

Greenhouse Gas Assessment

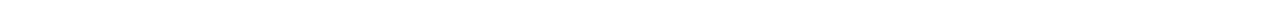


SIMTA

SYDNEY INTERMODAL TERMINAL ALLIANCE

Transitional Part 3A Concept Plan Application

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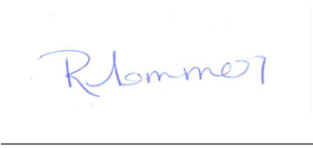
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SIMTA

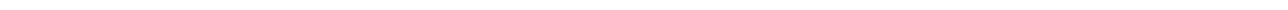
Part 3A Concept Plan Application

Greenhouse gas assessment

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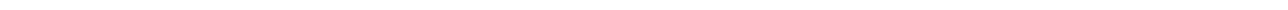
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CONTENTS

Executive Summary	1
1 Background	6
1.1 Site history	7
1.2 Project description	7
1.3 Staging	10
1.4 Planning approvals	11
1.5 Proposed operation of SIMTA Moorebank Intermodal Terminal Facility	11
1.6 Context of greenhouse gas	12
1.7 Scope of works	13
2 Construction based GHG inventory	16
2.1 Phase 1 – Site preparation	16
2.2 Phase 2 – Earthworks, Drainage and Utilities Installations	19
2.3 Phase 3 – Rail construction	22
2.4 Phase 4 – Pavement construction and ancillary works	24
2.5 Phase 5 – Building structures	27
2.6 Operation of site offices	29
2.7 Total GHG emissions: site preparation and construction	29
3 Embodied emissions of materials	31
3.1 Background and methodology	31
3.2 Assumptions	32
3.3 Embodied GHG impact results	35
4 Operational Greenhouse Gas Emissions	40
4.1 Electricity use – SIMTA site	40
4.2 Natural gas use – SIMTA site	41
4.3 Summary – SIMTA site	42
4.4 Operational emissions - Alternative scenario	42
5 Freight transport operations	44
6 Assessment of GHG Impact of Proposal	47
6.1 Summary of SIMTA proposal GHG emissions	47
6.2 Assessment against alternative scenario	47
7 GHG management and mitigation options	50
7.1 Operational versus embodied GHG emissions	51
8 References	54

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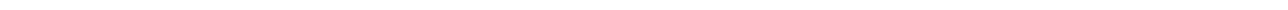


Appendices

Appendix A

Edge Environment Embodied Energy Report

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Executive Summary

This report has been developed for The Sydney Intermodal Terminal Alliance (SIMTA), which is a consortium of Qube Logistics and Aurizon. The assessment is required for the following section of the Director Generals Requirements:

Director General's requirements	Where addressed
Air Quality Impacts – including but not limited to direct and indirect greenhouse gas emissions.	Section 7.4.2

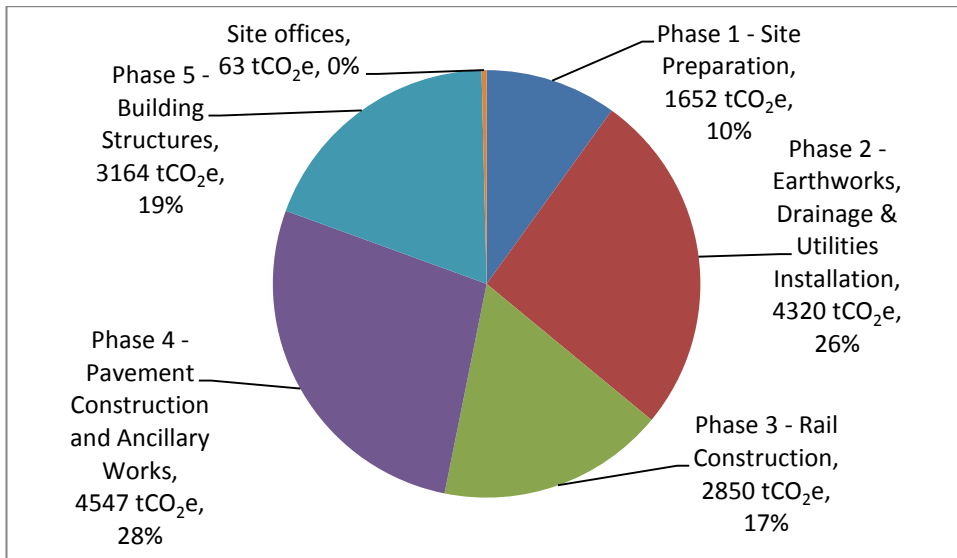
An assessment of greenhouse gas (GHG) emissions was undertaken using the best available data at concept plan stage, where detailed information on construction and operation is limited.

This report investigated the following measurement boundaries and emissions sources.

<p><u>Site preparation</u></p> <ul style="list-style-type: none"> ▪ Decomposition of cleared vegetation off-site ▪ Operation of mobile equipment ▪ Operation of stationary equipment ▪ Transport of fill to site ▪ Transport of materials to site ▪ Demolition of buildings on existing site <p><u>Construction phase</u></p> <ul style="list-style-type: none"> ▪ Operation of mobile equipment ▪ Operation of stationary equipment ▪ Electricity use ▪ Transport of materials onto site
<p><u>Embodied emissions in materials</u></p>
<p><u>Operation</u></p> <ul style="list-style-type: none"> ▪ Estimated electricity consumption of buildings ▪ Estimated electricity consumption of cranes ▪ Estimated natural gas consumption ▪ Estimated emissions from alternative scenario
<p><u>Freight transport emissions</u></p> <ul style="list-style-type: none"> ▪ SIMTA proposal vs Alternative scenario

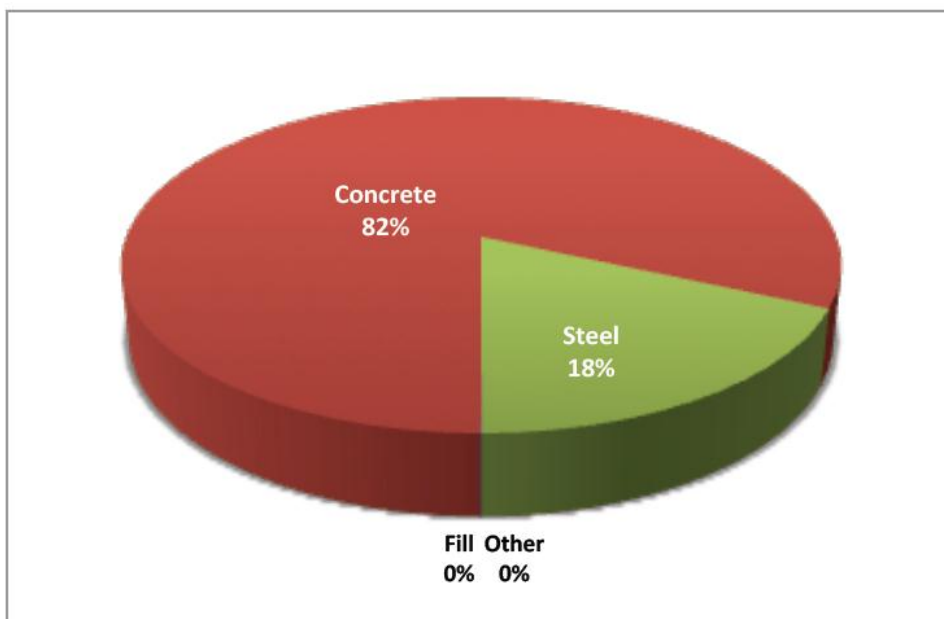
Site preparation and construction – SIMTA site

Emissions from the construction and preparation phases were calculated, the breakdown of which is shown below. Emissions estimates from construction were based on estimated machinery types, days used and fuel use and areas of clearing and construction required. Emissions from the transport of material to and from site were also included, based on truck fuel use and distances to the closest waste facilities and materials providers. Approximately 16,597 tCO₂e is expected to be emitted during site preparation and construction.



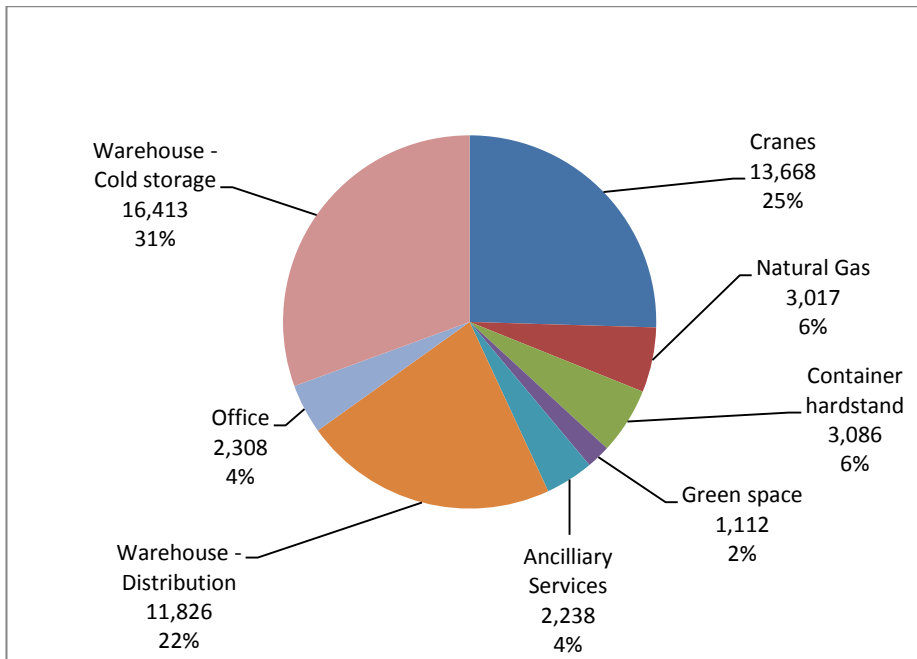
Embodied emissions of materials – SIMTA site

Hyder consulting contracted Edge Environment who estimated the embodied GHG emissions in construction material and products to be used on the project. It was estimated that 196,201 tCO₂e is embodied in materials, predominantly within steel and concrete. This is illustrated in the figure below.



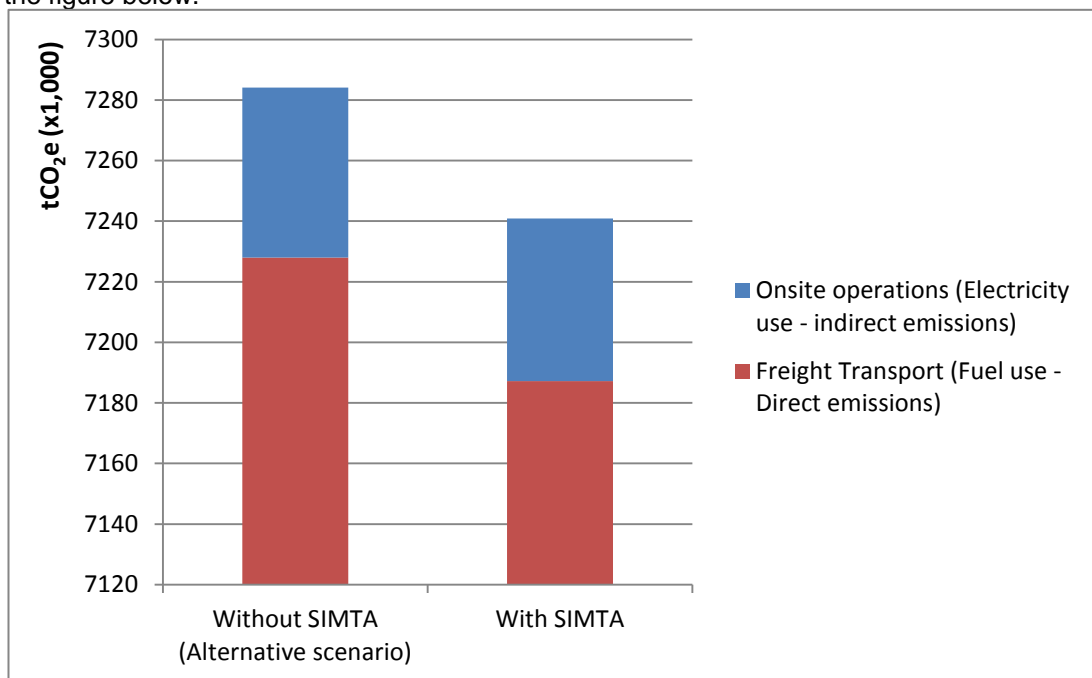
▪ **Operation – SIMTA proposal**

Emissions from on site energy use, once the site is fully operational, was calculated to be 53,668 tCO₂e per annum. Operational emissions were based on electricity and gas demand estimates developed during concept planning. The breakdown of operational emissions per annum is shown in the following figure.

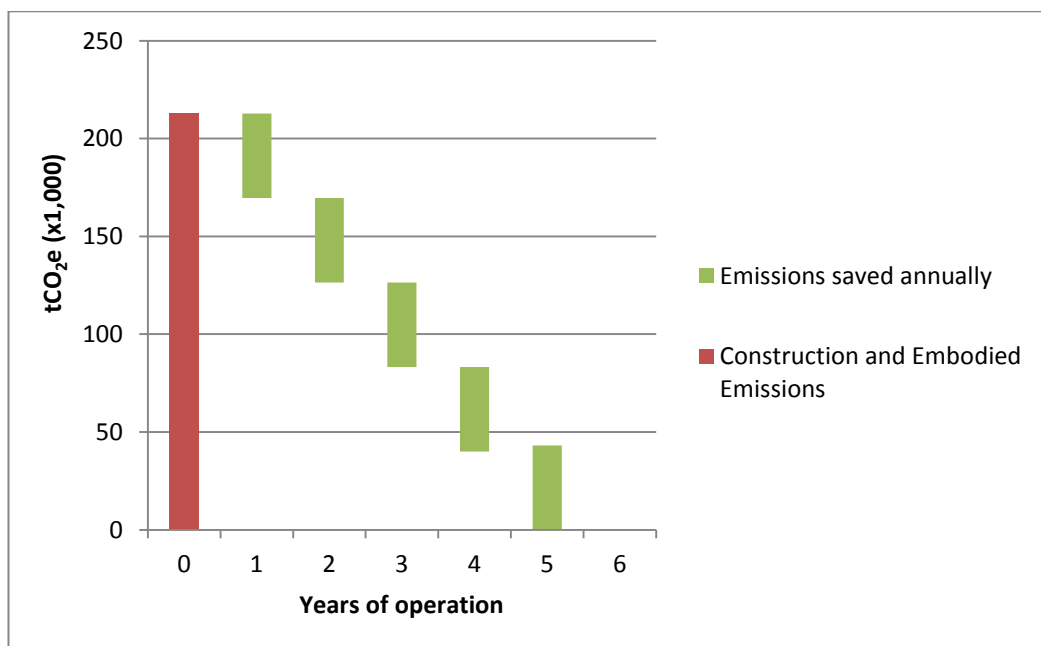


- Emissions associated with the operation of the rail corridor/link are considered to be negligible as there is no lighting or other energy use associated with this part of the development. Emissions associated with the operation of the rail corridor/link are limited to those from diesel combustion in the freight trains. This has been included in the alternative scenario estimations in the following section.
- **Alternative scenario - SIMTA proposal**

A feasible alternative scenario was developed to determine an emissions profile of the area if the SIMTA proposal were not developed. The alternative scenario was developed using the Liverpool Local Environmental Plan 2008 and the projected freight demand in the area. A comparison between the SIMTA proposal and the alternative scenario showed that there was an annual GHG saving of 43,206 tCO₂e per annum which can be achieved through operational and transport efficiencies through the implementation of the SIMTA proposal. This illustrated in the figure below.



It is estimated that the annual emissions savings from operation of the SIMTA proposal will equalise the emissions associated with construction and those embodied within construction materials within 6 years of operation. This is shown in the following figure.



GHG management and mitigation

Regular monitoring of emissions is recommended throughout the project to assess the effectiveness of emissions mitigation actions. The following actions are recommended for mitigation of GHG emissions **during construction**:

- Where possible, use locally sourced materials to reduce emissions associated with transport;
- Recycle/compost waste wherever possible;
- When importing fill source from nearby construction sites, wherever possible aim to reduce transport related emissions;
- Plan construction works to avoid double handling of materials;
- Make use of recycled emissions to reduce emissions associated with embodied energy (not estimated in this report);
- Develop construction/transport plans to minimise the use of fuel during each construction stage. For example throttling down and switching off construction equipment when not in use;
- Assess the fuel efficiency of the construction plant/equipment prior to selection, and where practical, use equipment with the highest fuel efficiency which use lower GHG intensive fuel (eg gas, ethanol); and
- Regular maintenance of equipment to maintain optimum operations and fuel efficiency.

The following actions are recommended for mitigation of GHG emissions **during the operation** of the facility:

- Incorporate energy efficiency design aspects wherever possible to reduce energy demand. More information on this can be found in the Hyder ESD report. Examples could include energy efficient lighting systems, natural ventilation, insulation and other renewable forms of energy (eg co-generation/tri-generation on site);

- Investigate the procurement of energy efficient equipment for the site (ie cranes, forklifts, street lighting);
- Investigate the feasibility of on-site renewable energy, such as photo-voltaics to reduce demand from the grid; and
- Tune buildings during commissioning to optimise energy performance.

The main GHG emissions embodied in the materials are from production of concrete for the site pavement and structural steel for warehouses. There is significant scope to reduce construction emissions by, for example, replacing Portland cement with, for example, fly ash, silica fume, ground granulated blast furnace slag. However, the overall focus in terms of reducing GHG emissions should focus on minimising energy related emissions from operation of the facility. The following recommendations are suggested for the mitigation of GHG emissions embodied in materials:

- Investigate the feasibility to use supplementary cementitious materials for the concrete pavement;
- Source concrete from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies);
- Avoid using recycled content in steel products as a single indicator for low GHG intensity as this has been proven to be misleading;
- Achieve high steel scrap recycling rates;
- Use low GHG intensive energy in production (ie renewable energy for electricity); and
- Minimize GHG emissions from steel making by sourcing from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies).

1 Background

The Sydney Intermodal Terminal Alliance (SIMTA) is a consortium of Qube Logistics and Aurizon. The SIMTA Moorebank Intermodal Terminal Facility (SIMTA proposal) is proposed to be located on the land parcel currently occupied by the Defence National Storage and Distribution Centre (DNSDC) on Moorebank Avenue, Moorebank, south west of Sydney. SIMTA proposes to develop the DNSDC occupied site into an intermodal terminal facility and warehouse/distribution facility, which will offer container storage and warehousing solutions with direct rail access to Port Botany. Construction of the rail connection from the SIMTA site to the Southern Sydney Freight Line (**SSFL**) will be undertaken as part of the first stage of works for the SIMTA proposal.

The SIMTA site is located in the Liverpool Local Government Area. It is 27 kilometres west of the Sydney CBD, 17 kilometres south of the Parramatta CBD, 5 kilometres east of the M5/M7 Interchange, 2 kilometres from the main north-south rail line and future Southern Sydney Freight Line, and 0.6 kilometres from the M5 motorway.

The **SIMTA site**, approximately 83 hectares in area, is currently operating as a Defence storage and distribution centre. The SIMTA site is legally identified as Lot 1 in DP1048263 and zoned as General Industrial under Liverpool City Council LEP 2008. The parcels of land to the south and south west that would be utilised for the proposed rail link are referred to as the **rail corridor**. The proposed rail corridor covers approximately 75 hectares and adjoins the Main Southern Railway to the north. The rail line is approximately 3.5 kilometres in length, 20 metres in width (variable width) and includes two connections to the SSFL, one south and one north.

The proposed rail corridor is owned by third parties, including the Commonwealth of Australia, RailCorp, private owners and Crown Land held by the Department of Primary Industries, and would link the SIMTA site with the Southern Sydney Freight Line. Existing uses include vacant land, existing rail corridors (East Hills Railway and Main Southern Railway), extractive industries, and a waste disposal facility. The rail corridor is intersected by Moorebank Ave, Georges River and Anzac Creek. Native vegetation cover includes woodland, forest and wetland communities in varying condition. The proposed rail corridor is zoned partly 'SP2 Infrastructure (Defence and Railway)' and partly 'RE1 - Public Recreation'. The surrounding Commonwealth lands are zoned 'SP2 Infrastructure (Defence)'.

Table 1 shows the lot and deposited plan number of the land parcels that will be impacted by the SIMTA proposal.

Table 1: Land parcels of the SIMTA proposal

Lot	Deposited Plan	Property Address/Description
1	1048263	Moorebank Avenue, Moorebank (SIMTA Site)
3001	1125930	Moorebank Avenue, Moorebank (land immediately south and south-west of SIMTA Site, including School of Military Engineering)
1	825352	Railway land and to the north of East Hills Railway Line
2	825348	
1	1061150	
2	1061150	
1	712701	

Lot	Deposited Plan	Property Address/Description
5	833516	Privately owned land north of East Hills Railway Line, east of Cumberland & South Passenger Line and Southern Sydney Freight line and west of Georges River
7	833516	
51	515696	
52	517310	
104	1143827	
103	1143827	
91	1155962	
4	1130937	Land west of the Georges River, north of the above privately owned land
5	833516	Railway land along shared railway line – Cumberland & South Passenger Line and Southern Sydney Freight Line
101	1143827	
102	1143827	
Conveyance Book 76	Number 361	Main Southern Rail Corridor
NA	NA	Georges River (Crown Land)

The report considers the construction and operational impacts of the SIMTA proposal as a whole for the full operational capacity of 1 million twenty-foot equivalent unit (TEU) throughput per annum.

1.1 Site history

The DNSDC has been used as a major defence material, storage and distribution and maintenance site since the early 1900s. The original storage depot facilities were established in the northern portion of the site in the period 1910-1920, followed by expansion southward into vacant Defence land in 1944-1945. This expansion included the construction of large permanent warehouses and workshop facilities, where large areas of open land were utilised for vehicles and other field equipment storage on improved hard-stands.

