the change in freight movements cannot be considered proportionately to those identified in the Concept Plan Approval. Freight transportation efficiency continues to improve rapidly in Australia, notably following mandatory heavy vehicle exhaust emissions standards that were brought in for all heavy vehicles built after 1 January 2011 (Australian Standard ADR 80/03). As the proportion of the transportation fleet built post 2011 increases, the average GHG emissions produced per vehicle will continue to decrease.

Furthermore reporting methods and data are continually improving and being updated. The culmination of the above considerations is that the proportion of GHG emissions reduced by the modal shift in freight transportation caused by the Project would become gradually lower as total emissions produced by heavy vehicles reduce.

Table 8-2 outlines the GHG savings from the reduction in road transport and the corresponding GHG emissions increase due to increased rail transport.

Table 8-2 GHG estimates from freight transport as a result of the Proposal[3]

Freight Transport Type	Projected GHG emissions from estimate VKT in 2031 (tCO_2-e)		Difference (tCO_2-e)
	Without SIMTA proposal (tCO_2-e)	With Stage 1 SIMTA Proposal (tCO_2-e)	
Road	3,057,681	3,052,628	5,053 (savings)
Rail	-	1,146	1,146 (increase)
		Net GHG savings/increase	**3,907 (savings)**

[3] The VKT assessment was prepared as part of the Concept Approval EA for the entire SIMTA Project at full operation (2031). It has been assumed that the VKT assessment would be unchanged and the VKT attributable to the Stage 1 Proposal has been assumed to equate to one quarter of the total VKT modelled. It is noted, however, that the GHG emissions produced as a result of VKT reduction has not been assumed to be one quarter of those reported in the Concept Approval EA. GHG emissions have been updated to reflect the latest NGA emissions factors, Global Warming Potentials and an increased efficiency in transportation of freight. Average fuel consumption rates for articulated road haulers has been determined based on ABS data (ABS, 2013) and as reported by Roads and Maritime Service (2013).

Figure 8-1 demonstrates the GHG emissions savings that the Proposal will produce through the use of rail for freight transport to a consolidated intermodal terminal facility compared to road freight transport to a number of distribution facilities dispersed across all catchment areas within Sydney. The net reduction in GHG emissions from freight transport as a result of the Proposal has been estimated to be approximately 3,907 tCO_2-e/year. This is equivalent to more than 40 per cent of the annual operational emissions under the worst case scenario.

It shows that the savings generated from reduced road transport significantly outweighs the increase in GHG emissions from rail transport. The greater efficiencies are gained from transporting much larger quantities of freight (81 TEU) by a single train as opposed to a single truck journey (2.08 TEU).

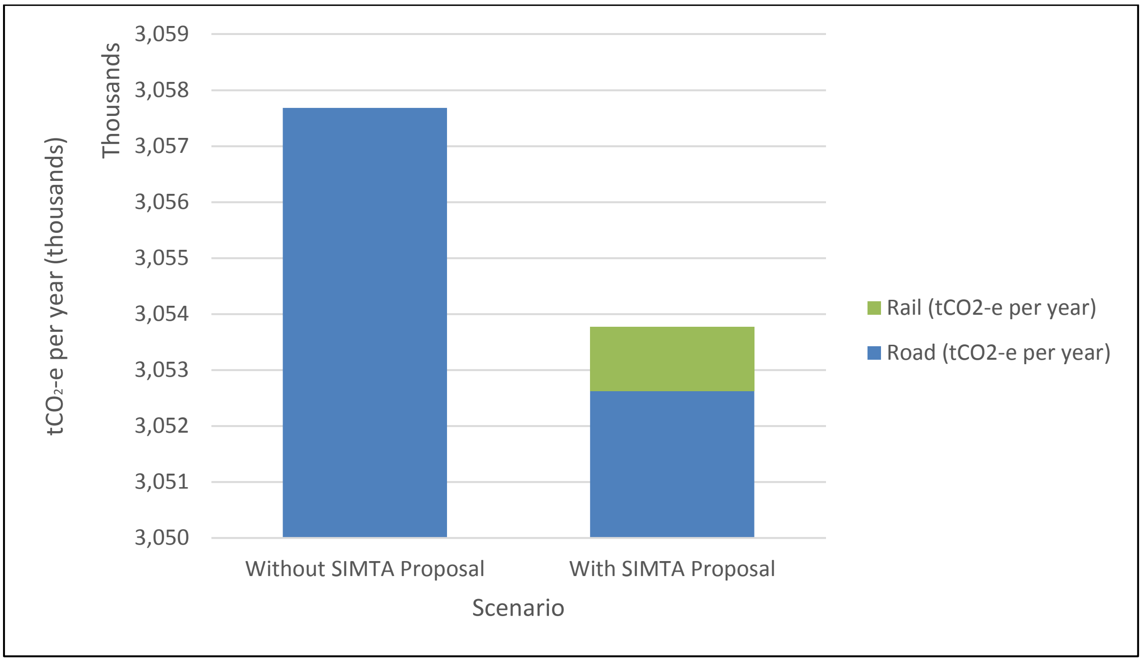

Figure 8-1 Estimated GHG emissions from freight transport with Proposal fully operational (2031)

9 GHG MITIGATION STRATEGIES

The carbon management principles (shown in Figure 9-1) provide a robust framework for the management and reduction of GHG emissions.

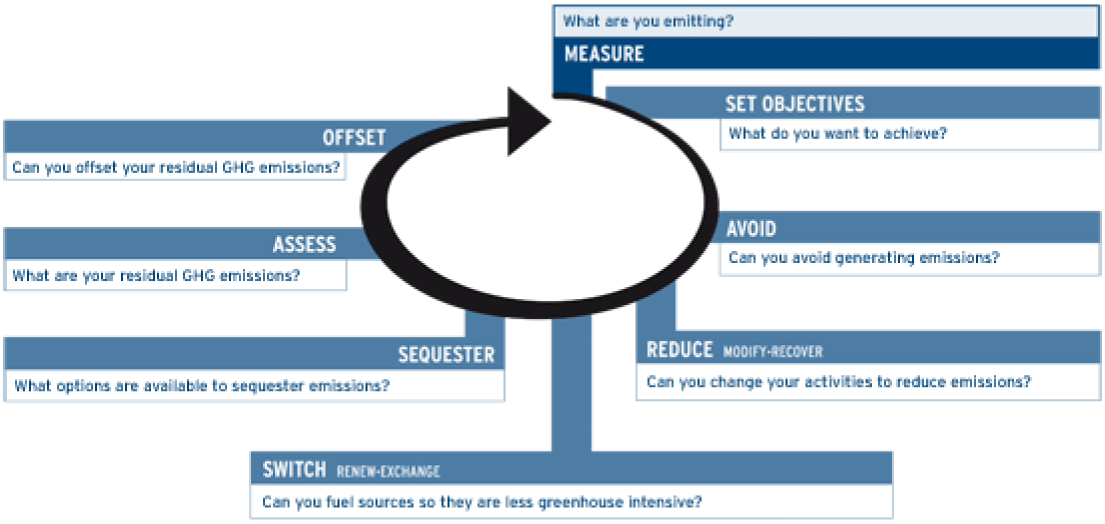

Figure 9-1 Carbon management principles for GHG emissions reduction (EPA Victorian, 2012)

The earlier sections in this assessment represent the GHG emissions measurement and setting objectives components of the carbon management principles. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles as illustrated below in Table 9-1.

Table 9-1 Carbon management principles and a brief description of each

Management principle	Description
Avoid	Actions which avoid emissions, in the first instance, should be considered as a priority
Reduce	Actions which result in a reduction of emissions should be considered next
Switch	Actions which switch energy sources to reduce emissions should be the next considered
Sequester	Actions which sequester GHG emissions do not reduce emissions but store them
Offset	Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

9.1 GREENHOUSE GAS MANAGEMENT PLAN

As per the conditions of the Concept Plan Approval, a Greenhouse Gas Management Plan will be prepared for each of the three major stages of the SIMTA Project. Section 1-8 of this report provides the context and updated GHG assessment for the GHG Management Plan for Stage 1 (the Proposal). The mitigation measures and management strategies identified for the Proposal are provided in Sections 9.2-9.3 below. In addition a number of additional potential abatement opportunities have been identified, including the marginal cost of abatement (refer Section 10). Furthermore climate change risks and adaptive measures are assessed in Section 11. A summary of the management strategy for GHGs and climate change risks is provided in Appendix A.

It is recommended that the mitigation measures, management strategies and abatement opportunities presented in this report are reviewed and updated as appropriate for incorporation into the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP), as required.

9.2 MITIGATION MEASURES

9.2.1 CONSTRUCTION

The following actions would be implemented, where reasonable and feasible, for mitigation of GHG emissions during construction:

- Where possible locally sourced materials will be used to reduce GHG emissions associated with transport
- Construction and demolition waste will be recovered and recycled where possible, and vegetation waste would be composted
- Construction works will be planned to minimise double handling of materials
- Recycled materials will be reused where possible to reduce GHG emissions associated with embodied energy
- Construction/transport plans will be incorporated within the CEMP to minimise the use of fuel during each construction.
- Fuel efficiency of the construction plant/equipment will be assessed prior to selection, and where practical, equipment with the highest fuel efficiency and which uses lower GHG intensive fuel (e.g. biodiesel) would be used
- On-site vehicles will be fitted with exhaust controls in accordance with the *Protection of the Environment Operations (Clean Air) Regulation 2010* as required
- Regular maintenance of equipment will be undertaken to maintain good operations and fuel efficiency
- Where practicable, trucks removing waste from the site or bringing materials to the site will be filled to the maximum amount allowable, depending on the truck size and load weight, to reduce the number of traffic movements required
- Consideration will be given to the embodied energy content of construction materials selected
- The mitigation measures, management strategies and abatement opportunities presented in this report will be reviewed and considered where appropriate for incorporation into the Construction Environmental Management Plan (CEMP).

9.2.2 CPERATION

The following actions will be implemented, where reasonable and feasible, for mitigation of GHG emissions during the operation of the Proposal:

- Energy efficiency design aspects will be incorporated wherever possible to reduce energy demand
- The procurement of energy efficient equipment will be investigated for the site
- Regular maintenance of equipment with be undertaken to maintain good operations and fuel efficiency
- The potential liabilities under the NGER Act will be identified by the proponent to determine any requirement's for monitoring and reporting. If required, monitoring and reporting of GHG emissions will be carried out for the operation of the Proposal on an annual operational basis for incorporation into NGER reporting for the operationally controlling corporation
- Consideration will be given to undertake further investigation and implementation of cost negative abatement opportunities
- Further investigation of abatement opportunities will be considered once the facility moves from the use of forklifts to the operation of gantry cranes
- The mitigation measures, management strategies and abatement opportunities presented in this report will be reviewed and considered where appropriate for incorporation into the Operational Environmental Management Plan (OEMP).

10 MARGINAL ABATEMENT COST ANALYSIS

In addition to the mitigation measures outlined in Section 9 above, a marginal abatement cost analysis has been undertaken to determine the feasibility of implementing additional mitigation and abatement opportunities. Marginal Abatement Cost (MAC) curves are one of the principle tools used to measure the relative economic impact of GHG emissions abatement mechanisms. Marginal abatement means the cost to reduce or offset one unit of pollution; in this case one tonne of GHG emissions. MAC curves generally show the cost, in $ per tonne CO_2-e, associated with the GHG emissions reductions achievable by different energy efficiency projects at a given point in time (CitySwitch, 2015).

10.1 METHODOLOGY

To produce the MCA curve, the abatement costs of technical reduction options have been calculated based on annual total costs and benefits. Construction and embodied energy have not been considered within the cost abatement analysis as operational GHG emissions will substantially contribute the majority of the GHG emissions over the Proposal life (refer Figure 7-1).

The methodology used to compile the MCA curve has been through the following key steps (described in detail below):

1 Establish a BAU baseline and abatement target

2 Identify and quantify potential emissions-reduction opportunities and their associated costs

3 Combine costs and benefits to form the operational GHG abatement cost curve for the Proposal

All cost and abatement potential estimates have been determined through a desktop analysis based on available market data and technical publications, to provide indicative MAC curves for the Proposal. SIMTA would need to obtain Proposal specific quotes and undertake a detailed cost analysis prior to procurement, if applicable.

10.1.1 DETERMINATION OF A BASELINE

In December 2007, Australia ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change. Under the Kyoto Protocol Australia committed to limiting its annual GHG emissions to an average of 108 per cent of 1990 levels over the period 2008 to 2012. Over this period Australia's GHG emissions averaged 104 per cent, allowing a carryover to its 2013-2020 Kyoto commitment of 166 MT CO_2-e.

Despite this Australia has committed unconditionally to reducing its GHG emissions by 5 per cent below 2000 levels by 2020.

Australia has also committed to reducing its GHG emissions by between 5 and 15 or 25 per cent below 2000 levels by 2020. As noted the five per cent target is unconditional. The up to 15 per cent and 25 per cent targets are conditional on the extent of international action. On 27 January 2010, Australia formally submitted its full target range to the Copenhagen Accord. The decision to maintain the full range is consistent with the approach taken by other countries.

Australia has committed to reduce its GHG emissions by 25 per cent compared with 2000 levels by 2020 if the world agrees to an ambitious deal capable of stabilising the level of GHGs in the atmosphere to 450 parts per million (ppm) CO_2-e or lower. If there is a global agreement that falls short of securing atmospheric stabilisation at 450 ppm CO_2-e under which major developing economies commit to substantially restraining their GHG emissions and advanced economies take on commitments comparable to Australia's, Australia has pledged to reduce GHG emissions by up to 15 per cent. These targets have been anchored under the Cancun Agreement (DoE, 2015).

