Great Western Highway
Blackheath to Little Hartley

Appendix Q
Climate change and sustainability

Great Western Highway Blackheath to Little Hartley

Appendix Q - Technical report - Climate change and sustainability

Client:Transport for NSW

ABN: 18 804 239 602

Prepared by

AECOM Australia Pty Ltd
Gadigal Country, Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8008 1700 www.aecom.com
ABN 20 093 846 925

18-Jan-2023

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 and ISO45001.

Table of Contents

List of Tables

List of Figures

Glossary and abbreviations

Key terms	Description
Climate adaptation	Actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities. Adaptation actions may include physical changes to an asset to achieve or facilitate adaptation including changes/upgrades to technology and equipment or design standards for particular project elements (e.g., flood protection designed to the Probable Maximum Flood (PMF)). Adaptation actions may also include changes to contracts, setting specific targets or objectives, scheduling regular reviews or inspections, development of an emergency management plan, development of design guidelines, etc.
Climate change	A change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC).
Climate mitigation	Refers to efforts to reduce or prevent emission of greenhouse gases.
Climate resilience	Climate resilience is the capacity of organisations to survive, adapt, and grow no matter what kinds of climate-related chronic stresses and acute shocks they experience.
Climate change mitigation	Climate change mitigation includes actions we take globally, nationally and individually to limit changes caused in the global climate by human activities. Mitigation activities are designed to reduce greenhouse emissions and/or increase the amounts of greenhouse gases removed from the atmosphere by greenhouse sinks.
Construction footprint	The area required for construction of the project
Critical infrastructure	The assets, systems and networks required to maintain security, health and safety, operations of the project.
GreenPower	GreenPower is a government accredited renewable energy product offered by most electricity retailers to households and businesses in Australia.
Operational footprint	The area required for operation of the project
Physical risks	Risks driven by physical changes in climate such as heatwaves, flooding, and sea level rise. These can be event driven (acute) or longer-term shifts (chronic) in climate patterns.
Proposed upgrade	Construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel
Scope 1	Direct emissions: greenhouse gas emissions generated by sources owned or controlled by the project, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment or vehicles.
Scope 2	Indirect emissions: greenhouse gas emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These greenhouse gas emissions are generated outside the project’s boundaries, for example the use of electricity purchased from the grid.

Key terms	Description
Scope 3	Indirect upstream/downstream emissions: greenhouse gas emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the project, for example greenhouse gas emissions associated with the mining, production and transport of materials used in construction (referred to as the embodied energy of a material).
Shocks	Acute shocks are sudden, short-term events that disrupt individuals, communities, institutions, business and systems. Examples include major storms, foods, bushfires, heatwaves, disease outbreaks, terrorism and cyber-attacks.
Stresses	Chronic stresses weaken a systems and communities on a day-to-day or cyclical basis. Examples include homelessness and housing affordability, lack of access to public transportation systems, family violence, climate change, structural inequity, and chronic food or water shortages.
Transport for NSW (Transport)	The proponent seeking approval for the project.
Ventilation outlet option	A ventilation building and ventilation outlet at Blackheath and Little Hartley exit portals
Portal emissions option	Emissions leave the tunnel at entry and exit portals

Acronym	Definition
AR6	The Sixth Assessment Report of the Intergovernmental Panel on Climate Change
CCRA	Climate change risk assessment
CERT	Carbon Estimate & Reporting Tool
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent emissions
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EPA	NSW Environment Protection Authority
GHG	Greenhouse gases - any various gaseous compounds (such as carbon dioxide or methane) that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect.
IPCC	Intergovernmental Panel on Climate Change
km	Kilometres
LGA	Local Government Area
m	Metres
MPa	Megapascals
SEARs	Secretary’s Environmental Assessment Requirements
t	Tonnes
t CO2e	Tonnes of carbon dioxide equivalent emissions

Acronym	Definition
Transport	Transport for NSW
VMS	Variable message signs

Executive summary

Transport for NSW (Transport) is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act* (NSW) *1979* (EP&A Act) to upgrade the Great Western Highway between Blackheath and Little Hartley (the project).

The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for tie-ins to the east and west of the proposed tunnel portals.

Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project would be open to traffic by 2030.

This technical report provides a climate change, sustainability and greenhouse gas (GHG) assessment of the proposed project and has been prepared to inform the Environmental Impact Statement. The aim of this report is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) issued for the project.

Climate change risk assessment

The climate change risk assessment was completed in line with the Transport *Climate Risk Assessment Guidelines* (Transport, 2021). The assessment identified the climate effects relevant to the construction and operational phases of the project for two time periods - the short-term time period of 2030, and a longer-term time period of 2090 – allowing a view of the climate impacts throughout the design life of the project based on the publicly available project ion data. It recommends appropriate risk management and adaptation measures to be incorporated into the design, construction and operational phases of the project.

Climate change risks were identified for key climate hazards (extreme heat, bushfire, drought, extreme rainfall and flooding, and extreme storms). For the construction phase a total of four risks were identified and assessed pre-mitigation, one of which was rated low in 2030 and medium in 2090 (relating to impacts from bushfires on the construction and maintenance schedule), one which was rated a medium risk in 2030 and a high risk in 2090 (relating to impacts of storms on workers during construction) and one which was rated a high risk in 2030 and an extreme risk in 2090 (relating to impacts of extreme heat on workers during construction).

For the operational phase, 50 risks were identified and assessed with pre-mitigation. For the 2030 time period, three risks were rated as high (relating to drought impacts on fire prevention systems, bushfires potentially trapping motorists in the tunnel, and bushfires impacting the physical infrastructure of the project). For the 2090 time period 19 risks were rated high (predominantly relating to extreme heat, bushfires, and flooding hazards).

Potential mitigation and adaptation measures were identified to address all high and extreme risks, and the majority of medium risks. These measures will be considered for implementation in later phases of the project. A residual risk assessment was undertaken to consider climate change risks to the project post-mitigation, following the implementation of adaptation measures identified. Adaptation measures identified as part of this climate change risk assessment would increase the project's resilience to climate change, thereby reducing the consequence of potential impacts and lowering residual risks.

Of the one high risk and one medium risk identified for project construction, proposed adaptation measures have resulted in a residual risk rating of two medium risks.

For project operation in 2030 and 2090, proposed adaptation measures have resulted in all high risks lowered to a residual risk rating of medium or low.

This assessment of climate risks will be reviewed and updated during future stages of the project lifecycle to ensure new and emerging risks are addressed and appropriate controls have been implemented.

Sustainability

The sustainability of the project is guided by relevant Australian and NSW government strategy documents and policies including the *Future Transport Strategy: Our vision for transport in NSW* (Transport 2022b) and *Transport Sustainability Plan* 2021 (Transport 2020a).

Sustainability of the project will be assessed in accordance with the Infrastructure Sustainability Council Rating Tool and the project is seeking a minimum IS 'Design' and 'As-Built' rating of 'Excellent', applying version 1.2 of the tool.

Sustainability initiatives have been identified for planning and design consideration to embed specific sustainability commitments and targets for implementation by the construction contractor. A project specific Infrastructure Sustainability Management Plan will be prepared to guide the implementation of sustainability throughout the design and construction phases and to facilitate the achievement of the IS rating.

Greenhouse gas assessment

A GHG impact assessment has also been undertaken to determine the impacts of the project and to identify management and mitigation options to reduce the GHG emissions associated with the project. The Carbon Estimate and Reporting Tool (CERT) provided by Transport was used to calculate the GHG emissions produced from construction and operation of the project over a 100-year operation period. Two ventilation scenarios were assessed: (1) emissions from ventilation outlet (ventilation outlet option); and (2) emissions from portals (portal emissions option).

Construction impacts from the project represent the majority of scope 1 (direct emissions), 2 (indirect emissions) and 3 (indirect upstream/downstream emissions) GHG emissions associated with the project lifecycle. Construction is estimated to produce 1,407,140 tonnes of carbon dioxide equivalent emissions (t CO_2e). The difference in construction GHG emissions between the two ventilation options is assumed to be negligible. The majority of emissions during construction are estimated to occur from the large electricity requirements of the tunnelling plant and equipment over the construction period.

For the ventilation outlet option, around 3,549,990 t CO_2e emissions are estimated over a nominal 100-year operation and maintenance period. For the portal emissions option, around 1,274,820 t CO_2e emissions are estimated over the same period. Electricity consumption for ventilation, lighting, and other electrical equipment make up the majority of operational emissions from the project. A reduction in tailpipe emissions from road users is anticipated as a result of the project's impact on traffic flow, based on GHG emissions outputs from traffic and air quality modelling. This anticipated reduction in tailpipe emissions during operations led to a reduction in scope 3 emissions under the ventilation outlet option, and net negative scope 3 emissions for the portal emissions option. A negative quantity of scope 3 emissions means the project is anticipated to reduce more scope 3 emissions during operation than it creates.

A summary of the total GHG emissions by project phase is presented in Table ES1.

Table ES1 Summary of greenhouse gas emissions by project phase

Emission source	GHG emissions (total t CO2e over project phase)[1]			
	Scope 1	Scope 2	Scope 3	Total
Construction	138,900	525,200	743,040	1,407,140
Operation and Maintenance: ventilation outlet option	13,410	3,484,780	51,800	3,549,990
Operation and Maintenance: portal emissions option	13,410	1,396,980	-135,570	1,274,820

Note 1: Estimates rounded to the nearest 10 t CO2e

Mitigation measures have been recommended to reduce GHG emissions associated with the project, including taking measures to improve energy efficiency, sourcing electricity from renewable sources, and sustainable material selection (among others).

1.0 Introduction

1.1 Project context and overview

The Great Western Highway is the key east-west road freight and transport route between Sydney and Central West New South Wales (NSW). Together, the Australian Government and the NSW Government are investing more than $4.5 billion towards upgrading the Great Western Highway between Katoomba and Lithgow (the Upgrade Program). Once upgraded, over 95 kilometres of the Great Western Highway will be two lanes in each direction between Emu Plains and Wallerawang.

The Upgrade Program comprises the following components:

- Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade): upgrade and duplication of the existing surface road corridor with intersection improvements and a new pedestrian bridge (approved)
- Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway east of Blackheath (approved)
- Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway at Little Hartley (approved)
- Great Western Highway Blackheath to Little Hartley: construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel (the project).

The components of the Upgrade Program are shown in Figure 1-1.

Transport for NSW (Transport) is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) to upgrade the Great Western Highway between Blackheath and Little Hartley (the project).

The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for tie-ins to the east and west of the proposed tunnel portals.

The project would be located around 90 kilometres northwest of the Sydney CBD and located within the Blue Mountains and Lithgow Local Government Areas (LGA).

The majority of the project would be located below ground generally along or adjacent to the west of the existing Great Western Highway between around Blackheath and Little Hartley.

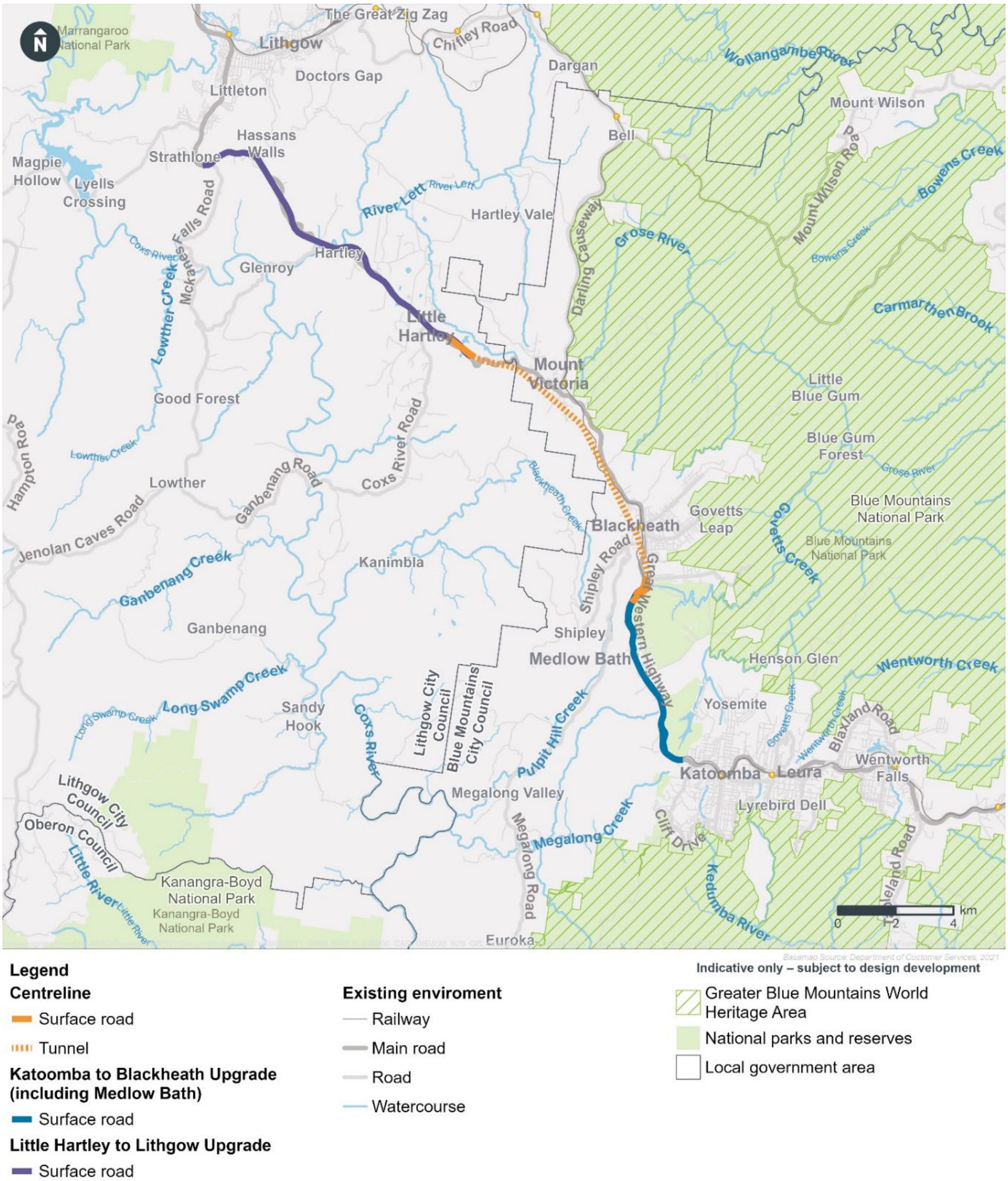


Figure 1-1 The Great Western Highway Upgrade Program

1.2 The project

1.2.1 Key components of the project

Key components of the project are summarised in Table 1-1 and shown in Figure 1-2. These components are described in more detail in Chapter 4 (Project description) of the environmental impact statement (EIS).

The indicative operational configuration of the surface road network at Blackheath and Little Hartley is shown Figure 1-3 and Figure 1-4.

Subject to approval, the project is anticipated to be open to traffic in 2030.

Table 1-1 Key components of the project

Key project component	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriage ways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Operational infrastructure	Operational infrastructure that would be provided by the project includes:
	• a tunnel operations facility adjacent to the Blackheath portal
	• in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
	• one of two potential options for tunnel ventilation currently being investigated, being:
	  - ventilation design to support emissions via ventilation outlets; or
	  - ventilation design to support emissions via portals
	• water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley
	• fire and life safety systems, emergency evacuation and ventilation infrastructure and Closed Circuit Television
	• lighting and signage including variable message signs and associated infrastructure such as overhead gantries.

Utilities	Key utilities required for the project would include: • a new electricity substation at Little Hartley to facilitate construction and operational power supply • a new water supply pipeline between Little Hartley and Lithgow to facilitate construction and operational water supply • other utility connections and modifications, including electricity substations in the tunnel.
Other project elements	The project would also include: • integrated urban design initiatives • landscape planting.