A further upgrade of the site occurred in the late 1980s when the first of several stages of new facility construction took place, culminating in 1993-94 with the construction of new centralised distribution buildings and the re-cladding of many of the original storehouses. External hard-stands were also retained and improved.

1.2 Project description

The Concept Plan application comprises four key components:

- Rail Corridor.
- Intermodal Terminal.
- Warehouse and Distribution Facilities (including Freight Village).
- Ancillary Terminal Facilities.

Each of these components is described briefly in the sections below.

Rail Corridor and Rail Link

The proposed rail link is proposed to connect to the Southern SSFL, approximately 500 metres south of Casula railway station. It would then extend south, then east, crossing Georges River from the south-east corner of the Glenfield Waste Disposal Centre. The rail link would then continue east within the East Hills rail corridor, before heading north into the SIMTA Site.

The proposed rail link would be constructed over the following parcels of land:

- SSFL rail corridor on the western side of the Georges River.
- Glenfield Waste Disposal Centre on the western side of the Georges River.
- East Hills rail corridor.
- Irregular shaped portion of land owned by RailCorp and located to the east of the intersection between Moorebank Avenue and the East Hills Railway Line.
- Land to the south of the DNSDC site owned by the Commonwealth.

The proposed rail link would include the following infrastructure:

- Culvert crossing of Anzac Creek.
- A crossing under Moorebank Avenue in proximity to the existing grade-separated crossing which supports the existing East Hills Railway Corridor.
- Bridging the Georges River.

The indicative rail link alignment is shown in Figure 1.



Figure 1: SIMTA indicative rail link alignment

Intermodal Terminal

The intermodal terminal is proposed to be located on the western part of the site, adjacent to Moorebank Avenue and away from the nearest residential properties. Key elements include:

- Five rail tracks of approximately 650 to 1,200 metres in length, including four permanent and one temporary siding.
- Container hardstand of approximately 90,000m² located on both sides of the rail tracks to be used for container sorting and storage.
- Terminal administration offices and ancillary operational facilities of approximately 2,100m²
- The intermodal terminal is proposed to operate 24 hours a day, 7 days a week to enable continuous receipt and dispatch of freight, accommodating a wide range of servicing demands. It will be serviced by world class and leading practice intermodal facilities including:
 - Automatic gantry systems
 - Modern container handling equipment
 - Modern control tower and support facilities
 - State-of-the-art rolling stock

The final selection of mobile and static equipment will be made at the detailed application stage for the rail terminal, taking into account compliance with the criteria established by way of the Concept Plan approval, including noise levels, visual impacts and air quality.

Warehouse and Distribution Facilities

Approximately 300,000m² of warehouses with ancillary offices are proposed to be constructed to the east of the intermodal terminal. The proposed warehouses are to be sited and designed to provide a physical barrier between the intermodal terminal and the nearest residential properties to assist with mitigating the potential acoustic and visual impacts of the rail activities. These warehouses include:

- Intermodal Terminal Warehouse and Distribution Facilities (Terminal Warehouses) – approximately 100,000m² of warehouse floorspace will be located immediately adjacent to the intermodal terminal. These buildings will be designed for cross-dock operations and are anticipated to be occupied by large logistics operators dispatching goods in short turn-around times and with limited freight break-down.
- Large Format Warehouse and Distribution Facilities - approximately 200,000m² of warehouse floorspace will be located on the eastern part of the SIMTA site, east of the Terminal Warehouse facilities. These buildings will have perimeter loading docks and are anticipated to be occupied by logistics operators who require larger areas for operations, hold stock for longer periods and/or undertake larger amounts of freight-breakdown before dispatching.

Each of the warehouses will be serviced by the central internal road system. The road system design and location of the car park to the east of the large format warehouse buildings are proposed to maximise the separation of staff and freight vehicle movements and minimise potential vehicle conflicts.

Ancillary Terminal Facilities

A range of ancillary support facilities are proposed within the SIMTA Intermodal Terminal Facility to meet the needs of employees and visitors to the site. The final composition of these facilities will be based on demand and will be privately operated by individual tenants, however, it is anticipated that a total floorspace of approximately 8,000m² will be provided and the uses are likely to include:

- Site management and security offices.

- Retail and business service centre, potentially including a convenience store, banking facilities and post office.
- Meeting rooms/conference facilities available for hire by individual tenants.
- Sleeping facilities for drivers.
- A café/restaurant.

A centralised staff car parking area provided adjacent to the ancillary facilities will enable separation of heavy vehicle movements from private vehicle movements, particularly around the intermodal terminal warehouses.

1.3 Staging

The SIMTA Moorebank Intermodal Terminal Facility is proposed to be constructed in three stages. The anticipated scope of works and timing for each stage is described in **Table 2** below.

Table 2: Indicative staging plan

Stage	Scope	Timing
Stage 1 – <i>Construction of the intermodal terminal and rail link</i>	Stage 1 shall include: Construction of the rail link between the SIMTA site and the SSFL. Establishment of hardstand for container storage. Construction of freight truck loading and circulating area. Construction of a control tower and maintenance shed. Construction of access driveways and internal circulation roads required to service the intermodal terminal. Provision/ upgrade of stormwater infrastructure and utility services required to service the intermodal terminal. Landscaping. Possible construction of some warehousing.*	Commencement: Late 2014 Completion: 2015
Stage 2 – <i>Construction of warehouses and distribution facilities</i>	Stage 2 shall comprise construction of the central portion of the intermodal terminal warehousing and distribution facilities and the south-eastern portion of the Large Format Warehousing and Distribution Facilities, including: Circulation roads required to service the proposed warehouses. Staff and visitor car parking spaces required to service the proposed warehouses. Landscaping treatments within the development areas. Provision/ upgrade of stormwater infrastructure and utility services required to service the Stage 2 warehouses.	Commencement: Subject to market demand Completion: Mid-2019

Stage	Scope	Timing
Stage 3 – <i>Extension of the intermodal terminal and completion of warehouses and distribution facilities</i>	<p>Stage 3 (the final stage) shall include:</p> <p>Extension of the intermodal terminal from 650 metres to 1,200 metres in length.</p> <p>Construction of the remaining warehouse and distribution facilities.</p> <p>Construction of the ancillary terminal facilities in the north-east corner of the site.</p> <p>Completion of the circulation roads.</p> <p>Staff and visitor car parking spaces required to service the additional warehouses.</p> <p>Completion of the landscaping treatments.</p> <p>Provision/ upgrade of stormwater infrastructure and utility services requires to service the additional warehouses,</p>	Completion: Mid-2022

1.4 Planning approvals

A Concept Plan approval is being sought under the transitional provisions relating to Part 3A assessments under the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the SIMTA proposal.

1.5 Proposed operation of SIMTA Moorebank Intermodal Terminal Facility

SIMTA is proposing to build an intermodal rail to truck freight terminal with the capability to process up to one million twenty-foot equivalent freight container units (TEU). The facility is to cater for port shuttle rail traffic from Port Botany. The design capacity is anticipated to be realised within a decade depending on the supply and demand of freighting services utilising the facility. The one million TEUs will generally be divided equally between inbound and outbound containers (loaded containers from Port Botany and a combination of loaded and empty containers to Port Botany) and is expected to involve the following:

- Inbound TEUs will be warehoused, unpacked and the contents distributed by trucks throughout south and south western Sydney with subsequent empty TEUs returned to Port Botany by return rail movements from the site; and
- Outbound TEUs will be processed through the terminal and forwarded to Port Botany by rail. Of the outbound TEUs, approximately a quarter will contain export freight whilst the remaining three quarters will be empty containers returned to Port Botany.

1.5.1 Operation description

The function of the SIMTA proposal will be the transfer of container freight to and from Port Botany by rail and to facilitate the ongoing distribution of freight throughout south and south-western Sydney. Operations would involve the following:

- Unloading of containers from rail onto stacks within the intermodal facility;
- Transportation of containers to warehouses within the intermodal facility, or directly onto trucks for transport offsite; and
- Loading of containers onto trains for export or return to Port Botany.

Operations within the facility would function 24 hours a day, seven days a week.

1.6 Context of greenhouse gas

In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report on climate change. It stated that warming of the climate system is unequivocal, as is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. It also states that most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas (GHG) concentrations (IPCC 2007).

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

- The Australian Government has committed to reduce its emissions by between 5 and 25 per cent below 2000 levels by 2020. It has also committed to a long term emissions reduction target of at least 60 per cent below 2000 levels by 2050;
- The National Greenhouse and Energy Reporting (NGER) Act was introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. For GHG emissions, thresholds are currently set at 25,000 tonnes carbon dioxide equivalent (tCO₂e) for a facility under a corporation and 50,000 tCO₂e for a corporation as a whole for 2010-2011 (DCC 2008); and
- The NSW Department of Infrastructure, Planning and Natural Resources – Department of Energy, Utilities and Sustainability *Guidelines for Energy and Greenhouse in EIA* provides guidance on the consideration of energy and greenhouse issues when developing projects and when undertaking environmental impact assessment (EIA) under the *Environmental Planning and Assessment Act 1979 (EP&A Act)*.

In May 2010, the Commonwealth Department of Climate Change and Energy Efficiency published its *State and Territory Greenhouse Gas Inventories for 2008*. 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. Table 3 outlines the 2008 emissions estimates for Australia and NSW broken down by sector; note that sectors relevant to this project are highlighted in blue. It can be seen that emissions from transport, waste and manufacturing and construction make up a significant proportion of emissions in Australia. This assessment will estimate the CO₂ emissions associated with the construction and operation of the proposed facility and identify actions to manage and minimise these emissions where feasible. Specifically:

- The scope does not include decommissioning of the facility after its life.
- This study assumes that all vegetation waste is sent to a composting facility and not to landfill. The emissions estimates would increase to approximately 2,754 tCO₂e if the waste was sent to traditional landfill.
- Emissions were estimated using the DCCEE NGA factors and methods 2009

Table 3: National and NSW emissions by sector in 2008 (DCCEE 2010)

Sector/key subsector	Australia	NSW	
	Emissions (Mt)	Emissions (Mt)	% Contribution to National Emissions
TOTAL NET EMISSIONS	575.8	164.7	28.5
ENERGY SECTOR	476.6	122.7	29.5
Stationary energy	296.4	81.2	37.4
Energy industries	226.4	67.6	29.9
Electricity generation	204.3	63.2	30.9
Other energy industries	22.1	4.4	20.1
Manufacturing and construction	48.7	9.0	18.5
Other sectors	21.4	4.6	21.3
Transport	80.2	21.8	27.2
Fugitive emissions	39.9	19.8	49.5
INDUSTRIAL PROCESSES	31.1	11.9	38.2
AGRICULTURE	87.4	16.5	18.9
Livestock	58.9	13.2	22.4
Other agriculture	28.5	3.4	11.8
WASTE	14.4	5.2	36.4
OTHER	N/A	N/A	N/A
LAND USE, LAND USE CHANGE AND FORESTRY	26.3	8.2	31.4
Afforestation and reforestation	-23.0	-2.3	10.1
Land use change (Deforestation)	49.3	10.6	21.5

Blue highlight indicates sectors relevant to the SIMTA proposal

1.7 Scope of works

The scope of this GHG assessment is to develop an inventory of projected GHG emissions from construction and operation of the project. The inventory will be used to identify actions for mitigating or reducing emissions, where possible. The report will also compare the difference in GHG emissions associated with this proposal against an alternative development scenario. The scope of works for this assessment includes:

- Identify the main sources of emissions during construction (including embodied emissions in materials) and operational stages of the development;
- Scope and calculate the emissions from each source using factors and methods outlined in the *National Greenhouse Accounts (NGA) Factors*, published by the Australian Government Department of Climate Change and Energy Efficiency (2009), the GHG

Protocol published by the World Business Council for Sustainable Development (2001) and the BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database;

- Estimate the emissions associated with road and rail freight transport as a result of the SIMTA proposal;
- Assess the overall impact of the SIMTA proposal in relation the GHG emissions; and
- Investigate and recommend strategies for emissions mitigation to reduce GHG emissions associated with project development and operation.

Figure 2 illustrates the measurement boundaries and emissions sources investigated in this GHG assessment.

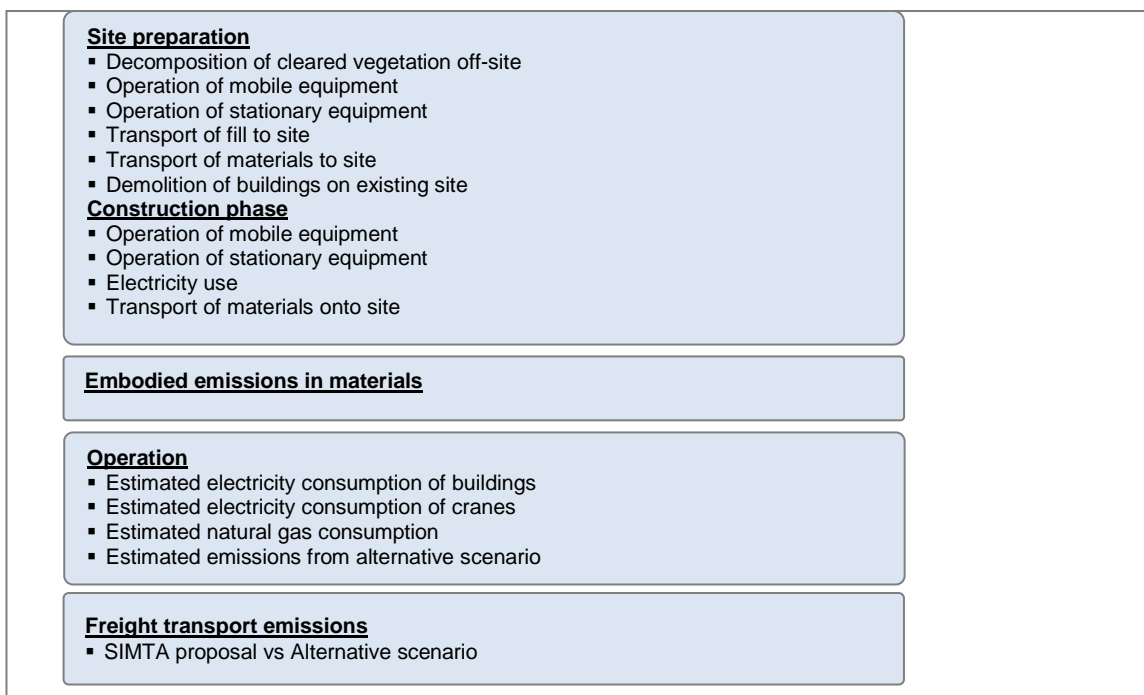


Figure 2: GHG emissions boundary for construction of this project

The scoping processes used within this report for the operation of the facility are adapted from the 'The Greenhouse Gas Protocol' (WBCSD 2001). Under this protocol, the projects direct and indirect emissions sources can be delineated into three 'scopes' (Scope1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. This method of scoping helps to improve transparency, and assists in setting emissions reduction objectives.

The GHG protocol definitions for each scope are presented in Figure 3 and described in further detail below.

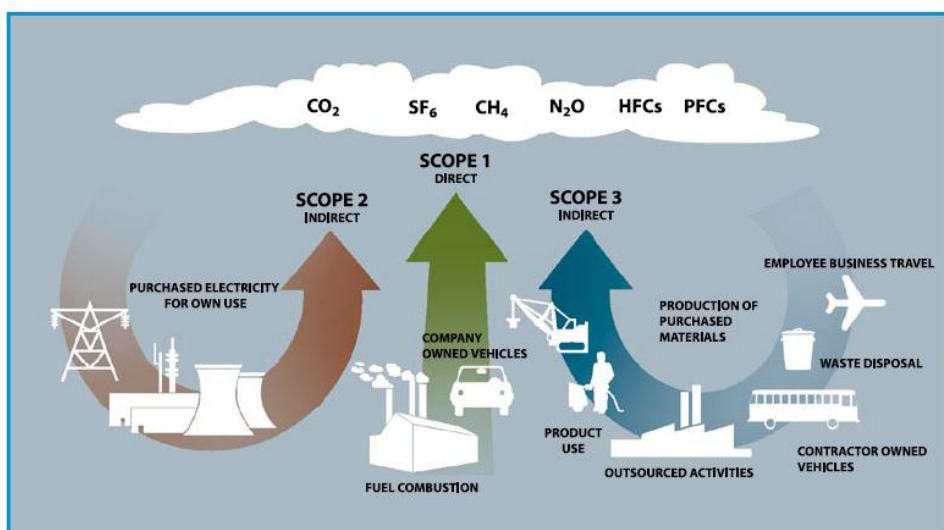


Figure 3: Overview of scopes and emission sources (Source: World Business Council for Sustainable Development, 2001)

- **Scope 1 – Direct GHG emissions:** Scope 1 emissions are direct emissions that occur from sources on site. This would include emissions arising from the combustion of fuels in equipment on-site (eg boilers, furnaces, generators, vehicles, machinery, fugitive emissions).
- **Scope 2 – Electricity indirect GHG emissions:** Scope 2 emissions account for GHG emissions arising from the generation of purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated.
- **Scope 3 – Other indirect GHG emissions:** Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities on, but occur away from the development site.

This assessment has been undertaken using the best available data at concept plan stage, where detailed information on construction and operation will be incorporated into subsequent Project Applications for each stage of development and therefore details at this time are limited. Assumptions have been outlined, where appropriate, to maintain transparency. The estimates in this report may be refined as more information becomes available such as in detailed design stages of the project.

Assessment boundary

Sufficient design information to undertake this assessment was available for the SIMTA site only at the time of writing. Emissions associated with the operation of the SIMTA site and associated rail corridor/link are included as part of this study. Operational emissions includes net emissions associated with transport of freight as well as those associated with the energy use within the intermodal facility and rail corridor/link

The design information was not available to undertake a GHG assessment to sufficient accuracy and precision for construction of the rail corridor/link development and therefore construction associated emissions on these areas are not included within this scope of work. Further assessments at the detailed design phase will include the rail corridor/link as sufficient design information becomes available.

2 Construction based GHG inventory

The construction of the proposed development will include the transport of materials on and off the site, decomposition of vegetation waste and the use of machinery and vehicles for preparation of the site, civil works and construction of the warehouses. These activities require the use of fuels and electricity which will result in the release of associated GHG emissions.

Accurately quantifying these emissions at the concept stage requires a number of assumptions to be made including distances travelled and hours of use for vehicles and machinery. Other factors which will affect GHG emissions during the construction phase include construction methods, time table, materials sources and transport methods.

Emissions were calculated by estimating fuel use, electricity consumption and vegetation decomposition using data available at concept stage. Emissions in tonnes CO₂ equivalent were calculated using factors and methods from the Australian Government *National Greenhouse Accounts Methods and Factors Workbook*. Specific assumptions were made with regard to fuel use, electricity consumption, construction schedules, material quantities, material transport and waste decomposition are outlined in detail in the following sections. These assumptions are based on Hyder's experience in similar construction projects and information in the civil engineering report associated with this project (Hyder 2012).

This assessment was undertaken using the indicative 5 phases of construction outlined in the civil engineering report undertaken for the site (Hyder 2012). This assessment also includes emissions estimates of warehouse construction (not included in the civil report) and from electricity use associated with site offices during the construction stage. These estimates were undertaken using information gained through communications with Hyder structural engineers. This GHG assessment was undertaken with best available data at concept plan stage and it is anticipated that this assessment will become more detailed as relevant information becomes available in the detailed design stage.

2.1 Phase 1 – Site preparation

The estimated emissions from Phase 1 of construction were **1,652 tCO₂e**. The breakdown of these emissions is detailed in the following sections.

2.1.1 Construction activities and Emissions sources

Phase 1 includes the following construction activities:

- Site establishment;
- Demolition;
- Clearing and grubbing;
- Vegetation decomposition; and
- Contamination removal.

Figure 4 illustrates the GHG emissions quantities and relative proportions from each construction activity in Phase 1.

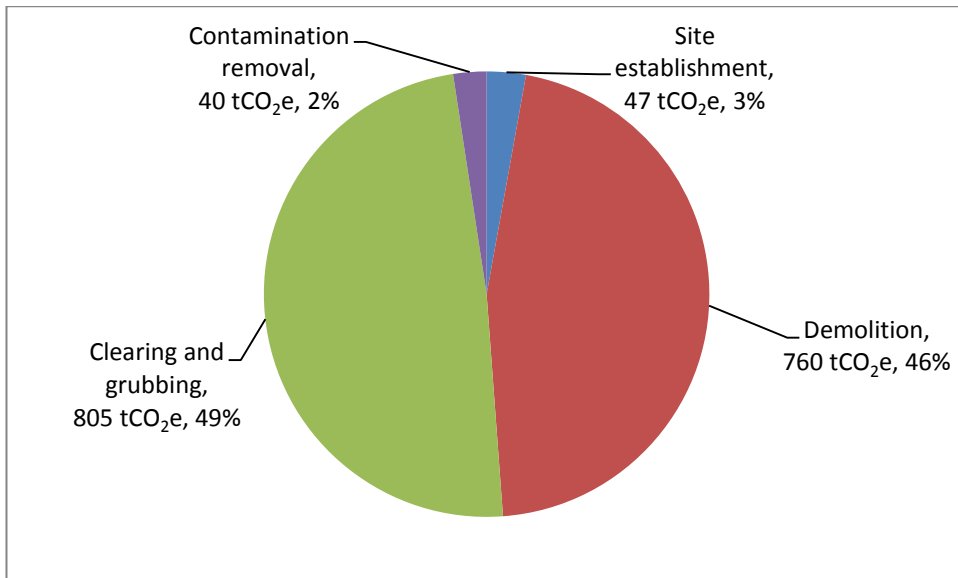


Figure 4: Emissions breakdown for site preparation phase by construction activity

These are detailed further in Table 4.

Table 4: Summary of GHG emissions from site preparation by construction activity

Construction activity	Emissions (tCO ₂ e)
Clearing and grubbing	805
Demolition	760
Site establishment	47
Contamination removal	40
TOTAL	1,652

For the purposes of this assessment, emissions from site preparation phase included the following direct emissions sources:

- Compost of removed vegetation¹;
- Fuel use from transport of materials; and
- Fuel use from construction activities

Figure 5 illustrates the breakdown of emissions sources during the site preparation phase.