The Australian Government has also committed to a long-term target to cut pollution by 80 per cent below 2000 levels by 2050.

The MAC curve prepared for the Proposal has been determined using the operational GHG inventory (Section 5) as the baseline, or BAU, scenario. To align to the current non-conditional target, a five per cent reduction target for the Proposal has been used to generate the MCA curve. In addition, a 15 per cent target has been set as an alternate scenario to align with the federal government's commitment to consider a 15 to 25 per cent target conditional on the extent of international action.

As discussed in Section 5, there are two operational scenarios for the Proposal; Scenario One (Forklifts) and Scenario Two (Gantry Cranes). As the two scenarios would produce different annual GHG emissions and would have different key sources of GHG emissions, separate abatement cost curves have been prepared; one for each scenario and for each abatement target. The target abatement potential for each scenario is shown Table 10-1 below.

Table 10-1 MAC curve abatement reduction targets

Scenario	Annual operational Emissions (tCO2-e/year) - BAU	Target Reduction (tCO2-e/year) 5 per cent target	Target Reduction (tCO2-e/year) 15 per cent target
Scenario One (Forklifts)	7,723	386	1,159
Scenario Two (Gantry Cranes)	9,221	461	1,383

10.2 ABATEMENT TECHNOLOGIES

A broad range of abatement technologies exist that could be employed as part of the Proposal. The MAC curve prepared as part of this report has not endeavoured to be exhaustive or prescriptive, and does not claim to cover every single emission abatement measure worthy of consideration. Instead, it aims to contain a reasonable sample of abatement opportunities, as an indicative exercise in determining an abatement cost curve. Primarily the technologies assessed are those that have been considered to have the largest abatement potential. For example lighting systems within the Administration facility have not been included as it is anticipated that, being a new development, a high level of efficiency will already be strived towards, and there will be little scope for significant efficiency improvements.

The assessment has also been limited to available technology today, and has not made an attempt to consider future technologies that may emerge. For example, while electric trucks may become available in the future, current electric trucks within Australia are limited to small or medium duty vehicles, with a range of up to approximately 200 km (requiring 5-6 hours of charge overnight) (Toll, 2015). While this is not a feasible option for the Proposal using today's technologies, it may become feasible as technology improves and Australia's electricity industry decarbonises.

Each technology has been assessed in isolation, so that the cost and abatement potential reported should be considered on an individual merit basis. If abatement measures are employed in sequence this is likely to have an impact on the total costs and benefits realised. For example, if both biofuels and eco-driving measures (described below) are employed the total savings from employing the latter will be dependent on the fuel reduction realised from employing the former technology.

Finally, the assessment has been prepared prioritising the *Carbon Management Principles for Emissions Reduction* (refer Section 9), such that offsetting has been considered as a last resort. The analysis indicated that the cost to abate through the purchase of offsets may present a more cost effective option than implementation of some alternate technologies. Therefore each technology's use has been prioritised based on its abatement merits, and offsetting has been modelled only to the extent required to achieve any gaps in the target reduction, where this is applicable.

A brief description of the technologies analysed, and the methodology employed to determine the costs and benefits of each technology, is provided below.

Biofuels

Biofuels in Australia are predominantly manufactured from used cooking oil and animal fats (tallow). The *National Greenhouse Gas Account Factors* (NGA Factors) indicate that the use of Biodiesel when compared with regular diesel fuel results in a reduction in GHG emissions of greater than 95 per cent. However, it should be noted that while on a tailpipe emission basis the opportunity for GHG emissions reduction is high, this does not take into consideration a complete life cycle assessment of biofuels; such as consideration of land clearing loss of carbon sequestration associated with the use of some biofuels.

CSIRO (2012) estimate that a mid-range abatement fraction for biodiesel, which allows for all upstream GHG emissions from the feedstock and fuel production stages, of 65 per cent abatement potential is a more realistic life cycle estimate than adopting a tailpipe emission reduction. Consequently an emission saving fraction of 0.65 has been adopted for the purpose of this assessment. B20 Biodiesel contains up to 20 per cent volume Biodiesel and is suitable for high speed diesel engines servicing wide load and speed variation and suitable for the transport automotive industry. Biodiesel B20 is suitable for use in modern engines fitted with exhaust after-treatment devices. An adoption fraction of 0.7 (i.e. 70 per cent of trucks being able to adopt the use of Biodiesel) has been estimated for the purpose of this assessment (CSIRO, 2012).

Roads and Maritime Service (2012) indicated that fuel consumption rates associated with the use of B20 result in a fuel economy benefit in the order of 0.5 per cent, or a reduction in fuel used per 100 km of 0.69 litres.

SIMTA are expected to have operational control of approximately 10 per cent of the truck fleet used for the operation of the facility. Using the inputs above, the costs and benefits of potentially using B20 within the SIMTA operated truck fleet has been assessed.

Similarly, B20 is suitable for use in most heavy machinery types and models. Little discernible difference between fuel economies for heavy machinery has been reported between B20 biodiesel and regular diesel. Therefore for both Scenario One (Forklifts) and Scenario Two (Gantry Cranes) the assessment has allowed for the possible use of B20 biodiesel within the onsite heavy machinery. It is noted that no consideration has been given to costs associated with refuelling machinery with B20 fuel. For example if it would be required to be tankered to the site this may increase the marginal cost of abatement associated with its use. This cost is likely to be partially offset by bulk consumption of biodiesel (whereas costs have been estimated based on current bowser prices).

Eco Driving

Driver behaviour has been identified as having the greatest single energy and cost saving operational efficiency potential with regard to heavy vehicles use (CSIRO, 2012). Advances in new vehicle technology have continued to increase horsepower by some 20 to 50 per cent, which can easily result in drivers using excessive fuel by prematurely accelerating in varying traffic conditions (DRET, 2011). Driver training can have a significant impact on behaviours linked with; controlling vehicle speeds where conditions safely allow, improved awareness and reduced engine idling times.

There is a high level of variability in the reported fuel efficiency and savings associated with the implementation of eco-driving, ranging between 5 and 40 per cent (Alam and McNabola, 2014). The level of training provided has been shown to have a direct correlation with the fuel saving potential, such that full day extensive training courses have generally be shown to reduce fuel use by more than 15 per cent, while a reduction of 5 per cent may be realised through the use of on-line learning (RACQ, 2012).

This assessment has included the possibility of full day training course for those drivers that are under the direct control of SIMTA (i.e. approximately 10 per cent of the fleet distributing freight as part of the Proposal). A conservative estimate of an 11 per cent reduction in fuel use has been allocated for this portion of the fleet. The direct savings from fuel reductions would be realised for SIMTA under this scenario.

Solar Panels

Research and development associated with solar panels has resulted in rapid improvements in their efficiency and a subsequent reduction in the GHG emissions payback period, such that the average payback period for photovoltaic panels is 0.5 to 3 years (Solaria, 2015). No consideration of the lifecycle assessment has therefore been incorporated due to the relatively small volume of embodied GHG emissions, and anticipating continued improvements in solar panel efficiency.

A 50 kW solar panel system capable of generating195 kWh/day has been modelled for potential installation on the roof of the Administration facility[4]. Costs have been determined based on the market value of an equivalent system. No allowance has been made for the inclusion of rebates provided by the Government to offset these costs, such that the cost of abatement may be higher than what can potentially be achieved.

The possible use of individual solar panels associated with the luminaries for the Stage 1 site has also been modelled. The cost of installation of a solar luminaire, compared with a regular luminaire has been assumed to be equal, however an increase in the number of luminaires required has been modelled to allow for the lower wattage that a solar luminaire would generally be able to support.

In addition to solar luminaries and solar panels on the roof of the administration facilities, there may be potential opportunities to install free standing solar panels. This option may become more feasible in future stages of the SIMTA Project as additional land areas become available. This opportunity, or similar opportunities that may become available in the future, would help achieve the proponent’s commitment (as per the statement of commitments within the Concept Plan Approval) to implementing on-site renewable energy generation where applicable.

[4] This is the maximum system that could be installed given the roof area of the office.

Green energy

Currently coal and gas comprise of 74 per cent and 14 per cent of Australia's electricity mix respectively. Purchasing a percentage of GreenPower as part of the electricity mix replaces that proportion with electricity generated from a renewable source, including solar, wind, geothermal, biomass and low-impact hydropower. GreenPower is a national accreditation program for renewable energy, which sources energy that produce no net greenhouse gas emissions and has negligible impact on the environment. The potential purchase of green energy has been considered as a low priority abatement opportunity with regard to the *Carbon Management Principles for Emissions Reduction.* The percentage of green energy to be purchased has been assessed based on the target and the scenario assessed.

Carbon offsets

The purchase of carbon offsets has been considered as the lowest priority abatement opportunity for the Proposal with regard to the *Carbon Management Principles for Emissions Reduction*. An offset price of \$22/tCO_2-e has been used as required, where offsets would potentially be required to reach the defined target.

10.3 GHG EMISSIONS REDUCTION OPPORTUNITIES AND COSTS

For each opportunity analysis, the abatement cost is taken to be the additional cost to society of implementing the opportunity compared to the cost of the activity that would otherwise occur in the business-as-usual case. The volume of each initiative is its potential to reduce GHG emissions.

The various abatement measures were ordered from lowest to highest cost. Aggregating these possible opportunities in the form of a cost curve allows for analysis of the potential for GHG emissions reduction for the Proposal at a freight throughput of 250,000 TEU per annum. The cost and potential volume of each opportunity is plotted left to right in order from lowest to highest cost.

10.3.1 SCENARIO ONE (FORKLIFTS)

Figure 10-1 and Figure 10-2 show the MAC curve for operational Scenario One (Forklifts) for a 5 per cent and 15 per cent reduction target respectively. Both figures indicate that the use of Eco Driving (for the SIMTA fleet) and installation of solar panels represent negative cost opportunities whereby their possible implementation leads to cost savings. Figure 10-1 shows that only four technology types would be required to achieve a five per cent reduction in total annual operational GHG emissions. Whereas to achieve a 15 per cent reduction a broader range of technologies would need to be considered.

Based on the technologies modelled, the total potential cost of reducing GHG emissions by 5 per cent would be approximately \$50,000 per year, with an average cost of \$129/tCO_2-e abated. To achieve a 15 per cent reduction, this cost would increase to \$279,000 per year at an average cost of \$241/tCO_2-e abated.