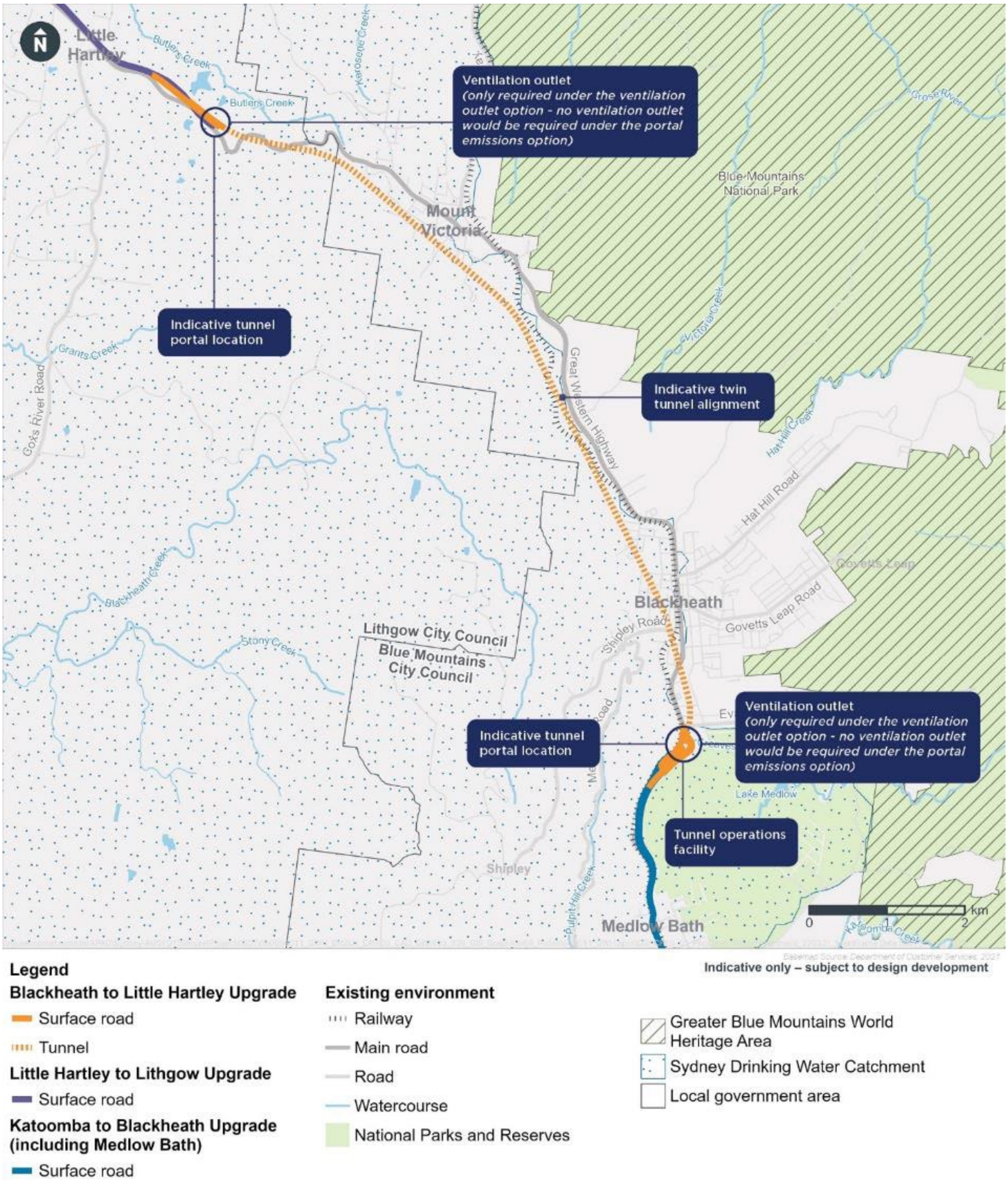


Figure 1-2 Overview of the project

Figure 1-3 Indicative operational configuration at Blackheath

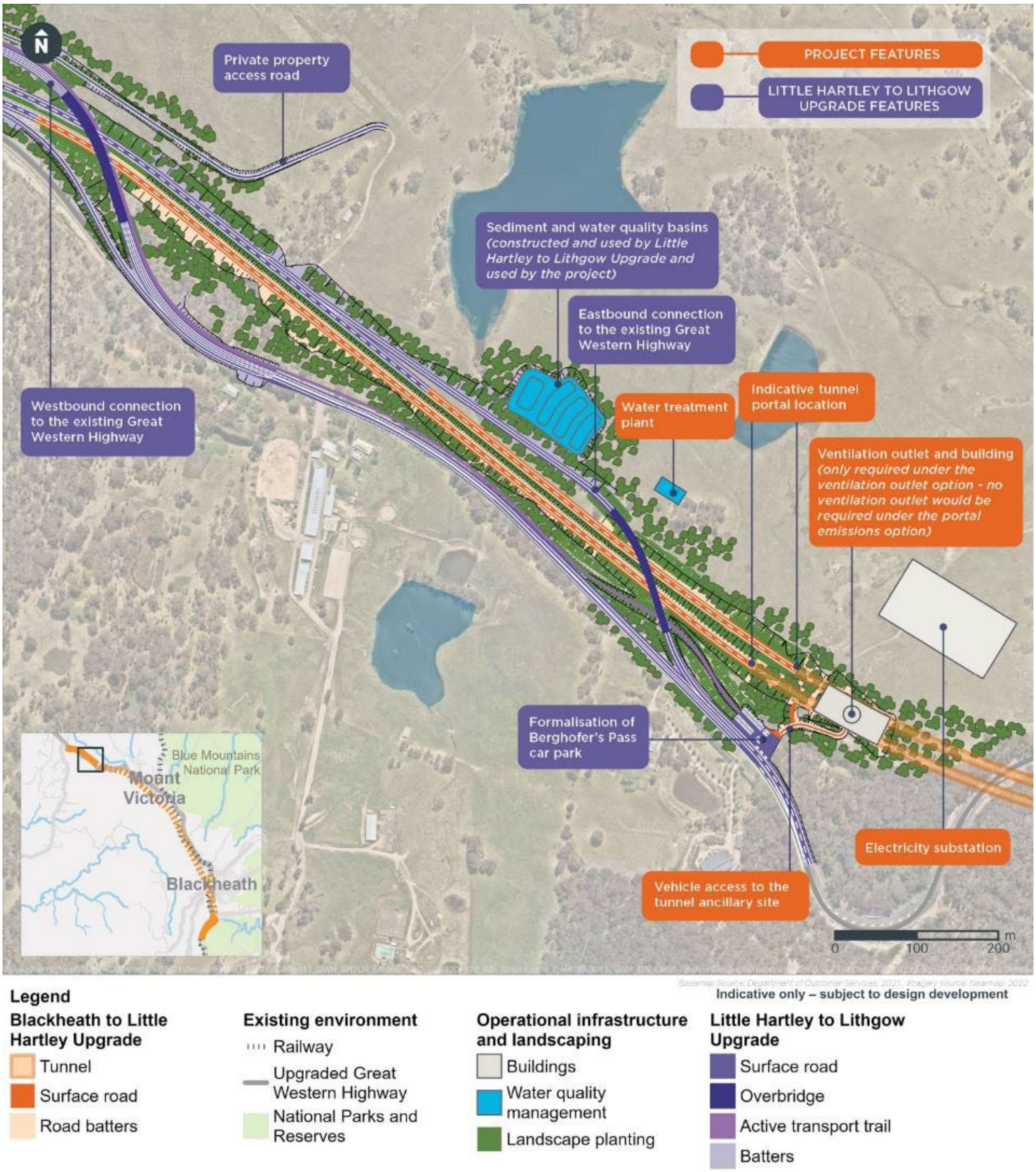


Figure 1-4 Indicative operational configuration at Little Hartley

1.2.2 Project construction

Construction of the project would include:

- site establishment and enabling works
- tunnel portal construction
- tunnelling and associated works
- surface road upgrade works
- operational infrastructure construction and fit-out, including construction of operational environmental controls
- finishing works, testing, and commissioning.

These activities are described in more detail in Chapter 5 (Construction) of the EIS.

The indicative construction footprint for the project is shown in Figure 1-5 to Figure 1-7, including construction site layout and access arrangements.

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project is anticipated to be open to traffic by 2030.

Figure 1-5 Indicative construction footprint at Blackheath

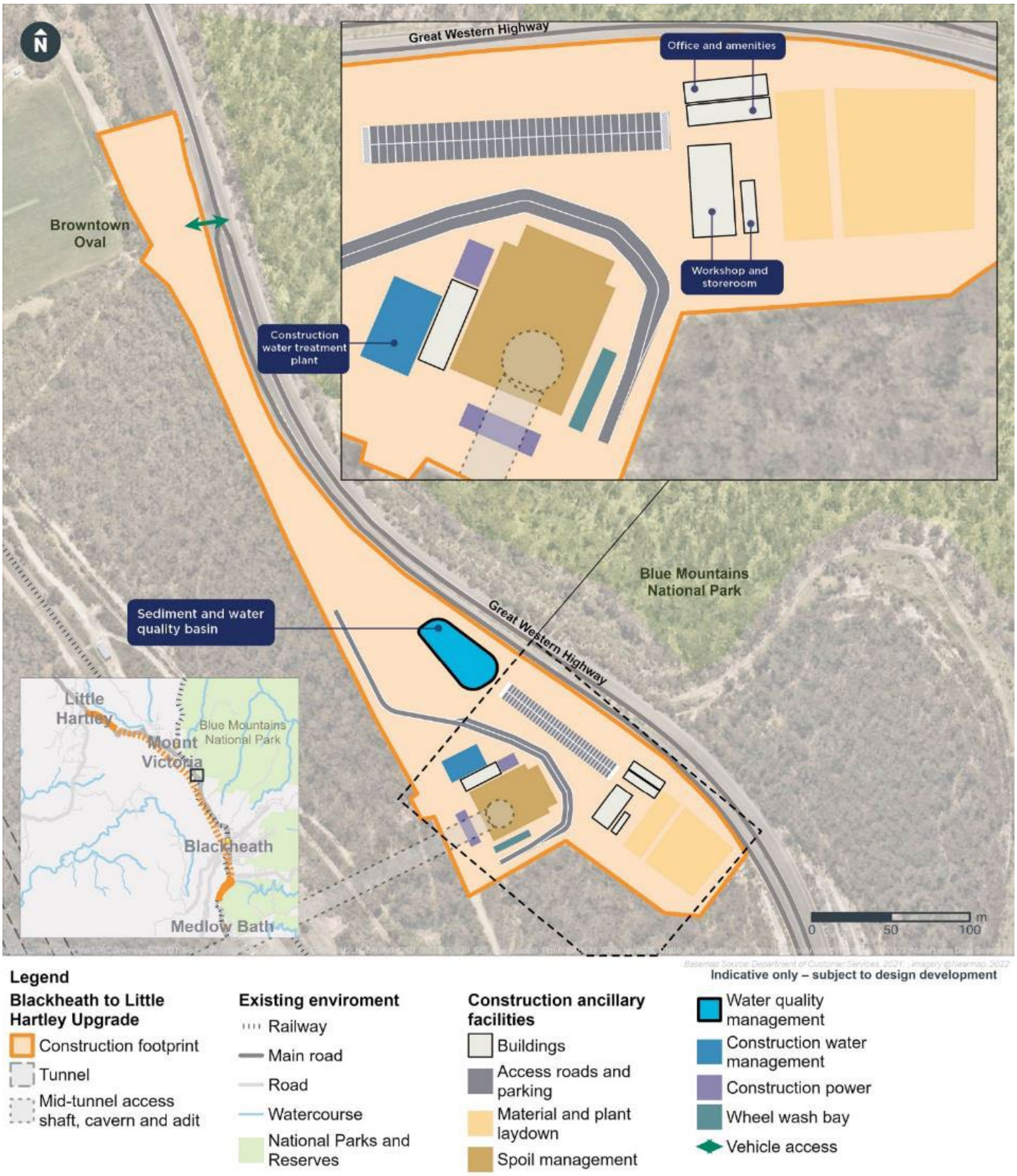


Figure 1-6 Indicative construction footprint at Soldiers Pinch

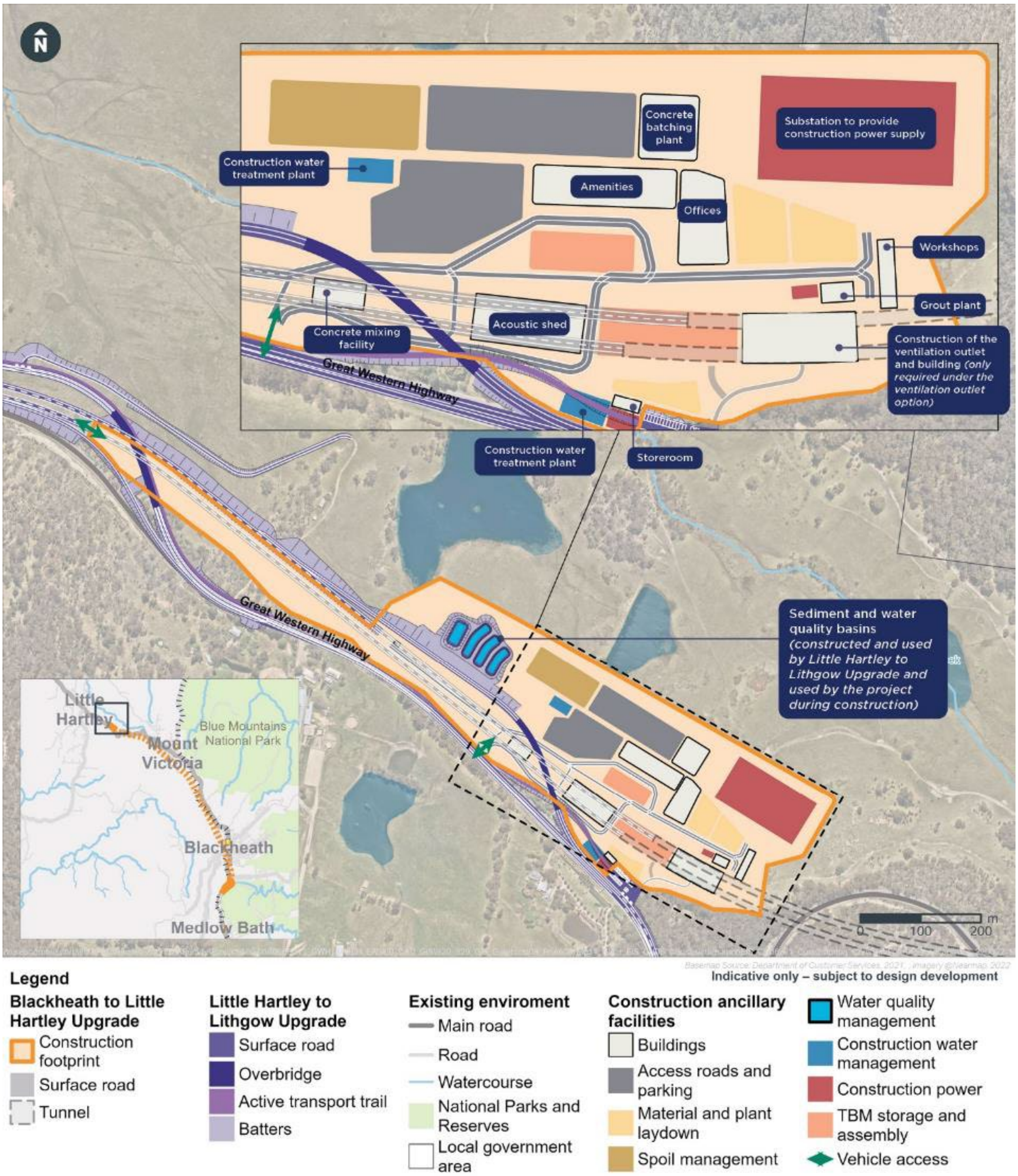


Figure 1-7 Indicative construction footprint at Little Hartley

1.2.3 Baseline environment

The Katoomba to Blackheath and Little Hartley to Lithgow Upgrades adjoining the project to the east and west respectively would be under construction when construction of the project commences (refer to Figure 1-8). To minimise environmental impacts, parts of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade construction footprints would be used to support construction of the project.