¹ This study assumes that all vegetation waste is sent to a composting facility and not to landfill. The emissions estimates would increase to approximately 2,754 tCO₂e if the waste was sent to traditional landfill.

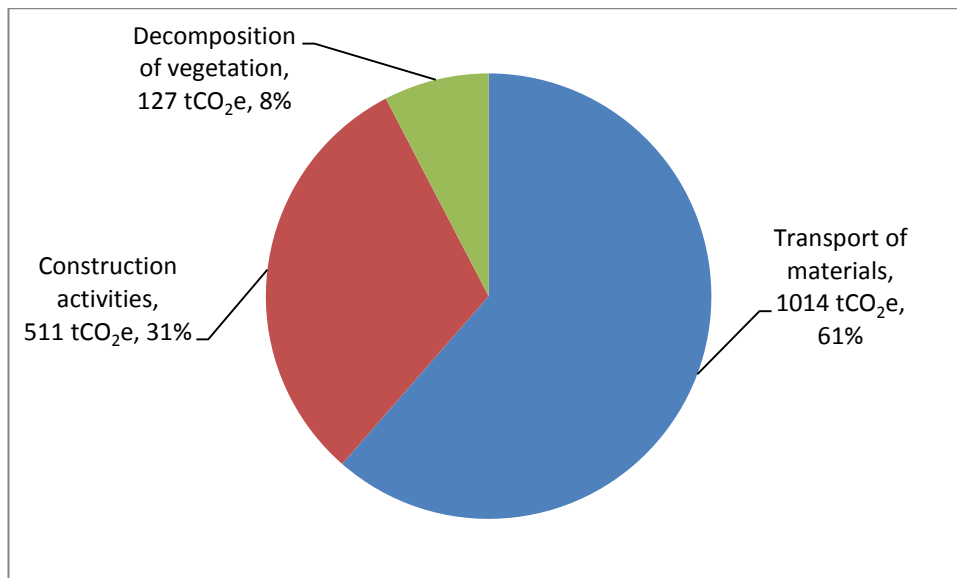


Figure 5: Emissions breakdown for site preparation phase by emissions source

These are detailed further in Table 5.

Table 5: Summary of GHG emissions from site preparation by emissions source

Construction activity	Emissions (tCO ₂ e)
Transport of materials	1,014
Construction activities	511
Decomposition of vegetation	127
TOTAL	1,652

Assumptions used in calculating the above emissions are set out below:

- The site preparation phase is expected to take approximately 18 months;
- It was assumed that all machinery and vehicles were re-fuelled every 2 days on average;
- It was assumed that the cleared vegetation was 50,000m² of grass at 0.15m depth as outlined in the Civil Engineering Report (Hyder 2012). This results in a volume of approximately 8,250m³ of grass equating to a mass of approximately 1,980 tonnes (Tchobanoglous *et al.* 1993); and
- It was assumed that all cleared vegetation was transported and composted at the Eastern Creek waste facility.

The machinery and relative fuel capacity of the vehicles used during Phase 1 are assumed to be as set out in the following tables:

Table 6: Specifications for machines/vehicles used during site preparation

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Backhoe	N/A	170
Static Roller	N/A	100
Mobile crane	N/A	400

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
Delivery trucks	N/A	150
Excavators	N/A	410
Concrete crushing plant	N/A	230
Air compressor	N/A	300
Dozer	N/A	909

The estimated program for the site preparation phase of the project along with estimated machine/vehicle days and associated fuel use are outlined in Table 7:

Table 7: Summary of assumptions for machinery use associated with site preparation

Construction activity	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type
Site establishment	132	17,340	Diesel
Demolition	1440		Diesel
Clearing and grubbing	1008		Diesel
Contamination removal	72		Diesel

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.2 Phase 2 – Earthworks, Drainage and Utilities Installations

The estimated emissions from Phase 2 of construction were **4,320 tCO₂e**. The breakdown of these emissions is detailed in the following sections.

2.2.1 Construction activities and Emissions sources

Phase 2 includes the following construction activities:

- Bulk earthworks;
- Stormwater drainage; and
- Utility services

Figure 6 illustrates the GHG emissions quantities and relative proportions estimated from each construction activity in Phase 2.

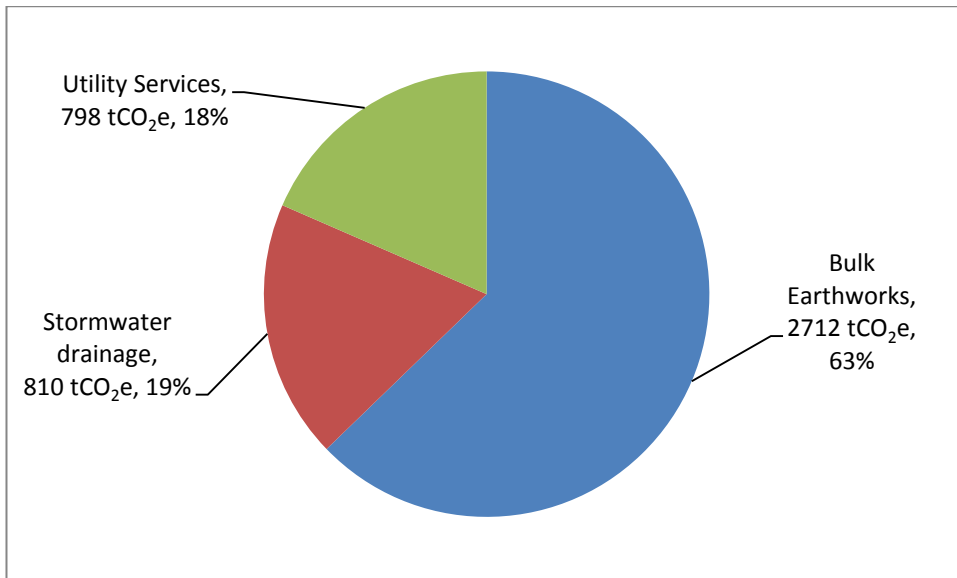


Figure 6: Emissions breakdown for earthworks, drainage and utilities installations phase by construction activity

These are detailed further in Table 8.

Table 8: Summary of GHG emissions from earthworks, drainage and utilities installations by construction activity

Construction activity	Emissions (tCO ₂ e)
Bulk earthworks	2,712
Stormwater drainage	810
Utility services	798
TOTAL	4,320

For the purposes of this assessment, emissions from earthworks, drainage and utilities installations phase included the following direct emissions sources:

- Fuel use from transport of materials; and
- Fuel use from construction activities.

Figure 7 illustrates the estimated breakdown of emissions sources during the earthworks, drainage and utilities installations phase.

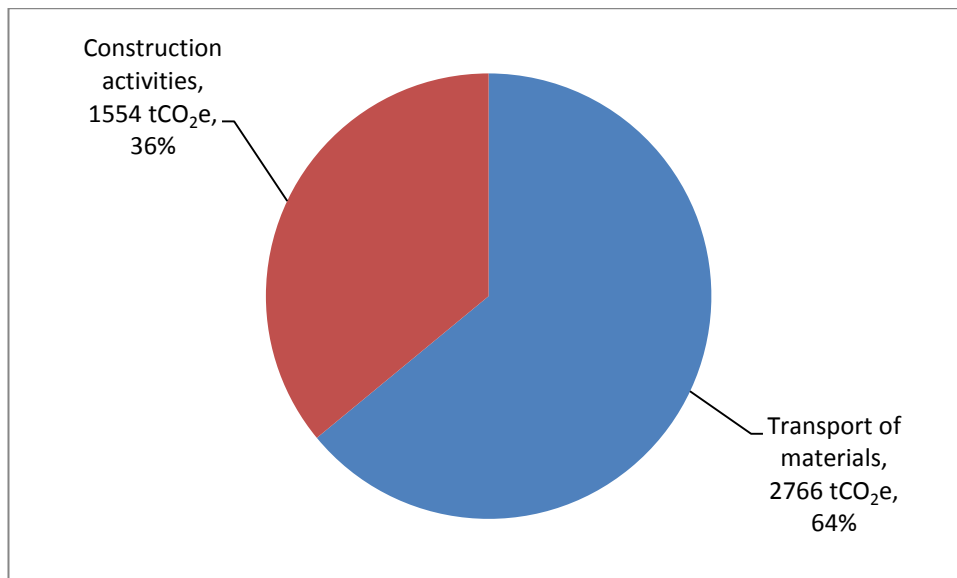


Figure 7: Emissions breakdown for earthworks, drainage and utilities installations by emissions source

These are detailed further in Table 9.

Table 9: Summary of GHG emissions from earthworks, drainage and utilities installations by emissions source

Construction activity	Emissions (tCO ₂ e)
Transport of materials	2,766
Construction activities	1,554
TOTAL	4,320

Assumptions used in calculating the above emissions are set out below:

- The site preparation phase is expected to take approximately 18 months;
- It was assumed that all machinery and vehicles were re-fuelled every 2 days on average;
- Calculations at concept design stage have determined that there is an excess of approximately 35,400m³ of fill from the site. However, as stated in the Civil Engineering report, it is currently intended that there be no import or export of bulk earthworks from the site, therefore emissions associated with fill transport were not included as part of this assessment; and
- It was assumed that concrete will be used to pave the site to an average thickness of 0.5m.

The machinery and relative fuel capacity of the vehicles used during Phase 2 are assumed to be as set out in the following table:

Table 10: Specifications for machines/vehicles used during earthworks, drainage and utilities installations

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Backhoe	N/A	170
Static Roller	N/A	100

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
Graders	N/A	344
Delivery trucks	N/A	150
Excavators	N/A	410
Concrete agitators	N/A	410
Water trucks	N/A	125
Air compressor	N/A	300
Compaction equipment	N/A	672
Dozer	N/A	909

The estimated program for the earthworks, drainage and utilities installations phase of the project along with estimated machine/vehicle days and associated fuel use are outlined in Table 11:

Table 11: Summary of assumptions for machinery use associated with earthworks, drainage and utilities installations

Construction activity	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type
Bulk earthworks	5,088	1,004,280	Diesel
Stormwater drainage	1,800	300,420	Diesel
Utility services	1,890	295,470	Diesel

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.3 Phase 3 – Rail construction

The estimated emissions from Phase 3 of construction were **2,850 tCO₂e**. The breakdown of these emissions is detailed in the following sections.

2.3.1 Construction activities and Emissions sources

Phase 3 includes the following construction activities:

- Rail siding construction; and
- Gantry rail construction.

Figure 8 illustrates the estimated GHG emissions quantities and relative proportions from each construction activity in Phase 3.

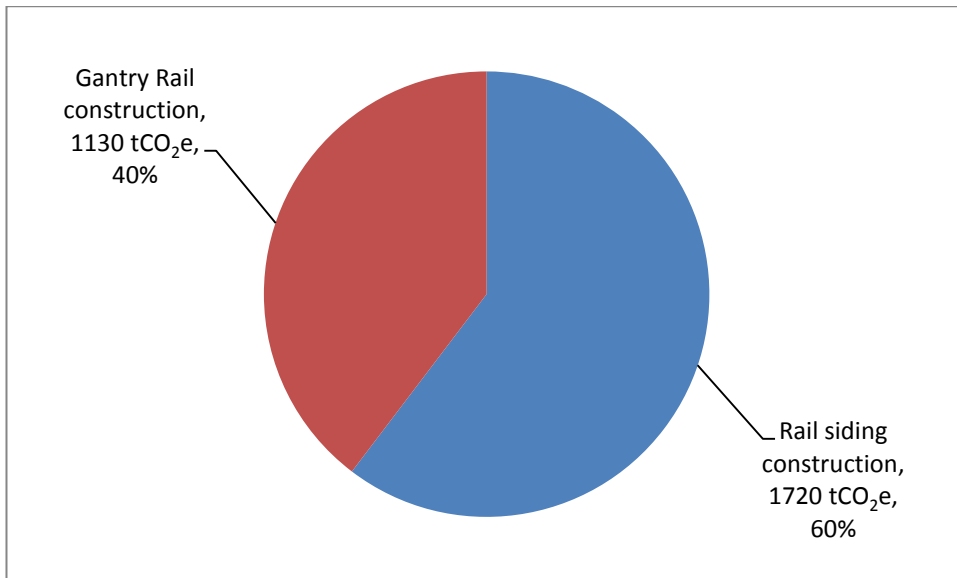


Figure 8: Emissions breakdown for rail construction phase by construction activity

These are detailed further in Table 12.

Table 12: Summary of GHG emissions from rail construction by construction activity

Construction activity	Emissions (tCO ₂ e)
Rail siding construction	1,720
Gantry rail construction	1,130
TOTAL	2,850

For the purposes of this assessment, emissions from rail construction phase included the following direct emissions sources:

- Fuel use from transport of materials; and
- Fuel use from construction activities.

Figure 9 illustrates the breakdown of emissions sources during the rail construction phase.

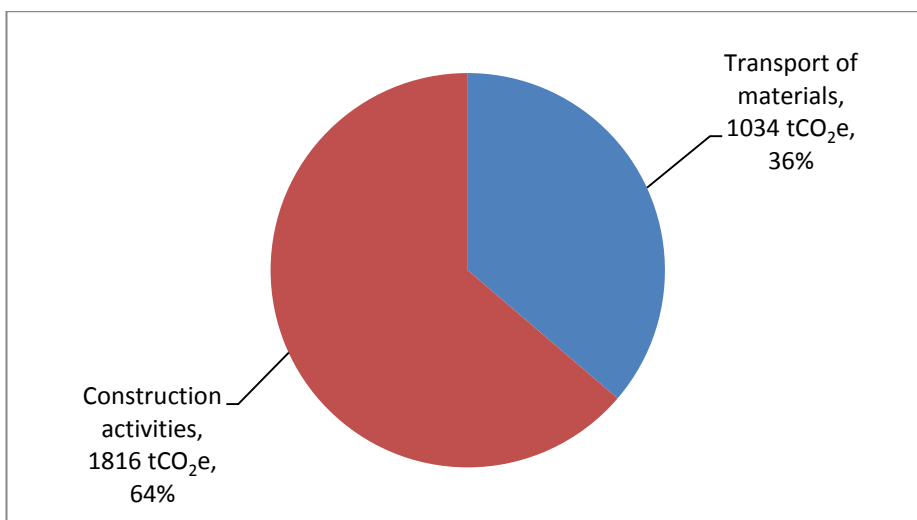


Figure 9: Emissions breakdown for rail construction by emissions source

These are detailed further in Table 13.

Table 13: Summary of GHG emissions from rail construction by emissions source

Construction activity	Emissions (tCO ₂ e)
Transport of materials	1,034
Construction activities	1,816
TOTAL	2,850

Assumptions used in calculating the above emissions are set out below:

- It was assumed that all machinery and vehicles were re-fuelled every 2 days on average.

The machinery and relative fuel capacity of the vehicles used during Phase 3 are assumed to be as set out in the following tables:

Table 14: Specifications for machines/vehicles used during earthworks, drainage and utilities installations

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Backhoe	N/A	170
Static Roller	N/A	100
Piling drilling rig	N/A	1100
Delivery trucks	N/A	150
Concrete agitators	N/A	410
Concrete pumping equipment	N/A	300
Mobile cranes	N/A	400
Air compressor	N/A	300

The estimated program for the earthworks, drainage and utilities installations phase of the project along with estimated machine/vehicle days and associated fuel use are outlined within Table 15.

Table 15: Summary of assumptions for machinery use associated with earthworks, drainage and utilities installations

Construction activity	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type
Rail siding construction	3,360	636,960	Diesel
Gantry rail construction	2,232	418,680	Diesel

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.4 Phase 4 – Pavement construction and ancillary works

The estimated emissions from Phase 4 of construction were **4,547 tCO₂e**. The breakdown of these emissions is detailed in the following sections.

2.4.1 Construction activities and Emissions sources

Phase 4 includes the following construction activities:

- Pavement construction; and
- Ancillary works.

Figure 10 illustrates the estimated GHG emissions quantities and relative proportions from each construction activity in Phase 4.

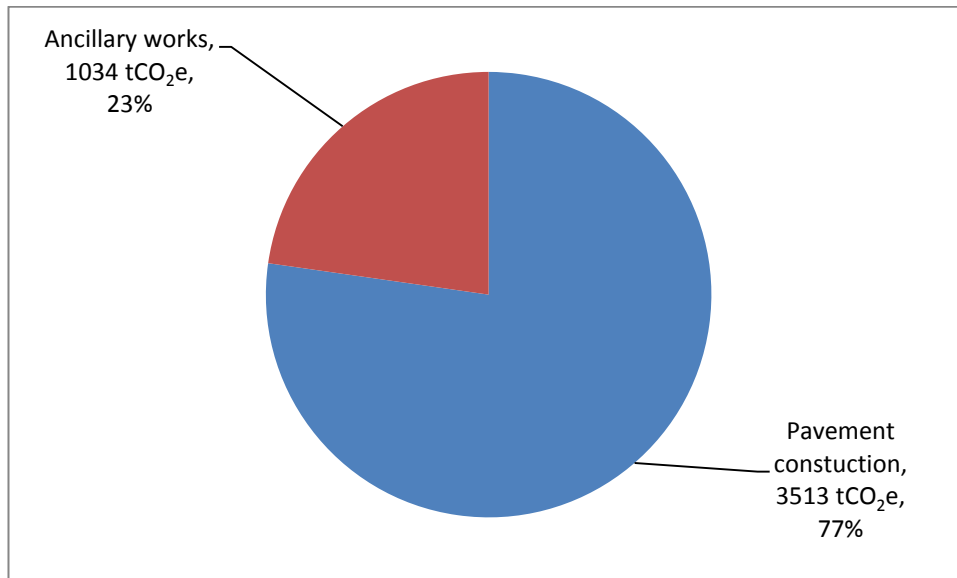


Figure 10: Emissions breakdown for pavement construction and ancillary works phase by construction activity

These are detailed further in Table 16.

Table 16: Summary of GHG emissions from pavement construction and ancillary works by construction activity

Construction activity	Emissions (tCO ₂ e)
Pavement construction	3,513
Ancillary works	1,034
TOTAL	4,547

For the purposes of this assessment, emissions from pavement construction and ancillary works phase included the following direct emissions sources:

- Fuel use from transport of materials; and
- Fuel use from construction activities.

Figure 11 illustrates the breakdown of emissions sources during the pavement construction and ancillary works phase.

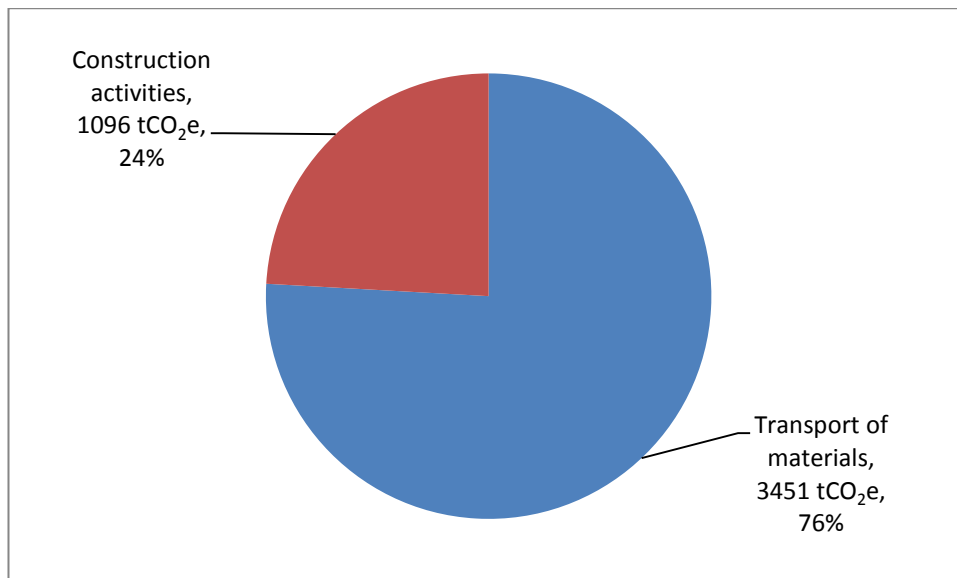


Figure 11: Emissions breakdown for pavement construction and ancillary works by emissions source

These are detailed further in Table 17.

Table 17: Summary of GHG emissions from pavement construction and ancillary works by emissions source

Construction activity	Emissions (tCO ₂ e)
Transport of materials	3,451
Construction activities	1,096
TOTAL	4,547

Assumptions used in calculating the above emissions are set out below:

- It was assumed that all machinery and vehicles were re-fuelled every 2 days on average.

The machinery and relative fuel capacity of the vehicles used during Phase 4 are assumed to be as set out in the following tables:

Table 18: Specifications for machines/vehicles used during pavement construction and ancillary works

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Backhoe	N/A	170
Static Roller	N/A	100
Mobile crane	N/A	400
Delivery trucks	N/A	150
Concrete agitators	N/A	410
Concrete pumping equipment	N/A	300
Excavator	N/A	410
Air compressor	N/A	300

The estimated program for pavement construction and ancillary works along with estimated machine/vehicle days and associated fuel use are outlined within Table 19.

Table 19: Summary of assumptions for machinery use associated with pavement construction and ancillary works

Construction activity	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type
Pavement construction	8,424	1,301,040	Diesel
Ancillary works	2,736	383,040	Diesel

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.5 Phase 5 – Building structures

The estimated emissions from Phase 5 of construction were **3,164 tCO₂e**. The breakdown of these emissions is detailed in the following sections.

2.5.1 Construction activities and Emissions sources

Phase 5 includes the following construction activities:

- Building construction; and
- Warehouse construction.

Figure 12 illustrates the estimated GHG emissions quantities and relative proportions from each construction activity in Phase 5.