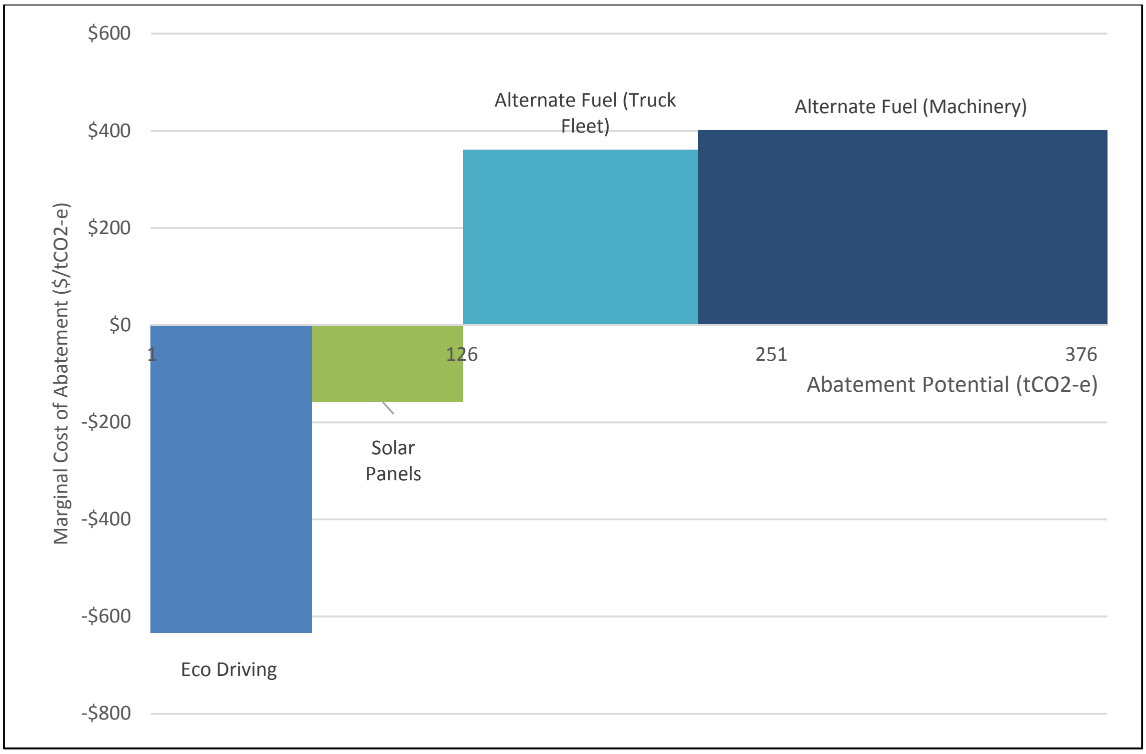

Figure 10-1 Scenario One (Forklifts) Five Per Cent Marginal Abatement Cost Curve

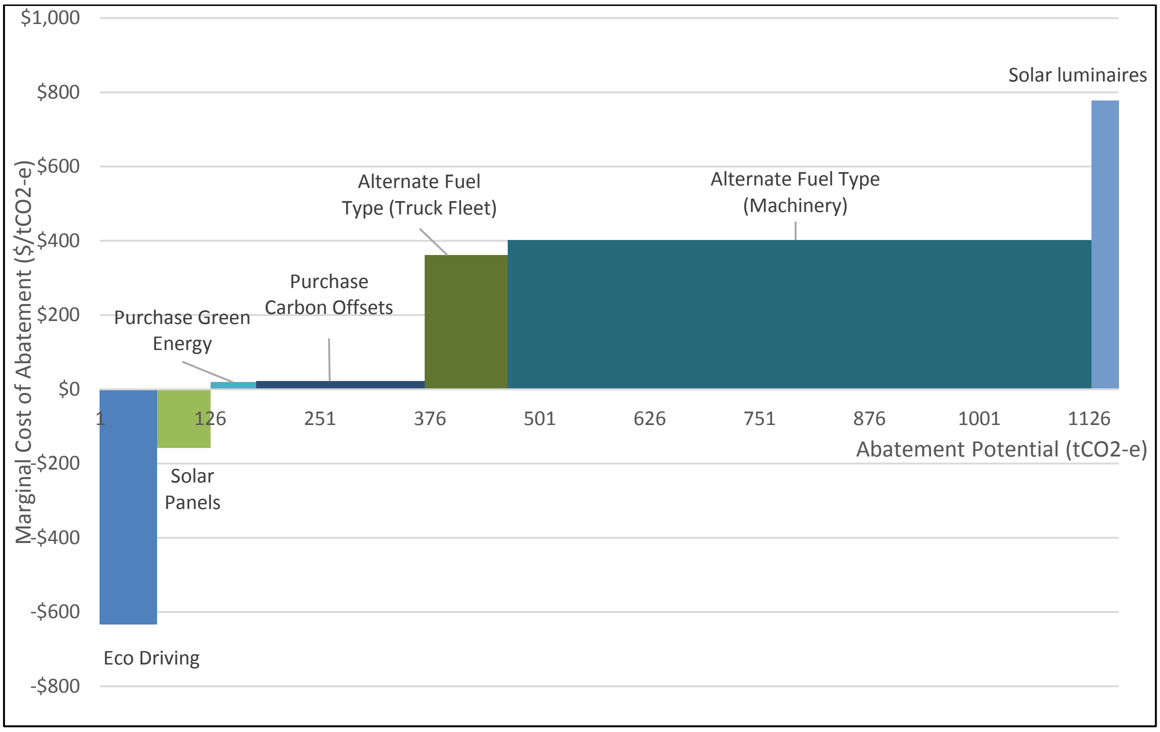

Figure 10-2 Scenario One (Forklifts) 15 Per Cent Abatement Cost Curve

10.3.2 SCENARIO TWO (GANTRY CRANES)

Figure 10-3 and Figure 10-4 show the 5 per cent and 15 per reduction target MAC curves for Scenario Two, where gantry cranes would be operational. As per Scenario One the use of eco driving and solar panels represent a possible cost saving opportunity. To achieve a five per cent reduction in GHG emissions under Scenario Two a capital cost of $32,000 per year would be required, with an average cost of $70/tCO$_2$-e abated. To achieve a 15 per cent reduction this cost would increase to $51,000, with an average cost of $37/tCO$_2$-e abated. Despite producing a greater volume of GHG emissions than Scenario One, Scenario Two would theoretically have a lower total cost of abatement. This is a result of the lower cost to abate per tonne associated with electricity consumption when compared to fuel consumption (i.e. the key difference in emissions sources associated with Scenario One and Scenario Two).

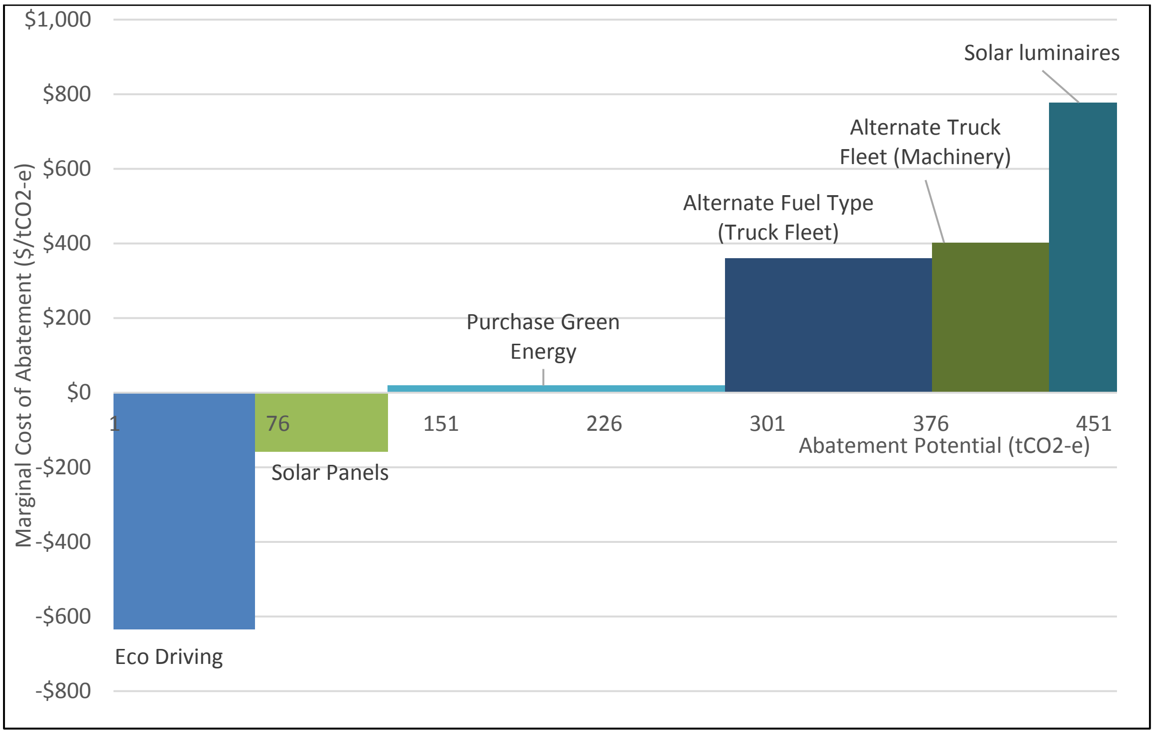

Figure 10-3 Scenario Two (Gantry Cranes) Five Per Cent Marginal Abatement Cost Curve

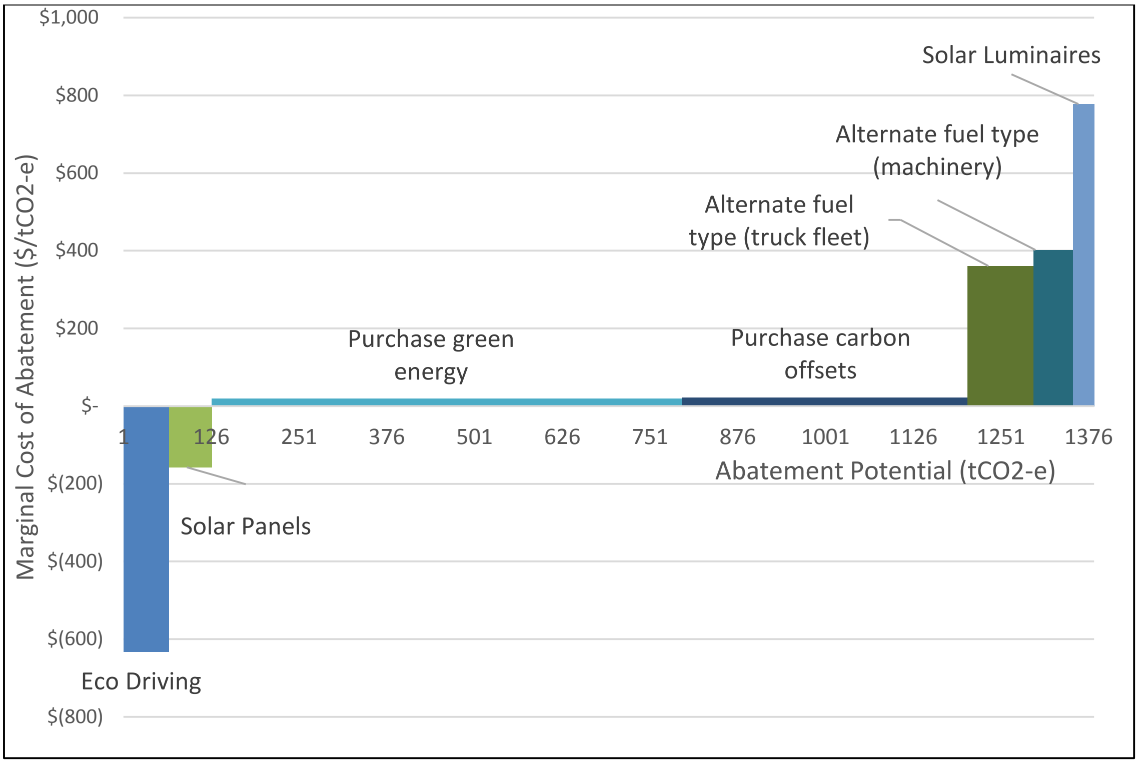

Figure 10-4 Scenario Two (Gantry Cranes) 15 Per Cent Marginal Abatement Cost Curve

Given that Scenario Two offers a potentially lower annual operational cost to abate GHG emissions than Scenario one, despite generating a greater volume of GHGs, it is considered more feasible to consider abatement opportunities once Scenario Two is realised. Notwithstanding this it is recommended that consideration be given to implementation of possible cost negative opportunities prior to commencement of and during operation.

11 CLIMATE CHANGE RISK AND ADAPTATION ASSESSMENT

Risks to the Proposal associated with climate change need to be understood and managed, where practicable to avoid impacts on customers, service reliability, environmental values, safety, project capital and operating costs. The purpose of assessing risks posed by climate change is to build adaptive capacity and resilience of the Proposal to potential hazards and risks associated with a changing climate.

There is a strong body of scientific evidence that climate change is occurring and that these changes are associated with release of GHG emissions from human activities. Future changes in climate have the potential to impact significantly on human and natural systems (IPCC, 2014). NSW is projected to experience the following climate changes:

- Most of the State is expected to become hotter, with higher maximum and minimum temperatures to be experienced across the State in all seasons
- Many parts of the State will experience a shift from winter-dominated to summer-dominated rainfall
- Higher evaporation is expected to impact much of NSW by 2050
- Increased risk of flooding due to increases in extreme rainfall

Due to the inertia of the climate system, even if GHGs released in the atmosphere are dramatically reduced, the warming trend is likely to continue during the 21st century (DECCW, 2010).

This section of the report provides summary information on the existing environment, climate change context, an assessment of potential impacts and risks for the Proposal and adaptation options that can be implemented to reduce the likelihood or consequences of potential risks.

Assessment Objectives

The objectives of the climate change risk assessment are:

- Determine the current climate and climate change context for the Proposal
- Identify the potential impacts of climate change on the Proposal
- Assess the level of climate related risks for the Proposal
- Identify appropriate climate change adaptation responses.

11.1 EXISTING ENVIRONMENT

11.1.1 CURRENT CLIMATE REGIME

Most of the Sydney region has a warm temperate climate. Average annual rainfall in greater Sydney is slightly less than 950 mm, ranging from more than 1200 mm near the coast to slightly less than 800 mm in the west. Rainfall throughout the region is greatest in summer and autumn, with a slightly higher proportion of winter rainfall on the coast than inland. Because evaporation and transpiration are lowest in autumn and winter, run-off is highest in autumn and winter and lowest in spring.

The Proposal area has a temperate climate with warm summers and cool winters. The warmest month is January and the coldest month is July. Rainfall fluctuates slightly through the year, but is marginally higher during the first half of the year, when easterly winds dominate. The El Niño

Southern Oscillation plays an important role in determining the region's weather patterns. Drought and bushfire on the one hand, and storms and flooding on the other, are associated with the opposite phases of the oscillation. El Niño (dry) and La Niña (wet) episodes can often be detected through the Southern Oscillation Index. These events impact directly on climate variables.

Historic weather data was obtained from the Bureau of Meteorology (BoM) Bankstown Airport weather station (Station ID 066137) for rainfall, temperature, humidity and wind speed.

A review of these records found the following:

- Highest average rainfall is in February (107 millimetres)
- The highest daily rainfall event was in February 1990 with 439.8 millimetres being recorded
- The lowest average rainfall month is September (43.8 millimetres)
- The average maximum temperature ranges between 17.2 °C (July) and 28.2 °C (January)
- The highest recorded maximum at the weather station was 46.1 °C recorded on 18 January 2013
- Average wind speeds for any month range from 6.6 km/h (9am) to 22.6 km/h (3pm), with highest wind speeds recorded most frequently from the southwest to westerly direction
- The windiest months are generally January (20.9 km/h), October (20.9 km/h), November (21.6 km/h) and December (22.6 km/h)
- Relative humidity in the area typically ranges between 44 per cent (3pm) and 80 per cent (9am)

The climate regime determined for the Proposal site, based on historical data (1968-2014) is presented in the sections below.

Rainfall

Figure 11-1 shows the historic monthly rainfall recorded at the Bankstown Airport weather station over the period 1968 to 2014. On average, the highest rainfall month is February (439.8 millimetres) with the lowest rainfall month being July (150.2 millimetres). The highest and lowest monthly average records for rainfall are also presented as an indication of the variability in monthly rainfall. As an indication of extreme rainfall events the highest daily rainfall is also presented. The data shows that there have been daily rainfall events recorded in every month that has exceeded the average rainfall for the entire month.