As a result, the following activities will be undertaken at the construction sites as part of the Katoomba to Blackheath and Little Hartley to Lithgow Upgrades:

- vegetation would be cleared
- topsoil would be levelled and compacted
- site access tracks would be established
- water quality controls such as water quality and sediment basins would be installed.

The environmental impacts associated with these works have been assessed as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade.

The construction footprint for these projects are shown in Figure 1-9 and Figure 1-10 and form the baseline environment considered at Blackheath and Little Hartley for this EIS.

No work is proposed at Soldiers Pinch as part of the Katoomba to Blackheath Upgrade or the Little Hartley to Lithgow Upgrade and therefore the existing environment forms the baseline environment for this EIS.

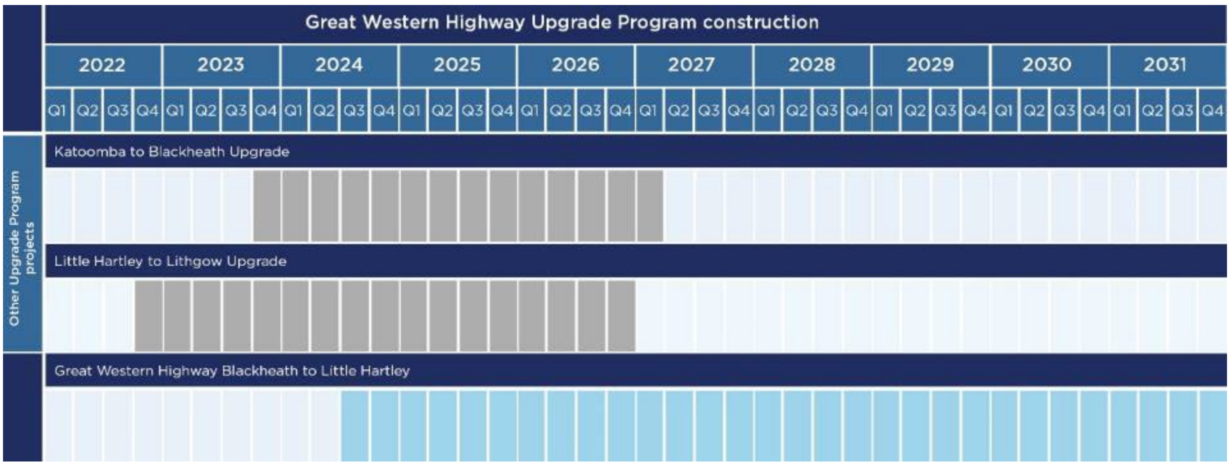


Figure 1-8 Great Western Highway Upgrade Program construction

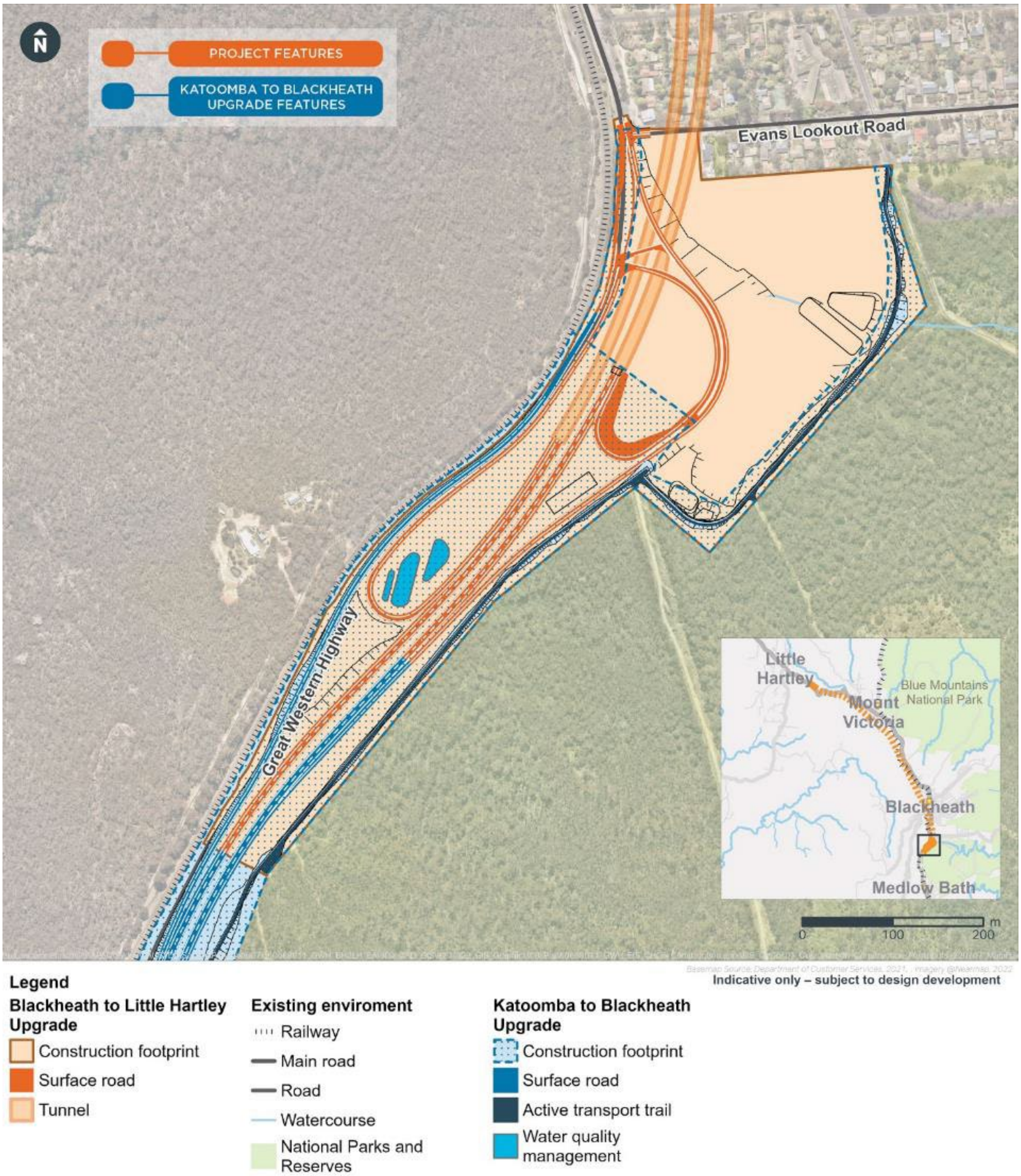


Figure 1-9 Baseline environment at Blackheath

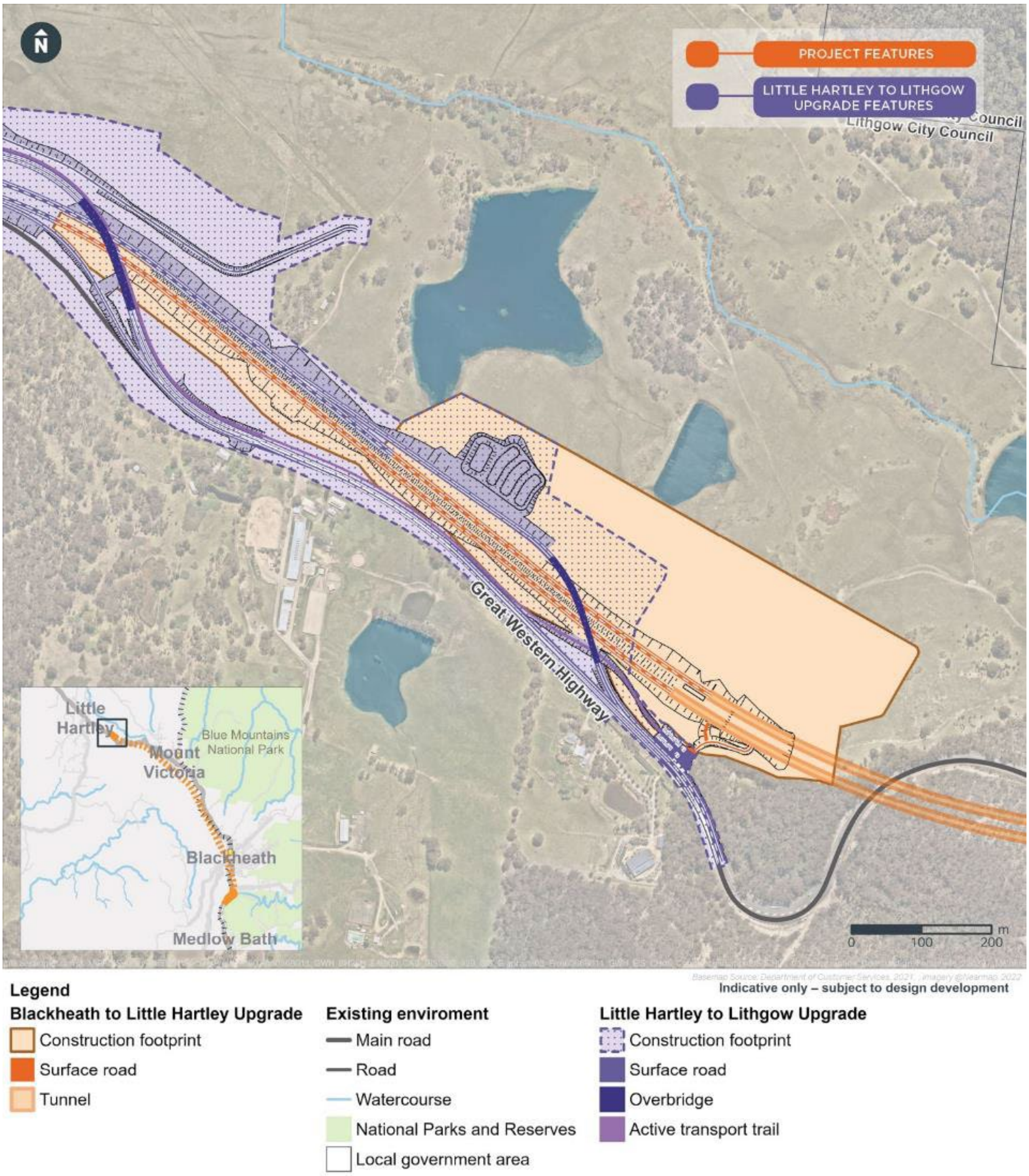


Figure 1-10 Baseline environment at Little Hartley

1.2.4 Other project specific aspects

They key feature of the project relevant to the GHG assessment is the tunnelling works. The tunnelling works will require large amounts of electricity over a sustained period, as well as large volumes of concrete and steel, all of which are GHG intensive. The tunnelling is also expected to encounter coal deposits along part of the project alignment, leading to likely fugitive emissions from coal seam gas.

1.3 Purpose of this report

This climate change and sustainability technical report is one of a number of technical documents that forms part of the EIS. The purpose of this technical report is to:

- provide an assessment of the impacts due to climate change on the project and identify mitigation measures to be implemented in the design, construction and operations phases of the project
- outline how the project would embed sustainability measures in accordance with the Infrastructure Sustainability Council (ISC) Infrastructure Sustainability Rating Tool version 1.2.
- provide an assessment of the greenhouse gas emissions across the lifecycle of the project and identify opportunities for emissions reduction in the design, construction and operations phases of the project.

1.3.1 Assessment requirements

The Secretary's environmental assessment requirements (SEARs) issued by the NSW Department of Planning and Environment (DPE), relating to climate change, sustainability and greenhouse gases and where these requirements are addressed in this technical report are outlined in Table 1-2.

Table 1-2 Secretary's environmental assessment requirements – Climate change, sustainability and greenhouse gases

SEARs		
Climate change risk		
Desired performance outcome	**Requirement**	**Section where addressed in report**
The project is designed, constructed and operated to be resilient to the future impacts of climate change.	1. The risk and vulnerability of the project to climate change in accordance with the current guidelines. 2. Climate change risks must be quantified with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) or equivalent projection tool (such as the Climate Futures Tool from CSIRO and BoM (attenuated for project region)) and specific adaptation actions incorporated in the design.	Section 2.0
Sustainability		
Desired performance outcome	**Requirement**	**Section where addressed in report**
The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	1. The sustainability of the project in accordance with the Infrastructure Sustainability Council (ISC) Infrastructure Sustainability Rating Tool and recommend an appropriate target rating for the project. 2. Consider and assess the project against current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Section 3.0 Section 4.0

2.0 Climate change risk assessment

2.1 Assessment methodology

2.1.1 Relevant guidelines and policies

Risk assessment describes the overall process of risk identification, analysis and evaluation, informed by findings of the previous stage.

Risk management for physical risks has been assessed in accordance with:

- Climate Risk Assessment Guidelines (Transport, 2021d)
- Australian Government, *Climate Change Impacts & Risk Management – A Guide for Business and Government*, Australian Government (2006).
- *AS/NZS ISO 31000*:2009, Risk management – Principles and guidelines, Australian Standard (2009)

The risk management for physical risks has also considered the following:

- the risk assessment approach set out in the *TfNSW Enterprise Risk Management Standard,* TfNSW Enterprise Risk Management Team (2020)
- *ISO 14091 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment, ISO standard* (2021)
- *Climate Risk Ready NSW Guide*, Adapt NSW (2021)
- *ISv1.2 Technical Manual, Infrastructure Sustainability Council (2018)*
- *AS 5334-2013 Climate change adaptation for settlements and infrastructure* – A risk-based approach, Australian Standard (2013)

2.1.2 Climate change risk framework

The risk assessment followed the procedures outlined by the *AS 5334:2013 Climate change adaptation for settlements and infrastructure standards*. This involved:

1. the collection of reputable and scientifically validated climate datasets relevant to the project location and reviewing the regional climate change projections.
2. facilitating a workshop with the project team (including relevant stakeholders) to identify physical risks associated with each climate change variable (e.g., temperature, relative humidity, rainfall, windspeed and solar radiation)
3. classifying the likelihood and consequence to determine the overall risk rating that would be anticipated in 2030 (near future) and 2090 (closest reliable projection to the design life with available data[1]) timescales
4. identifying potential adaptation and mitigation measures to respond to each physical risk with input from the project team
5. determining the residual risks by classifying the risk likelihood and consequence after considering the impact of the potential adaptation and mitigation measures.

2.1.3 Climate datasets (projection models)

The risk assessment was carried out using climate models to inform the physical risks to the project. Climate models predict the anticipated changes to the local climate system seasonally and at different timescales (e.g., near future or far future). These projections are used as a decision support tool to

[1] Projections extending beyond 2090 can vary and this variation increases exponentially with time. Additionally, there are few publicly available sources for projection data relating to all climate hazards. Therefore 2090 is referred to in this report as a reliable long-term prediction of the likely climate change impacts of each RCP scenario.

determine the likelihood, consequence, and overall risk severity (impact) of climate change to physical assets.

This report obtained climate datasets from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Climate Science Centre which provides the most comprehensive and statistically rigorous climate change projections to date and are used by policy makers in the Intergovernmental Panel on Climate Change (IPCC).