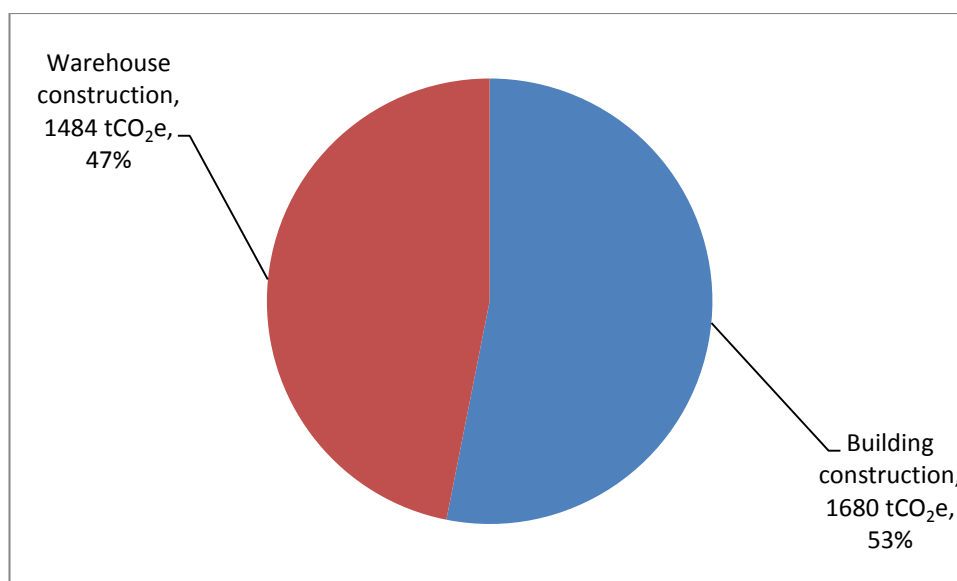


Figure 12: Emissions breakdown for building structures by construction activity

These are detailed further in Table 20.

Table 20: Summary of GHG emissions from building structures by construction activity

Construction activity	Emissions (tCO ₂ e)
Building construction	1,680
Warehouse construction	1,484

Construction activity	Emissions (tCO ₂ e)
TOTAL	3,164

For the purposes of this assessment, emissions from building structures phase included the following direct emissions sources:

- Fuel use from transport of materials
- Fuel use from construction activities

Figure 13 illustrates the breakdown of emissions sources during the building structures phase.

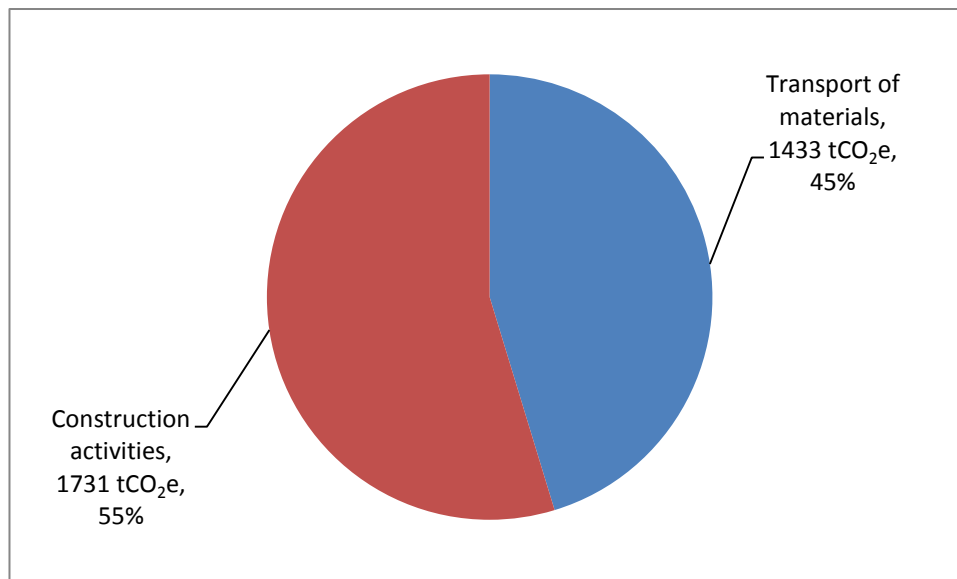


Figure 13: Emissions breakdown for building structures by emissions source

These are detailed further in Table 21.

Table 21: Summary of GHG emissions from building structures by emissions source

Construction activity	Emissions (tCO ₂ e)
Transport of materials	1,433
Construction activities	1,731
TOTAL	3,164

Assumptions used in calculating the above emissions are set out below:

- It was assumed that all machinery and vehicles were re-fuelled every 2 days on average;
- It was assumed that approximately 22kg/m² of steel is required in the construction of a typical warehouse and 24kg/m² of steel is required in the construction of the cold storage warehouse. These assumptions include structural steel elements and purlins/girts supporting the roof/wall sheeting and also cladding of the entire warehouse. The reinforcement in concrete was assumed as 6kg/m²; and
- The steel provider was assumed to be in Greystanes at a distance of 20km from the site and is assumed to be transported using a 20 tonne semi-trailer. Table 20 and 21 summarises the total distance to be covered to transport concrete and steel, the number of truck days and the associated fuel consumption.

The machinery and relative fuel capacity of the vehicles used during Phase 5 are assumed to be as set out in the following table.

Table 22: Specifications for machines/vehicles used during building structures

Machine and model required	Capacity (m ³)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Backhoe	N/A	170
Static Roller	N/A	100
Mobile crane	N/A	400
Delivery trucks	N/A	150
Concrete agitators	N/A	410
Concrete pumping equipment	N/A	300
Cherry picker	N/A	150
Air compressor	N/A	300

The estimated program for building structures and ancillary works along with estimated machine/vehicle days and associated fuel use are outlined within Table 23.

Table 23: Summary of assumptions for machinery use associated with building structures and ancillary works

Construction activity	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type
Transport of materials	4,320	622,440	Diesel
Construction activities	3,600	549,453	Diesel

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.6 Operation of site offices

Six site offices are assumed to be on the site during phase 1 - 4. Each office is assumed to have an area of about 18m² with a demand of 50VA/m². It is assumed that these offices are powered by mains energy with a power factor of 0.95. This results in electricity consumption of approximately 16,370.5 kWh which equates to estimated emissions of 15 tCO₂e during these phases. During Phase 5 of construction, it is estimated that twenty site offices are required with an area of 18m² with a demand of 50VA/m². It is assumed that these offices are powered by mains energy with a power factor of 0.95 for a further 18 months of construction, resulting in electricity consumption of approximately 54,568.4 kWh. This equates to an estimated emissions of 48 tCO₂e. During the entire construction phase, the total estimated emissions are approximately **63 tCO₂e**.

2.7 Total GHG emissions: site preparation and construction

Figure 14 illustrates the breakdown of emissions from the construction phase. It can be seen that phase 2 and 4 are the most significant emissions sources during the construction phase.

This is closely followed by emissions resulting from phase 3 and 5. It is important to note that composting of the vegetation waste significantly reduces the resulting emissions from the decomposition of vegetation waste.

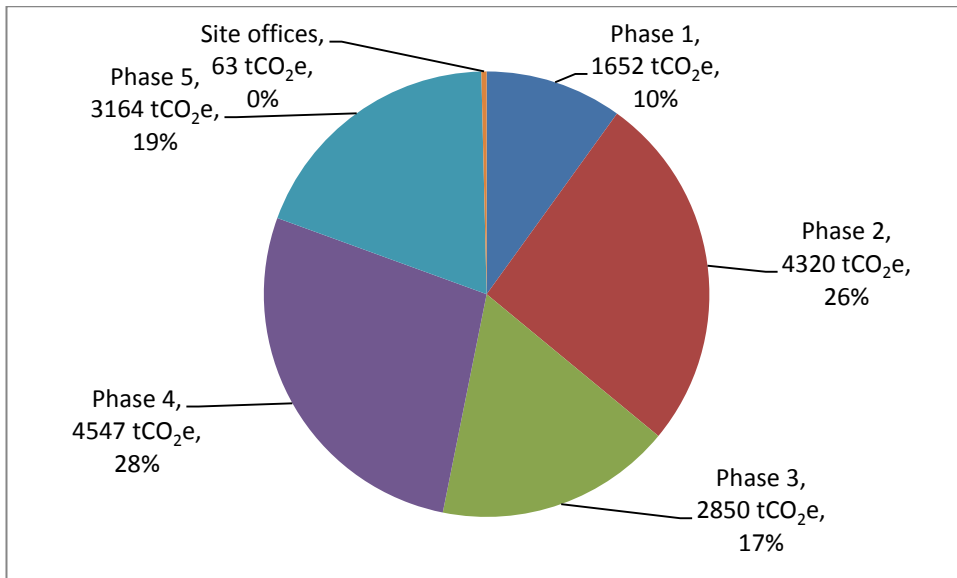


Figure 14: Emissions breakdown by construction phase

3 Embodied emissions of materials

This section of the report has been prepared by Edge Environment on behalf of Hyder Consulting to estimate embodied greenhouse gas emissions (GHGs) in construction material and products used in this project. The following sections are taken from Edge Environments full report which is available in Appendix A

3.1 Background and methodology

3.1.1 Life cycle assessment

Life cycle assessment (LCA) addresses the environmental aspects and potential environmental impacts (eg use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (ie cradle-to-grave).

Australian life cycle inventory database

The Australian Life Cycle Inventory (AusLCI) Data Guidelines are being developed to provide the rules for data collection for the AusLCI Database. The Guidelines have been developed by the Guidelines committee of the AusLCI data project after a consultative session held in the latter half of 2008. The development has been informed by the Ecoinvent data guidelines (a Swiss global database project) and the US LCI guidelines.

The ultimate objective of the project is to develop publicly available LCI data modules for commonly used, generic materials, products and processes. This is important to support public, private, and non-profit sector efforts to undertake product LCAs and LCA-based decision support systems and tools such as eco-labels, environmental impact calculators and simplified design tools.

The AusLCI database was launched at the 7th Australian LCA Conference in Melbourne in March 2011. AusLCI resources are available at www.auslci.com.au.

Australian LCA dataset

The Australian LCA Dataset supplied with the SimaPro software has traditionally been the most widely used LCA data in Australia. This data mostly originates from research undertaken by Royal Melbourne Institute of Technology (RMIT) and CSIRO. Where required data are not available, Edge Environment has used data from the Ecoinvent database, which originates from the Ecoinvent Centre in Switzerland and compiles data for most European countries. The Australian LCA Dataset comes with the Australasian version of the SimaPro software.

Building products life cycle inventory (BP LCI)

To facilitate the reduction of environmental impacts of buildings in Australia, the building and construction materials and products sector, represented by the Building Products Innovation Council (BPIC), are committed to help the Australian community make informed, research based and level playing field decisions about the environmental impact of building material and products. 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.

It is the intention of the building and construction materials and products industry sector that the LCI data will be widely used by LCA professionals to make informed decisions that can assist in the reduction of CO₂ and other building environmental impacts.

To facilitate this, the publically available BP LCI tool kit includes:

- Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database, adapted from the AusLCI Guidelines Committee Draft Guidelines for Data Development for an Australian Life Cycle Inventory Database. The adaptations interprets consensus from the BPIC Project's Technical Working Group and input from BPIC contributing member associations facilitated to discuss LCI/LCA methodology;
- The Methodology Guidelines describe how life cycle inventory data will be consistently compiled for Australian construction materials and building products, the Protocol describes how the data is to be used appropriately to represent and evaluate building products, systems and materials. Uses of the building and construction materials and products life cycle inventory data that do not comply with this Protocol are not considered to be appropriate uses of the data; and
- The life cycle impact assessment (LCIA) reports recommending methodology and factors for impact assessment.

These documents and additional components in the BP LCI tool kit are available on: <http://www.bpic.asn.au/LCIMethodology.htm>

3.1.2 Methodology

The embodied GHG assessment has been conducted according to the following methodology:

- 1 Goal and scope workshop between Edge Environment and Hyder project teams.
- 2 Compile 'bill of materials' based inputs/outputs and processes included in the assessment.
- 3 Determine quantities of inputs/outputs and processes from drawings and consultation with Hyder to estimate material quantities.
- 4 Model the inventory data in accordance with the *BPIC/ICIP Project's Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*. Economic allocation was used to determine the impacts between primary (eg steel production) and retained burden (if any) in recycled or re-used products.
- 5 Carbon Footprint assessment: Edge Environment modelled the inventory flows in the SimaPro LCA database system (v7.2.4), linking it to existing life cycle environmental impact for upstream and downstream components. Edge Environment will use:
 - a Generic Australian life cycle data
 - b Generic International life cycle data where Australian data is not available
 - c Generic life cycle data for analogous processes where specific process data are not available
 - d Best estimates of life cycle impacts by analogy to similar processes where no data is available
- 6 Sensitivity analysis and scenario modelling will be used to demonstrate the influence of key assumptions to the overall result and conclusions.

3.2 Assumptions

The following assumptions were used as part of this assessment.

3.2.1 System diagram and major emission sources

Figure 15 shows the main input, outputs and project activities in terms of GHG emissions.

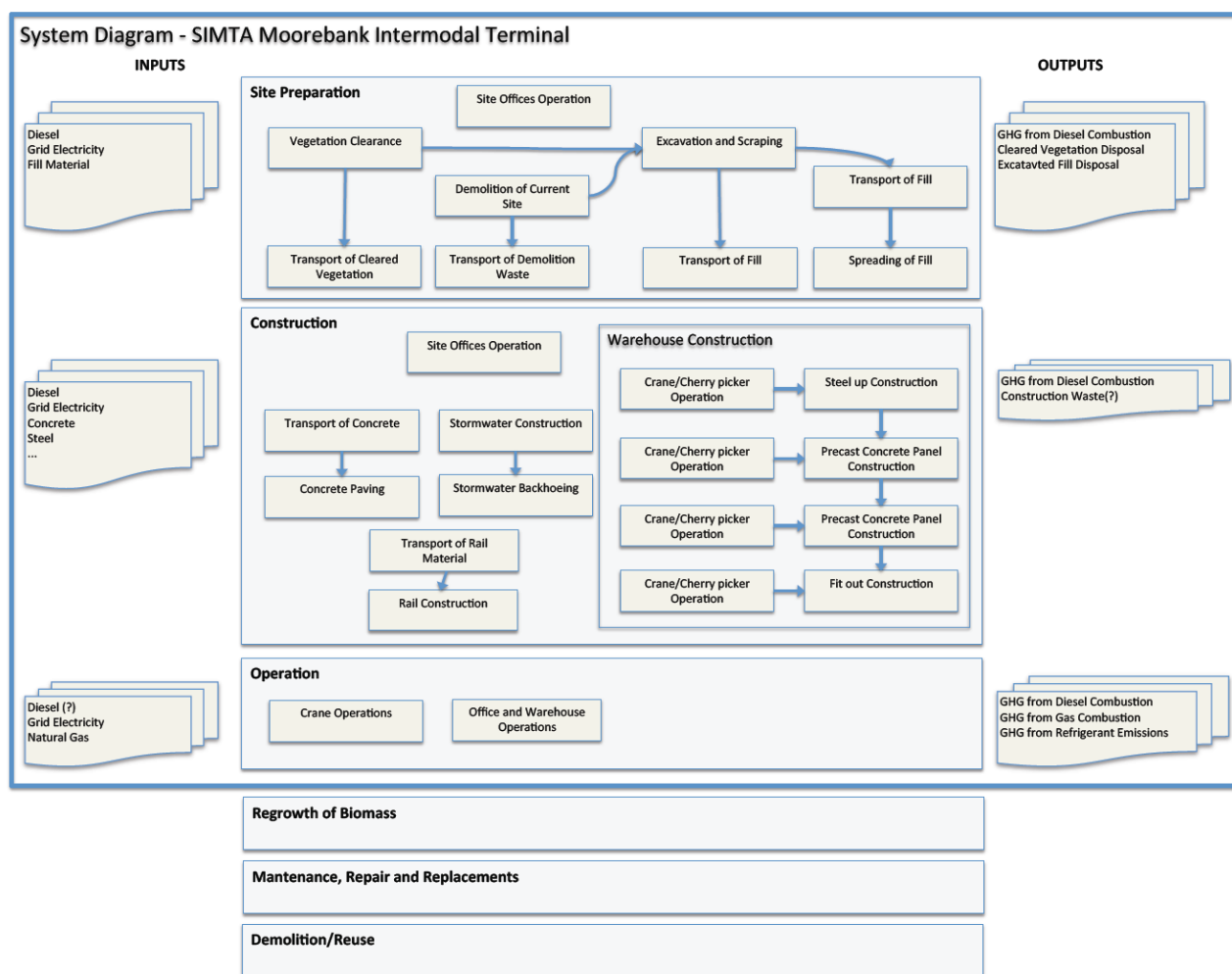


Figure 15: Schematic overview of the project GHG assessment system

Hyder Consulting undertook an assessment of the GHG emissions associated with:

- On-site fuel combustion and electricity consumption from site preparation, construction and operation;
- Transport of material, products and waste to and from site; and
- Decomposition of organic waste on- and off-site.

The proposed scope for assessing embodied construction material and product GHG emissions includes:

- Permanent piping material for stormwater infrastructure;
- Concrete paving, including mesh and bar reinforcement;
- Rail lines; and
- Warehouse structure, including steel frame, roof and wall sheets and insulated panels.

Note: GHG emissions from end of life of Moorebank Intermodal Terminal Facility have been excluded from the assessment due to large uncertainties in terms of degree of re-use of facilities and infrastructure, as well as degree of re-use, recycling and disposal of construction materials.

3.2.2 Project material quantities and use scenarios

The following scenarios are modelled in order to explore key data sensitivities and embodied greenhouse gas emission reduction potential:

1. Baseline scenario based on best available conservative data;
2. Cement substitution material scenario exploring 20% of Portland cement substituted with fly ash in the concrete; and
3. Concrete pavement slab thickness reduction by 20%.

3.2.3 Scenario 1: Baseline

The following assumptions (all subject to refinement/confirmation by the design team) have been used to establish the project construction material inventory:

- Surplus of on-site cut to fill will be used on site with assumed negligible import and disposal impact;
- 32MPa concrete for pavement, with no cement substitution materials (CSM);
- Mesh reinforcement of concrete pavement, ie no bar reinforcement;
- Added 500m of PVC plastic pipe for stormwater infrastructure;
- Added Steel sheet warehouse walls (1.6kg/m²) and roof (5.0kg/m²);
- Added reinforced concrete wall sections for the warehouse; and
- Added rail line material quantities for an estimated 3km rail line track for the project.

Table 24: Project construction material quantities

Phase	Material	Quantity (t)	Quantity (m3)	Quantity (m2)	Density (t/m3)	Density (t/m2)	Density (t/m)	Length (m)
Site Preparation								
	Fill material							
Construction								
Pavement								
	Concrete 32MPa	996,000	415,000		2.4			
	Mesh Reinforcing Steel	2,158						
Stormwater								
	Plastic Pipe	15			30.0			0.5
Warehouse								
	Structural Steel (typical)	5,072						
	Structural Steel (cooling)	480						
	Mesh Reinforcing Steel	1,383						
	Steel Sheet (walls)	1,253				0.0050		
	Steel Sheet (roof)	401				0.0016		
	Precast Concrete Panels (Wall)	23,227				0.0927		
	Precast Concrete Panel (Wall)	376				0.0015		

Phase	Material	Quantity (t)	Quantity (m3)	Quantity (m2)	Density (t/m3)	Density (t/m2)	Density (t/m)	Length (m)
	reinf.)							
	Insulated Panel							
	Rail Line							3,000
	Steel Rail	180				0.060		
	Sleeper Reinforcement	22				0.0072		
	Sleepers (concrete)	855				0.285		
	Aggregate	5,970				1.990		

3.2.4 Scenario 2: Cement substitution material

In this scenario 20% of Portland cement in the concrete pavement is substituted by fly ash from NSW coal fired power station. See section 7.1.1 below for more details on cement substitution.

3.2.5 Scenario 3: Pavement thickness

In this scenario the concrete pavement is reduced by an average of 20% to explore the overall sensitivity to a key project parameter affecting the overall embodied greenhouse gas emission assessment.

3.3 Embodied GHG impact results

3.3.1 Scenario 1: Baseline

The total embodied GHG emissions in construction materials were calculated as 196 ktCO₂-e, or approximately 27 times the previously estimated GHG emissions from the construction phase (excluding material impacts). However, the embodied construction material impacts only account to approximately the equivalence of three years of operation. Embodied GHG emissions by construction activity/phase are presented in Figure 16 and Table 25

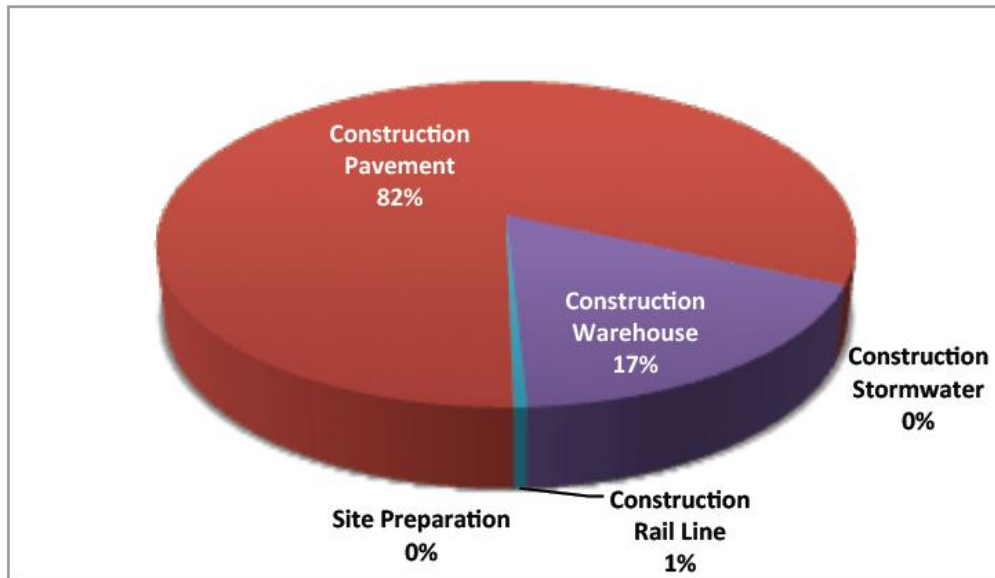


Figure 16: Embodied material GHG emissions by construction activity

Table 25: Embodied construction material GHG emissions by construction activity

Construction Activity/Phase	tCO ₂ -e
Site Preparation	0
Construction Pavement	161,022
Construction Stormwater	33
Construction Warehouse	34,134
Construction Rail Line	1,012

Figure 17 and Table 26 show GHG emissions by construction material category/type.