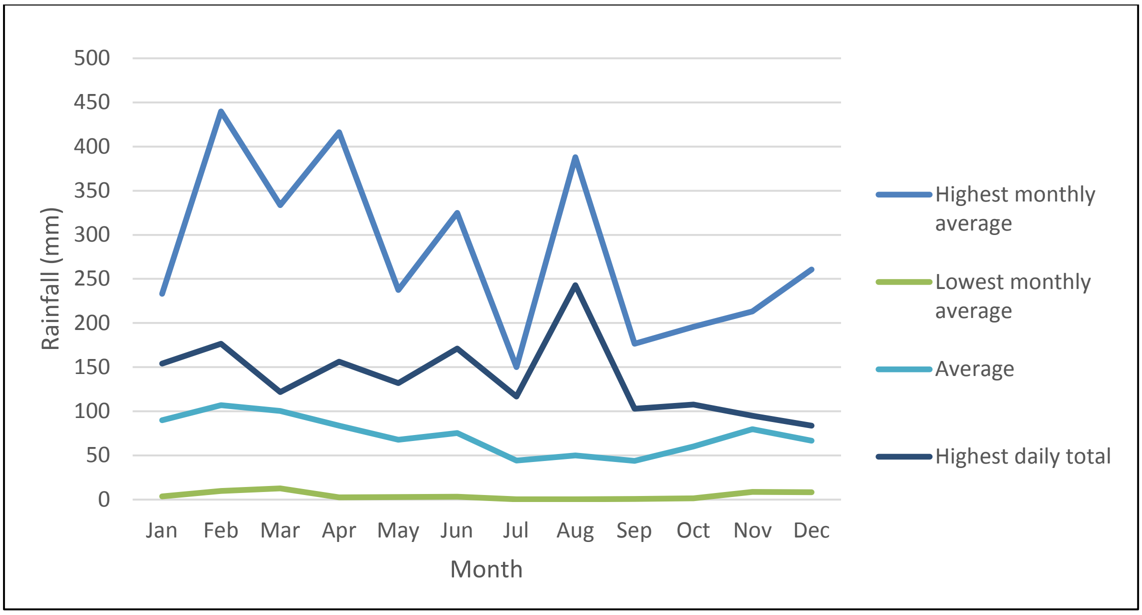

Figure 11-1 Average historic annual rainfall (BoM, 2015a)

Temperature

Based on long-term (1910-2013) observations, temperatures in the Sydney Region have been increasing since about 1960, with higher temperatures experienced in recent decades (OEH, 2014). 2014 was Australia's third-warmest year since national temperature observations commenced in 1910. Following Australia's warmest year on record in 2013, both maximum and minimum temperatures remained well above average, with frequent periods of abnormally warm weather throughout the year.

Historic temperature data from the BoM was analysed for the period 1968–2014. Figure 11-2 shows the mean monthly maximum and minimum temperatures between 1968 and 2014. On average the hottest month is January (mean maximum 28.2 °C and mean minimum 18.1°C) and the coolest is July (mean maximum 17.2 °C and mean minimum 5.1°C). The highest and lowest recorded temperatures for each month since monitoring began in 1968 are also presented as an indication of the variability.

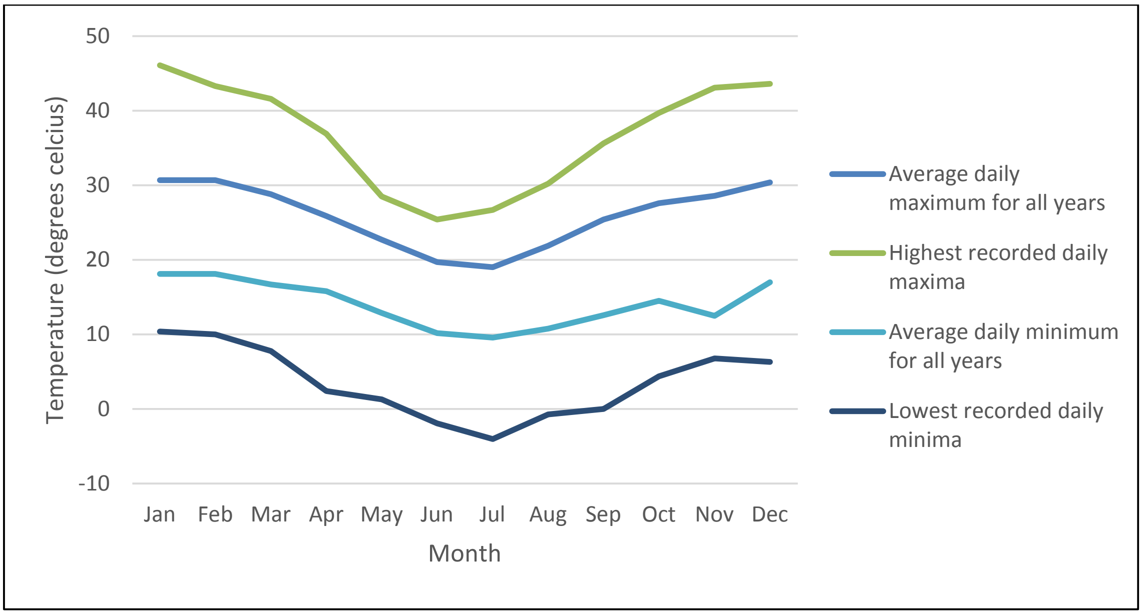

Figure 11-2 Historic average annual temperatures (BoM, 2015a)

Figure 11-3 shows the number of days with temperatures greater than 30, 35 and 40 °C recorded for each month since 1968. January had the most number of days above 30 °C (11.6 days).

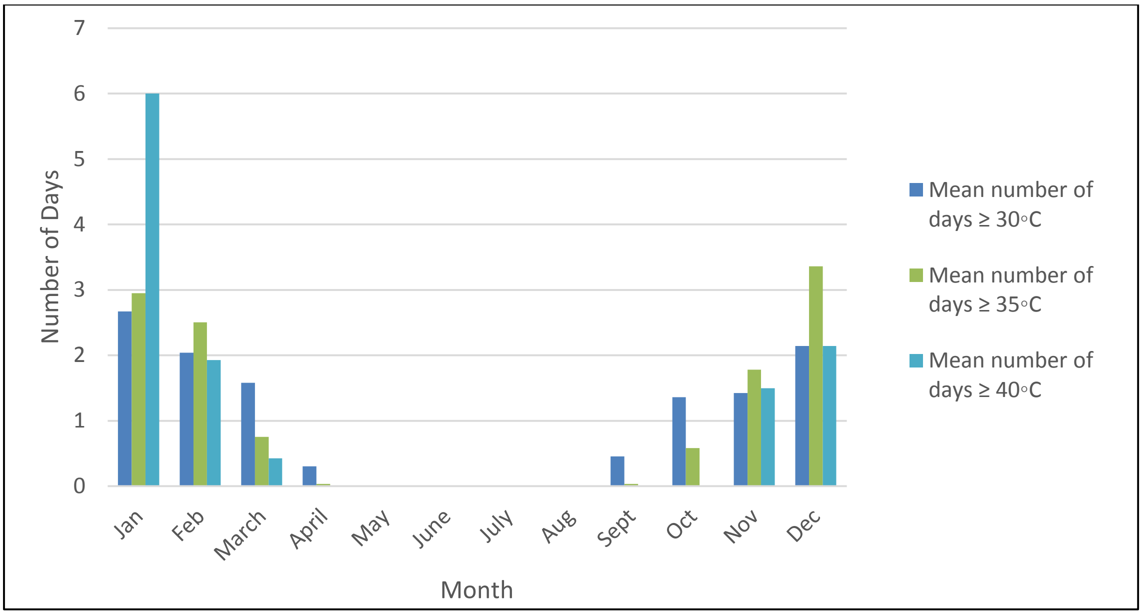

Figure 11-3 Average number of days above 30, 34 and 40ºC recorded at the Bankstown Airport weather station (BoM, 2015a)

Wind speed

The mean wind speed recorded at 9am and 3pm at the Bankstown Airport weather station is shown in Figure 11-4. Mean wind speeds were generally lower in the morning and during the months March to July.

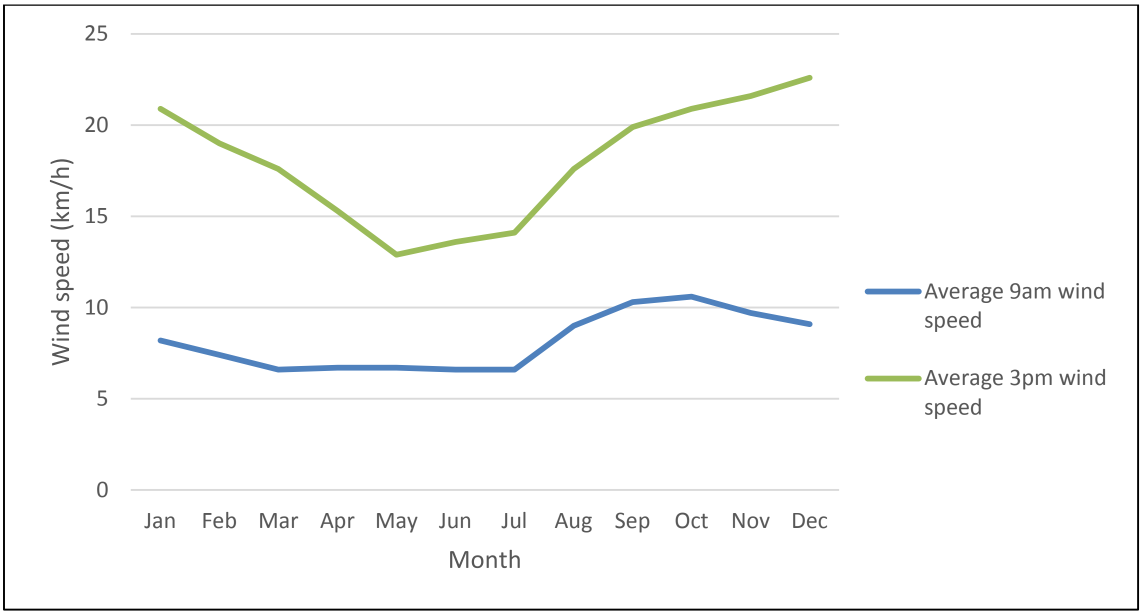

Figure 11-4 Mean 9am and 3pm wind speeds for each month (BoM, 2015a)

Relative humidity

The mean relative humidity at the Bankstown Airport weather station is higher at 9am in the morning relative to 3pm in the afternoon for all months (refer to Figure 11-5) This is likely to be due to the lower wind speeds in the morning that increase in the afternoon, which have the effect of lowering the relative humidity.

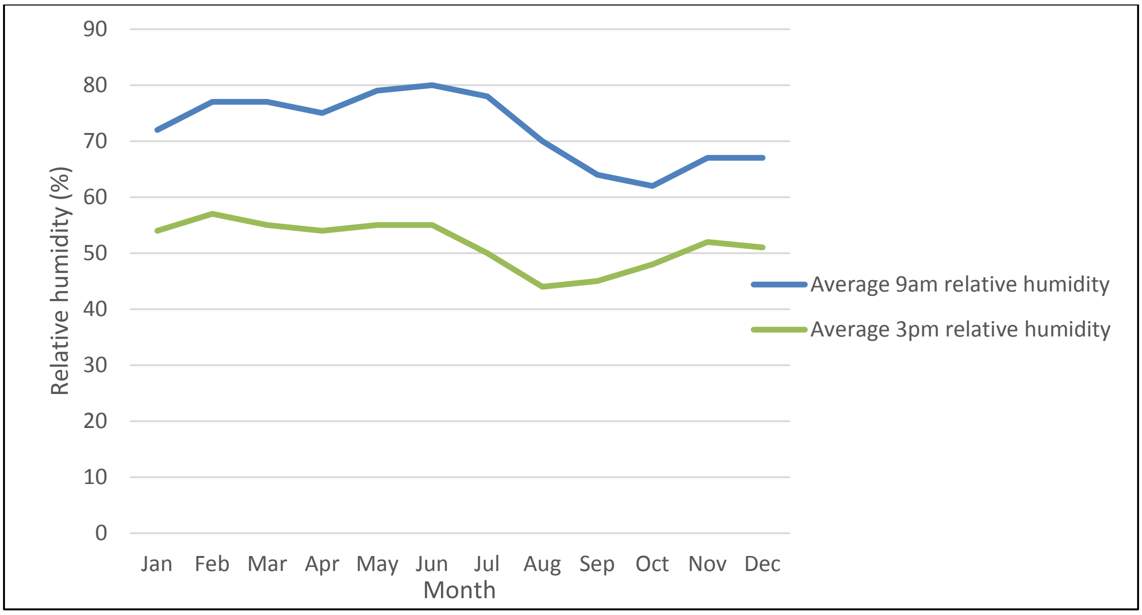

Figure 11-5 Mean 9am and 3pm relative humidity for each month (BoM, 2015a)

11.2 EXISITNG CLIMATE RISKS

It is likely that the area is predisposed to the following natural hazards as a result of the locations climate regime:

- Flooding
- Bushfire
- Hail, lightning and wind from severe thunderstorms
- Heat waves.

Flooding

The eastern portion of the Stage 1 site is adjacent to, and sits within the catchment of, Anzac Creek, a small tributary of the Georges River with a catchment area of some 10.6-squared-kilometres.The *Anzac Creek Flood Study* was completed in December 2005 (Bewsher Consulting, 2005), the outcome of which was the production of flood inundation and flood risk mapping generated from detailed hydrologic and hydraulic modelling of the catchment. The study established peak flood levels, flows and inundation extents for a range of probabilistic design event magnitudes up to the Probable Maximum Flood (PMF). The Flood Planning Level is the level below which planning controls are generally applied to development. The Flood Prone Land is PMF extent of inundation. The *Anzac Creek Floodplain Risk Management Study and Plan* was developed in 2008 (BMT WBM, 2008).