2.1.4 Climate change scenarios

The CMIP5 is the 5th generation of climate projection data used by the CSIRO Climate Science Centre[2]. It accounts for downscaling between coarse resolution atmospheric and local climate data (e.g., localised weather data measured by the Bureau of Meteorology). These are prepared at various timescales for risk assessments across different scenarios referred to as the representative concentration pathways (RCPs).

RCPs represent different climate futures quantified in CO_2-equivalent concentrations (parts-per-million-by-volume). Currently, the IPCC and the CSIRO considers four climate future scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) that represent socio-economic assumptions (anthropogenic activities) that would contribute to greenhouse gas concentrations. Table 2-1 is a summary of the four RCPs.

Table 2-1 Definition of representative concentration pathways (RCPs)

RCP scenario	Scenario
RCP8.5 (Worst case scenario)	• little curbing of emissions • CO_2 concentration continues to rapidly rise, reaching 940 ppm by 2100
RCP6.0	• lower emissions achieved by application of some mitigation strategies and technologies • CO_2 concentration reaching 660 ppm and total radiative forcing stabilising shortly after 2100.
RCP4.5	• CO_2 concentrations are slightly above the RCP6.0 until after the mid-century • CO_2 concentration reaches 540 ppm by 2100 • radiative forcing peaks around 2040 at 2.9 W/m^2.
RCP2.6 (Best case scenario)	• emissions peak around 2020 and then rapidly decline • requires early participation from all emitters as well as technologies that will actively remove carbon dioxide from the atmosphere • CO_2 concentration reaches a maximum of 440 ppm by 2040 and then declines to 420 ppm.

2.1.5 Climate change clusters

The CSIRO provides climate projections based on Australia's 54 natural resource management (NRM) regions (biophysical regions) that are grouped into clusters.

The GWHC sits on the boarder of the East Coast South Sub-Cluster of the major East Coast Cluster (see Figure 2-1). The East Coast cluster contains the six coastal regions from Rockhampton to Sydney that also form the central part of the eastern seaboard of Australia. This includes the drainage basins from the subtropical mountain ranges that flow through the coastal zone and to the Pacific Ocean. Dominant land uses include urban, peri-urban, large scale dryland grazing, large mining centres and agricultural development.

[2] Further details on the climate modelling methodology, see: https://www.climatechangeinaustralia.gov.au/en/overview/methodology/

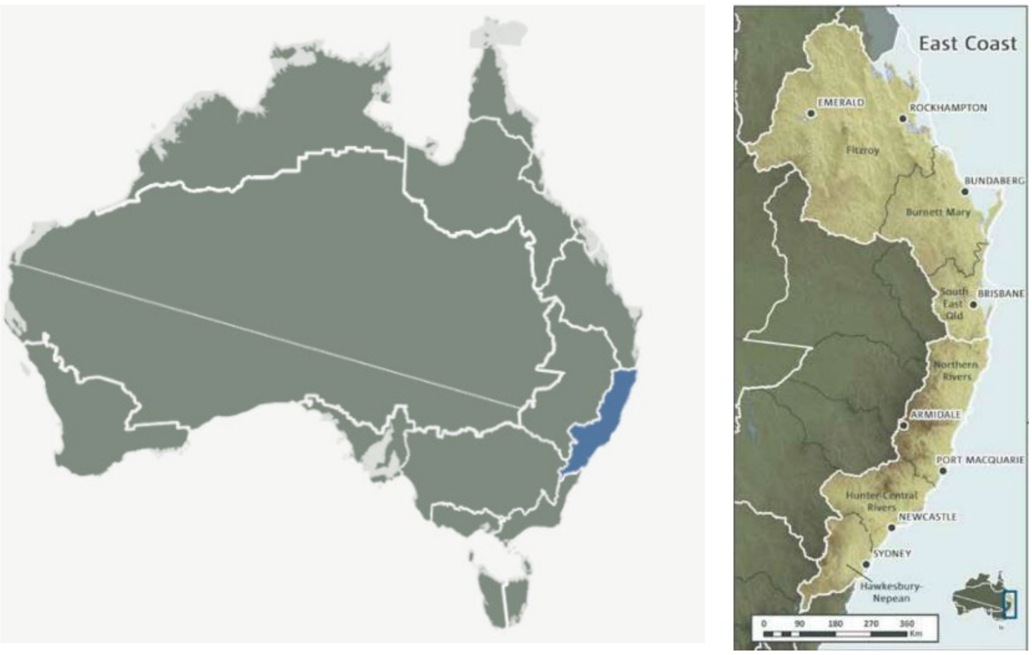


Figure 2-1 East Coast South sub-cluster where the project sits

2.1.6 Climate risk assessment workshop

A risk workshop was conducted on the 10 June 2022 with key stakeholders and the project team.

Physical risks were considered for the RCP8.5 (worst-case) emissions scenario for 2030 (near future) and 2090 (closest reliable forecast to the design life of the asset) (see Table 2-2). Risks were classified in accordance with the AS 5334:2013 likelihood and consequence matrices (see Annexure A).

Table 2-2 Tunnel structures design life

Asset	Design life
• permanent ground support elements for mainline tunnels, cross passages, underground substations, and associated enlargements including: • rock reinforcement • primary lining • secondary lining • segmental lining including gaskets.	100 years
• permanent ground support elements for other tunnel structures such as shafts including: • pile walls and capping beams etc. • ground anchors (if applicable) • rock reinforcement • primary lining and secondary lining.	100 years
• permanent ground water control systems • waterproofing measures, such as pre-excavation and post-excavation grouting and surface grouting • groundwater control drainage systems, such as membranes and strip drains.	100 years
• buildings – buildings integral with civil infrastructure and other in tunnel structures. • underground substation buildings	100 years

2.2 Existing environment

The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2022) states with high confidence that Australia is already experiencing impacts from climate change. Observed trends include increases in the frequency of air temperature extremes, changes in mean and extreme rainfall, increases in the frequency and intensity of storm events, increases in bushfire weather conditions, ocean warming, ocean acidification and sea level rise.

In 2015, the CSIRO and the Australian Bureau of Meteorology (BoM) released an assessment of observed climate change and projected future changes in Australia over the 21st century. This recent assessment confirms the long-term warming trend, showing that in Australia, the average surface air temperature has increased by 0.9°C since records began in 1910, with most of the warming occurring since 1950. Australia's warmest year since 1910 was 2013 (Australian Government Department of the Environment and Energy, 2017).

In addition to an increase in annual mean temperature, oceans around Australia are warming and acidifying while sea levels are rising. Longer droughts are predicted in southern Australia, in addition to increased flooding in the north. A long-term increase in extreme fire weather and length of fire season will be progressively experienced. The effects of climate change will not only be felt within Australia, but across the globe. These extreme weather events pose significant threat to the environment, society and the economy, and building self-resilience throughout Australian communities is critical.

The possible impacts of climate change are identified through an analysis of available climate models and projections of how the climate will respond to changes of GHG concentrations. The models are based on historical climate data and future trends of GHG concentrations. As future GHG concentrations are not known, many different models have been developed to provide a range of possible future climate scenarios.

The key climate hazards identified for this assessment include:

- extreme heat
- bushfire
- drought
- extreme rainfall and flooding
- extreme storms.

2.2.1 Historical climate

Historical climate data was used to provide context to the potential severity of the climate change projections for 2030 and 2090 under the RCP8.5 worst-case scenario. The data was obtained from the BoM from the Katoomba Weather Station[3] (Station Number: 063039) to best represent historical climate characteristics of the project.

Figure 2-2 shows the average maximum temperature (top), the average minimum temperature (middle) and the average rainfall (bottom) for the region. Temperature conditions dropped as low as 2°C as shown in the average minimum temperature. High rainfall occurred across summer and autumn and dropped below 100mm during winter and spring. Table 2-4 presents the historical data with the CMIP5 RP8.5 climate projections side-by-side for context.

[3] Historical climate data obtained from the Bureau of Meteorology: http://www.bom.gov.au/jsp/ncc/cdio/cvg/av?p_stn_num=063039&p_prim_element_index=0&p_comp_element_index=0&redraw=null&p_display_type=full_statistics_table&normals_years=1981-2010&tablesizebutt=normal

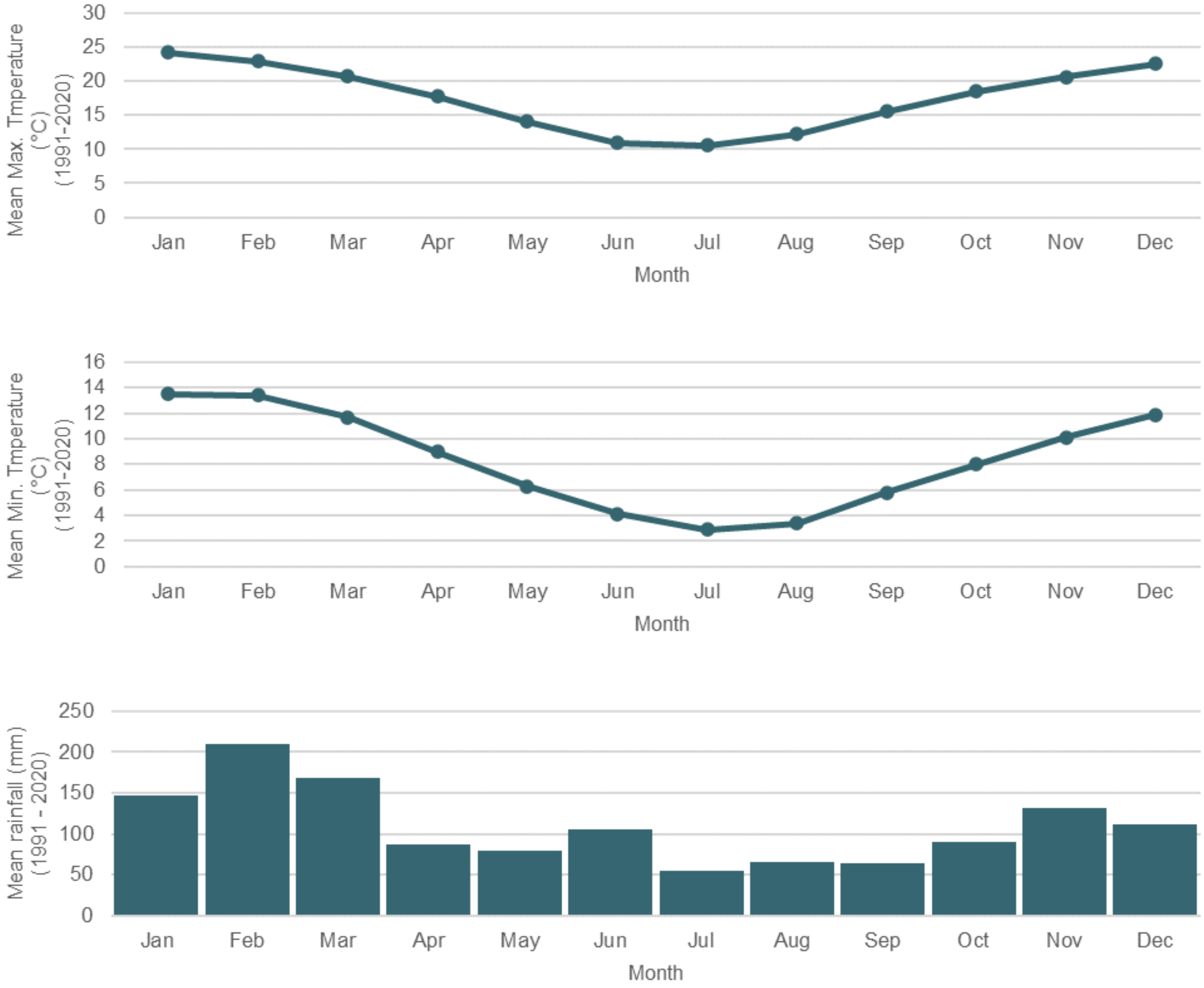


Figure 2-2 Historical weather data from 1991 to 2020 obtained from the Katoomba Weather Station 063039

Table 2-3 Summary of climate change projections

Climate variable	Historical data 1991 2020	RCP8.5 2030	RCP8.5 2090
Rainfall (mm)			
Mean (yearly)	1309.2	1298	1267
Wettest day	226	235	261
Increase in severe rainfall event intensity (%)	-	3.9	15.3
Temperature (°C)			
Hottest day (°C)	39.8	41.2	43.9
Coldest night (°C)	-3.6	-2.8	-0.2

Climate variable	Historical data 1991 2020	RCP8.5 2030	RCP8.5 2090
Days/y ≥ 30°C	11.9	15.5	37.3
Days/y ≥ 35°C	1.1	1.5	7.2
Days/y ≥ 40°C	0.0	0.0	0.4
Days/y ≤ 2°C	35.8	31.2	5.0
Days/y ≤ 0°C	10.9	7.3	0.4

2.2.2 Climate projections

Climate projections for temperature, rainfall, relative humidity, solar radiation, and wind speed are presented from Figure 2-3 to Figure 2-8. The projections represent the anticipated or predicted changes for each variable under the four RCP scenarios starting from 2005 to 2090 for the East Coast South sub-cluster. A summary of the climate change projections is presented in Table 2-4.

Table 2-4 Summary of the climate change projections for the East Coast South sub-cluster

Hazard	Climate change projections	Potential impact
Extreme heat	• average temperature will continue to increase in all seasons with *very high confidence.* The annual averaged warming across all emission scenarios is projected to be around 0.5 to 1.3°C above the climate of 1986 to 2005 in the near future, and 2.9 to 4.6°C in the late century (2090) under the worse-case scenario RCP8.5 • more hotter days, warm spells, and fewer frosts are forecast with *very high confidence,* with some areas forecasted with 2-3 times the average number of hot days above 35°C.	• health and safety concerns for road users and workers through the tunnel • melting asphalt and road surface damage.
Bushfires	• harsher fire weather is forecast with *high confidence* (magnitude of change is uncertain at this stage).	• physical danger to workers and road users • smoke reducing visibility for road users and reducing air quality • destruction of physical infrastructure (e.g. electrical equipment, signage, barriers) • fallen trees and debris blocking and impacting traffic.

Hazard	Climate change projections	Potential impact
Rainfall and storms	• increase intensity of extreme rainfall events is forecast with *high confidence* • decrease in winter rainfall projected with *medium confidence* (other changes are possible but unclear).	• flooding resulting in road closures and impacting traffic • reduced visibility of hazards on the road • safety impacts on road users due to slipping • scour of embankments and cuttings resulting in landslips causing damage to infrastructure • damage and disruption to electrical equipment, signage and barriers. • reduced visibility leading to safety incidents • fallen trees and debris blocking and impacting traffic
Drought	• time spent in drought is projected to increase with *medium confidence* over the course of the next century.	• reduction in the availability of water for landscaping and increased cracking of soils • Decreased water availability during construction.
Sea level rise	• main sea level will continue to rise, and height of extreme sea-level events will also increase with *very high confidence.*	• unlikely to impact project site due to distance from the coast.