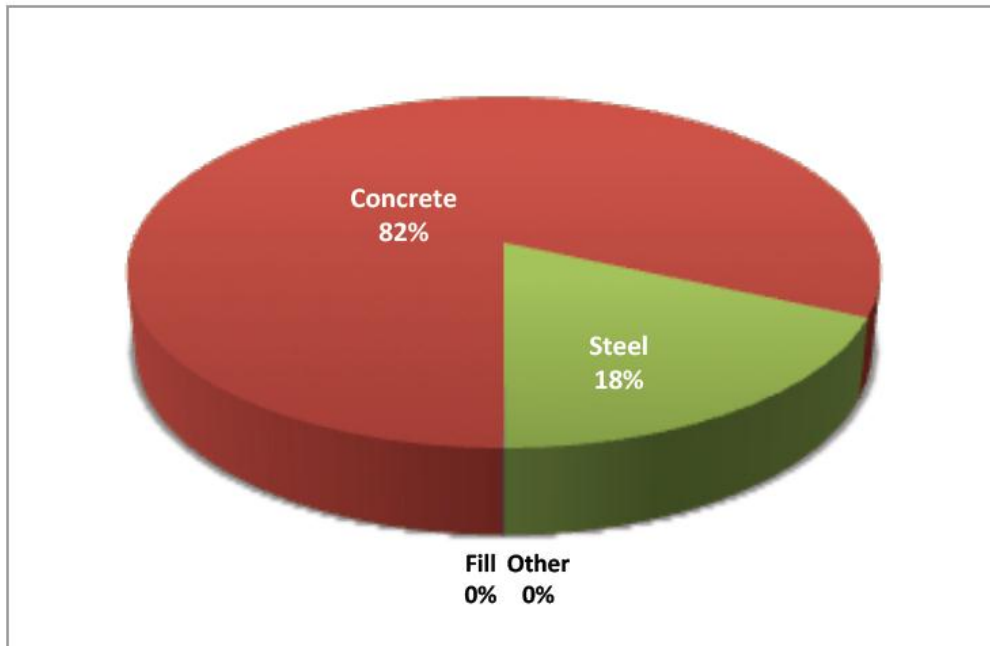


Figure 17: Embodied GHG emissions by material category

Table 26: Embodied construction material GHG emissions by material type

Material Category/Type	tCO ₂ -e
Fill	24
Concrete	160,337
Steel	35,808
Other	24

Figure 18 and Table 27 show GHG emissions by steel type/use.

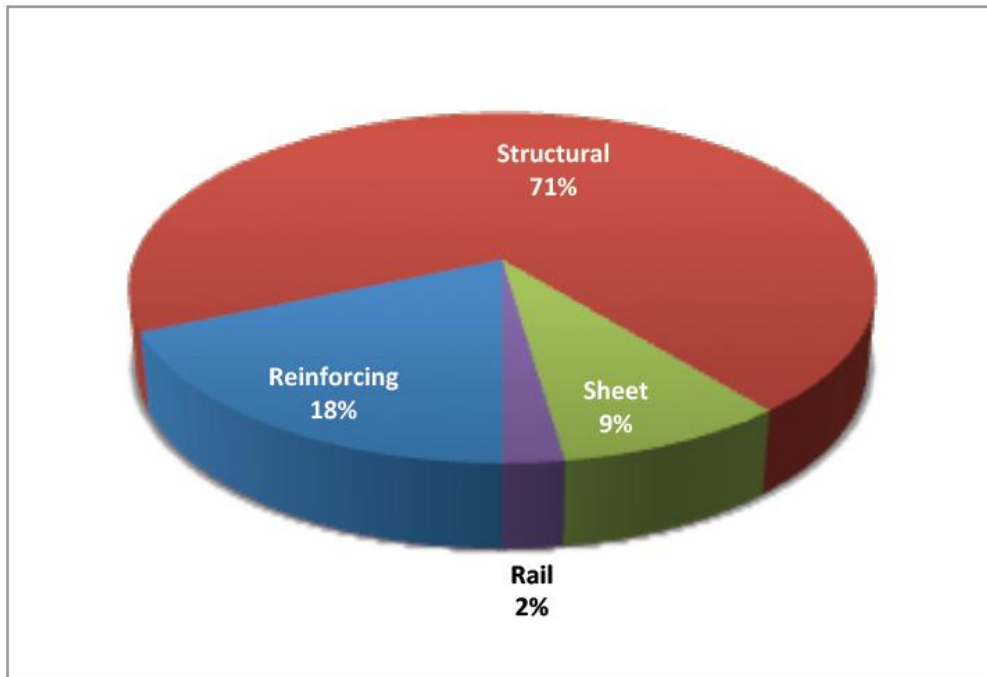


Figure 18: Embodied GHG emissions by steel type/use

Table 27: Embodied steel GHG emissions by type/use

Steel type/Use	tCO ₂ -e
Reinforcing	6,619
Structural	25,286
Sheet	3,084
Rail	820

Further GHG breakdown and detail from concrete use will be added if/when more details are available on concrete grades used for the project construction elements.

Scenario 2 and 3

The embodied GHG results from scenario 2 and 3 described above show:

- 172 ktCO₂-e in scenario 2; and
- 165 ktCO₂-e in scenario 3.

Overall the scenario have 12% and 16% reduction in overall GHG embodied emission, and 15% and 20% reduction of GHG emissions in the concrete pavement by replacing 20% of Portland cement with fly ash and reducing the pavement thickness by 20% respectively.

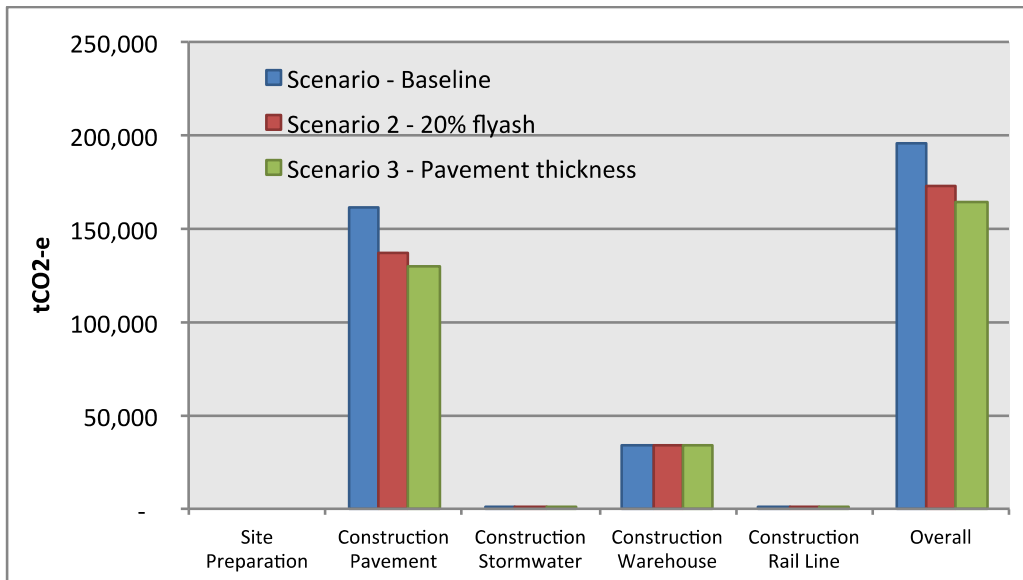


Figure 19: Embodied GHG emission scenario comparison.

4 Operational Greenhouse Gas Emissions

This section will outline the GHG emissions associated with the operation of the specific site. The intermodal terminal is expected to house the following facilities:

- Container hardstand areas;
- Ancillary facilities;
- Warehousing areas (including cold storage);
- Office spaces; and
- Green space.

The main sources of GHG emissions emitted from the operational activities within these areas are expected to be from:

- Electricity use (including lighting, heating, cooling, ventilation and crane use); and
- Natural gas use on-site.

This section will also estimate the electricity demand of an alternative scenario where the SIMTA site has not been developed. The alternative scenario is based on a number of assumptions which are detailed in the relevant section.

4.1 Electricity use – SIMTA site

The range of activities (along with details and assumptions) to be conducted on the site during the operational phase is shown in Table 28, along with a description of each activity and the assumptions applied in determining the GHG emissions. Where applicable, the average energy demand stipulated in AS3000:2007 was applied. Where the standard was not applicable, an estimate of energy demand was provided by Hyder’s electrical engineers based on similar projects.

Although the site will be operating 24 hrs/day it will not be at full capacity across all activities. The hours of operation per day for each type of activity are based on the number of hours that the activity will occur at full demand.

During the operational phase, the total GHG emissions from electricity use on the site have been calculated to be **50,651 tCO₂ per annum**.

Table 28: Activities using electricity and the GHG emissions

Operational activity	Details & assumptions	Emissions (tCO ₂ e)
Container hardstand area	<ul style="list-style-type: none"> ▪ The container hardstand areas are the areas where containers are transferred and stored. ▪ Area of site = 90,251 m² ▪ VA/m² = 10 ▪ PF = 0.95 ▪ Hrs operation/day = 10 	<ul style="list-style-type: none"> ▪ Per day = 8.5 ▪ Per annum = 3,086
Green space	<ul style="list-style-type: none"> ▪ Green spaces include energised, landscaped and non-paved areas ▪ Area of site = 65,013 m² ▪ VA/m² = 5 ▪ PF = 0.95 ▪ Hrs operation/day = 10 	<ul style="list-style-type: none"> ▪ Per day = 3.0 ▪ Per annum = 1,112
Ancillary facilities	<ul style="list-style-type: none"> ▪ Ancillary facilities include food courts and other commercial areas 	<ul style="list-style-type: none"> ▪ Per day = 6.1 ▪ Per annum = 2,238

Operational activity	Details & assumptions	Emissions (tCO ₂ e)
	<ul style="list-style-type: none"> Area of site = 13,090 m² VA/m² = 50 PF = 0.95 Hrs operation/day = 10 	
Warehousing – distribution	<ul style="list-style-type: none"> Warehousing areas are all the warehouse except for the cold storage Area of site = 230,560m² VA/m² = 15 PF = 0.95 Hrs operation/day = 10 	<ul style="list-style-type: none"> Per day = 32.4 Per annum = 11,826
Office space	<ul style="list-style-type: none"> Office space includes all the office spaces associated with the intermodal facility Area of site = 9,000 m² VA/m² = 75 PF = 0.95 Hrs operation/day = 10 	<ul style="list-style-type: none"> Per day = 6.3 Per annum = 2,308
Warehouse cold storage	<ul style="list-style-type: none"> This includes one warehouse which is planned to be a cold storage warehouse Area of site = 20,000m² VA/m² = 100 PF = 0.95 Hrs operation/day = 24 	<ul style="list-style-type: none"> Per day = 45.0 Per annum = 16,413
Crane operation	<ul style="list-style-type: none"> Ten cranes will be in use on the site; five large and five small Energy use was calculated based on the motors associated with all crane components (ie hoist, trolley travel and slewing) & the power rate Hrs operation/day = 5 	<ul style="list-style-type: none"> 5 x large per day = 25.0 5 x small per day = 12.48 Total per day = 37.4 Total per annum = 13,668
TOTAL		<ul style="list-style-type: none"> Per day = 138.8 Per annum = 50,651

PF = power factor

4.2 Natural gas use – SIMTA site

The activities using natural gas on the site include domestic hot water and food preparation. (note: room heating will be provided for by reverse cycle air conditioning).

Table 29: Energy usage from the use of natural gas

	Estimated population and their daily usage	mJ/hr
Hot water	<ul style="list-style-type: none"> 4,051.2 staff using 5L hot water/day 256 hotel guests using 110L hot water/day 160 office staff using 75L hot water/ day Total hot water = 60,416L/ day 	12,687mJ/hr based on a temperature rise of 50°C.
Food preparation	<ul style="list-style-type: none"> 256 patrons using 5mJ/hr 160 office staff using 20mJ/hr 	3,413mJ/hr
Subtotal		16,100.8mJ/hr
TOTAL	<ul style="list-style-type: none"> Assuming 10hrs usage/day 	161,008mJ/day

The GHG emissions from 161,008 mJ/day of natural gas are equivalent to 8.3 tCO₂e/day or **3,017 tCO₂e/annum**.

4.3 Summary – SIMTA site

The total estimated GHG emissions from operations based on the above boundary at the site is **147.0 tCO₂e/day** or **53,668 tCO₂e per annum**. The breakdown of these emissions is illustrated in Figure 20.

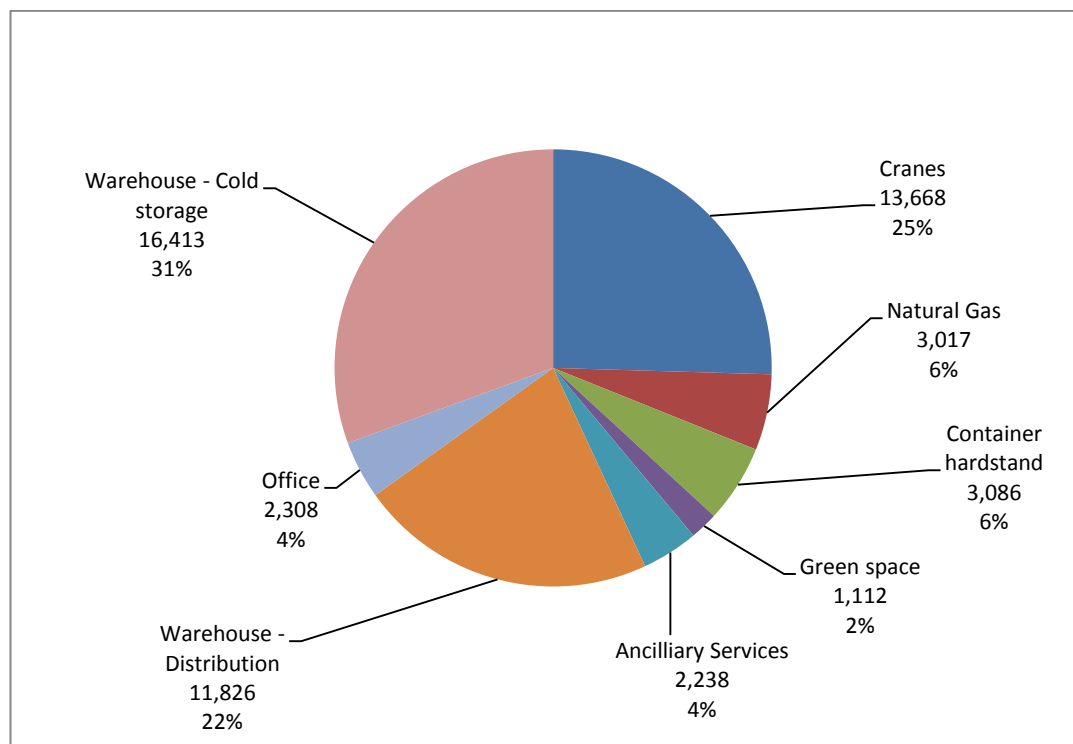


Figure 20: Emissions breakdown for SIMTA site operations

Operational emissions of over 25,000 tCO₂e/year at a facility will trigger reporting requirements under the National Greenhouse and Energy Reporting (NGER) Act 2007. Emissions from the SIMTA site are likely to trigger the corporate reporting threshold of 50,000 tCO₂e/year and responsible parties should be aware of the requirements under this legislation. The NGER act is based on corporate emissions and ownership of those emissions is based on operational control. All corporations with operational control of the SIMTA site should seek legal advice on liability under the NGER Act.

4.4 Operational emissions - Alternative scenario

The proposed SIMTA site has been zoned as 'General Industrial' (IN1) under the Liverpool Local Environmental Plan 2008. This is illustrated in Figure 21. Using the current LEP and the projected freight demand in the area, a feasible alternative scenario is that the site would be developed into industrial warehousing and distribution facilities rather than the proposed SIMTA site. This section estimates the emissions from such an alternative scenario for comparison with the proposed project.

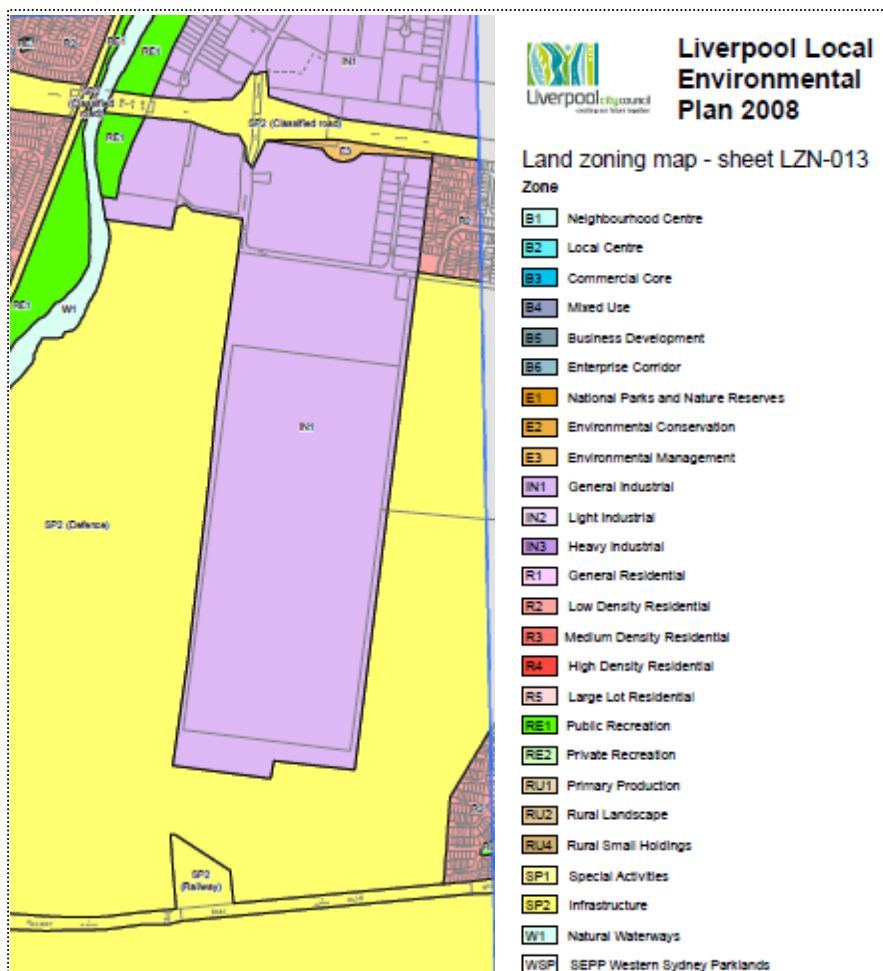


Figure 21: Current zoning of the proposed SIMTA site according to the Liverpool LEP 2008

In the alternative scenario it was assumed that 65% (54 hectares) of the site would be developed into industrial sites and 10% (8.3 hectares) would be offices associated with the industrial facilities. Under this scenario, the remaining 25% would remain undeveloped. The potential emissions from this alternative scenario can be estimated using the same electricity demands and power factor (PF) used for office space and industrial warehousing in the SIMTA site. The hours of operation were assumed to be 10 hours a day. The estimated emissions² and the associated assumptions for the alternative scenario are summarised in Table 30. The estimated emissions from electricity use in the alternative scenario are **56,054 tCO₂e**.

Table 30: Estimated emissions from electricity use of the alternative scenario

Site type	Area (m ²)	Average demand (VA/m ²)	Power Factor (PF)	Total VA	kW	kWh/day (based on 10 hour days)	tCO ₂ e per annum
Industrial	539,500	15	0.95	8,092,500	8518	85184	27,672
Office	83,000	100	0.95	8,300,000	8737	87368	28,382
Total Emissions 56,054							

² Emissions were estimated using the DCCEE NGA factors and methods 2009

5 Freight transport operations

The proposed intermodal facility at Moorebank is intended to improve freight transport efficiency within the Moorebank freight catchment. Transporting freight by rail from Port Botany to the intermodal facility will result in a significant reduction in road transport from Port Botany to the Moorebank freight catchment. One train can capacitate transport of up to 81 TEU from Port Botany to the proposed facility, whereas one truck will accommodate 2 TEU of freight per trip. The consolidation of freight distribution facilities within the Moorebank freight catchment will also result in a central distribution point where freight can be efficiently delivered to end points within the catchment. The benefits of this consolidation are expected to be twofold:

- 1 A significant reduction in road traffic both within the local Moorebank area and surrounding associated region; and
- 2 A significant reduction in transport related emissions associated with the transfer of road transport to more efficient rail transport.

The logistical improvements as a result of the consolidation of freight distribution through the SIMTA proposal are illustrated in the schematic diagram in Figure 22.