Figure 11-6, shows the extent of flooding relevant to the Proposal site. This indicates that the Stage 1 site is not part of the flood planning area.

The Rail Corridor, and rail link is intersected by the Anzac Creek catchment in the eastern section of the corridor, adjacent to the southern boundary of the Stage 1 site. The Georges River dissects the central section of the Rail Corridor and flows almost parallel to the eastern boundary of the Stage 1 site. Figure 11-6 shows that area of the Rail Corridor that is identified as flood prone land, particularly the eastern section, located south of the Stage 1 site and in the Anzac Creek catchment and the central and western areas located in the Georges River catchment. The latter area of flood prone land is located within the Glenfield Waste Disposal facility (BMT WBM, 2008; Bewsher Consulting, 2005).

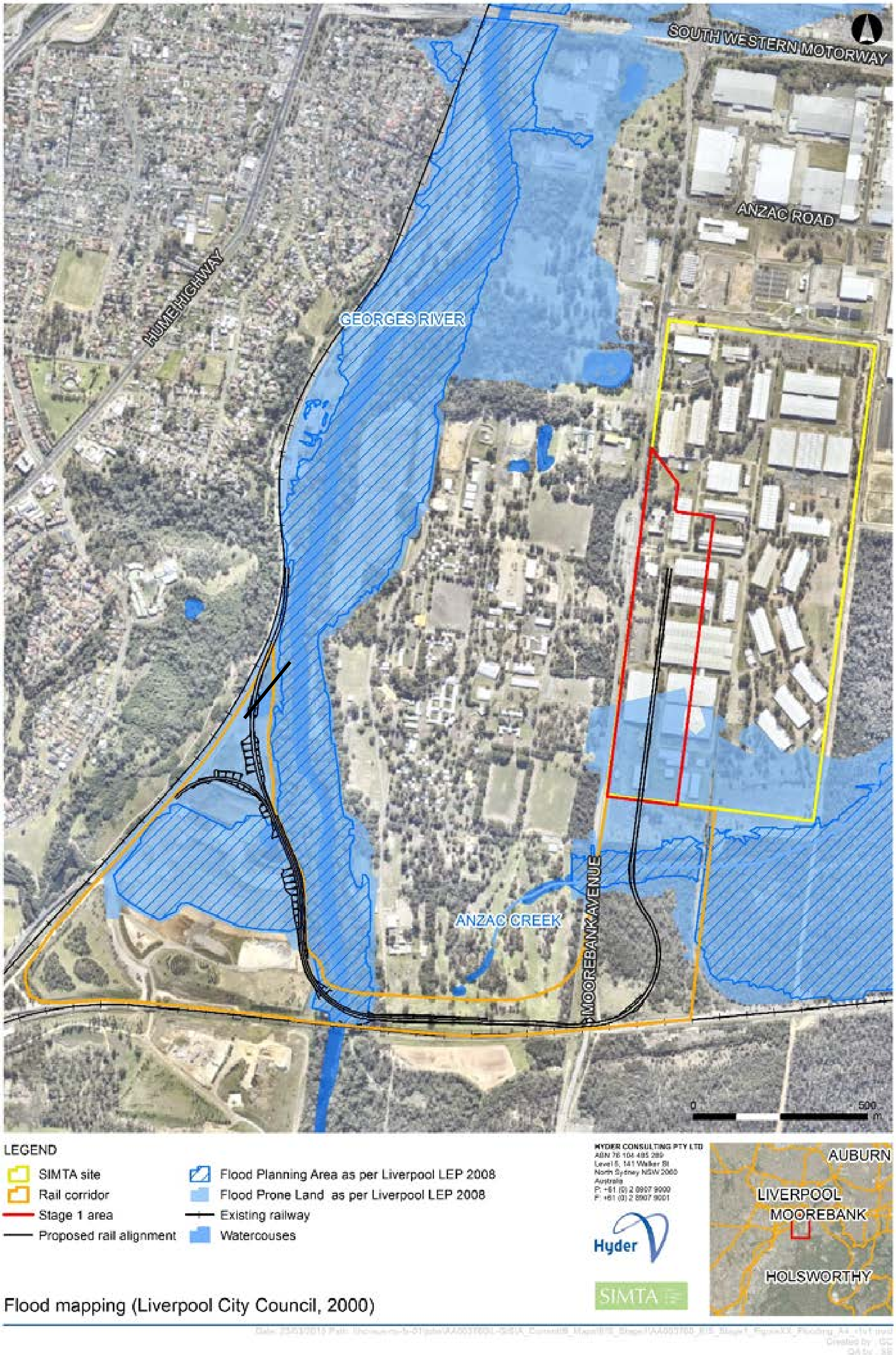

Figure 11-6 Proposal site overlain with Liverpool City Council Regional Flood Planning Areas

Bushfire

The definition of bushfire vegetation categories is as follows:

- Category 1 (orange): forest, woodland, heath and wetlands
- Category 2 (yellow): moist rainforests, shrublands, open woodlands, mallee and grasslands

Vegetation Category 1 bushfire prone land encroaches the Proposal site to the east, south and west. For the Rail Corridor Vegetation Category 1 accounts for a large portion of the eastern section as well as bordering the eastern boundary of the western segment.

The Proposal site also lies within nominated vegetation buffer areas for Category 1 bushfire vegetation. Areas mapped as Vegetation Category 1 bushfire prone land require consideration under *Planning for Bushfire Protection* (PBP) (NSW RFS, 2006). PBP outlines planning considerations for development and applies to all "development applications" on land that is classified as "bush fire prone land" (NSW RFS, 200). PBP does not explicitly provide planning considerations with regard to industrial development. Instead, industrial development should comply with the broad aims and objectives of PBP.

Adequate defendable space is incorporated within the Stage 1 site boundary. The rail link would be maintained relatively free of vegetation.

Hail, lightning and wind from severe thunderstorms

The BoM classifies a severe thunderstorm as an event that produces any of the following:

- Hailstones with a diameter of two centimetres or more at the ground
- Wind gusts of 90 kilometres per hour or greater at 10 metres above the ground
- Flash flooding
- A tornado

In 2014, NSW experienced severe storms on 15 and 16 March, with wind gusts exceeding 90 km/h across much of the northeast, and again on 30 March, affecting Western Sydney and the Illawarra. Heavy rain and large hail was reported, with substantial roof damage and flash flooding in western Sydney. Thunderstorms producing large hail and severe wind gusts were also reported in Sydney in September, November and December 2014. In October 2014 the SES received 100 calls following damage associated with strong winds in western Sydney and the Central Tablelands (BoM, 2015b).

Current risks due to hail, lightning and wind are:

- Damage to structures
- Damage to machinery and construction materials
- Dust generated by wind erosion
- Damage to overhead power lines and signals
- Damage to electrical equipment on-site
- Occupational Health & Safety issues for site workers and employees

Heat waves

A formal definition of a heat wave was developed in 2013. The BoM (2014) defines a heatwave as three days or more of high maximum and minimum temperatures that is unusual for that location.

Current risks to the Proposal from heat waves may include:

- Proposal delays due to Occupational Health & Safety issues
- Increased incidence of heat related illness on-site
- Overheating of machinery and equipment
- Degradation of building materials

Summary

Existing risks associated with historical climate for the Proposal include:

- Flooding within the Rail Corridor
- Bushfire impacts along the eastern, southern and western boundaries of the Stage 1 site and parallel to the Rail Corridor
- Hail, lightning and wind associated with severe thunderstorms causing damage to infrastructure and structures
- Heatwaves causing Occupational Health & Safety issues as well as impacts on machinery and equipment.

Consideration of the increase in frequency and magnitude of these impacts is addressed in Section 11.6.

11.3 CLIMATE CHANGE PROJECTIONS

Climate change projection scenarios for the near future (2030) and far future (2070 to 2090), compared to the bassline climate (1990-2009) have been developed by the NSW Government and Commonwealth Scientific and Industrial Research Organisation (CSIRO) for the City of Sydney and south-eastern coast of NSW based on simulations form a suite of climate models (OEH, 2014 and CSIRO, 2014). Climate change projections have been ascertained for:

- Temperature
- Extreme temperatures
- Rainfall
- Fire weather.

Temperature

Temperature is the most reliable indicator of climate change. Across all the NSW models analysed to determine the climate change impacts for Sydney, all indicated that the average, minimum and maximum temperatures are all increasing. The implications of increased temperatures include increased incidence of illness and death (particularly among vulnerable populations groups), impacts on bushfire danger, infrastructure development and native species diversity. The projected changes in temperatures include (OEH, 2014):

- Maximum temperatures are projected to increase in the near future by 0.7ºC
- Maximum temperatures are projected to increase in the far future by 1.9 ºC
- Minimum temperatures are projected to increase by 0.6 ºC in the near future
- Minimum temperatures are projected to increase by 2.0 ºC in the far future
- There are projected to be more hot days and fewer cold nights

The far future change in maximum and minimum temperatures for Metropolitan Sydney are shown in Figure 11-3 and Figure 11-4 respectively.

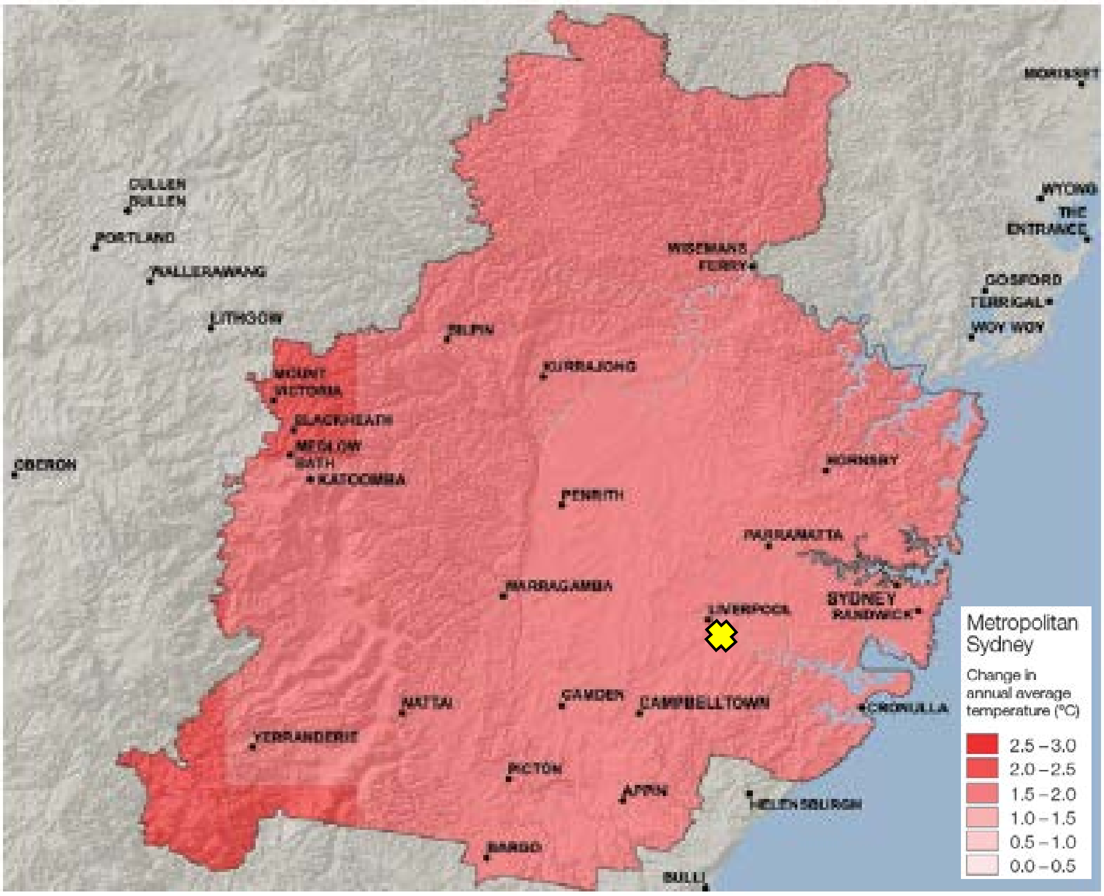

Figure 11-7 Far Future change in max temperatures (OEH, 2014)