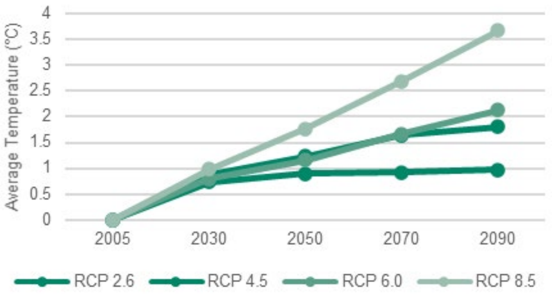


Figure 2-3 Projected average temperature to 2090 under different RCP scenarios

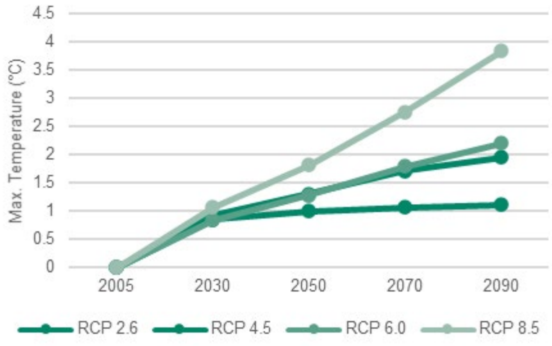


Figure 2-4 Projected maximum temperature to 2090 under different RCP scenarios

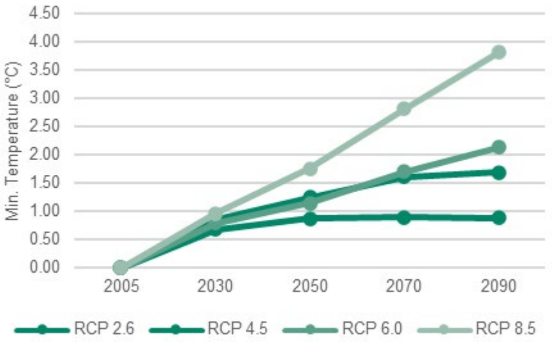


Figure 2-5 Projected minimum temperature to 2090 under different RCP scenarios

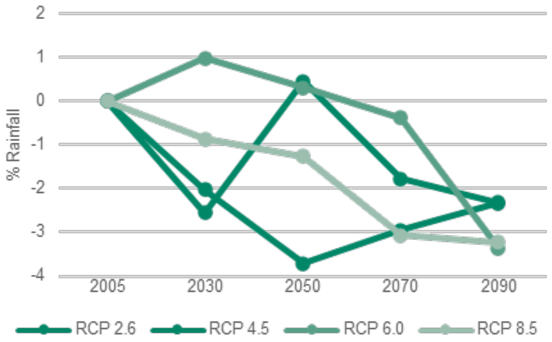


Figure 2-6 Projected rainfall to 2090 under different RCP scenarios

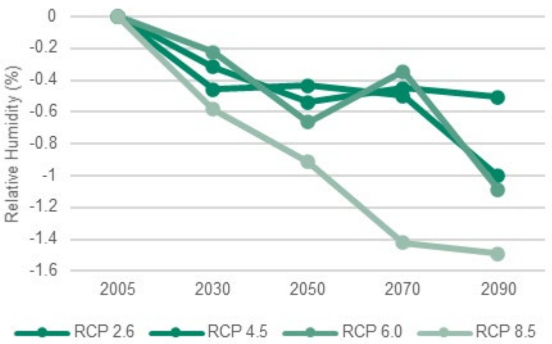


Figure 2-7 Projected relative humidity to 2090 under different RCP scenarios

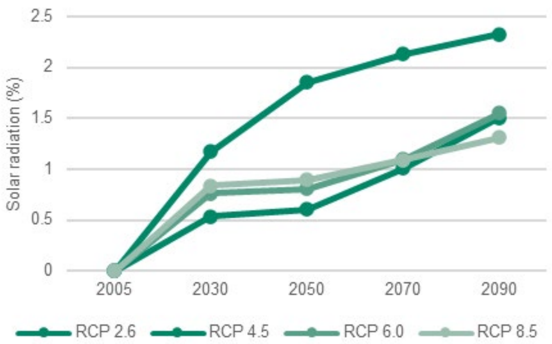


Figure 2-8 Projected solar radiation % change to 2090 under different RCP scenarios

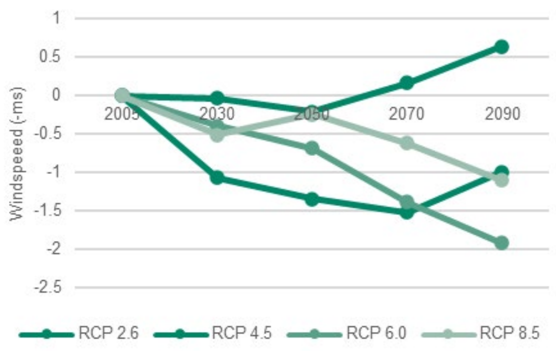


Figure 2-9 Projected change in windspeed to 2090 under different RCP scenarios

2.3 Risk assessment

2.3.1 Risks (pre-mitigation/adaptation)

A total of 54 physical risks were identified in the risk workshop, four of which relate to the construction phase (including maintenance during operations) and 50 of which relate to the operational phase of the project. These were classified according to the risk likelihood and consequence in accordance with the AS 5334:2013 (see Annexure A for consequence and likelihood criteria).Table 2-5 is the summary of the total number of risks by risk rating for 2030 and 2090. Detailed results of the climate change risk assessment are provided in Annexure B. Classification of risks are sensitive to the project design strategies and would be continually reviewed at each phase of the project.

Table 2-5 The total number of risks classified by risk rating for 2030 and 2090.

Risk rating	Construction risks, pre-mitigation/adaptation		Operational risks, pre-mitigation/adaptation	
	2030	2090[4]	2030	2090
Low	2	1	16	3
Medium	1	1	31	28
High	1	1	3	19
Extreme	0	1	0	0
Total	**4**	**4**	**50**	**50**

2.3.2 Assessment of construction impacts

Climate change projections for the near future (2030) are considered relevant to the project's proposed construction timeframes, planned for the period between 2024 and 2031.

A total of four risks were identified for the construction period, one of which was a high risk, one of which was a medium risk, with remaining risks rated as low for 2030. Table 2-6 outlines the risks identified as extreme, high and medium, prior to the implementation of mitigation measures. Mitigation measures are discussed further in Section 5.0, and a residual risk assessment is provided in Section 2.4.

[4] The 2090 risk rating for construction risks also applies to the maintenance workers during the operational phase of the project.

Table 2-6 Construction risks

Risk #	Climate hazard	Risk impact statement	2030 rating	2090 rating[5]
2	Temperature	Increased temperatures lead to increased surface temperature of elements such as handrails and health and safety risk to construction and maintenance workers and passengers	Low	Low
11	Temperature	Increased extreme heat days leads to an increased risk of heat stress for construction and maintenance workers	High	Extreme
33	Increased storm intensity	Increased storm intensity leading to safety risk to construction and maintenance workers	Medium	High
46	Bushfire Risk	Increased frequency and intensity of bushfires impacting access to the project site leading to construction and maintenance delays	Low	Medium

2.3.2.1 Cumulative construction impacts

The nature of the project, primarily comprising underground tunnel infrastructure, is likely to offer protection from a number of climate impacts (e.g., solar radiation, rainfall, storm events, urban heat island), however, the construction of surface infrastructure, including interchanges, surface road upgrades and project buildings, and the project's construction footprints are likely to be susceptible to such impacts.

The vulnerability of project infrastructure would be specific to the location of each surface element. As a result, the cumulative climate change risks are considered to occur at locations where project construction would overlap with construction of other major infrastructure projects. Cumulative climate change risks would be associated with an increase in extreme climate events and delays to respective construction programs, resulting in a cumulative increase in the duration of construction periods. Climate change risk assessments undertaken for each project would address risks specific to each project respectively.

2.3.3 Assessment of operational impacts

The climate change risk assessment identified a total of 50 direct and indirect risks during the operations period of the project. Of these risks, three high and 31 medium risks were identified for 2030 and 17 were rated as medium and 17 rated as high for 2090, as summarised in Table 2-7. Operational risks assessed as high for this project are related to both drought and bushfire hazards. These risks are assessed prior to consideration of adaptation measures, which are detailed in Section 5.0. A residual risk assessment is presented in Section 2.4.

Table 2-7 Operational risks

Risk #	Climate hazard	Risk impact statement	2030 rating	2090 rating
1	Temperature	Increased heat causing accelerated degradation of materials leading to increased maintenance and replacement	Medium	Medium
3	Temperature	Increased exposure to higher temperatures affects the resilience of soil and vegetation and results in a loss of biodiversity and impacts to project landscaping	Medium	High
4	Temperature	High temperatures lead to an preference for private vehicles compared to other transport modes which will increase traffic through the tunnel and increase emissions within the tunnel and put excess load on the ventilation system,	Medium	Medium

[5] The 2090 risk rating for construction risks also applies to the maintenance workers during the operational phase of the project.

Risk #	Climate hazard	Risk impact statement	2030 rating	2090 rating
		leading to increased maintenance and possible failure		
5	Temperature	High temperatures lead to an preference for private vehicles compared to other transport modes which will increase traffic through the tunnel increasing wear of road surface leading to increased maintenance (e.g., resurfacing)	Medium	High
6	Temperature	Increased temperatures lead to power supply disruptions leading to interruption to transport services, traffic congestion or outages	Medium	Medium
7	Temperature	Increase temperatures leads to more cooling days and an increase in energy consumption and carbon emissions	Low	Medium
8	Temperature	Extreme heat days lead to potential failure of mechanical and electrical systems	Medium	High
9	Temperature	Increased temperatures lead to increased expansion and slacking between transmission lines decreases clearance from ground leading to increased health and safety incidents for workers and motorists	Low	Medium
10	Temperature	Increased temperatures lead to increased evaporation from hydrology systems impacting capacity of downstream swamps to act as retention basins for runoff from the project leading to biodiversity and reputational impacts	Medium	Medium
12	Temperature	Increased temperatures lead to increased deterioration of road surfaces and increased safety risk for motorists	Medium	Medium
13	Drought	Increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to infrastructure within the tunnel and a health risk for workers and motorists	High	High
14	Drought	Increased frequency and severity of drought conditions leads to increased dust build up in mechanical ventilation systems requiring additional maintenance	Medium	Medium
15	Drought	Increased frequency and severity of drought conditions leads to increased dust storms creating visibility issues within the tunnel for motorists and increased health and safety impacts	Medium	Medium
16	Drought	Increased frequency and severity of drought conditions leads to increased water scarcity impacting water services in the project	Low	Medium
17	Drought	Increased frequency and severity of drought conditions leads to increased risk of erosion and landslips from vegetation loss	Low	Medium
18	Drought	Increased frequency and severity of drought conditions leads to impacts on project landscaping	Medium	High
19	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to water quality impacts to downstream receivers (groundwater dependent ecosystems, drinking water catchments etc.) leading to biodiversity and reputational impacts	Medium	Medium
20	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to flooding of the carriageway leading to unsafe driving conditions	Medium	High
21	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to overloading of upstream	Medium	High

Risk #	Climate hazard	Risk impact statement	2030 rating	2090 rating
		detention basins and flooding impacts to the project site		
22	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to drainage issue over green roof covered ancillary structures and damage to property	Low	Medium
23	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to corrosion of steel structures and decreased durability of other structural materials requiring additional maintenance or replacement	Medium	High
24	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events impacting traveller choices, reducing active transport such as walking and cycling and increasing traffic through the tunnel leading to congestion and reduced safety of motorists	Low	Medium
25	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to increased risk of landslides to new and existing embankments and damage to structures	Medium	Medium
26	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to overloading capacity of downstream retention basins leading to downstream flood impacts	Low	Medium
27	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to increased operational maintenance costs from water pumping and repairs	Low	High
28	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to flooding of surrounding access roads leading to reduced traffic and impacting operational profits	Medium	High
29	Increased storm intensity	Increased storm intensity leading to damage to structures	Medium	Medium
30	Increased storm intensity	Increased storm frequency and intensity leading to increased risk of lightning strike to pedestrians	Medium	Medium
31	Increased storm intensity	Increased storm frequency and intensity leading to increased risk of lighting strike to infrastructure and increasing repair and maintenance costs	Low	Medium
32	Increased storm intensity	Increased storm intensity leading to damage to power supply infrastructure and service disruptions	Medium	Medium
33	Increased storm intensity	Increased intensity of extreme winds causing falling trees and debris leading to direct safety impacts for motorists	Medium	High
34	Increased storm intensity	Increased frequency and severity of storm events leads to overloading capacity of downstream retention basins leading to downstream flood impacts	Low	Low
35	Increased storm intensity	Increased storm intensity leading to safety risk to travellers transitioning from outside to inside of tunnel and vice versa	Medium	Medium
36	Increased storm intensity	Increased storm intensity leading to resulting in delays in construction and maintenance and reputational impacts	Low	Medium
37	Increased storm intensity	Increased intensity of extreme winds causing falling trees and debris leading to direct safety impacts for motorists	Low	High

Risk #	Climate hazard	Risk impact statement	2030 rating	2090 rating
38	Increased storm intensity	Increased intensity of extreme winds causing falling trees and debris on road or on essential infrastructure leading to safety impacts for motorists	Medium	Medium
39	Increased storm intensity	Increased storm intensity leading to reduced driving visibility causing road accidents and traffic congestion	Medium	High
40	Increased storm intensity	Increased storm intensity leading to increased hail speed and size causing impact on vehicles at tunnel exits and entries	Medium	Medium
41	Increased storm intensity	Increased storm intensity diverting tunnel ventilation flow causing an increase in emission concentration	Low	Low
42	Bushfire	Increased frequency and intensity of bushfires leading to road closures, congestion and safety impacts to motorists	Medium	High
43	Bushfire	Increased frequency and intensity of bushfires leading to entry and exit of the tunnel becoming blocked and travellers becoming trapped inside the tunnel	High	High
44	Bushfire	Increased frequency and intensity of bushfires leading to a loss of biodiversity and impacts to project landscaping	Medium	High
45	Bushfire Risk	Increased frequency and intensity of bushfires leading to smoke inhalation risk for workers, travellers and fauna	Low	Medium
47	Bushfire Risk	Increased frequency and intensity of bushfires leading to increased smoke and reduced performance of the tunnel ventilation system requiring increased maintenance	Low	Low
48	Bushfire	Increased frequency and intensity of bushfires leading to damage to infrastructure (e.g. noise walls, pavement) resulting in increased maintenance and decrease in operational safety	High	High
49	Bushfire	Increased frequency and intensity of bushfires leading to damage to power infrastructure impacting tunnel operations	Medium	Medium
50	Bushfire	Increased frequency and intensity of bushfires leading to increased strike risk for displaced fauna	Medium	Medium
51	Bushfire	Increased frequency and intensity of bushfires leading to smoke pollution impacting road visibility and increasing safety risk to motorists	Medium	High
52	Increased solar radiation	Increased solar radiation leading to increased strike risk for fauna seeking shade	Medium	High
53	Increased solar radiation	Increased solar radiation leading to deterioration of tunnel surfaces and requiring additional maintenance	Low	Medium
54	Increased solar radiation	Increased solar radiation leading to increased harmful UV effects to operations personnel	Medium	High

2.3.3.1 Cumulative operational impacts

Cumulative impacts associated with climate change risk would primarily occur as a result of interdependencies between the project and the upstream and downstream environment. These impacts may occur where the introduction of the project increases climate change risks for receiving environments. Examples of interdependencies for the project, which may be susceptible to climate change risks, include:

- increased overland flow and changes to drainage lines associated with the project resulting in increased risk of localised flooding and/or increased flows to receiving environments

- the project would contribute to a cumulative increase in impervious surfaces, however given that the majority of project infrastructure would be below the surface in tunnels, this increase is not anticipated to result in significant cumulative impacts
- project infrastructure at surface locations would interact with existing drainage systems. The design for project drainage infrastructure has been undertaken to account for the capacity of these existing drainage systems, such that project drainage infrastructure has been designed to meet or improve current drainage flows
- project infrastructure acting as an evacuation route during extreme events, with implications for emergency management and response.

Adaptation measures identified in Section 5.0 will improve the project's resilience to climate change and reduce potential interdependencies and cumulative climate change risks. The implementation of adaptation measures to address climate change risks provides opportunities to improve the resilience of infrastructure within the region.