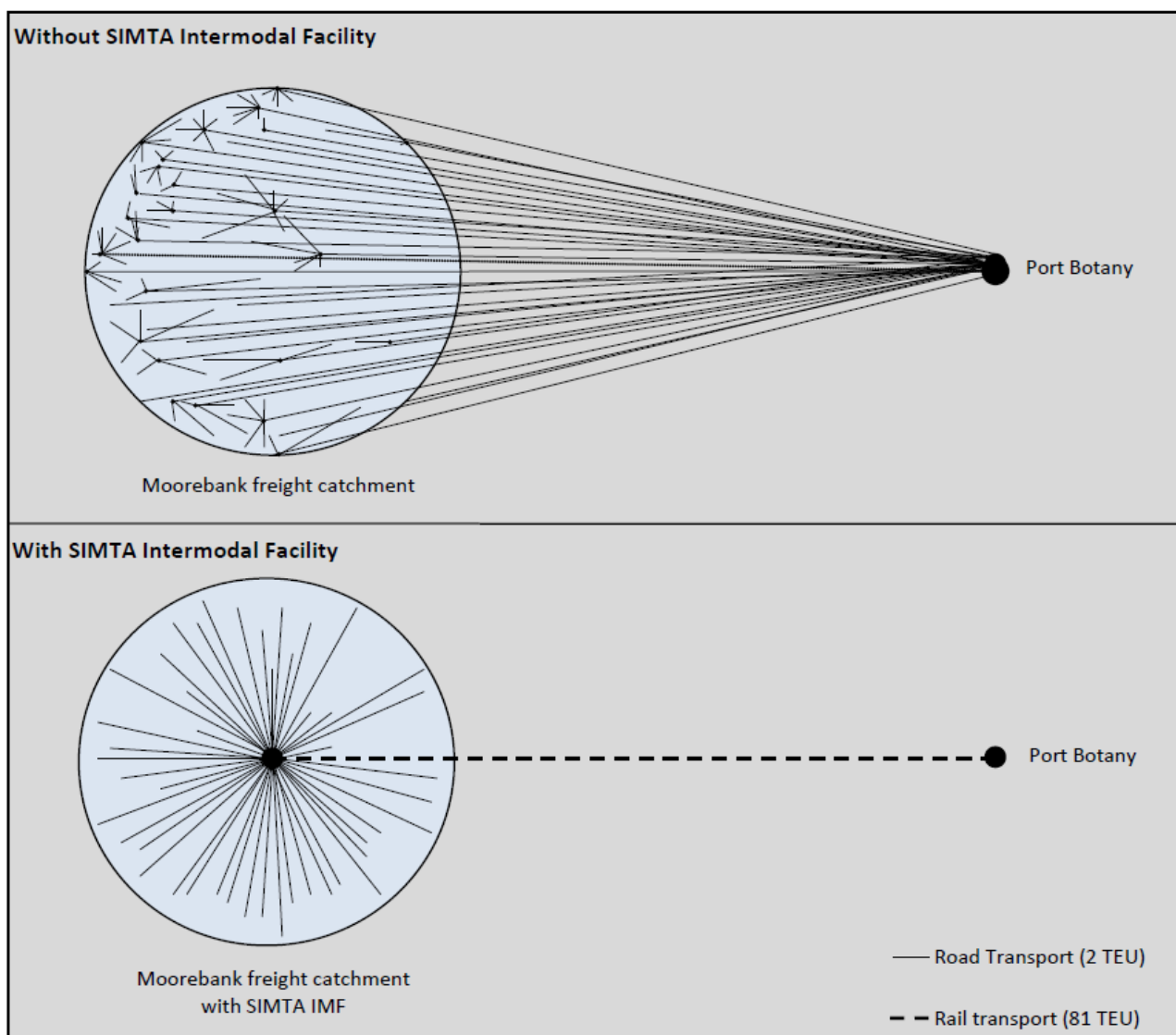


Figure 22: Schematic diagram showing freight transport from Port Botany without and with the proposal.

The vehicle kilometres travelled (VKT) for road and rail freight were projected for 2031 when the intermodal facility is expected to be at full operational capacity. These projections have been made based on expected increases in freight demand by 2031. The 'without SIMTA' projection uses freight demand projections to estimate the VKT required using unconsolidated distribution facilities. The 'with SIMTA' projections use the same freight demand but estimates VKT required using the consolidated distribution centre proposed in this project. The projections are summarised in Table 31

Table 31: Comparison of VKT required to meet freight demands in the Moorebank catchment with and without the SIMTA proposal

Freight Transport Type	Projected annual vehicle kilometres (VKT) required to meet freight demands in 2031		Difference
	Without SIMTA proposal	With SIMTA proposal	
Road	1,979,579,000	1,966,579,000	13,000,000 (savings)
Rail	0	332,000	332,000 (increase)

The traffic projections suggest that freight road transport from Port Botany will be reduced by approximately 13,000,000 VKT per annum regionally by the time the facility is fully operational. The resulting increase in rail transport as a result of the facility is projected to be approximately 332,000 VKT. Table 32 outlines the equivalent GHG savings from the reduction in road transport and the corresponding emissions increase due to increased rail transport using methods and factors from the greenhouse gas protocol (WBCSD 2011). The net emissions reduction from freight transport as a result of the SIMTA proposal has been estimated at **40,820 tCO₂e**

Table 32: GHG estimates from freight transport as a result of the proposed intermodal facility

Freight Transport Type	Projected GHG emissions from estimated VKT in 2031 (tCO ₂ e)		Difference
	Without SIMTA proposal	With SIMTA proposal	
Road	7,228,013	7,180,546	47,467(savings)
Rail	0	6,647	6,647(increase)
Net GHG savings/increase 40,820 (savings)			

Use of rail to transport freight from Port Botany through the intermodal terminal to the Moorebank freight catchment can be considered approximately 40 times more efficient than transport by road to the same catchment area. This is due to the efficiencies gained from transporting much larger quantities of freight (81 TEU) by a single train journey as opposed to a single truck journey (2 TEU). Figure 23 demonstrates the GHG emissions savings that the SIMTA proposal will produce through the use of rail for freight transport to a consolidated intermodal facility compared to road freight transport to a number of distribution facilities dispersed around the catchment. It shows that the savings generated from reduced road transport significantly outweighs the increase in emissions from rail transport.

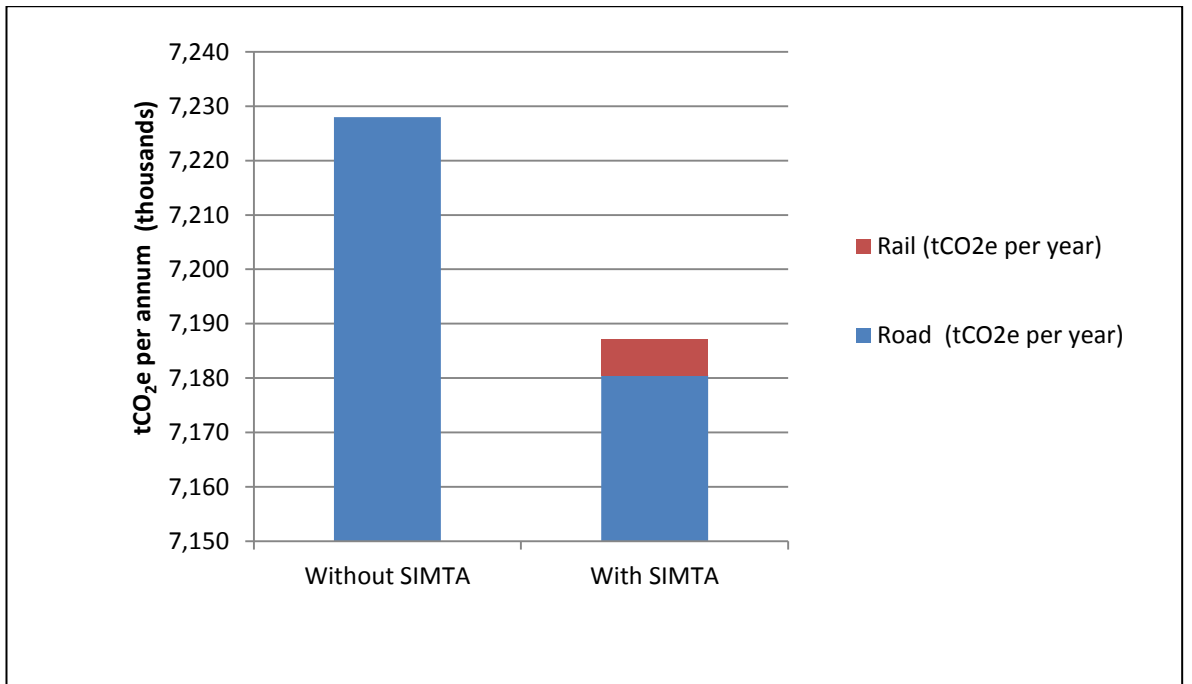


Figure 23: Estimated GHG emissions from freight transport with SIMTA proposal fully operational (2031)

6 Assessment of GHG Impact of Proposal

This section will summarise the overall GHG emissions from the SIMTA proposal. This will be compared against the emissions projected from an alternative scenario where the SIMTA proposal is not developed, with the same freight demand and LEP zoning.

6.1 Summary of SIMTA proposal GHG emissions

Figure 24 illustrates the comparison between the estimated emissions from the embodied emissions of materials, the construction phase and operation phase of this development. The emissions from operations are represented as annual emissions.

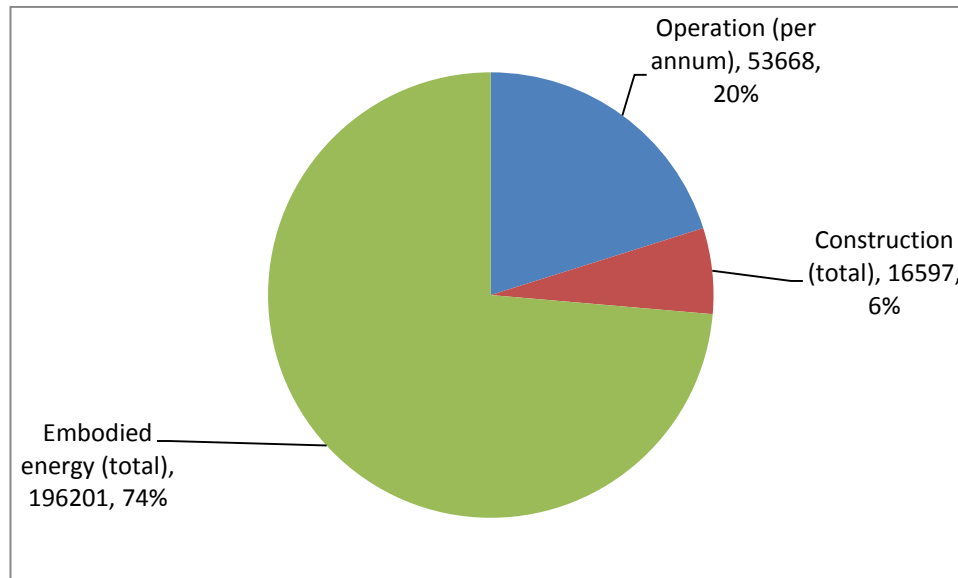


Figure 24: Emissions breakdown from construction and operational phases.

The construction emissions of 16,597 tCO₂e represents approximately 0.1% of emissions produced by the manufacturing and construction sector in NSW in 2007 (see Table 3). It is also likely that these emissions will be emitted over the course of several years which is the expected timeline of the development. The operational emissions of 53,668 tCO₂e/annum represents approximately 0.3% of emissions produced by the transport sector in NSW in 2007 (see Table 3).

6.2 Assessment against alternative scenario

Freight demand in the Moorebank area and the Liverpool LEP 2008 were used to develop an alternative scenario if the SIMTA proposal was not developed and operating. Table 33 summarises the emissions projected from the alternative scenario compared to those estimated from the SIMTA proposal. Embodied emissions and emissions associated with construction could not be determined for the alternative scenario with the available information. The consolidated SIMTA proposal results in a reduction of approximately 2,386 tCO₂e of GHG emissions when compared to the alternative scenario for site operations. For freight transport, the SIMTA proposal results in an annual emissions reduction of 40,820 tCO₂e due to efficiencies gained from switching freight transport from road to rail. Figure 25 illustrates the annual emissions savings as a result of the SIMTA proposal. Note that most of the operations emissions are a result of electricity use. These are indirect emissions as they are emitted at site of power production. The freight emissions are a direct result of burning diesel in the transport vehicles. The more significant savings are in the emissions associated with freight transport.

Table 33: Comparison of emissions between the SIMTA proposal and the alternative scenario

Scenario	Embodied Emissions tCO ₂ e	Emissions from construction tCO ₂ e	Emissions from site operation (per annum) tCO ₂ e	Total emissions from freight transport (per annum) tCO ₂ e
Alternative Scenario	N/A	N/A	56,054	7,228,013
SIMTA Proposal	196,201	16,597	53,668	7,187,193
Emissions savings from SIMTA proposal	None	None	2,386	40,820

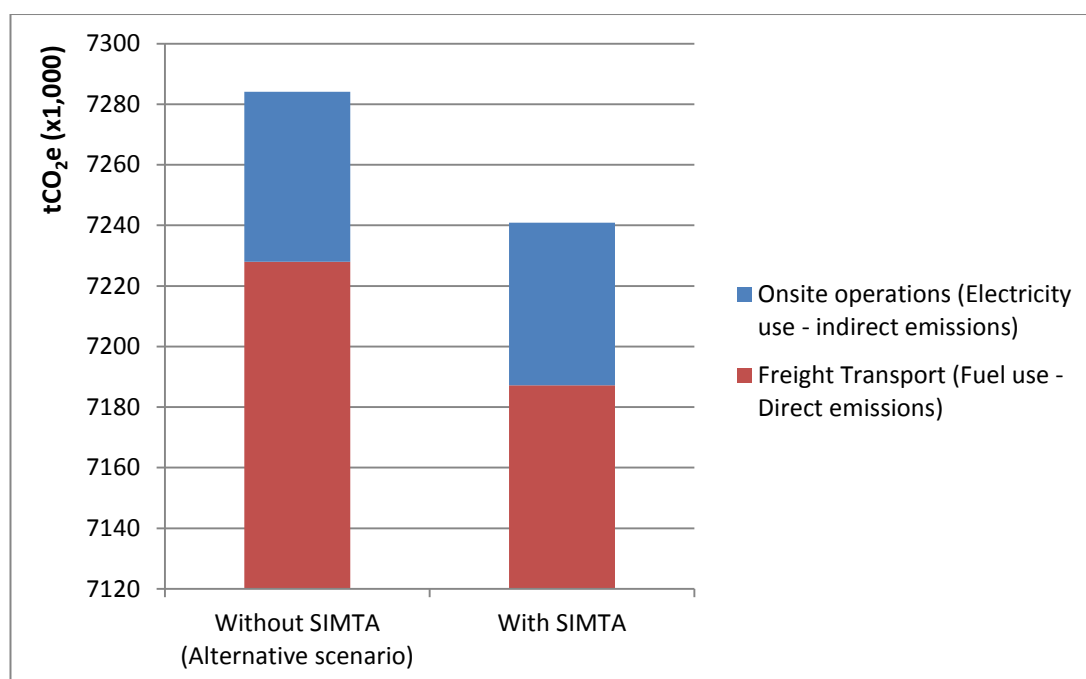


Figure 25: Comparison of emissions between the SIMTA proposal and the alternative scenario

The overall emissions savings from the SIMTA proposal over the alternative scenario is approximately **43,206 tCO₂e per annum**. Figure 26 shows the estimated annual emissions savings over a 6 year period where the savings will equalise the emissions from both the construction of the SIMTA proposal and those embodied in the construction materials. Further emissions savings can be made during construction and operation of the SIMTA site through the implementation of GHG management and mitigation actions. These are described in further detail in the next section.



Figure 26: Annual emissions savings from operation of the SIMTA proposal equalising construction and embodied emissions in approximately 6 years of operation compared to the alternative scenario.

7

GHG management and mitigation options

The carbon management principles (shown in Figure 27) provide a robust framework for the management and reduction of GHG emissions.

Carbon Management Principles

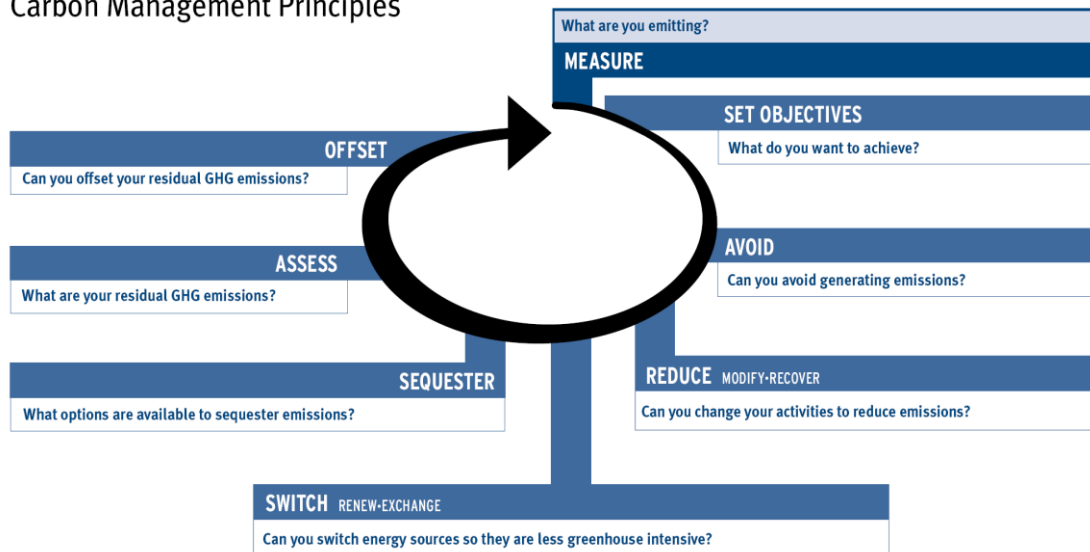


Figure 27: Carbon management principles for emissions reduction (Victorian EPA)

The earlier sections in this assessment represent the emissions measurement and setting objectives components of the carbon management principles. This section recommends actions to further reduce emissions throughout the project development. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles.

- **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; and
- **Offset:** Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

Regular monitoring of emissions is recommended throughout the project to assess the effectiveness of emissions mitigation actions. The following actions are recommended for mitigation of GHG emissions **during construction**:

- Where possible, use locally sourced materials to reduce emissions associated with transport;
- Recycle/compost waste wherever possible;
- When importing fill source from nearby construction sites wherever possible to reduce transport related emissions;
- Plan construction works to avoid double handling of materials;
- Make use of recycled emissions to reduce emissions associated with embodied energy (not estimated in this report);

- Develop construction/transport plans to minimise the use of fuel during each construction stage. For example throttling down and switching off construction equipment when not in use;
- Assess the fuel efficiency of the construction plant/equipment prior to selection, and where practical, use equipment with the highest fuel efficiency which use lower GHG intensive fuel (eg gas, ethanol); and
- Regular maintenance of equipment to maintain optimum operations and fuel efficiency.

The following actions are recommended for mitigation of GHG emissions **during the operation** of the facility:

- Incorporate energy efficiency design aspects wherever possible to reduce energy demand. More information on this can be found in the Hyder ESD report. Examples could include energy efficient lighting systems, natural ventilation, insulation and other renewable forms of energy (eg co-generation/tri-generation on site);
- Investigate the procurement of energy efficient equipment for the site (ie cranes, forklifts, street lighting);
- Investigate the feasibility of on-site renewable energy, such as photo-voltaics to reduce demand from the grid; and
- Tune buildings during commissioning to optimise energy performance.

7.1 Operational versus embodied GHG emissions

Provided GHG emissions from operation will dominate the overall life cycle emissions, design and material selection should be optimized for operational energy efficiency and GHG emission performance over life. This could include:

- Optimizing building thermal performance, or even surface colour and reflectance to reduce lighting requirements; and
- Sourcing electricity and fuels with low GHG intensity.

7.1.1 Concrete

A significant opportunity to minimize GHG emissions from concrete consumption is to substitute Portland cement with substitute materials such as local fly ash and blast furnace slag.

Several efforts are in progress to reduce the use of Portland cement in concrete. These include the utilisation of supplementary cementitious materials such as fly ash, silica fume, ground granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement (Your Building, 2009) ³.

A brief literature review was undertaken to determine the current knowledge on the use of cementitious materials for structural cement. Some of the research recently undertaken on the properties, benefits and potential limitations of the use of blast furnace slag as supplementary cementitious material for structural concrete. Generally, the majority of the studies did not rule out the use of a significant proportion of for example Blast Furnace Slag for structural concrete.

Further investigations should be undertaken, with more project specific information related to the level and type of exposure expected for the concrete structures of the project. The research suggests that close attention be paid to the processes of curing and covering of reinforcement when substituting cementitious material.

Additionally, transport of concrete contributes significantly to the overall impact of the project. The impacts of the sand and aggregate components of concrete are dominated by their transport, representing up to 90% of the mass of the concrete.

Recommendations:

- Investigate the feasibility to use supplementary cementitious materials for the concrete pavement; and
- Source concrete from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies).

7.1.2 Steel

The building and construction industry accounts for about half of the steel used in Australia. From a resource recovery and material stewardship point of view, the proportion of steel that is recycled and re-used at the end of its life is more relevant than the recycled content in production at a particular point in time (Crucible, 2006). Based on 2003 tonnages for recycled scrap and an estimate of steel deposited in landfills, the Australian steel recovery rate at end of life is calculated to be above 80%.

However, even with 100% recovery, scrap steel would not meet steel demand. Furthermore, there is a time lag: the scrap arising today comes from a period when steel production was lower (Crucible, 2006). The environmental benefits of prescribing recycled content rates needs to be evaluated carefully, taken into consideration the integrated international steel market and scrap trade.

The steel industry has articulated views against mandating 100% recycled steel, as follows:

³ The uses of supplementary cementitious materials do not come without associated embodied environmental impacts in a LCA. AusLCI and BP LCI use economic values to allocate environmental impacts between products and co-products. For instance in the case of fly ash, the greenhouse gases (and other environmental impacts) from burning coal for electricity are shared between the electricity generated and the fly ash produced based on, and proportionate to, the market value of electricity and fly ash respectively. The fly ash would come free of embodied CO₂ at the gate of the power station, only if there would be no market value for fly ash.

- ASI: The drive to increase recycling is understandable and for many materials this kind of incentive may act to prevent post-consumer product, such as glass, paper, and plastic going to landfill. However, in the case of steel, recycling of scrap has been maximised worldwide and the development of efficient low-cost electric arc furnace (EAF) technology has put a premium on it (ASI, 2009); and
- US Steel Recycling Institute: Understanding the recycled content of BOF and EAF steels, one should not attempt to select one steel producer over another on the basis of a simplistic comparison of relative scrap usage or recycled content. Rather than providing an enhanced environmental benefit, such a selection could prove more costly in terms of total life cycle assessment energy consumption or other variables. Steel does not rely on 'recycled content' purchasing to incorporate or drive scrap use. It already happens because of the economics. Recycled content for steel is a function of the steelmaking process itself (US Steel Recycling Institute, 2009).