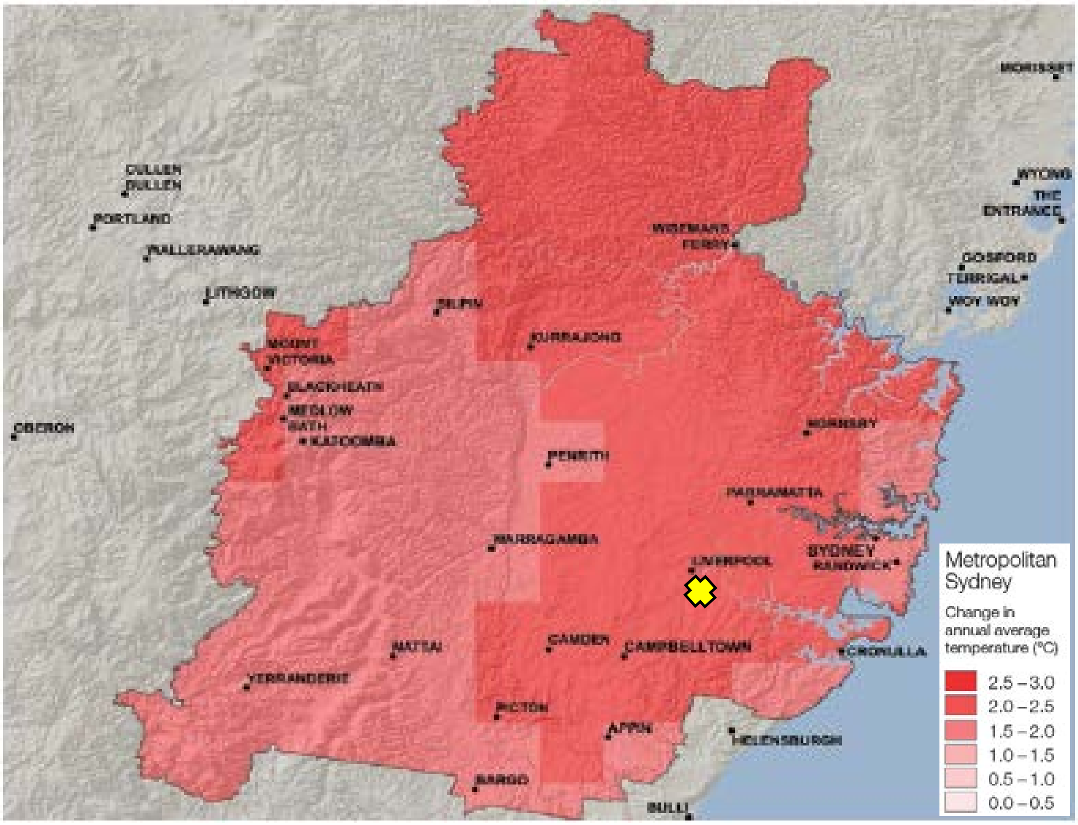

Figure 11-8 Far future ichange in minimum temperature (OEH, 2014)

Extreme Temperatures

Extreme temperatures are projected to increase at a similar rate to mean temperature, with substantial increases in the temperature reached on hot days, the frequency of hot days, and the durations of warm spells (CSIRO, 2014). OEH (2014) have reported the following likely changes:

- The region, on average, is projected to experience an additional four hot days (with daily maximum temperature of above 35 ºC) in the near future and 11 more hot days in the far future
- The region, on average, will experience an average of five fewer cold nights per year in the near future and 12 fewer cold nights in the far future

Table 11-1 Average annual number of hot days (CSIRO, 2014)

Parameter	1995	2030 (Intermediate GHG emissions scenario)	2090 (Intermediate GHG emissions scenario)	2090 (High GHG emissions Scenario)
Over 35ºC	3.1 days	4.3 days	6.0 days	11 days
Over 40 ºC	0.3 days	0.5 days	0.9 days	2 days
Below 2 ºC	0.0 days	0.0 days	0.0 days	0.0 days

Rainfall

Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts can often impact native species' reproductive cycles as well as impacting agricultural productivity. Rainfall changes are also associated with changes in extremes, such as floods and droughts, as well as secondary impacts such as water quality and soil erosion that occur as a result of changes to rainfall (OEH, 2014).

Modelling results for projected changes in rainfall vary significantly, with some models indicating that rainfall will decrease, with others projecting increased rainfall patterns. Projections for the region's annual average rainfall range from decrease (drying) of 13 per cent to an increase (wetting) of 18 per cent by 2030 and continue to span both drying and wetting scenarios (-9 per cent to +24 per cent) by 2070 (OEH, 2014). Notwithstanding this the majority of models indicate that autumn rainfall will increase in the near and far future, while spring rainfall will decrease in the near future (with the far future projections less clear).

Understanding of the physical processes that cause extreme rainfall, coupled with modelled projections, indicate with high confidence a future increase in the intensity of extreme rainfall events (CSIRO, 2014). The level of magnitude of the increases, however, has not been confidently projected, with forecasts for 2090 under a high GHG emissions scenario ranging between a 10-40 per cent increases in the twenty year wettest day (CSIRO, 2014)

Fire Weather

Measuring and understanding fire weather patterns is usually accomplished through the use of the McArthur Forest Fire Danger Index (FFDI). The FFDI is a measure of the factors most strongly present during periods of high risk bushfire activity and is calculated as an 'exponential function of dryness, temperature, wind speed and humidity' (Clarke *et al.* 2011). The BoM issues fire weather warnings when the FFDI is projected to be over 50.

Similar to rainfall projections there are notable disparities between many studies and models regarding future fire behaviours in Australia. For example, Clarke *et al* (2011) predicted increase in FDI of between 30 per cent (for a low emissions scenario), and 300 per cent (under high emissions scenario) for NSW by 2050.

The OEH (2014) model results projected an increase in fire weather and severe fire weather days in the future. These increases are projected mainly in summer and spring. The results indicate that in the Liverpool Local Government Area, the projected changes in average annual days with an FFDI greater than 50, compared to the baseline period, will increase by 0.5-1 days in the far future. An FFDI above 40, predicts near-certain property loss should a fire occur, so that an increase of even one day per year in excess of this should be considered dangerous[5] (Clarke *et al.* 2011).

The far future change in average daily FDI in summer and spring is shown in Figure 11-9 and Figure 11-10 respectively.

[5] Typically, but not exclusively, the McArthur scale has an upper limit of 100, with any ratings exceeding 50 indicating 'extreme' fire danger and the need for Total Fire Bans. On February 7 2009 in parts of Victoria, the FFDI readings were absolutely unprecedented, surpassing 300.

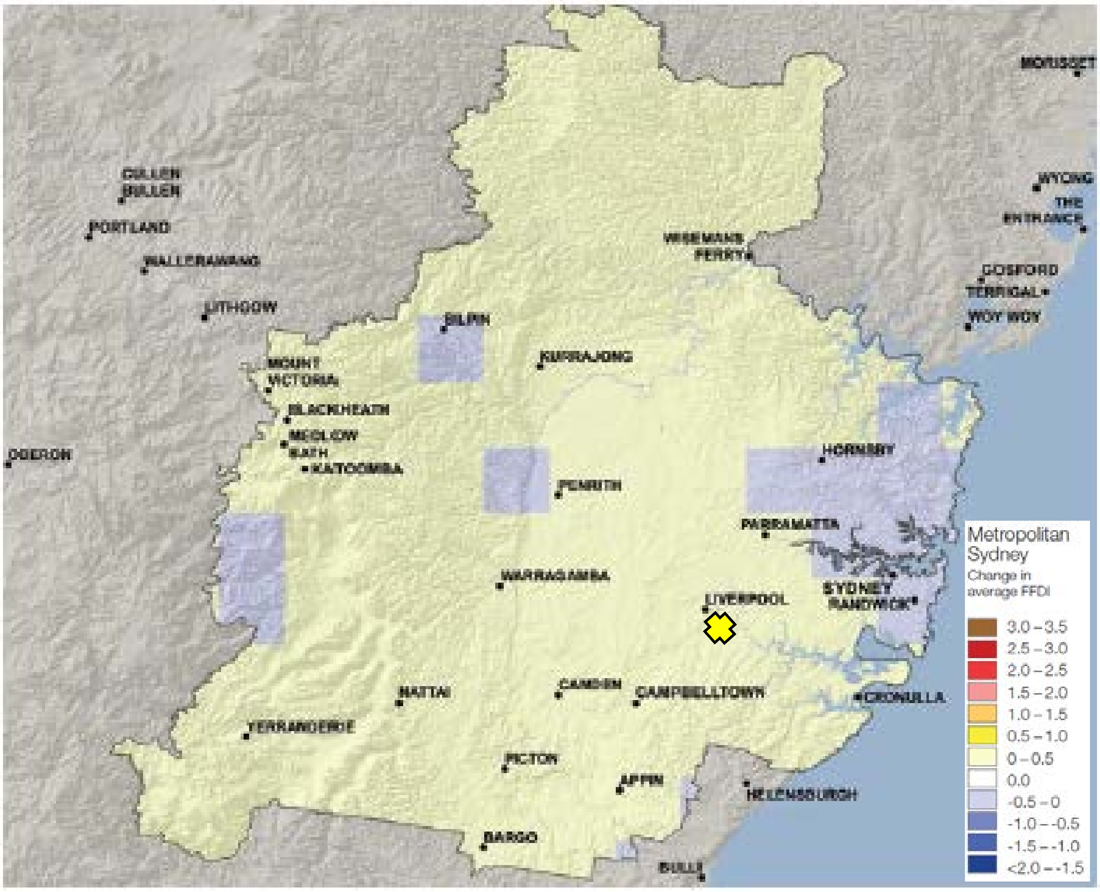

Figure 11-9 Far Future change in average daily FDI in Summer (OEH, 2014)

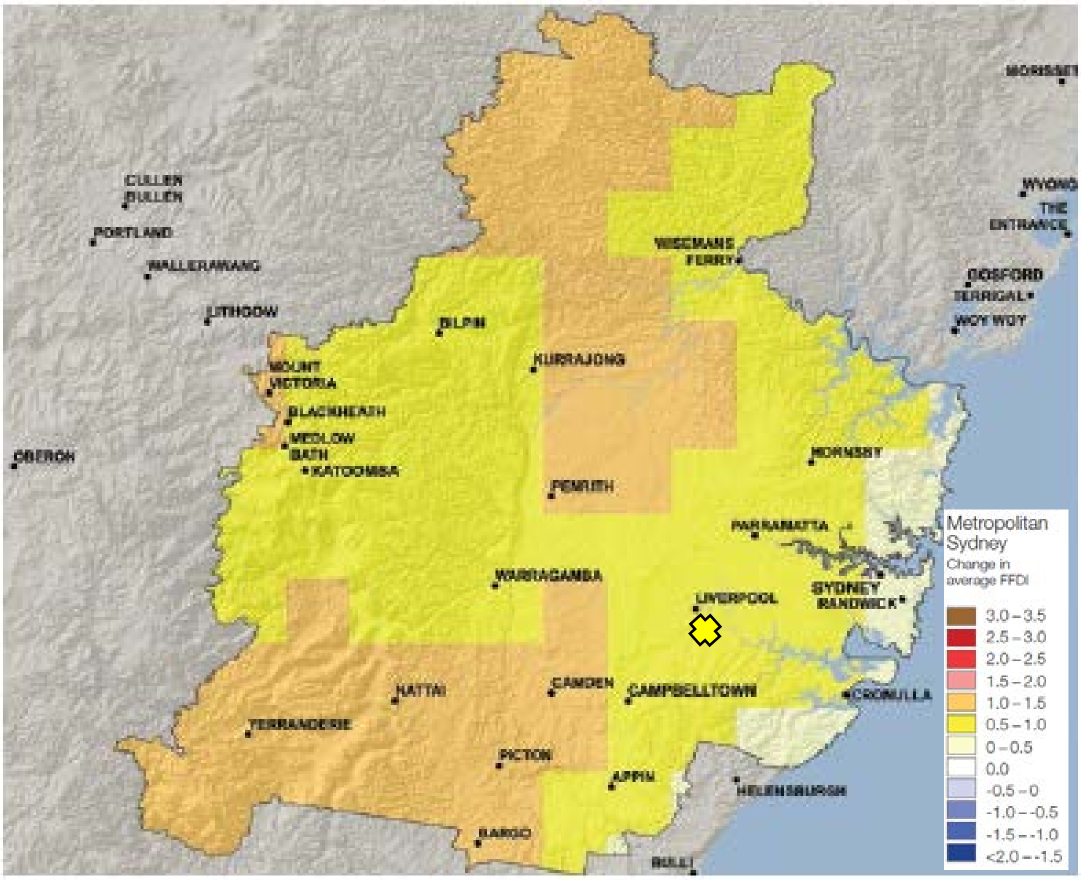

Figure 11-10 Far future change in average daily FDI in Spring (OEH 2014)

11.3.1 SUMMARY OF CLIMATE CHANGE PROJECTIONS

Table 11-2 provides a summary of the projected changes in key climate parameters for the south-eastern coast of Australia and Sydney. The data shows the median (50th percentile) change as projected relative to the 1986-2005 period, with the 10th to 90th percentile change shown in brackets where applicable. The projections have been reported for the period 2030 and 2090 under intermediate and high emission scenarios.

Table 11-2 Summary of climate change projection data for the South-eastern coast of Australia and Sydney (CSIRO, 2014)

Variable	2030 (Intermediate GHG emissions scenario)	2030 (High GHG emissions scenario)	2090 (Intermediate GHG emissions scenario)	2090 (High GHG emissions scenario)
Temperature (ºC) Average	0.9 (0.6 to 1.1)	0.9 (0.7 to 1.3)	1.8 (1.3 to 2.5)	3.7 (2.9 to 4.5)
No. of days over 35 ºC*	1.2 (0.9 to1.9)	-	2.9 (1.8 to 5.1)	7.9 (5.1 to11.9)
No. of days over 40ºC*	0.2 (0.2 to0.5)	-	0.6 (0.5 to 1.0)	1.7 (1.3 to 3.0)
Rainfall (%)	-3 (-10 to 6)	-1 (-11 to 6)	-2 (-16 to 9)	-3 (-20 to 16)
Relative humidity (% absolute)	-0.5 (-1.6 to 0.8)	-0.6 (-1.4 to 0.9)	-1 (-3.1 to 3)	-1.5 (-3.8 to 1.3)
Wind speed (%)	-1.1 (-2.9 to 0.5)	-0.5 (-2.3 to 1.9)	-1 (-4.2 to 0.2)	-1.1 (-6.9 to 4.2)
Increase in No. of sever Fire Danger Days**	0.1 to 0.4	0.4 to 0.5	0.3 to 0.6	1.4 to 1.9

* Compared to 1981-2010 average

** Compared to 1995 Baseline

11.4 RISK AND ADAPTATION ASSESSMENT METHODOLOGY

The risks assessment was undertaken in accordance with:

- Risk management approach set out in AS/NZ 31000:2009 Risk Management – Principles and Guidelines
- Australian Standard AS5334 – Climate Change Adaptation for Settlements and Infrastructure

It is important to note that a preliminary climate change risk assessment (Hyder Consulting, 2013b) was undertaken as part of the Concept Approval EA for the SIMTA Project. The current climate risk assessment builds on the findings of this earlier study supported by current climate change projection data.