2.4 Residual risk assessment

In line with volume1.2 of the ISC IS Rating Scheme Cli-2 criteria, adaptation measures for all high and extreme risks and a percentage of medium priority risks have been identified (Annexure C). Specifically, to comply with Cli-2 level 2 requirements between 25 – 50 per cent of medium risks must be treated. To comply with Cli-2 level 3 requirements at least 50 per cent of medium priority risks must be treated and the optimal scale and timing be addressed.

A residual risk assessment was undertaken to consider climate change risks to the project post-mitigation, following the implementation of adaptation measures identified in Section 5.0. Adaptation measures identified as part of this climate change risk assessment would increase the project's resilience to climate change, thereby reducing the consequence of potential impacts and lowering residual risks. The residual risk ratings are provided in Table 2-8.

Of the one high risk and one medium risk identified for project construction, proposed adaptation measures have resulted in a residual risk rating of two medium risks.

For project operation, proposed adaptation measures have resulted in all high risks lowered to a residual risk rating of medium or low.

Table 2-8 Residual risk ratings after proposed mitigation and controls have been implemented for construction and operational phase risks

Risk #	Element	Risk impact statement	2030 Rating (before mitigation and controls)	2030 Residual risk rating (after mitigation and controls)	2090 Rating (before mitigation and controls)	2090 Residual risk rating (after mitigation and controls)
1	Temperature	Increased heat causing accelerated degradation of materials leading to increased maintenance and replacement	Medium	Low	Medium	Low
3	Temperature	Increased exposure to higher temperatures affects the resilience of soil and vegetation and results in a loss of biodiversity and impacts to project landscaping	Medium	Low	High	Medium
4	Temperature	High temperatures lead to an preference for private vehicles compared to other transport modes which will increase traffic through the tunnel and increase emissions within the tunnel and put excess load on the ventilation system, leading to increased maintenance and possible failure	Medium	Low	Medium	Medium
5	Temperature	High temperatures lead to an preference for private vehicles compared to other transport modes which will increase traffic through the tunnel increasing wear of road surface leading to increased maintenance (e.g., resurfacing)	Medium	Medium	High	Medium
6	Temperature	Increased temperatures lead to power supply disruptions leading to interruption to transport services, traffic congestion or outages	Medium	Medium	Medium	Medium
8	Temperature	Extreme heat days lead to potential failure of mechanical and electrical systems	Medium	Medium	High	Medium
10	Temperature	Increased temperatures lead to increased evaporation from hydrology systems impacting capacity of downstream swamps to act as retention basins for runoff from the project leading to biodiversity and reputational impacts	Medium	Low	Medium	Low
11	Temperature	Increased extreme heat days leads to an increased risk of heat stress for workers	High	Medium	Extreme	Medium
12	Temperature	Increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to infrastructure within the tunnel and a health risk for workers and motorists	Medium	Medium	Medium	Medium
13	Drought	Increased frequency and severity of drought conditions leads to increased dust build up in mechanical ventilation systems requiring additional maintenance	High	Low	High	Medium
14	Drought	Increased frequency and severity of drought conditions leads to increased dust storms creating visibility issues within the tunnel for motorists and increased health and safety impacts	Medium	Low	Medium	Low
15	Drought	Increased frequency and severity of drought conditions leads to impacts on project landscaping	Medium	Low	Medium	Medium

Risk #	Element	Risk impact statement	2030 Rating (before mitigation and controls)	2030 Residual risk rating (after mitigation and controls)	2090 Rating (before mitigation and controls)	2090 Residual risk rating (after mitigation and controls)
18	Drought	Increased frequency and severity of extreme rainfall events leads to water quality impacts to downstream receivers (groundwater dependent ecosystems, drinking water catchments etc.) leading to biodiversity and reputational impacts	Medium	Low	High	Medium
19	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to flooding of the carriageway leading to unsafe driving conditions	Medium	Low	Medium	Medium
20	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to overloading of upstream detention basins and flooding impacts to the project site	Medium	Low	High	Medium
21	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to corrosion of steel structures and decreased durability of other structural materials requiring additional maintenance or replacement	Medium	Low	High	Medium
23	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to increased risk of landslides to new and existing embankments and damage to structures	Medium	Low	High	Medium
25	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to flooding of surrounding access roads leading to reduced traffic and impacting operational profits	Medium	Medium	Medium	Medium
28	Extreme rainfall and flooding	Increased storm intensity leading to damage to structures	Medium	Low	High	Medium
29	Increased storm intensity	Increased storm frequency and intensity leading to increased risk of lightning strike to pedestrians	Medium	Low	Medium	Medium
30	Increased storm intensity	Increased storm intensity leading to damage to power supply infrastructure and service disruptions	Medium	Low	Medium	Low
32	Increased storm intensity	Increased intensity of extreme winds causing falling trees and debris leading to direct safety impacts for motorists	Medium	Low	Medium	Low
33	Increased storm intensity	Increased storm intensity leading to safety risk to travellers transitioning from outside to inside of tunnel and vice versa	Medium	Medium	High	Medium
35	Increased storm intensity	Increased intensity of extreme winds causing falling trees and debris on road or on essential infrastructure leading to safety impacts for motorists	Medium	Medium	Medium	Medium

Risk #	Element	Risk impact statement	2030 Rating (before mitigation and controls)	2030 Residual risk rating (after mitigation and controls)	2090 Rating (before mitigation and controls)	2090 Residual risk rating (after mitigation and controls)
38	Increased storm intensity	Increased storm intensity leading to reduced driving visibility causing road accidents and traffic congestion	Medium	Medium	Medium	Medium
39	Increased storm intensity	Increased storm intensity leading to increased hail speed and size causing impact on vehicles at tunnel exits and entries	Medium	Medium	High	Medium
40	Increased storm intensity	Increased frequency and intensity of bushfires leading to road closures, congestion and safety impacts to motorists	Medium	Low	Medium	Medium
42	Bushfire Risk	Increased frequency and intensity of bushfires leading to entry and exit of the tunnel becoming blocked and travellers becoming trapped inside the tunnel	Medium	Medium	High	Medium
43	Bushfire Risk	Increased frequency and intensity of bushfires leading to a loss of biodiversity and impacts to project landscaping	High	Medium	High	Medium
44	Bushfire Risk	Increased frequency and intensity of bushfires leading to damage to infrastructure (e.g. noise walls, pavement) resulting in increased maintenance and decrease in operational safety	Medium	Medium	High	Medium
48	Bushfire Risk	Increased frequency and intensity of bushfires leading to damage to power infrastructure impacting tunnel operations	High	Low	High	Medium
49	Bushfire Risk	Increased frequency and intensity of bushfires leading to increased strike risk for displaced fauna	Medium	Low	Medium	Medium
50	Bushfire Risk	Increased frequency and intensity of bushfires leading to smoke pollution impacting road visibility and increasing safety risk to motorists	Medium	Medium	Medium	Medium
51	Bushfire Risk	Increased solar radiation leading to increased strike risk for fauna seeking shade	Medium	Medium	High	Medium
52	Increased solar radiation	Increased solar radiation leading to increased harmful UV effects to operations personnel	Medium	Medium	High	Medium
54	Increased solar radiation	Increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to infrastructure within the tunnel and a health risk for workers and motorists	Medium	Low	High	Medium

3.0 Sustainability

3.1 Relevant guidelines and policies

An assessment of the sustainability policy framework relevant to the project, including NSW Government targets and strategies to improve efficiency in the use of water, energy and transport, included the following documents:

- *GWHUP – Blackheath to Little Hartley Sustainability Strategy* (Transport 2022a)
- *Transport Environment and Sustainability Policy* (Transport 2020a)
- *Transport Sustainability Plan 2021* (Transport 2021a)
- *Future Transport Strategy: Our vision for transport in NSW* (Transport 2022b)
- *A Metropolis of Three Cities – the Greater Sydney Region Plan* (Greater Sydney Commission 2018)
- *NSW Sustainable Design Guidelines Version 4.0* (Transport 2017)
- *NSW Climate Change Policy Framework* (NSW Office of Environment and Heritage (OEH) November 2016)
- *NSW Government Resource Efficiency Policy* (OEH 2019)
- *NSW Waste Avoidance and Resource Recovery Strategy 2014-21* (NSW Environment Protection Authority (NSW EPA) 2014)
- *Net Zero Plan Stage 1: 2020–2030* (Department of Planning, Industry and Environment, 2020)
- *NSW Climate Change Policy Framework* (Office of Environment and Heritage 2016)
- *NSW Waste and Sustainable Materials Strategy 2041* (Department of Planning, Industry and Environment 2021)
- *Beyond the Pavement* (Transport 2020c).

Together, these documents provide the sustainability principles that inform the design of the project. In addition, Transport has set out specific requirements for sustainability under the *GWHUP – Blackheath to Little Hartley Sustainability Strategy* (Transport 2022a) (Table 3-1).

Table 3-1 Sustainability focus areas (taken from GWHUP – Blackheath to Little Hartley Sustainability Strategy (Transport 2022a))

Transport sustainability focus areas	GWHUP Blackheath to Little Hartley sustainability focus areas
Respond to climate change • net zero emissions by 2050 • consider climate change risks in all decisions.	**Zero Carbon** • working towards net zero carbon emissions and impact. **Resilience** • resilient and adaptive to natural hazards and the impact of a changing climate.
Protect and enhance biodiversity • no net loss of biodiversity.	**Biodiversity** • working with the landscape rather than against it and finding opportunities for green infrastructure solutions.
Improve environmental outcomes • develop a circular economy for Transport by designing waste and pollution out and keeping products and materials in use • reduce environmental impacts of projects and operation.	**Circular Economy** • A closed-loop system that eliminates waste, minimises the use of resource inputs and minimises the creation of waste, pollution and carbon emissions.

Transport sustainability focus areas	GWHUP Blackheath to Little Hartley sustainability focus areas
Procure responsibly • all suppliers meet the standards in the Transport • supplier Sustainability Charter • social and environmental outcomes included in all procurement decisions • go beyond minimal compliance targets and Aboriginal Procurement Policy.	
Partner with Communities • always leave a positive legacy for communities as a result of projects • enable, apply and report on community engagement	**Community Buy-in** • culture, communities and people are at the heart of design and decisions.
Respect culture and heritage • aboriginal culture is integrated and preserved • acknowledge and incorporate through stories, examples and best practice.	
Align spend and impact • all decisions consider value created from sustainability alongside financial analysis • reduce whole of life costs for the transport network.	**Third Party Assurance and Transparency** • being transparent about actions and progress. **Whole of Life Approach** • considers all aspects of the use, operation, maintenance and disposal of the asset from concept development, design and construction, through to infrastructure redundancy and demolition.
Empower customers to make sustainable choices • use customer journeys to inform, engage and inspire more sustainable practices and demonstrate Transport's progress.	

3.2 Infrastructure Sustainability Rating

Sustainability of the project will be assessed in accordance with the Infrastructure Sustainability Council Rating Tool to determine and set an appropriate target rating for the project, in accordance with the SEARs.

In August 2021, ISC released Version 2.1 of the ISC Rating Tool. This update provides a number of improved and additional categories and credits to further enhance the sustainability performance of major infrastructure projects. The scheduled retirement of version 1.2 of the ISC Rating Tool is at the end of 2023. Transport is updating its internal procedures to enable a gradual and successful transition of future projects to version 2.1. Although ISC version 1.2 is being applied to this project, Transport is managing this transition by continuing to investigate and implement ISC version 2.1 credits where possible to enhance sustainable project outcomes.

The IS rating scheme was developed and is administered by ISC. The IS rating scheme is a comprehensive rating system for evaluating sustainability across the design, construction and operation of infrastructure, as shown in Figure 3-1. For Version 1.2 the three types of ratings as part of the IS rating scheme are Design, As Built and Operation.

The project is seeking a minimum IS 'Design' and 'As-Built' rating of 'Excellent'. This is outlined in the *Great Western Highway – Central: Preliminary Infrastructure Sustainability Management Plan* (AECOM & Aurecon 2022) (ISMP). The ISMP also provides a timeline for achieving the 'Excellent' rating and a preliminary assessment to determine the targets and strategies to be implemented to improve sustainability across a range of areas including water and energy use.

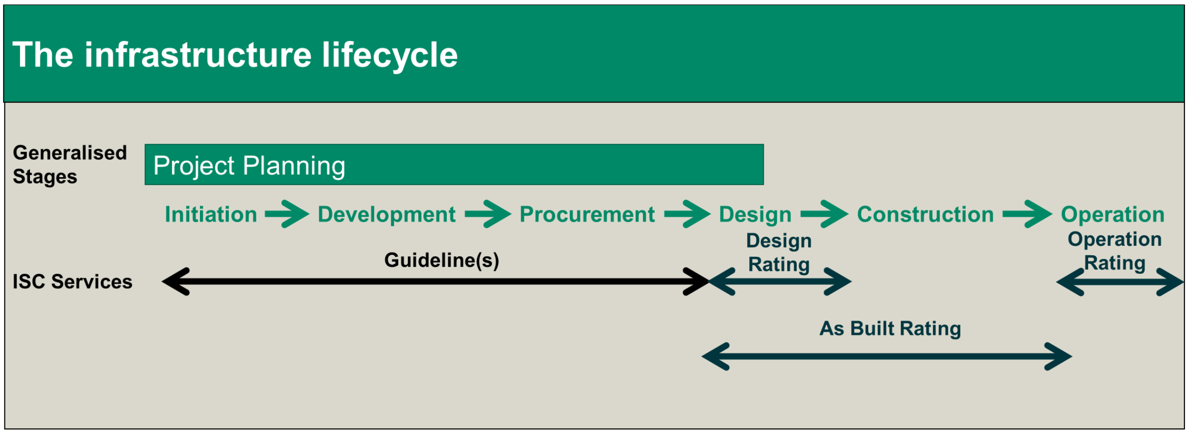


Figure 3-1 IS rating scheme

3.3 Sustainability initiatives

Sustainability workshops and meetings were held with planning and design teams during EIS development to assess and progress initiatives for achieving the target IS 'Design' and 'As-Built' rating criteria. Opportunities for future detailed design development suggested in these workshops were also taken into account.

Sustainability initiatives were identified under the following headings:

- **energy use:** initiatives for achieving efficiencies in energy use through design of tunnel ventilation, construction programming, construction utilities provision, transport options, offsets and renewable energy generation
- **water use:** initiatives for achieving efficiencies in water use through design of stormwater drainage and utilities, and for reducing potable water use by exploring opportunities to use non-potable water sources instead
- **materials:** initiatives for achieving efficiencies in material lifecycle impacts through the selection of sustainable materials, sourcing in close proximity to the site to minimise transport, and innovating with recycled materials
- **waste:** including waste minimisation to realise a range of efficiencies (e.g. reduction in transport requirements), the development of a deconstruction plan to ensure all temporary infrastructure is able to be dismantled for reuse post construction, as well as the management and reuse of spoil during construction
- **urban design:** including provision of connectivity with local bushwalking trails
- **environment:** including initiatives to minimise the construction footprint, where possible, and protect ecologically sensitive areas including hollow-bearing trees
- **ecology:** consideration for landscaping to support native species, minimise groundwater drawdown and minimise habitat impacts
- **climate change:** including initiatives to improve the resilience of the project to future extreme climate events
- **heritage:** including initiatives for the preservation and enhancement of heritage values
- **health:** consideration of air and noise quality improvement initiatives
- **land use:** initiatives that conserve topsoil and subsoil and minimise impacts to previously undisturbed land

- **stakeholder engagement:** consideration of engagement methods that are tailored for each stakeholder group, particularly vulnerable stakeholders
- **innovation:** initiatives that encourage or rely on solar power such as battery storage to power infrastructure, optimised tunnel design to utilise space efficiently, and consider alternative materials including recycled materials in the structural design.