As opposed to concrete where transport can be a major factor in the GHG profile, for steel, the energy and greenhouse gas emission impacts of transport amount to approximately 2% of the impacts of the product (combining all routes for integrated steelmaking in Australia) (Crucible, 2006).

Recommendations

The keys to producing low impact steel are:

- Avoid using recycled content in steel products as a single indicator for low GHG intensity as this has proven to be misleading;
- Achieve high steel scrap recycling rates;
- Use low GHG intensive energy in production (ie renewable energy for electricity); and
- Minimize GHG emissions from steel making by sourcing from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies).

8 References

- AS1085.1-2002 Railway and Track Materials Part 1: Steel Rails, Australian Standard, last viewed 16 November 2010,
<[http://www.saiglobal.com/PDFTemp/Previews/OSH/as/as1000/1000/1085.1-2002\(+A1\).pdf](http://www.saiglobal.com/PDFTemp/Previews/OSH/as/as1000/1000/1085.1-2002(+A1).pdf)>.
- Australian Life Cycle Inventory and Australian Life Cycle Assessment Society [AusLCI & ALCAS], (2009), *Guidelines for Data Development for an Australian Life Cycle Inventory Database, Draft Standard*, June 28th 2009.
- Australian Steel Institute, (2009), *Rating Systems of Buildings*,
http://www.steel.org.au/inside_group.asp?ID=613&pnav=612
- Building Products Innovation Council (BPIC), (2010a), BPIC/ICIP Project, Draft : *Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*, 8th Draft April 2010.
- Building Products Innovation Council (BPIC), (2010b), *Protocol for the Correct Use of Australian Life Cycle Inventory Data for Building and Construction Materials and Products*, 7th Draft, 12 January 2010.
- Concrete Sleepers (Heavy Duty) – Design, Australian Rail Track Corporation Ltd, last viewed 16 November 2010,
<http://extranet.artc.com.au/docs/engineering/common_standards/track/etd_02_03_concrete_sleepers_heavy_design.pdf>.
- Crucible, (2006), *A Life Cycle Perspective on Steel Building Materials*, prepared for Australian Steel Institute on behalf of OneSteel, BlueScope Steel and Smorgon Steel.
- Frischknecht, R., et al., (2007), *The Environmental Relevance of Capital Goods in Life Cycle Assessments of Products and Services*, Int. J LCA 2007 (OnlineFirst): 11
- DCC (2008). *National Greenhouse and Energy Reporting Guidelines* Commonwealth of Australia, Canberra ACT.
- DCC (2009) *National Greenhouse Accounts (NGA) Factors* Commonwealth of Australia, Canberra ACT.
- DCCEE (2010) *State and Territory Greenhouse Gas Inventories for 2008* Commonwealth of Australia, Canberra ACT.
- IPCC, (2007) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,
- International Organization for Standardization (ISO) (2006) *International Organization for Standardization - Environmental management - Life cycle assessment – Principles and Framework*. ISO 14040:2006; Second Edition 2006-06, Geneva, CH.
- International Organization for Standardization (ISO) (2006) *International Organization for Standardization - Environmental management - Life cycle assessment – Requirements and Guidelines*. ISO 14044:2006; Second Edition 2006-06, Geneva, CH.
- Railway and Tramway Sleepers, Queensland Government Department of Primary Industries and Fisheries, last viewed 16 November 2010,
<http://www.cqfa.com.au/documents/1181619278_sleepers_fact_sheet.pdf>.

Review of CO₂-e Emissions from Concrete versus Timber Sleepers, Energy Strategies, last viewed 16 November 2010, <<http://www.enerstrat.com.au/lib/documents/Review-of-CO2-Emissions-from-Concrete-versus-Timber-Sleepers.pdf>>.

Tchobanoglous G., Theisen, H., and Vigil S. (1993) *Integrated Solid Waste Management – Engineering Principles and Management Issues* McGraw-Hill, Inc.

US Steel Recycling Institute, (2009), *Steel Takes LEED® with Recycled Content*, <http://www.recycle-steel.org/PDFs/leed/LEEDMAR09.pdf>

World Business Council for Sustainable Development & World Resources Institute (2001) *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard*, Revised Edition.

Your Building, (2008), *Fly Ash-Based Geopolymer Concrete*, www.yourbuilding.org/display/yb/Fly+Ash-Based+Geopolymer+Concrete

Appendix A

Edge Environment Embodied Energy Report

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Embodied Greenhouse Gas Emission Assessment of the Moorebank Development

16 August 2011



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TABLE OF CONTENTS

1. INTRODUCTION	1
2. BACKGROUND	1
2.1 GHG POLICY AND REGULATION	1
2.2 MOOREBANK INTERMODAL TERMINAL FACILITY	1
2.3 LIFE CYCLE ASSESSMENT	1
2.3.1 <i>Australian life cycle inventory database</i>	1
2.3.2 <i>Australian LCA dataset</i>	2
2.3.3 <i>Building products life cycle inventory (BP LCI)</i>	2
3. METHODOLOGY	3
4. RESULTS	3
4.1 GOAL AND SCOPE	3
4.1.1 <i>System diagram and major emission sources</i>	6
4.2 PROJECT MATERIAL QUANTITIES	8
4.2.1 <i>Scenario 1: Baseline</i>	8
4.2.2 <i>Scenario 2: Cement substitution material</i>	9
4.2.3 <i>Scenario 3: Pavement thickness</i>	9
4.3 EMBODIED GHG IMPACT RESULTS	9
4.3.1 <i>Scenario 1: Baseline</i>	9
4.3.2 <i>Scenario 2 and 3</i>	12
5. DISCUSSION AND RECOMMENDATIONS	13
5.1 OPERATIONAL VERSUS EMBODIED GHG EMISSIONS	13
5.2 CONCRETE	13
5.3 STEEL	14
6. SUMMARY	15
7. REFERENCES	16

TABLE OF FIGURES

Figure 1: Schematic overview of the project GHG assessment system	7
Figure 2: GHG emissions over 40 years of operation.	10
Figure 3: Embodied material GHG emissions by construction activity	10
Figure 4: Embodied GHG emissions by material category	11
Figure 5: Embodied GHG emissions by steel type/use	12
Figure 6: Embodied GHG emission scenario comparison	13

TABLE OF TABLES

Table 1: Project construction material quantities.....	8
Table 2: Embodied construction material GHG emissions by construction activity	10
Table 3: Embodied construction material GHG emissions by material type	11
Table 4: Embodied steel GHG emissions by type/use.....	12

1. Introduction

This report is prepared to complement Hyder Consulting's report "Stockland - SIMTA Moorebank Intermodal Terminal Facility - Greenhouse gas assessment" to include embodied greenhouse gas emissions (GHGs) in construction material and products.

2. Background

2.1 GHG policy and regulation

In Australia and NSW a number of policies and regulations have been introduced to manage and reduce GHG emissions to be released into the atmosphere. These include:

- The Australian Government has committed to reduce its emissions by between 5 and 15 per cent below 2000 levels by 2020. It has also committed to a long-term emissions reduction target of at least 60 per cent below 2000 levels by 2050.
- The National Greenhouse and Energy Reporting (NGER) Act was introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. For GHG emissions, thresholds are currently set at 25kt CO₂e for a facility under a corporation and 50kt CO₂e for a corporation as a whole for 2010-2011.
- The NSW Department of Infrastructure, Planning and Natural Resources – Department of Energy, Utilities and Sustainability Guidelines for Energy and Greenhouse in EIA provides guidance on the consideration of energy and greenhouse issues when developing projects and when undertaking environmental impact assessment under the Environmental Planning and Assessment Act 1979 (EP&A Act)

2.2 Moorebank intermodal terminal facility

The Defence National Storage and Distribution Centre (DNSDC) site is located in Moorebank Avenue, Moorebank in south-western Sydney. The site area is approximately 83 hectares and is located approximately 26 km south-west of Sydney's CBD. The site encompasses an area of 238,000 m² of existing low rise buildings comprising of warehouses and administrative offices.

Stockland and their joint venture partners intend to develop the site into an Intermodal Freight Terminal (IMT) and warehouse/distribution facility, including container storage and warehouse solutions with direct rail access.

2.3 Life cycle assessment

Life cycle assessment (LCA) addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave).

2.3.1 Australian life cycle inventory database

The Australian Life Cycle Inventory (AusLCI) Data Guidelines are being developed to provide the rules for data collection for the AusLCI Database. The Guidelines have been developed by the Guidelines committee of the AusLCI data project after a consultative session held in the latter

half of 2008. The development has been informed by the Ecoinvent data guidelines (a Swiss global database project) and the US LCI guidelines.

The ultimate objective of the project is to develop publicly available LCI data modules for commonly used, generic materials, products and processes. This is important to support public, private, and non-profit sector efforts to undertake product LCAs and LCA-based decision support systems and tools such as eco-labels, environmental impact calculators and simplified design tools.

The AusLCI database was launched at the 7th Australian LCA Conference in Melbourne in March 2011. AusLCI resources are available at www.auslci.com.au.

2.3.2 Australian LCA dataset

The Australian LCA Dataset supplied with the SimaPro software has traditionally been the mostly widely used LCA data in Australia. This data mostly originates from research undertaken by Royal Melbourne Institute of Technology (RMIT) and CSIRO. Where required data are not available, Edge Environment has used data from the Ecoinvent database, which originates from the Ecoinvent Centre in Switzerland and compiles data for most European countries. The Australian LCA Dataset comes with the Australasian version of the SimaPro software.

2.3.3 Building products life cycle inventory (BP LCI)

To facilitate the reduction of environmental impacts of buildings in Australia, the building and construction materials and products sector, represented by the Building Products Innovation Council (BPIC), are committed to help the Australian community make informed, research based and level playing field decisions about the environmental impact of building material and products. 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.

It is the intention of the building and construction materials and products industry sector that the LCI data will be widely used by LCA professionals to make informed decisions that can assist in the reduction of CO₂ and other building environmental impacts.

To facilitate this, the publically available BP LCI tool kit includes:

- *Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*, adapted from the AusLCI Guidelines Committee Draft *Guidelines for Data Development for an Australian Life Cycle Inventory Database*. The adaptations interprets consensus from the BPIC Project's Technical Working Group and input from BPIC contributing member associations facilitated to discuss LCI/LCA methodology.
- The Methodology Guidelines describe how life cycle inventory data will be consistently compiled for Australian construction materials and building products, the Protocol describes how the data is to be used appropriately to represent and evaluate building products, systems and materials. Uses of the building and construction materials and products life cycle inventory data that do not comply with this Protocol are not considered to be appropriate uses of the data.
- The life cycle impact assessment (LCIA) reports recommending methodology and factors for impact assessment.

These documents and additional components in the BP LCI tool kit are available on: <http://www.bpic.asn.au/LCIMethodology.htm>

3. Methodology

The embodied GHG assessment have been conducted according to the following methodology:

1. Goal and scope workshop between Edge Environment and Hyder project teams (see section 4.1 below).
2. Compile “bill of materials”. Hyder is coordinating the delivery so should be able to provide Edge with lists of inputs/outputs and processes to be included in the assessment.
3. Determine quantities of inputs/outputs and processes. Edge will work from drawings and consulting with Hyder’s structural engineers where required to estimate material quantities.
4. Model the inventory data in accordance with the *BPIC/ICIP Project’s Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*. Economic allocation will be used to determine the impacts between primary (e.g. steel production) and retained burden (if any) in recycled or reused products.
5. Carbon Footprint assessment: Edge Environment will model the inventory flows in the SimaPro LCA database system (v7.2.4), linking it to existing life cycle environmental impact for upstream and downstream components. Edge Environment will use:
 - a. Generic Australian life cycle data;
 - b. Generic International life cycle data where Australian data is not available
 - c. Generic life cycle data for analogous processes where specific process data are not available
 - d. Best estimates of life cycle impacts by analogy to similar processes where no data is available
6. Sensitivity analysis and scenario modelling will be used to demonstrate the influence of key assumptions to the overall result and conclusions.
7. Technical review of the greenhouse gas estimates for construction and operation of the facility. The estimate will be very basic and will use factors from the GHG protocol and the NGA factors, with any assumptions outlined.
8. Draft report to Hyder Consulting.
9. Final report incorporating Hyder’s feedback and comments

4. Results

4.1 Goal and scope

The goal and scope for the project “Embodied Greenhouse Gas Emissions of the Moorebank Development”, primarily based on a meeting between Ken Luty of Hyder Consulting, and Jonas Bengtsson and Ben Kneppers of Edge Environment on the 21st of April 2011 and follow up email conversations.

Information Requirement	Definition
Reasons for LCA	Fulfil Director General’s requirements for GHG assessment section of environmental approval

	Complement Hyder's study with embodied material emissions "SIMTA Moorebank Intermodal Terminal Facility - Greenhouse gas assessment"
System definition and boundary	See section 4.1.1 below
Function of the system	Intermodal transport facility (Road and rail freight, including cold storage)
Functional unit	Whole of project – not going to be compared or benchmarked
Environmental impacts to be considered	Global warming: Characterised in 100 year global warming potential factors (GWP100) for carbon dioxide equivalents (kg CO ₂ -eq);
Allocation procedure	<p>The allocation approach for this study is aligned with the BPIC/ICIP methodology http://www.bpic.asn.au/LCIMethodology.htm).</p> <p>Primary materials/products that are recyclable/reusable provide two services to humanity – firstly as a material/product for immediate use and secondly as a scrap material that has remaining utility by virtue of its recyclable/reusable properties.</p> <p>Essentially, recycled material may have a lower environmental impact than primary material, but it can only be available for recycling if, in the past, this material was produced from primary sources. The recycled material should therefore take a share of the primary production burdens. Equally, the primary material deserves some recognition for the fact that it has future potential to be recycled.</p> <p>Economic allocation is used to establish the life cycle impacts between primary production and recycled scrap. The economic allocation has been based on the nationally relevant average recycling rates for each material and average market prices for primary and recycled products (if the market price of a given scrap is zero, the scrap is treated a true waste and retains no burden from primary production).</p>
Data interpretation method	Scenario modelling to explore sensitivity on the result to key assumptions
Data sources	<ul style="list-style-type: none"> • Material quantity and transport data from Hyder/Stockland based on: <ul style="list-style-type: none"> ○ Moorebank Greenhouse Gas Assessment_FINAL DRAFT.docx ○ GHG Assessmentv3.xlsx ○ Additional data to be requested by Edge from Hyder/Stockland • Cradle to site background life cycle inventory data will be based on (in order of preference): <ul style="list-style-type: none"> ○ Building Products Life Cycle Inventory ○ AusLCI data (when available)

	<ul style="list-style-type: none"> ○ The Australian LCA dataset provided with SimaPro v7.2.4¹ ○ Peer reviewed Australian LCI/LCA studies ○ International data from the Ecoinvent (v2.2) database, adapted to Australian conditions when required following the BP LCI methodology and the AusLCI guidelines
Value choices and optional elements	None identified
Data limitations	Still in concept design – design not finalised
Data quality requirements	<ul style="list-style-type: none"> • Time related coverage: Data as close as possible to the current conditions • Geographical coverage: National/Australian average – identify overseas production/source when possible • Technology coverage: National/Australian average • Completeness: All major components of the development (as defined in section 4.1.1) should be included in accordance with concept drawings. <p>It is common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a threshold % of the total mass of the product, but with the exception that where the a small input/output has a “significant” impact it should be included.</p> <p>Procedure for modelling minor process flows will be adopted by using sensitivity analysis to test the dependence of the final impact assessment to certain inputs/outputs. This is done by changing individual inputs; by doubling and halving each data item, and observing the change to the overall impact. Provided the final environmental significance for the product varies by less than 10%, approximate values can be used. Where the variation is greater than 10%, further investigation of this parameter should be undertaken.</p>

¹ Edge Environment have made adaptations to the data for this project (in accordance with the BP LCI methodology) were as follows:

- Universal and consistent application of economic allocation between all co-products and recycled wastes from all processes, including to end-of-life recycled materials going to recycled products. This affects all components and energy sources and feedstocks either directly (or indirectly from their upstream supply chain).
- Provision of discounts to the primary products that are recyclable on the basis of the value and quantity of scrap recycled compared to the value and quantity of primary product produced
- Transfer of this discount and spreading it between the recycled materials that derive from the primary product in proportion to their value and quantity
- Review of the unit process data for all material inputs to ensure consistency of feedstock emissions accounting.
- Review of the unit process data for all renewable material inputs (mainly timber, but also some vegetable oils) to ensure that the scope accounted for sequestered CO₂ and solar energy is consistent and appropriate.
- Numerous minor changes to maximise the consistency of the assessment.

	<p>Capital equipment and buildings typically account for under 1% of nearly all life cycle inventory parameters and this is usually much smaller than the error in the inventory data itself. For this project, approximate estimates of the impacts of capital equipment and buildings will be made and provided these contribute to less than 5% of the normalized impacts, no further elaboration will be needed².</p> <ul style="list-style-type: none"> • Representativeness: Australian or state based average background data is deemed appropriate at this stage given limited availability of supplier or project specific data. • Consistency: Guided by the BPIC Building Products Life Cycle Inventory methodology • Reproducibility: The systems shall be modelled described in a manner which allows for reproduction of the study/results. • Uncertainty of the information: Concept design
Type of critical review	Final draft and final to be reviewed by Hyder Consulting and Urbis/Arden respectively
Type and format of the report required for the study	Project report and MS Excel based LCI/LCA tool.

4.1.1 System diagram and major emission sources

The diagram below shows the main input, outputs and project activities in terms of GHG emissions.

² Frischknecht et al (2007) found the contribution of greenhouse gas emissions from capital goods in construction material represent approximately 4% (0.7% - 7.7%) of the total footprint.

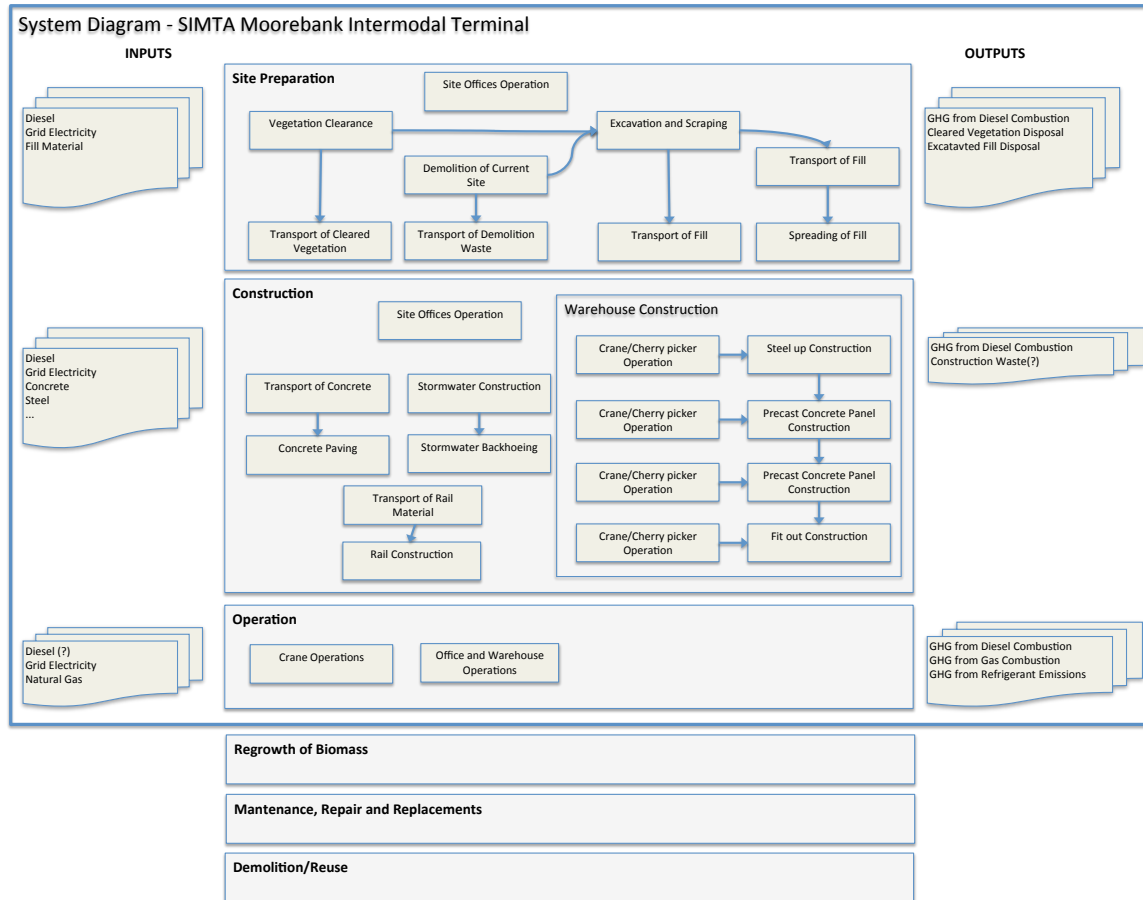


Figure 1: Schematic overview of the project GHG assessment system

Hyder Consulting have already assessed the GHG emissions associated with:

- Onsite fuel combustion and electricity consumption from site preparation, construction and operation
- Transport of material, products and waste to and from site;
- Decomposition of organic waste on and off site

The proposed scope for assessing embodied construction material and product GHG emissions include:

- Imported fill for site preparation;
- Permanent piping material for stormwater infrastructure;
- Concrete paving, including mesh and bar reinforcement;
- Rail lines; and
- Warehouse structure, including steel frame, roof and wall sheets and insulated panels.

Note: GHG emissions from end of life of Moorebank Intermodal Terminal Facility 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.