The following steps were undertaken to complete this risk assessment:

1. Determine the climate change context in accordance with AS5334:
   a) Define the GHG emission scenarios
   b) Define future time horizons for the assessment

c) Define the climate variables

d) Select climate data for the assessment

e) Obtain past meteorological record

2. Identify relevant climate risks and evaluate the likelihood and consequence of each risk

3. Identify adaptation responses.

Due to the typical design life of assets such as buildings, drainage infrastructure and rail that comprise the SIMTA project (60 to 100 years) the period 2030 to 2090 was selected to facilitate the climate change risk and adaptation assessment.

Climate change risks were identified from a desktop assessment process based on the historic climate and projected changes to climate variables under a high emissions scenario for 2090. Risk statements were developed for the Proposal (based on predicted climate impacts), outlining the vulnerability of the site to the climate change impacts associated with the locality. Each climate impact was recorded in a risk register (see Appendix B).

Each risk statement was assessed using the following likelihood and consequence scales and was documented in a risk register (see Appendix B). Existing controls already in place for risk mitigation (e.g. environmental features, natural and man-made structures and mechanisms, procedures and factors) are considered in the analysis of risks.

Table 11-3 Likelihood ratings (Hyder Consulting, 2013a)

Rating	Recurrent risk	Single events
Almost certain	Could occur several times a year.	More likely than not – probability greater than 50%.
Likely	May arise about once per year.	As likely as not – 50/50 chance.
Moderate	May arise once in ten years.	Less likely than not but still appreciable – probability less than 50% but still quite high.
Unlikely	May arise once in ten years to 25 years.	Unlikely but not negligible – probability low but noticeably greater than zero.
Rare	Unlikely during the next 25 years.	Negligible – probability low, very close to zero.

Table 11-4 Consequence ratings (Hyder Consulting, 2013a)

Level	Structural consequence	Environmental & sustainability consequence
Insignificant	No structural damage.	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage.
Minor	Localised structural damage and slight service disruption. No permanent damage.	Severe loss of environmental amenity and a danger of continuing environmental damage.
Moderate	Widespread structural damage and loss of service. Damage recoverable by maintenance and minor repair.	Isolated but significant instances of environmental damage that may be reversed.
Major	Extensive damage requiring extensive repair.	Minor instances of environmental damage that could be reversed.
Catastrophic	Permanent structural damage to property and infrastructure.	No environmental damage.

Table 11-5 Risk matrix (Hyder Consulting, 2013a)

Likelihood \ Consequence	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	Moderate	High	Extreme
Moderate	Low	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Moderate	High
Rare	Low	Low	Low	Moderate	Moderate

11.5 POTENTIAL IMPACTS TO DEVELOPMENT

Potential climate change hazards and risks were identified for the Proposal. Climate change risks are presented in Table 11-6. In summary the unmitigated climate change risk assessment for the year 2090 found:

- No *extreme* risks
- Four *high* risks
- 11 *medium* risks
- One *low* risks.

Table 11-6 Climate change risks for the Proposal for the year 2090

Risk Category	Risk Description	Uncontrolled Risk 2090
Temperature Increases		
Track buckling	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to rail track movement/cracking/ buckling.	High
Power outages	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to more frequent interruptions to mains power supply.	Moderate
Failure of signalling and reduced functionality of electrical systems	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased failure of air conditioning equipment on critical communications and control equipment resulting in reduced network capacity and increasing potential for major safety incidents.	Moderate
Heat-related sag in power lines	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to heat-related sag in overhead powerlines potentially causing loss of power and reduced network capacity.	Moderate
Stop work events	Increase in days over 35 °C will result in greater number of stop work days resulting in reduced operating hours for SIMTA	High
Increased rainfall intensity		
Flooding of site impacting asset lifecycle	Flood events within Stage 1 site resulting in disrupted operations to the site resulting in impacts on costs and reduced asset lifecycle. Extreme rainfall by 2090 has the potential interrupt service and cause damage to infrastructure.	Moderate
Stormwater infrastructure failure	Overflows from on-site stormwater detention systems impacting on water quality in local creek systems such as Anzac Ck and Georges Rv.	Moderate
Appropriateness of design for flood mitigation structures	Flood mitigation structures such as culverts not appropriately designed to accommodate increased intense rainfall events resulting in reduced asset lifecycle and potential impacts on adjacent environmental values.	Moderate
Flooding of rail infrastructure	Flooding of rail infrastructure and secondary loading/unloading truck storage areas resulting in declines in serviceability due to operational impacts	High

Risk Category	Risk Description	Uncontrolled Risk 2090
Ground stability issues	Increased frequency and severity of extreme rainfall events leading to flooding or saturation of embankments and ground conditions.	Moderate
Off-site impacts on local watercourses	Increased run-off from hard surfaces due to inadequate controls for the provision of soft surfaces (landscaped areas) leading to increase in impacts (e.g. water quality, geomorphology) on natural creek systems	Moderate
Reduced annual rainfall		
Impacts on landscaping plant species	Changes in seasonal rainfall may result in dieback of site plantings increasing maintenance costs	Low
Storms, hail and wind events		
Storm, hail and wind events impacting site infrastructure	Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure (structural, electrical and communications) and customers.	Moderate
Storm, hail and wind impacts on site operation	Increased frequency and severity of extreme storm, hail and wind events leading to operational service disruptions and delays.	Moderate
Increased frequency of bushfire		
Bushfire damage to site infrastructure, health and safety impacts	Increased frequency, severity and duration of bushfires damaging aboveground infrastructure and generating health and safety impacts on customers	High

11.6 PROPOSED ADAPTATION MEASURES AND CONTROLS

Adaptation responses for treatment of the climate change risks identified above will be incorporated into the design and operation of the Proposal to promote resilience to projected future climate change. Table 11-7 presents a suite of engineering design and procedural responses for treatment of climate change risks, and the residual level of risk following their implementation. Importantly the assessment identified no extreme or high risks once adaptation responses have been implemented. The residual climate change risk assessment for the year 2090 identified nine moderate risks and seven low risks.

Table 11-7 Adaptation responses for treatment of the Proposal's climate change risks

Risk Title	Adaptation Response	Mitigated Risk (2090)
Temperature Increases		
Track buckling	Rail track movement would be controlled by undertaking annual pre-summer reviews to identify areas requiring maintenance. Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance. Speed management plans may be implemented on very hot days (i.e. over 43ºC for track with concrete sleepers)	Moderate
Power outages	High priority electrical systems will consider diversity and redundancy in the electrical systems design.	Moderate
Failure of signalling and reduced functionality of electrical systems	Any signalling and communications equipment rooms would be air conditioned. Trackside signalling equipment would be protected in signalling cases	Low
Heat-related sag in power lines	A nominal maintenance cycle would identify any potential accelerated degradation of overhead wires, which will be addressed if and when it occurs. In-ground power reticulation could also be introduced within the utilities design	Low
Stop work events	Develop heatwave response procedure for the Proposal for inclusion within the OEMP as required.	Moderate

<table>
<tr><th>Risk Title</th><th>Adaptation Response</th><th>Mitigated Risk (2090)</th></tr>
<tr><td colspan="3">Increased rainfall intensity</td></tr>
<tr><td>Flooding of site impacting asset lifecycle</td><td rowspan="5">Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which will occur once every 100 years), plus an additional 20% increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.</td><td>Low</td></tr>
<tr><td>Stormwater infrastructure failure</td><td>Low</td></tr>
<tr><td>Appropriateness of design for flood mitigation structures</td><td>Low</td></tr>
<tr><td>Flooding of rail infrastructure</td><td>Moderate</td></tr>
<tr><td>Ground stability issues</td><td>Low</td></tr>
<tr><td>Off-site impacts on local watercourses</td><td>WSUD controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.</td><td>Low</td></tr>
<tr><td colspan="3">Reduced annual rainfall</td></tr>
<tr><td>Impacts on landscaping plant species</td><td>Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change</td><td>Low</td></tr>
<tr><td colspan="3">Storms, hail and wind events</td></tr>
<tr><td>Storm, hail and wind events impacting site infrastructure</td><td>Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.</td><td>Moderate</td></tr>
<tr><td>Storm, hail and wind impacts on site operation</td><td>The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.</td><td>Moderate</td></tr>
<tr><td colspan="3">Increased frequency of bushfire</td></tr>
<tr><td>Bushfire damage to site infrastructure, health and safety impacts</td><td>Buildings and structures have been designed to be fire resistant in accordance with relevant standards.

Asset protection zones have been incorporated into the layout of the Proposal to limit bushfire risk to acceptable levels.</td><td>Moderate</td></tr>
</table>

12 CONCLUSION

Hyder Consulting has been commissioned by Sydney Intermodal Transport Alliance (SIMTA) to prepare a greenhouse gas (GHG) assessment, Climate Change Risk and Adaptation Assessment and a Marginal Abatement Cost Analysis to support a State Significant Development Environmental Impact Statement (EIS) under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* for Stage 1 of the SIMTA Intermodal Terminal Facility (the Proposal).

The total GHG emissions associated with the construction of the Proposal are expected to be 4,262 tCO_2-e during the 18 month construction period, with the total embodied GHG emissions within the construction materials totalling approximately 44,668 tCO_2-e. The annual operational GHG emissions that would be generated by the Proposal would be 9,221 tCO_2-e/year under a worst case scenario. The majority of operational GHG emission would be Scope 2 GHG emissions from electricity consumption, amounting to 6,699 tCO_2-e/year, or 73 per cent of the total operational GHG emissions.

Annual GHG emissions from the Proposal represent approximately 0.0017 per cent of Australia’s total annual GHG emissions (554.6 Mt CO_2-e). The transport sector contributes 90.2 Mt CO2-e each year to Australia’s GHG emissions (DoE 2014d). The Proposal is predicted to contribute 0.01 per cent to Australia’s transport sector inventory and 0.035 per cent to NSW inventory for the transport sector (of a total 26.4 Mt CO_2-e). Accordingly, the contribution of the Proposal to Australia’s GHG emissions is not considered to be significant, in terms of both construction and operation.

Furthermore, the Proposal would facilitate a modal shift, from truck to train, in the transportation of freight to the Moorebank freight catchment. The net reduction in GHG emissions from the change in freight distribution would result in a saving of 3,907 tCO_2-e/year, which is equivalent to approximately 42 per cent of the annual operational GHG emission generated by the Proposal. Furthermore, a number of mitigation strategies have been identified to reduce the GHG emissions associated with the construction and operational phases of the Proposal. A series of Marginal Abatement Cost curves for the operation of the Proposal indicate that, for the ‘worst case’ emissions operational scenario, a total potential cost of $32,000/year would be required to reduce annual GHG emission by 5 per cent; aligning with the Federal Government’s reduction target under the Kyoto Protocol.

Climate change risks and adaptation measures for the Proposal were identified as part of a climate change risk and adaptation assessment. The assessment identified 4 high and 10 moderate climate change risks for the Proposal in the future case (2090) if no adaptive or management practices were implemented. However, a range of adaptive responses for treatment of the climate change risks identified will be considered into the design and operation of the Proposal to promote resilience to projected future climate change. Once implemented the engineering design and procedural responses for treatment of climate change risks would result in lowered residual risk rating; such that no high risks remained. The residual/mitigated climate change risk assessment for the year 2090 identified seven moderate risks and seven low risks.

13 REFERENCES

Alam, S and McNabola, A (2014). ‘A critical review and assessment of Eco-Driving policy & technology Benefits and limitations, *Transport Policy,* Vol 35: 42-49

Australian Bushfire Protection Planners Pty Ltd (ABPP) (2015), *Bushfire Protection Assessment For The Sydney Intermodel Terminal Alliance [SIMTA] Intermodel Terminal Facility – Stage 1 Moorebank Avenue, Moorebank,* prepared for SIMTA

Australasian Transport Research Forum (ATRF), ‘Eco-Driving in the Australian Context’, Royal Automobile Club of Queensland, 35th ARTF Conference 2012

Bewsher Consulting Pty Ltd. (2005), *Anzac Creek Flood Study,* Commissioned by Liverpool City Council, December 2005 Final report

BMT WMB (2008), *Anzac Creek Floodplain Risk Management Study and Plan,* prepared for Liverpool City Council, May 2008

Bureau of Meteorology (BoM) (2015a), ‘Climate Statistics for Australian locations: monthly Climate Statistics’, Australian Government, <accessed January 2015> <accessed from: http://www.bom.gov.au/climate/averages/tables/cw_066137.shtml>

BoM (2015b), *Annual Climate Statement 2014,* Australian Government

BoM (2014), ‘About Pilot Heatwave Forecast’, Australian Government, <accessed January 2015? <accessed from: http://www.bom.gov.au/weather-services/about/heatwave-forecast.shtml>

CitySwitch (2015), ‘Using Marginal Abatement Cost curves’, <accessed February 2015> <accessed from: http://www.cityswitch.net.au/Resources/CitySwitchResources/Planning,reportingandmonitoring/Planning,reportingandmonitoringarticle/TabId/150/ArtMID/787/ArticleID/10273/Using-Marginal-Abatement-Cost-curves-.aspx>

Clarke, H.G. Smith, P.L. And Pitman, A.J. (2011). ‘Regional Signatures of Future Fire Weather Over Eastern Australia from Global Climate Models’. *International Journal of Wildland Fire:* 20, 550-562

Department of Environment (DoE) (2015), ‘Australia’s emissions reduction targets’, accessed Jan 2015, access from < http://www.climatechange.gov.au/climate-change/greenhouse-gas-measurement-and-reporting/australias-emissions-projections/australias>

DoE (2014a) *National Greenhouse and Energy Reporting (NGER) System Measurement, Technical Guidelines for the estimation of greenhouse gas emissions by facilities, Commonwealth of Australia*, Canberra.