A number of initiatives were documented for planning and design consideration to embed specific sustainability commitments and targets for implementation by the construction contractor. The construction contractor would be responsible for ensuring that enough credits are achieved to meet the IS 'Excellent' rating.

4.0 Greenhouse gas assessment

4.1 Assessment methodology

This section provides a detailed description of the GHG assessment methodology, including the emissions factors used for all emission sources, and detailed calculation methods used to estimate the GHG emissions from fuel combustion, electricity consumption, vegetation removed, materials use and fugitive emissions during the construction and operational phases. Two ventilation scenarios were assessed: (1) emissions from ventilation outlet (ventilation outlet option); and (2) emissions from portals (portal emissions option).

4.1.1 Relevant guidelines and policies

The following summarises relevant GHG related legislation, policy and guidelines applicable to the assessment of the project:

- International:
  - Paris Agreement: Driver for setting Commonwealth and State GHG legislation, policy, and targets (United Nations Framework Convention on Climate Change, 2015)
  - *GHG Protocol: A Corporate Accounting and Reporting Standard* (World Business Council for Sustainable Development and the World Resources Institute, 2015)
  - *AS/ISO 14064.1:2006 GHG Part 1: Specification with guidance at the organisational level for quantification and reporting of GHG emissions and removals* (International Organization for Standardization, 2006).
  - *AS/ISO 14040:2019 Environmental management – Life cycle assessment – Principles and framework* (International Organization for Standardization, 2019).
  - *AS/ISO 14044:2019 Environmental management – Life cycle assessment – Requirements and guidelines* (International Organization for Standardization, 2019).
- Commonwealth:
  - *National Greenhouse and Energy Reporting Act 2007* (NGER Act)
  - *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
  - The current *Australian National Greenhouse Accounts: National Greenhouse Accounts Factors* (NGA Factors) (Department of Industry, Science, Energy and Resources, 2021).
- State:
  - *NSW Climate Change Policy Framework* (State of NSW and Office of Environment and Heritage, 2016)
  - *Transport Environment and Sustainability Policy* (Transport, 2020).
  - *NSW Net Zero Plan Stage 1: 2020-2030* (State of NSW and NSW Department of Planning, Industry and Environment)
  - *Transport Carbon Estimate and Reporting Tool (CERT).* Data sources used by the Transport CERT include:
    - AusLCI: *National Life Cycle Inventory database* set up by the Australian Life Cycle Assessment Society (Australian Life Cycle Assessment Society, 2011)
    - NGA 2016: *Australian National Greenhouse Accounts* published by the Australian Government Department of Industry, Science, Energy and Resources (Department of Industry, Science, Energy and Resources, 2016)
    - TAGG 2013: *Transport Authorities Greenhouse Group Australia and New Zealand* (TAGG), GHG Assessment Workbook for Road Projects (TAGG, 2013)

- EPDs: *Environmental Product Declarations*, published within the Australasian EPD Programme (2018).

Consideration of the project against current guidelines, targets and strategies to improve Government efficiency in transport is provided in Chapter 2 (Strategic context and project need) of the EIS.

4.1.2 Methodology

The CERT has been used to estimate GHG emissions associated with the project, as described in Chapter 5 (Project description) and Chapter 6 (Construction) of the EIS. The CERT is developed by Transport and assists with the measurement and report of GHG emissions. GHG emission sources are categorised into the following three ‘scopes’:

- Scope 1 – direct emissions: GHG emissions generated by sources owned or controlled by the project, for example emissions generated by the combustion of diesel fuel in project-owned construction plant, equipment, or vehicles
- Scope 2 – indirect emissions: GHG emissions from the consumption of purchased electricity in owned or controlled equipment or operations for the project. These GHG emissions are generated outside the construction and operational footprint of the project, for example the use of electricity purchased from the grid
- Scope 3 – indirect upstream/downstream emissions: GHG emissions generated in the wider economy due to third party supply chains as a consequence of activity within the boundary of the project, for example GHG emissions associated with the mining and production of materials used in construction (referred to as the embodied emissions of a material) and transport of materials to site.

A summary of the emissions sources included in the assessment is provided in Figure 4-1.

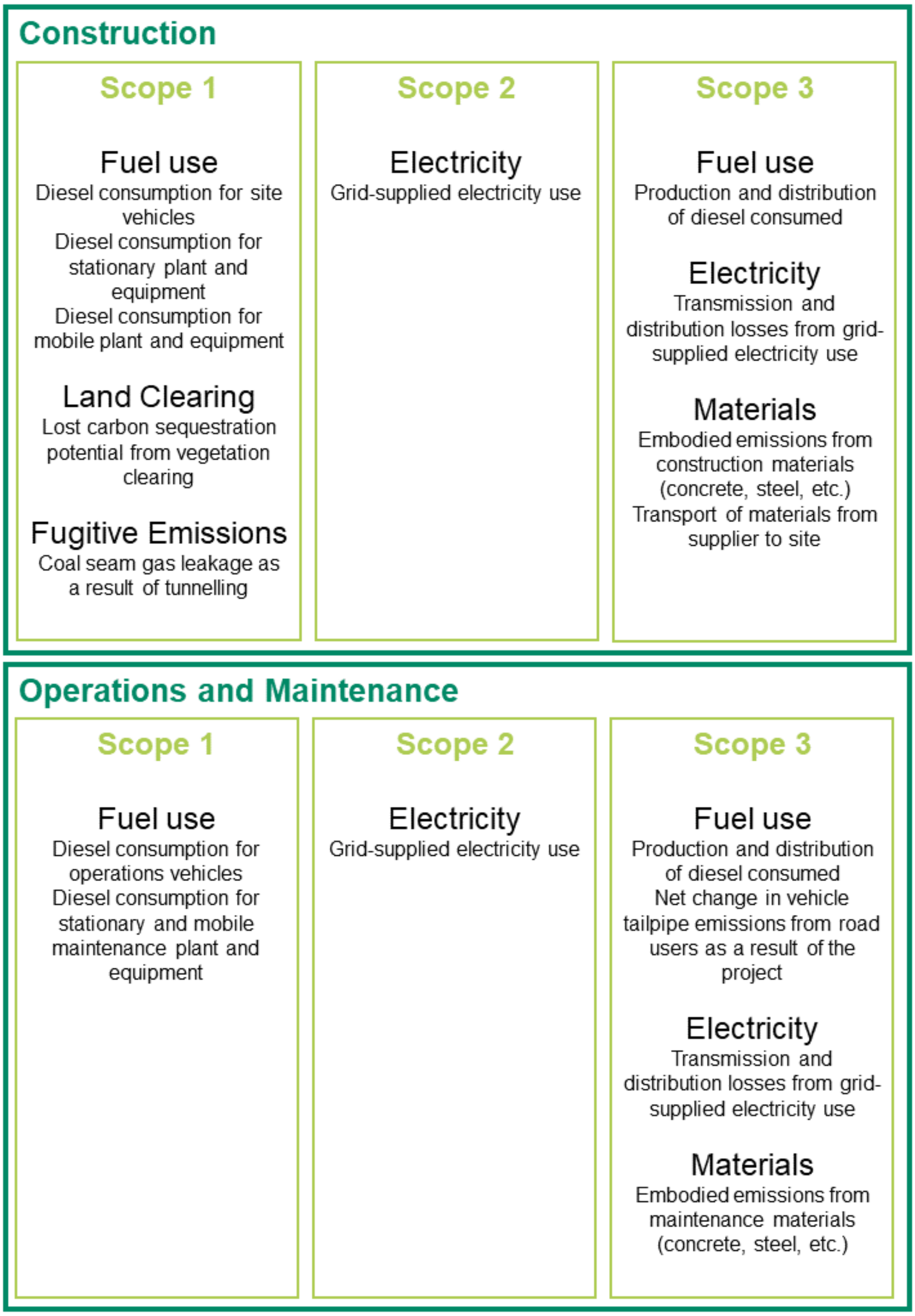


Figure 4-1 Summary of emission sources included in the GHG assessment

Once the emissions were quantified using the CERT, emissions were classified in accordance with the relevant reporting guidelines outlined in Section 4.1.1.

CERT provides generic calculations to convert quantities of materials, fuel use, vegetation removal, etc. into mass of GHG emissions produced. While the CERT sources emissions factors from the NGA 2016, the only relevant emissions factors that change significantly year-to-year are emissions from the electricity grid. For emissions from electricity use, an adjustment factor was applied to account for this change such that the GHG emissions reflect the most recent (2021) emissions factor for NSW grid electricity.

To calculate the potential GHG emissions associated with the project, the following steps were used:

1. define the assessment boundary and identify potential sources of GHG emissions associated with the project
2. determine the quantity of each emission source (fuel and electricity consumed, vegetation cleared, construction materials used, etc.)
3. quantify the potential GHG emissions associated with each GHG source, using equations and emission factors specified in the CERT
4. present the potential GHG emissions associated with the project.

GHG emissions are reported in this assessment as tonnes of carbon dioxide equivalent (t CO2e).

4.2 Existing environment

4.2.1 Current GHG activities

Transport in NSW accounts for 20 per cent of total emissions (25.9 million tonnes of carbon dioxide equivalent (Mt CO_2e) per year) (NSW Government, 2022), making it the state's second largest source of GHG emissions. Road transport is responsible for approximately 89 per cent of NSW transport emissions (23 Mt CO_2e) (NSW Government, 2022). GHG emissions in NSW across all sectors contributed to 132.408 Mt CO_2e in 2020 representing approximately 27 per cent of Australia's total emissions (Australian Government Department of Industry, Science, Energy and Resources, 2020).

Activities that will generate GHG emissions during usual operation of the project infrastructure include:

- operational energy e.g., lighting, signalling, ventilation, ancillary building energy
- maintenance materials e.g., protective coatings and paints, asphalt for road maintenance
- maintenance plant and equipment e.g., rollers for resurfacing.

4.3 Assessment of construction impacts

It is estimated that the project would generate approximately 1,407,140 t CO2e during construction. The breakdown of emissions by scope is shown in Table 4-1 and summarised as:

- 138,900 t CO2e of Scope 1 (direct) GHG emissions
- 525,200 t CO2e of Scope 2 (indirect) GHG emissions
- 743,040 t CO2e of Scope 3 (indirect) GHG emissions.

Key emissions sources during construction of the project are shown in Table 4-1. It was assumed that any difference in construction GHG emissions between the two ventilation options would be negligible.

Table 4-1 Construction GHG emissions

Emissions source	GHG emissions (t CO2e over construction period)[1]				
	Scope 1	Scope 2	Scope 3	**Total**	% of total
Fuel use					
Diesel consumption for site vehicles (incl. segment delivery and spoil haulage)	72,210	0	3,700	75,910	5%
Diesel consumption for stationary plant and equipment	1,140	0	60	1,200	0.1%
Diesel consumption for mobile plant and equipment	49,520	0	2,540	52,060	4%
Electricity					
Electricity consumption	0	525,200	47,130	572,330	41%
Construction materials					
Concrete	0	0	377,320	377,320	27%

Emissions source	GHG emissions (t CO2e over construction period)[1]				
	Scope 1	Scope 2	Scope 3	**Total**	% of total
Steel	0	0	290,860	290,860	21%
Asphalt	0	0	1,750	1,750	0.1%
Other	0	0	200	200	0%
Transport of materials	0	0	19,480	19,480	1%
Land clearing					
Land clearing	4,740	0	0	4,740	0.3%
Fugitive emissions					
Fugitive emissions (methane gas from coal seams) during tunnelling	11,290	0	0	11,290	0.8%
Total	**138,900**	**525,200**	**743,040**	**1,407,140**	**100%**

Note 1: Estimates rounded to the nearest 10 t CO2e

As shown in Table 4-1, the majority of GHG emissions produced during construction are associated with electricity (scope 2), followed by construction materials (particularly concrete and steel) (scope 3), and fuel use (scope 1). This is mainly due to the large and prolonged electricity requirements of tunnelling equipment. As noted in Annexure D, conservative assumptions regarding the use of electrical equipment have been used due to a lack of further detail. As such, emissions from electricity use may be smaller in practice. The large proportion of emissions from electricity use represents an opportunity for the project to achieve significant reductions in overall greenhouse gas emissions through the sourcing of electricity from a renewable source.

For the purposes of the assessment, it was assumed that the concrete to be used would have a Portland cement-based concrete mix design, with no supplementary cementitious materials. The emissions associated with concrete use may be reduced by using concrete mix designs with higher proportions of Portland cement replacement, so long as this does not lead to an increase in steel emissions.

Diesel combustion from plant, equipment and vehicles also contributes to the estimated GHG emissions for construction. Reducing GHG emissions from fuel use is an ongoing challenge across the broader construction industry. Reductions in emissions from fuel use can be made using biodiesel and bioethanol and more efficient plant and equipment such as hybrid and electric plant, equipment, and vehicles.

Refer to Section 5.0 for a full list of recommended mitigation measures to reduce GHG emissions associated with the construction of the project.

In addition to the quantitative GHG assessment outlined above, a qualitative assessment was carried out to assess the potential GHG impacts associated with the construction of a new water supply pipeline to supply the construction site at Little Hartley. It is anticipated that the construction of the pipeline would result in the following impacts to the project's GHG emissions:

- excavation of the pipeline trench and installation of the pipeline, including backfill and rehabilitation, are anticipated to increase plant and equipment energy requirements and materials use. These increased requirements would lead to an increase in GHG emissions
- concrete foundation and/or encasements works and thrust blocks are anticipated to increase plant and equipment energy requirements and materials use. These increased requirements would lead to an increase in GHG emissions
- connection to Lithgow water supply is anticipated to increase plant and equipment fuel requirements and materials use. These increased requirements would lead to an increase in GHG emissions.

4.4 Assessment of operational impacts

Key emissions sources during operations and maintenance of the project under the ventilation outlet option are shown in Table 4-2.

Table 4-2 Operation and maintenance GHG emissions: ventilation outlet option

Emission source	GHG Emissions (t CO2e over 100 year asset life) [1]			
	Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and operations vehicles)	8,370	3,484,780	313,170	3,806,320
Maintenance emissions (maintenance plant, equipment and materials)	5,040	0	37,560	42,600
Road users (net change in vehicle tailpipe emissions)	0	0	-298,930	-298,930
Total operations and maintenance emissions	**13,410**	**3,484,780**	**51,800**	**3,549,990**

Note 1: Estimates rounded to the nearest 10 t CO2e

Key emissions sources during operations and maintenance of the project under the portal emissions option are shown in Table 4-3.

Table 4-3 Operation and maintenance GHG emissions: portal emissions option

Emission source	GHG Emissions (t CO2e over 100 year asset life) [1]			
	Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and operations vehicles)	8,370	1,396,980	125,800	1,531,150
Maintenance emissions (maintenance plant, equipment and materials)	5,040	0	37,560	42,600
Road users (net change in vehicle tailpipe emissions)	0	0	-298,930	-298,930
Total operations and maintenance emissions	**13,410**	**1,396,980**	**-135,570**	**1,274,820**

Note 1: Estimates rounded to the nearest 10 t CO2e

The largest source of operations and maintenance GHG emissions is operational electricity use (scope 2) for both ventilation options. Ventilation equipment is the largest electricity-consuming component during operation in both options. Options for consideration and further investigation include minimising emissions from electricity through:

- improving energy efficiency in mechanical/ventilation equipment through the use of variable speed drives and appropriate sizing of ducts, mechanical and lighting efficiency in the operations buildings
- sourcing electricity from a renewable source e.g. through GreenPower or a power purchase agreement
- in line with the study's assumptions, ensuring building services are electrified (i.e. avoid all gas water and space heating).

Materials use to replace components with a design life of less than 100 years is the second-largest source of operations and maintenance GHG emissions (scope 3). These emissions can be reduced by designing components to be longer lasting, and choosing materials during replacement with lower embodied carbon, such as concrete with reduced Portland cement content.