4.2 Project material quantities

The following scenarios are modelled in order to explore key data sensitivities and embodied greenhouse gas emission reduction potential:

1. Baseline scenario based on best available conservative data
2. Cement substitution material scenario exploring 20% of Portland cement substituted with fly ash in the concrete
3. Concrete pavement slab thickness reduction by 20%

4.2.1 Scenario 1: Baseline

The following assumptions (all subject to refinement/confirmation by the design team) have been used to establish the project construction material inventory:

- Surplus of onsite cut to fill will be used on site with assumed negligible import and disposal impact.
- 32MPa concrete for pavement, with no cement substitution materials (CSM);
- Mesh reinforcement of concrete pavement, i.e. no bar reinforcement
- Added 500m of PVC plastic pipe for stormwater infrastructure
- Added Steel sheet warehouse walls (1.6kg/m²) and roof (5.0kg/m²)
- Added reinforced concrete wall sections for the warehouse
- Added rail line material quantities for an estimated 3km rail line track for the project³

Table 1: Project construction material quantities

Phase	Material	Quantity (t)	Quantity (m3)	Quantity (m2)	Density (t/m3)	Density (t/m2)	Density (t/m)	Length (m)
Site Preparation								
	Fill material							
Construction								
Pavement								
	Concrete 32MPa	996,000	415,000		2.4			
	Mesh Reinforcing Steel	2,158						
Stormwater								

³ Based on information from the following sources:

Review of CO₂-e Emissions from Concrete versus Timber Sleepers, Energy Strategies, last viewed 16 November 2010, <<http://www.enerstrat.com.au/lib/documents/Review-of-CO2-Emissions-from-Concrete-versus-Timber-Sleepers.pdf>>.

Concrete Sleepers (Heavy Duty) – Design, Australian Rail Track Corporation Ltd, last viewed 16 November 2010, <http://extranet.artc.com.au/docs/engineering/common_standards/track/etd_02_03_concrete_sleepers_heavy_design.pdf>.

Railway and Tramway Sleepers, Queensland Government Department of Primary Industries and Fisheries, last viewed 16 November 2010, <http://www.cqfa.com.au/documents/1181619278_sleepers_fact_sheet.pdf>.

AS1085.1-2002 Railway and Track Materials Part 1: Steel Rails, Australian Standard, last viewed 16 November 2010, <[http://www.saiglobal.com/PDFTemp/Previews/OSH/as/as1000/1000/1085.1-2002\(+A1\).pdf](http://www.saiglobal.com/PDFTemp/Previews/OSH/as/as1000/1000/1085.1-2002(+A1).pdf)>.

Phase	Material	Quantity (t)	Quantity (m3)	Quantity (m2)	Density (t/m3)	Density (t/m2)	Density (t/m)	Length (m)
	Plastic Pipe	15			30.0			0.5
	Warehouse							
	Structural Steel (typical)	5,072						
	Structural Steel (cooling)	480						
	Mesh Reinforcing Steel	1,383						
	Steel Sheet (walls)	1,253				0.0050		
	Steel Sheet (roof)	401				0.0016		
	Precast Concrete Panels (Wall)	23,227				0.0927		
	Precast Concrete Panel (Wall reinf.)	376				0.0015		
	Insulated Panel							
	Rail Line							3,000
	Steel Rail	180					0.060	
	Sleeper Reinforcement	22					0.0072	
	Sleepers (concrete)	855					0.285	
	Aggregate	5,970					1.990	

4.2.2 Scenario 2: Cement substitution material

In this scenario 20% of Portland cement in the concrete pavement is substituted by fly ash from NSW coal fired power station. See section 5.2 below for more details on cement substitution.

4.2.3 Scenario 3: Pavement thickness

In this scenario the concrete pavement is reduced by an average of 20% to explore the overall sensitivity to a key project parameter affecting the overall embodied greenhouse gas emission assessment.

4.3 Embodied GHG impact results

4.3.1 Scenario 1: Baseline

The total embodied GHG emissions in construction materials is calculated at **196ktCO₂-e**, or approximately 27 times the previously estimated GHG emissions from the construction phase (excluding material impacts). However, the embodied construction material impacts only account to approximately the equivalence of three years of operation.

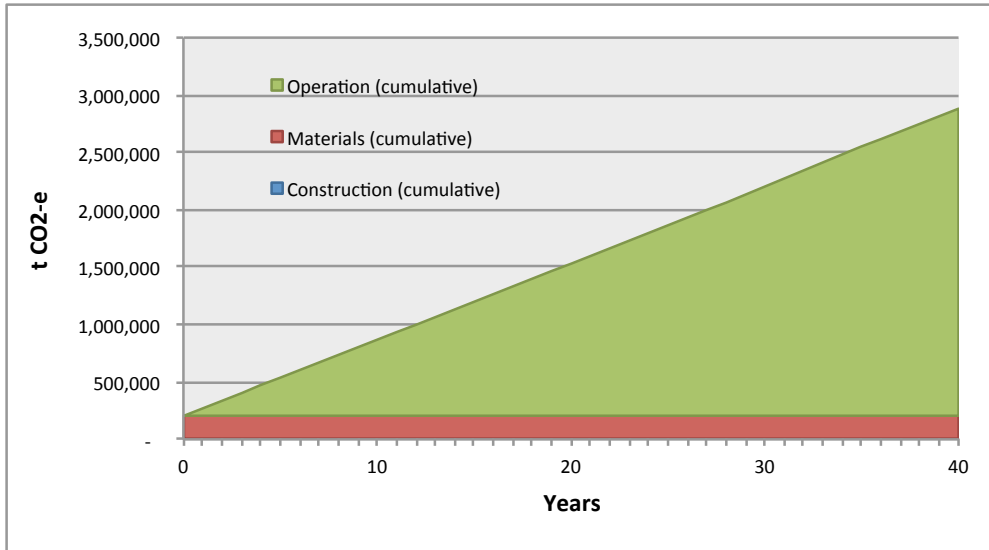


Figure 2: GHG emissions over 40 years of operation.

Embodied GHG emissions by construction activity/phase are presented in Figure 3 and Table 2.

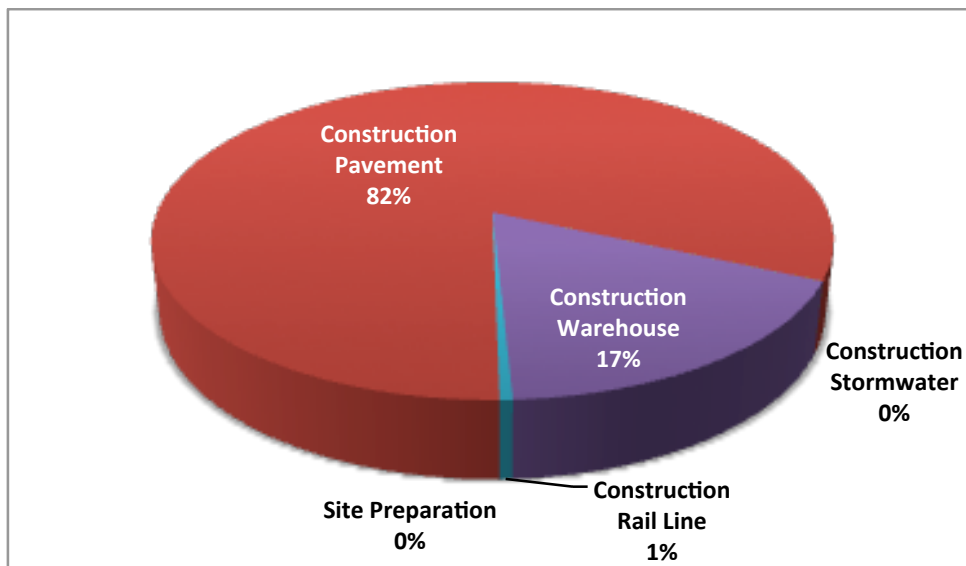


Figure 3: Embodied material GHG emissions by construction activity

Table 2: Embodied construction material GHG emissions by construction activity

Construction Activity/Phase	tCO ₂ -e
Site Preparation	0
Construction Pavement	161,022
Construction Stormwater	33
Construction Warehouse	34,134
Construction Rail Line	1,012

Figure 4 and Table 3 below show GHG emissions by construction material category/type.

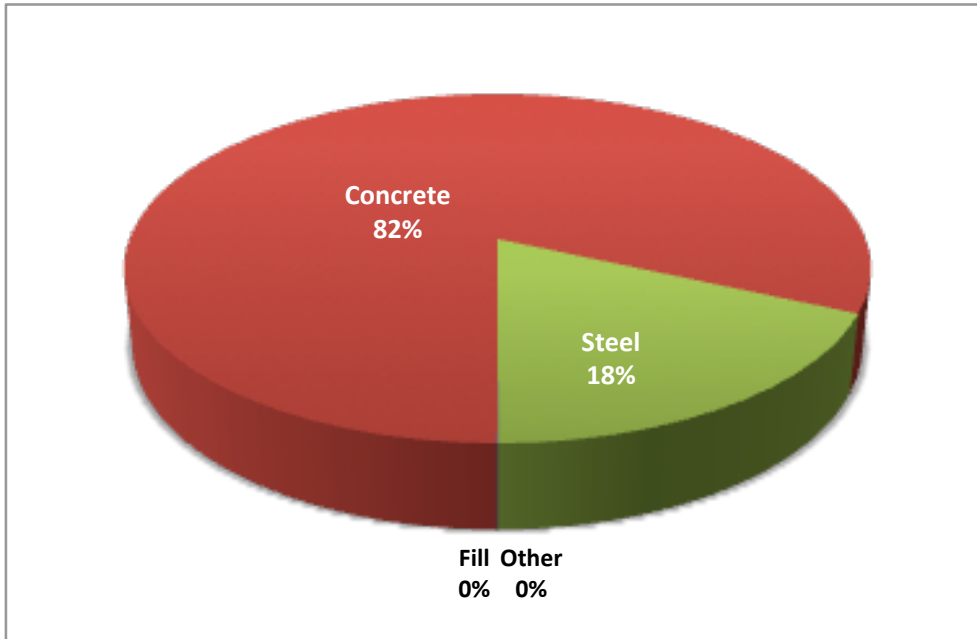


Figure 4: Embodied GHG emissions by material category

Table 3: Embodied construction material GHG emissions by material type

Material Category/Type	tCO ₂ -e
Fill	24
Concrete	160,337
Steel	35,808
Other	24

Figure 5 and Table 4 below show GHG emissions by steel type/use.

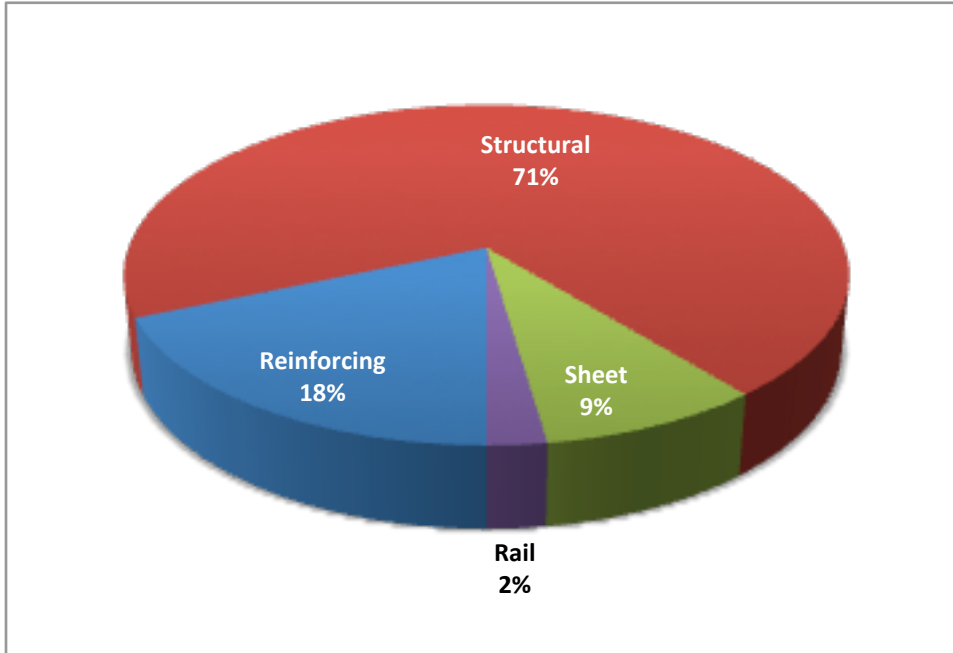


Figure 5: Embodied GHG emissions by steel type/use

Table 4: Embodied steel GHG emissions by type/use

Steel type/Use	tCO ₂ -e
Reinforcement	6,619
Structural	25,286
Sheet	3,084
Rail	820

Further GHG breakdown and detail from concrete use will be added if/when more details are available on concrete grades used for the project construction elements.

4.3.2 Scenario 2 and 3

The embodied GHG results from scenario 2 and 3 described above show:

- 172ktCO₂-e in scenario 2; and
- 165ktCO₂-e in scenario 3.

Overall the scenario have 12% and 16% reduction in overall GHG embodied emission, and 15% and 20% reduction of GHG emissions in the concrete pavement by replacing 20% of Portland cement with fly ash and reducing the pavement thickness by 20% respectively.

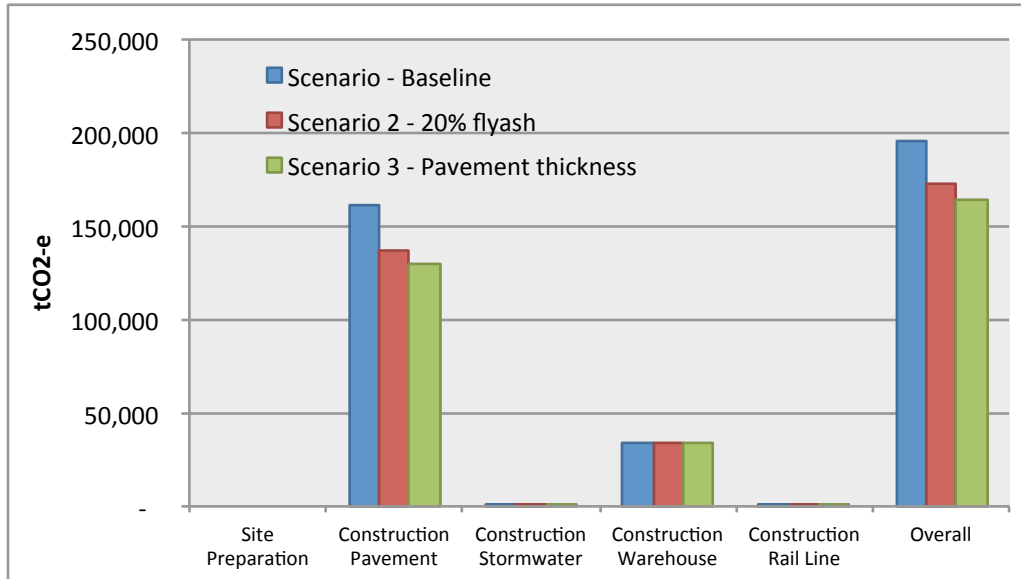


Figure 6: Embodied GHG emission scenario comparison.

5. Discussion and recommendations

5.1 Operational versus embodied GHG emissions

Provided GHG emissions from operation will dominate the overall life cycle emissions, design and material selection should be optimized for operational energy efficiency and GHG emission performance over life. This could include:

- Optimizing building thermal performance, or even surface colour and reflectance to reduce lighting requirements.
- Sourcing electricity and fuels with low GHG intensity

5.2 Concrete

A significant opportunity to minimize GHG emissions from concrete consumption is to substitute Portland cement with substitute materials such as local fly ash and blast furnace slag.

Several efforts are in progress to reduce the use of Portland cement in concrete. These include the utilisation of supplementary cementitious materials such as fly ash, silica fume, ground granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement (Your Building, 2009) ⁴.

⁴ The uses of supplementary cementitious materials do not come without associated embodied environmental impacts in a LCA. AusLCI and BP LCI use economic values to allocate environmental impacts between products and co-products. For instance in the case of fly-ash, the greenhouse gases (and other environmental impacts) from burning coal for electricity are shared between the electricity generated and the fly-ash produced based on, and proportionate to, the market value of electricity and fly-ash respectively. The fly-ash would come free of embodied CO₂ at the gate of the power station, only if there would be no market value for fly-ash.

A brief literature review was undertaken to determine the current knowledge on the use of cementitious materials for structural cement. Some of the research recently undertaken on the properties, benefits and potential limitations of the use of blast furnace slag as supplementary cementitious material for structural concrete. Generally, the majority of the studies did not rule out the use of a significant proportion of for example Blast Furnace Slag for structural concrete.

Further investigations should be undertaken, with more project specific information related to the level and type of exposure expected for the concrete structures of the project. The research suggests that close attention be paid to the processes of curing and covering of reinforcement when substituting cementitious material.

Additionally, transport of concrete contributes significantly to the overall impact of the project. The impacts of the sand and aggregate components of concrete are dominated by their transport, representing up to 90% of the mass of the concrete.

Project recommendations:

- Investigate the feasibility to use supplementary cementitious materials for the concrete pavement; and
- Source concrete from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies)

5.3 Steel

The building and construction industry accounts for about half of the steel used in Australia. From a resource recovery and material stewardship point of view, the proportion of steel that is recycled and re-used at the end of its life is more relevant than the recycled content in production at a particular point in time (Crucible, 2006). Based on 2003 tonnages for recycled scrap and an estimate of steel deposited in landfills, the Australian steel recovery rate at end of life is calculated to be above 80%.

However, even with 100% recovery, scrap steel would not meet steel demand. Furthermore, there is a time lag: the scrap arising today comes from a period when steel production was lower (Crucible, 2006). The environmental benefits of prescribing recycled content rates needs to be evaluated carefully, taken into consideration the integrated international steel market and scrap trade.

The steel industry has articulated views against mandating 100% recycled steel, as follows:

- ASI: The drive to increase recycling is understandable and for many materials this kind of incentive may act to prevent post-consumer product, such as glass, paper, and plastic (etc) going to landfill. However, in the case of steel, recycling of scrap has been maximised worldwide and the development of efficient low-cost electric arc furnace (EAF) technology has put a premium on it (ASI, 2009).
- US Steel Recycling Institute: Understanding the recycled content of BOF and EAF steels, one should not attempt to select one steel producer over another on the basis of a simplistic comparison of relative scrap usage or recycled content. Rather than providing an enhanced environmental benefit, such a selection could prove more costly in terms of total life cycle assessment energy consumption or other variables. Steel does not rely on “recycled content” purchasing to incorporate or drive scrap use. It already happens because of the economics. Recycled content for steel is a function of the steelmaking process itself (US Steel Recycling Institute, 2009).

As opposed to concrete where transport can be a major factor in the GHG profile, for steel, the energy and greenhouse gas emission impacts of transport amount to approximately 2% of the

impacts of the product (combining all routes for integrated steelmaking in Australia) (Crucible, 2006).

Project recommendations: The keys to producing low impact steel are:

- Avoid using recycled content in steel products as a single indicator for low GHG intensity as this has been proven to be misleading
- Achieve high steel scrap recycling rates; and
- Use low GHG intensive energy in production (i.e. renewable energy for electricity).
- Minimize GHG emissions from steel making by sourcing from suppliers who are able to demonstrate low embodied GHG emissions using LCA methodology (could for example be certified by eco-label bodies).

6. Summary

This GHG emission life cycle assessment has been prepared as an addition to Hyder Consulting's report "Stockland - SIMTA Moorebank Intermodal Terminal Facility - Greenhouse gas assessment" in order to fulfil the Director General's requirements for GHG assessment section of environmental approval.

The research calculates the total cradle to site embodied GHG emissions in construction materials to 196ktCO₂-e. The embodied material GHG emissions are the most significant emission source in the construction phase, approximately 27 times higher than the non-material GHG emissions estimated by Hyder Consulting. However, the construction phase impacts are modest compared to the projected emissions from operating the facilities, approximately equivalent to two years of operation.

The main GHG emissions from the construction phase are from production of concrete for the site pavement and structural steel for warehouses. There is significant scope to reduce construction emissions by for example replacing Portland cement with for example fly ash, silica fume, ground granulated blast furnace slag. However, the overall focus in terms of reducing GHG emissions should focus on minimising energy related emissions from operation of the facility.

The assessment presented is based estimates from early concept design. An Excel based assessment tool is provided with this report to allow for refinement of the modelling as more specific project details become available.

7. References

- Australian Life Cycle Inventory and Australian Life Cycle Assessment Society [AusLCI & ALCAS], 2009, *Guidelines for Data Development for an Australian Life Cycle Inventory Database*, Draft Standard, June 28th 2009.
- Australian Steel Institute, 2009, *Rating Systems of Buildings*, http://www.steel.org.au/inside_group.asp?ID=613&pnav=612
- Building Products Innovation Council (BPIC), 2010a, *BPIC/ICIP Project, Draft : Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database*, 8th Draft April 2010.
- Building Products Innovation Council (BPIC), 2010b, *Protocol for the Correct Use of Australian Life Cycle Inventory Data for Building and Construction Materials and Products*, 7th Draft, 12 January 2010.
- Crucible, 2006, *A Life Cycle Perspective on Steel Building Materials*, prepared for Australian Steel Institute on behalf of OneSteel, BlueScope Steel and Smorgon Steel.
- Frischknecht, R., et al., 2007, The Environmental Relevance of Capital Goods in Life Cycle Assessments of Products and Services, *Int. J LCA 2007 (OnlineFirst)*: 11
- International Organization for Standardization (ISO) 2006 International Organization for Standardization - Environmental management - Life cycle assessment – Principles and Framework. ISO 14040:2006; Second Edition 2006-06, Geneva, CH.
- International Organization for Standardization (ISO) 2006 International Organization for Standardization - Environmental management - Life cycle assessment – Requirements and Guidelines. ISO 14044:2006; Second Edition 2006-06, Geneva, CH.
- US Steel Recycling Institute, 2009, *Steel Takes LEED® with Recycled Content*, <http://www.recycle-steel.org/PDFs/leed/LEEDMAR09.pdf>
- Your Building, 2008, *Fly Ash-Based Geopolymer Concrete*, www.yourbuilding.org/display/yb/Fly+Ash-Based+Geopolymer+Concrete