DoE (2014b), *Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia: National Greenhouse and Energy Reporting (Measurement) Determination 2008,* Commonwealth of Australia 2014

DoE (2014c) *National Greenhouse Accounts (NGA) Factors*, Commonwealth of Australia, Canberra ACT.

DoE (2014d), State and Territory Greenhouse Gas Inventories 2011/12: Australia’s National Greenhouse Accounts, Commonwealth of Australia, ACT.

DoE (2014e), ‘National Greenhouse Gas Inventory – Kyoto Protocol Accounting Framework’, Australian Government, <accessed Dec 2014>, <accessed from http://ageis.climatechange.gov.au/NGGI.aspx>

Department of Environment, Climate Change & Water (DECCW) (2010), *NSW Climate Impact Profile: The impacts of climate change on the biophysical environment of New South Wales,* NSW Government

Department of Resources Energy and Tourism (2011), ‘Significant Opportunities Register – Transport’, Energy Efficiency Opportunities, DRET Australian Government

Hyder Consulting (2013a), *SIMTA: Part 3A Concept Plan Application - Greenhouse gas assessment,* prepared for SIMTA

Hyder Consulting (2013b), *SIMTA Moorebank Intermodal Terminal Facility - Climate Change Risk Assessment,* prepared for SIMTA

Intergovernmental Panel on Climate Change (IPCC) (2013), The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, New York.

Intergovernmental Panel on Climate Change (IPCC) (2014), *Climate Change 2014 Synthesis Report: Synthesis Report of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* IPCC in conjunction with World Health Organisation and United Nations Environment Program

Infrastructure Sustainability Council of Australia (ISCA) (2014), *Infrastructure Sustainability Rating Tool: Technical Manual,* ISCA

New South Wales Rural Fire Service (NSW RFS) (2006), *Planning for Bushfire Protection 2006,* NSW Government

Office of Environment & Heritage (OEH) (2014), *Metropolitan Sydney: Climate change snapshot,* AdaptNSW, NSW Government

Roads and Maritime Services (2012), ‘Case Study: Biodiesel (Tallow Derived)’, Roads and Maritime and Green Truck Partnership, NSW Government

Slag Cement Association (SCA) (2013), ‘Slag Cement and the Environment: Slag cement in Concrete’, SCA Publication No: 22

Solaria Corporation (2015), ‘Energy Payback’, <accessed February 2015> <accessed from: http://www.solaria.com/products/payback.html>

Toll Holdings Limited (2013), ‘Media Release: Toll Group Switches on with Australia’s first all-electric truck’, http://www.tollgroup.com/media-release/toll-switches-on-australias-first-all-electric-truck>

Transport Authorities Greenhouse Group (TAGG) (2013), *Greenhouse Gas Assessment Workbook for Road Projects,* Transport Authorities Greenhouse Group Australia and New Zealand

Victorian Environmental Protection Authority (EPA Victoria) (2012), ‘Carbon Management at Work’, <accessed February 2015>, <accessed from: http://www.epa.vic.gov.au/business-and-industry/lower-your-impact/carbon-management-at-work#_avoid>

World Resources Institute/World Business Council for Sustainable Development (2004), *Greenhouse Gas Protocol The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition*

APPENDIX A

SUMMARY OF GREENHOUSE GAS AND CLIMATE CHANGE RISK MANAGEMENT STRATEGIES

The following table provides a summary of the potential mitigation measures, climate change adaptive measures and the management strategies that could be considered for the Proposal. Management and mitigation measures have been identified for key GHG and climate change risks. Measures have been identified for each key stage of the Proposal; including detailed design, procurement, construction, and detailed design.

Aspect / Risk	Mitigation / management measure	Status / Timing
Risk of GHG emissions to the atmosphere; potential long term climate change impacts	Where possible locally sourced materials will be used to reduce GHG emissions associated with transport	Construction
	Construction and demolition waste will be recovered and recycled where possible, and vegetation waste would be composted	Construction
	Construction works will be planned to minimise double handling of materials	Pre-construction
	Recycled materials will be reused where possible to reduce GHG emissions associated with embodied energy	Construction
	Construction/transport plans will be incorporated within the CEMP to minimise the use of fuel during each construction.	Pre-construction and construction
	Fuel efficiency of the construction plant/equipment will be assessed prior to selection, and where practical, equipment with the highest fuel efficiency and which uses lower GHG intensive fuel (e.g. biodiesel) would be used	Pre-construction and construction
	On-site vehicles will be fitted with exhaust controls in accordance with the *Protection of the Environment Operations (Clean Air) Regulation 2010* as required	Construction
	Regular maintenance of equipment will be undertaken to maintain good operations and fuel efficiency	Construction and operation
	Where practicable trucks removing waste from the site or bringing materials to the site will be filled to the maximum amount allowable, depending on the truck size and load weight, to reduce the number of traffic movements required	Construction and operation
	Consideration will be given to the embodied energy content of construction materials selected	Pre-construction
	The mitigation measures, management strategies and abatement opportunities presented in this report will be reviewed and considered where appropriate for incorporation into the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP)	Pre-construction, pre-operation

Aspect / Risk	Mitigation / management measure	Status / Timing
	Energy efficiency design aspects will be incorporated wherever possible to reduce energy demand	Detailed design
	The procurement of energy efficient equipment will be investigated for the site	Pre-operation
	The potential liabilities under the NGER Act will be identified by the proponent to determine any requirement's for monitoring and reporting. If required, monitoring and reporting of GHG emissions will be carried out for the operation of the Proposal on an annual operational basis for incorporation into NGER reporting for the operationally controlling corporation	Pre-operation
	Consideration will be given to undertake further investigation and implementation of cost negative abatement opportunities	Pre-construction, operation
	Further investigation of abatement opportunities will be considered once the facility moves from the use of forklifts to the operation of gantry cranes	Operation
Track buckling	Rail track movement would be controlled by undertaking annual pre-summer reviews to identify areas requiring maintenance. Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance. Speed management plans may be implemented on very hot days (i.e. over 43oC for track with concrete sleepers)	Operation
Power outages	High priority electrical systems will consider diversity and redundancy in the electrical systems design	Detailed Design
Failure of signalling and reduced functionality of electrical systems	Any signalling and communications equipment rooms would be air conditioned. Trackside signalling equipment would be protected in signalling cases	Operation
Heat-related sag in power lines	A nominal maintenance cycle would identify any potential accelerated degradation of overhead wires, which will be addressed if and when it occurs. In-ground power reticulation could also be introduced within the utilities design	Operation
Stop work events	Develop heatwave procedure for the Proposal for inclusion within the OEMP as required.	Pre-construction and pre-operation

Aspect / Risk	Mitigation / management measure	Status / Timing
Flooding of site impacting asset lifecycle	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which will occur once every 100 years), plus an additional 20% increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Detailed Design
Stormwater infrastructure failure		
Appropriateness of design for flood mitigation structures		
Flooding of rail infrastructure		
Ground stability issues		
Off-site impacts on local watercourses	WSUD controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.	Detailed Design
Impacts on landscaping plant species	Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change	Detailed Design
Storm, hail and wind events impacting site infrastructure	Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.	Detailed Design
Storm, hail and wind impacts on site operation	The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.	Detailed Design
Bushfire damage to site infrastructure, health and safety impacts	Buildings and structures have been designed to be fire resistant in accordance with relevant standards. Asset protection zones have been incorporated into the layout of the SIMTA site to limit bushfire risk to acceptable levels.	Detailed Design
Storm surge events impacting operations at Port Botany	Ensure that adequate insurance policy is in place to mitigate impacts associated with loss of container throughput from port related shutdowns.	Operation

APPENDIX B

CLIMATE CHANGE RISK REGISTER

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Increased flooding	Flood events within Stage 1 site resulting in disrupted operations to the site resulting in impacts on costs and reduced asset lifecycle	Unlikely	Major	Moderate	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which will occur once every 100 years), plus an additional 20% increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Rare	Moderate	Low
Increased flooding	Overflows from on-site stormwater detention systems impacting on water quality in local creek systems such as Anzac Ck and Georges Rv.	Possible	Moderate	Moderate	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which will occur once every 100 years), plus an additional 20% increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Unlikely	Minor	Low
Increased flooding	Flood mitigation structures such as culverts are not appropriately designed to accommodate increased intense rainfall events resulting in reduced asset lifecycle and potential impacts on adjacent environmental values	Possible	Moderate	Moderate	As above	Unlikely	Minor	Low

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Increased flooding	Flooding of rail infrastructure resulting in declines in serviceability due to operational impacts	Possible	Major	High	Facilities are designed based on a 100 year average recurrence interval (ARI) event (i.e. a flood which will occur once every 100 years), plus an additional 20% increase in peak rainfall and storm volumes to provide a nominal allowance for potential impacts due to climate change.	Unlikely	Moderate	Moderate
Increased flooding	Climate change causes increased frequency and severity of extreme rainfall events leading to flooding or saturation of embankments and ground conditions.	Possible	Minor	Moderate	As above	Unlikely	Minor	Low
Increase in hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to heat-related sag in overhead powerlines potentially causing loss of power and reduced network capacity.	Possible	Moderate	Moderate	A nominal maintenance cycle would identify any potential accelerated degradation of overhead wires, which will be addressed if and when it occurs. In-ground power reticulation could also be introduced within the utilities design	Possible	Minor	Low

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Increase in hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to more frequent interruptions to mains power supply.	Likely	Minor	Moderate	High priority electrical systems will consider diversity and redundancy in the electrical systems design	Likely	Minor	Moderate
Increase in hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to rail track movement/cracking/ buckling.	Possible	Major	High	Rail track movement would be controlled by undertaking annual pre-summer reviews to identify areas requiring maintenance. Areas most vulnerable to heat related impacts would be subject of regular inspection and maintenance. Speed management plans may be implemented on very hot days (i.e. over 43oC for track with concrete sleepers)	Possible	Moderate	Moderate

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Increase in hot days	Increased frequency, severity and duration of extreme temperatures (days exceeding 35 °C) leading to increased failure of air conditioning equipment on critical communications and control equipment resulting in reduced network capacity and increasing potential for major safety incidents.	Likely	Minor	Moderate	Any signalling and communications equipment rooms would be air conditioned. Trackside signalling equipment would be protected in signalling cases	Unlikely	Minor	Low
Increased average temperature	Increased annual average UV radiation leading to accelerated degradation of external materials causing higher maintenance costs	Possible	Minor	Moderate	Resilience to degradation associated with UV radiation has been considered in materials selection.	Unlikely	Minor	Low
Increase in hot days	Increase in days over 35 0C will result in greater number of stop work days resulting in reduced operating hours for SIMTA	Almost Certain	Minor	High	Develop heatwave response procedure for the Proposal for inclusion within the OEMP as required	Almost Certain	Insignificant	Moderate

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Increased rainfall variability	Increased frequency and severity of extreme rainfall events leading to more frequent malfunctioning of power supplies and communications	Unlikely	Minor	Low	Cables would be well protected, insulated and have fail safe mechanisms built in to ensure no safety issues. Routine inspections of cable routes would be undertaken to identify and rectify flooded cable conduits to minimise potential water related malfunction.	Unlikely	Minor	Low
Increased rainfall variability	Increased run-off from hard surfaces due to inadequate controls for the provision of soft surfaces (landscaped areas) leading to increase in impacts on natural creek systems	Likely	Insignific ant	Moderate	WSUD controls (e.g. swales, biofiltration systems) have been incorporated into the Proposal stormwater system design and system performance has been found to meet water quality objectives.	Unlikely	Insignificant	Low
Increased fire risk	Increased frequency, severity and duration of bushfires damaging aboveground infrastructure and generating health and safety impacts on customers	Possible	Major	High	Buildings and structures have been designed to be fire resistant in accordance with relevant standards. Asset protection zones have been incorporated into the layout of the Proposal to limit bushfire risk to acceptable levels.	Possible	Moderate	Moderate

Climate Impact	Risk Statement	Likelihood	Cons.	Level of Risk	Design Control Measures	Likelihood	Cons.	Residual Risk
Storm event	Increased frequency and severity of extreme storm, hail and wind events leading to debris, fallen trees and branches impacting infrastructure (structural, electrical and communications) and customers.	Possible	Minor	Moderate	Appropriate setback for trees and other vegetation would ensure vegetative debris would not disrupt services, whilst maintaining visual aesthetics and soil stability.	Possible	Minor	Moderate
Storm event	Increased frequency and severity of extreme storm, hail and wind events leading to operational service disruptions and delays.	Likely	Minor	Moderate	The Proposal has been designed through aspects such as incorporating intense rainfall projections into the design of stormwater infrastructure and the selection of appropriate materials to minimise potential impacts associated with storm damage.	Likely	Minor	Moderate
Increased rainfall variability	Changes in seasonal rainfall may result in dieback of site plantings increasing maintenance costs.	Possible	Insignificant	Low	Plant species selected for landscaping have been selected based on their ability to tolerate projected climate change	Rare	Insignificant	Low