A smaller component of GHG emissions is from operations and maintenance plant, equipment, and vehicles. Opportunities exist to reduce these emissions by decarbonising the operations and maintenance vehicle fleet.

It is noted that emissions are anticipated to be produced as a result of maintenance activities throughout the 100-year asset life. Opportunities to lower and eliminate GHG emissions in line with the NSW Government's objective to achieve net zero GHG emissions by 2050 should be considered at a broader organisation level by the asset operator.

It is anticipated that the project would facilitate a reduction in tailpipe emissions from vehicles travelling along the Great Western Highway between Blackheath and Little Hartley (scope 3) compared to a ‘without project’ scenario. This is expected to occur (at least in the short-term) due to an easing of congestion, increased travel speed, and reduced travel time as a result of the project, resulting in lower emissions per vehicle per kilometre. Note that projected uptake of electric vehicles by motorists were not included in the assessment, however, it is expected that a gradual uptake of electric vehicles will result in a corresponding reduction in GHG emissions from road transport over time.

The difference in total, scope 1, 2 and 3 GHG emissions between the two scenarios is estimated to be 2,275,168 t CO_2e. This is driven by the higher electricity requirements from mechanical ventilation equipment for the ventilation outlet option. As noted in Annexure D, conservative assumptions were used to estimate the electricity requirements of the ventilation equipment under the ventilation outlet option.

In addition to the quantitative GHG assessment outlined above, a qualitative assessment was carried out to assess the potential GHG impacts associated with the operation of a new water supply pipeline. It is anticipated that the operation of the pipeline would result in negligible impacts to the project’s GHG emissions. Operation of the pipeline may impact emissions in areas outside the assessment boundary, such as pumping energy requirements by relevant water supply operators.

4.5 Assessment of cumulative impacts

Cumulative impacts have the potential to occur when benefits or impacts from a project overlap or interact with those of other projects, potentially resulting in a larger overall effect (positive or negative) on the environment or local communities. Cumulative impacts may occur when projects are constructed or operated concurrently or consecutively. Once the project is operational, other projects which interrelate may enhance the project and create positive cumulative benefits.

Four projects were reviewed against the following screening criteria for this cumulative impact assessment:

- spatially relevant (i.e., the development or activity overlaps with, is adjacent to or within two kilometres of the project)
- timing (i.e., the expected timing of its construction and/or operation overlaps or occurs consecutively to construction and/or operation of the project)
- scale (i.e., large-scale major development or infrastructure projects that have the potential to result in cumulative impacts with the project, as listed on the NSW Government Major Project website and on the relevant council websites)
- status (i.e., projects in development with sufficient publicly available information to inform this environmental impact statement and with an adequate level of detail to assess the potential cumulative impacts).

Projects identified as contributing to potential cumulative impacts have met these criteria and include:

- Katoomba to Blackheath Upgrade (including Medlow Bath Upgrade)
- Little Hartley to Lithgow Upgrade.

Given the regional setting of the project primarily within the Blue Mountains Local Government Area (LGA) and a small portion within the Lithgow LGA, there are fewer major projects within the locality.

Figure 1-8 shows the interface of the Katoomba to Blackheath Upgrade (including Medlow Bath) and the Little Hartley to Lithgow Upgrade with the project.

Chapter 24 (Cumulative impacts) details the full cumulative impact assessment methodology adopted for the project.

GHG emissions from the project would not increase in a localised area as a result of multiple projects being developed nearby, as GHGs are atmospherically mobile. Rather, cumulative impacts from GHG emissions are measured as the project's contribution to the global increase in GHG emissions which contribute to climate change. Cumulative GHG emissions have been presented as a proportion of the NSW annual emissions in 2020 as a benchmark, noting that the emissions are expected to be emitted over a number of years of construction and operation.

4.5.1 Construction

GHG emissions in NSW across all sectors contributed to 132.408 Mt CO_2e in 2020. The estimated average annual scope 1 and 2 emissions from the construction component of the project are 0.09 Mt CO_2e, equivalent to 0.07 per cent of total NSW annual emissions in 2020.

The Little Hartley to Lithgow Upgrade is predicted to cause 0.032 Mt CO_2e/year during construction (refer Great Western Highway Upgrade: Little Hartley to Lithgow (West Section) Technical Working Paper – Greenhouse Gas and Climate Change Risk Assessment). Combined with the Blackheath to Little Hartley project, these would cause 0.127 Mt CO_2e. This is equivalent to 0.096 per cent of total NSW annual emissions in 2020.

Note that the Katoomba to Blackheath Upgrade and Medlow Bath Upgrade did not undertake GHG assessments in the review of environmental factors process.

4.5.2 Operation

GHG emissions in NSW across all sectors contributed to 132.408 Mt CO_2e in 2020. The estimated average annual scope 1 and 2 emissions from the operation and maintenance of the proposed upgrade are 0.03 Mt CO_2e under the ventilation outlet option, and 0.01 Mt CO_2e under the portal emissions option. These are equivalent to 0.03 and 0.01 per cent of total NSW annual emissions in 2020 for the ventilation outlet option and portal emissions options respectively.

The Little Hartley to Lithgow Upgrade is predicted to cause 0.001 Mt CO_2e/year during operation (refer Great Western Highway Upgrade: Little Hartley to Lithgow (West Section) Technical Working Paper – Greenhouse Gas and Climate Change Risk Assessment). Combined with the Blackheath to Little Hartley project, these would cause 0.036 Mt CO_2e under the ventilation outlet option, and 0.015 Mt CO_2e under the portal emissions option. These are equivalent to 0.027 and 0.011 per cent of total NSW annual emissions in 2020 for the ventilation outlet and portal emissions options respectively.

Note that the Katoomba to Blackheath Upgrade and Medlow Bath Upgrade did not undertake GHG assessments in the review of environmental factors process. As such, the quantities in the cumulative impact assessment consider only the Blackheath to Little Hartley and Little Hartley to Lithgow projects.

5.0 Management of impacts

5.1 Performance outcomes

Performance outcomes have been developed that are consistent with the SEARs for the project. The performance outcomes for the project are summarised below in Table 5-1 and identify measurable, performance-based standards for environmental management.

Table 5-1 Performance outcomes for the project – Climate change and sustainability

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed, constructed and operated to be resilient to the future impacts of climate change.	Design and implement the project taking into account current climate change projections and potential future climate change impacts	Design, construction and operation
The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	Design and implement the project to minimise capital and operational costs, consistent with NSW Treasury requirements. Design and implement the project to achieve a minimum Infrastructure Sustainability 'Design' and 'As-built' rating of 'Excellent' under version 1.2 of the ISC rating tool	Construction and operation

5.2 Mitigation measures

An ISMP would be prepared for the project. The ISMP would detail the proposed approach to implementing sustainability initiatives, monitoring and reporting during design and construction. A number of sub-plans (and other supporting documentation, as required) would also be prepared as part of the ISMP.

A community and stakeholder engagement plan (Engagement Plan) has been prepared for the Upgrade Program and would be used to guide community and stakeholder engagement activities during construction of the project. Engagement during construction would include updates on planned construction activities and would respond to concerns and enquiries in a timely manner, seeking to minimize potential impacts where possible.

Mitigation measures to manage potential climate change, sustainability, and greenhouse gas emissions impacts of the project are outlined in Table 5-2. Further consideration is required as to the overall emissions reduction target of the project, in line with Transport's net zero targets. These targets should be achieved in line with the following hierarchy for GHG emission reduction:

- avoid and reduce energy demand and GHG emissions
- undertake necessary activities as efficiently as possible
- use renewable energy sources to replace non-renewable sources
- carbon offsetting.

Table 5-2 Management and mitigation measures – Climate change, sustainability, and greenhouse gas emissions

ID	Mitigation and management measure	Timing
CC1	A climate change risk assessment will be carried as part of further design development. Adaptation actions will be identified and implemented to address extreme and high climate change risks, and will be considered for medium climate change risks where reasonable and feasible.	Design
SU1	An Infrastructure Sustainability Management Plan will be prepared and implemented as part of further design development to guide the implementation of sustainability initiatives. The Plan will detail how the project will achieve an Infrastructure Sustainability rating of 'Excellent'.	Design
SU2	As part of further design development, construction and operation of the project, the initiatives identified in the Great Western Highway Upgrade Program's Sustainability Strategy will be considered.	Design and operation
GG1	Opportunities to minimise greenhouse gas emissions from the project, including as a result of interactions with coal seams, will be identified as part of further design development, and will be implemented during construction and operation where reasonable and feasible. Consideration of opportunities to minimise greenhouse gas emissions will include: • reducing the electricity requirements of the project and/ or sourcing electricity from a renewable energy source • selecting construction materials with reduced embodied greenhouse gas emissions, through reduced materials use, lower emissions construction materials, and/ or local sourcing of materials • selecting plant and equipment with lower fuel/ electricity consumption and/ or greater energy efficiency.	Design, construction and operation
GG2	The project will be designed and implemented with the aim of achieving the following: • at least a 10 per cent reduction in carbon emissions during construction • offset at least 25 per cent of the carbon emissions associated with consumption of fuel and electricity through the purchase of approved offsets and/ or renewable energy during construction • at least a 10 per cent reduction in scope 1 greenhouse gas emissions using Climate Active Standard eligible offsets during construction • at least 15 per cent reduction in carbon emissions during operation A baseline against which the target reductions above will be evaluated will be established during detailed design, with reference to typical construction materials and methodologies, and operational processes and procedures, applied to other road tunnels in NSW.	Design, construction and operation

6.0 Conclusion

The assessment has been prepared to support the EIS and to address the relevant SEARs issued for the project. These are outlined in Section 1.3. Specifically, this report has been prepared to assess the potential impacts of construction and operation of the project on climate change and GHG, to identify appropriate mitigation and management measures to address the impacts identified, and outline how the project will embed sustainability measures in accordance with the ISC Infrastructure Sustainability Rating Tool. For detail, please refer to Sections 2.0, 3.0 and 4.0 for the respective assessments.

Climate change assessment

Climate change risks were identified for key climate hazards (extreme heat, bushfire, drought, extreme rainfall and flooding, and extreme storms). For the construction phase a total of four risks were identified and assessed with no mitigation controls considered, one of which was rated a medium risk and one which was rated a high risk for the 2030 time period, and one of which was rated a medium risk, one which was rated a high risk and one which was rated an extreme risk for the 2090 time period.

For the operational phase, 50 risks were identified and assessed with no mitigation controls considered. For the 2030 time period, three risks were rated as high. For the 2090 time period 19 risks were rated high.

Mitigation and management measures were identified for the priority risk statements (as well as other non-priority risks). A number of the measures proposed can be applied to mitigate more than one of the risk statements identified.

It is recognised that while there is uncertainty regarding the extent to which the climate will change into the future, the adaptation actions identified within this report would reduce the impacts of the risks across a range of future scenarios (both emissions pathways and future time frames) and serve to build the resilience of the project to climate change.

Sustainability

Sustainability of the project will be assessed in accordance with the Infrastructure Sustainability Council Rating Tool and the project is seeking a minimum IS 'Design' and 'As-Built' rating of 'Excellent'.

Sustainability initiatives have been identified for planning and design consideration to embed specific sustainability commitments and targets for implementation by the construction contractor. A project specific Infrastructure Sustainability Management Plan will be prepared to guide the implementation of sustainability throughout the design and construction phases and to facilitate the achievement of the IS rating.

GHG assessment

A GHG impact assessment was undertaken to determine the impacts of the project and to identify management and mitigation options to reduce the associate GHG emissions. Construction impacts from the project represent the majority of GHG emissions associated the project lifecycle, as quantified within the scope of this assessment. Construction is estimated to produce around 1,407,140 t CO2e emissions. Operation and maintenance of the project is estimated to produce around 3,549,990 t CO2e emissions under the ventilation outlet option, and around 1,274,820 under the portal emissions option.

The scope 1 and 2 emissions from the construction of the project are equivalent to 0.07 per cent of total annual GHG emissions in NSW in 2020. The scope 1 and 2 emissions from the operation of the project are equivalent to 0.03 and 0.01 per cent of total NSW annual emissions in 2020 for the ventilation outlet and portal emissions options respectively. Opportunities to reduce and mitigate emissions have been recommended in Section 5.0.

7.0 References

Adapt NSW, 2021, *Climate Risk Ready NSW Guide*

AECOM & Aurecon Joint Venture, 2022, *Great Western Highway – Central: Preliminary Infrastructure Sustainability Management Plan*, GHWC-AEAU-GWH-ENSB-BHLHL-PLAN.

Australasian EPD Programme, *Environmental Product Declarations*, viewed 27 June 2022, https://epd-australasia.com/

Australian Government, 2006, *Climate Change Impacts & Risk Management – A Guide for Business and Government*

Australian Government Department of Industry, Science, Energy and Resources, *Australian National Greenhouse Accounts 2016*, viewed 27 June 2022, https://www.industry.gov.au/sites/default/files/2020-07/national-greenhouse-accounts-factors-august-2016.pdf

Australian Government Department of Industry, Science, Energy and Resources, *Australian National Greenhouse Accounts 2021,* viewed 27 June 2022, https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-2021.pdf

Australian Government Department of Industry, Science, Energy and Resources, *National Greenhouse Accounts 2020*, viewed on 19 July 2022, https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-2020-emissions

Australian Government Department of the Environment and Energy, 2017, *Review of Climate Change Policies*

Australian Life Cycle Assessment Society, *National Life Cycle Inventory database*, viewed 27 October 2021, http://auslci.com.au/

Australian Standard, 2013, *AS 5334-2013 Climate change adaptation for settlements and infrastructure* – A risk-based approach,

CSIRO & BoM, 2021, *East Coast Cluster Report, Climate Change in Australia Projections*, viewed 27 June 2022, https://www.climatechangeinaustralia.gov.au/media/ccia/2.2/cms_page_media/168/EAST_COAST_CLUSTER_REPORT_2021updated.pdf

Department of Planning, Industry and Environment, 2021, *NSW Waste and Sustainable Materials Strategy 2041*, viewed 22 August 2022, https://www.dpie.nsw.gov.au/__data/assets/pdf_file/0006/385683/NSW-Waste-and-Sustainable-Materials-Strategy-2041.pdf

Department of Planning, Industry and Environment, 2020, *Net Zero Plan Stage 1: 2020-2030*, viewed 22 August 2022, https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Climate-change/net-zero-plan-2020-2030-200057.pdf?la=en&hash=D65AA226F83B8113382956470EF649A31C74AAA7

Greater Sydney Commission, 2018, *A Metropolis of Three Cities – the Greater Sydney Region Plan*, Greater Sydney Commission

International Organization for Standardization, P 2006, *AS/ISO 14064.1:2006 GHG Part 1: Specification with guidance at the organisational level for quantification and reporting of GHG emissions and removals*, International Organization for Standardization

International Organization for Standardization, P 2019, *AS/ISO 14040:2019 Environmental management - Life cycle assessment - Principles and framework*, International Organization for Standardization

International Organization for Standardization, P 2019, *AS/ISO 14044:2019 Environmental management - Life cycle assessment – Requirements and guidelines*, International Organization for Standardization

IPCC, 2022: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

ISO standard, 2021, *ISO 14091 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment*

Infrastructure Sustainability Council, 2018, *ISv1.2 Technical Manual*

NSW Government, 2022, *NSW Net Zero Emissions Dashboard*, viewed 22 August 2022, https://www.seed.nsw.gov.au/net-zero-emissions-dashboard

NSW Environment Protection Authority, 2014, *NSW Waste Avoidance and Resource Recovery Strategy 2014-21*, NSW EPA

Office of Environment and Heritage, 2019, *NSW Government Resource Efficiency Policy*, viewed 22 August 2022, https://www.environment.nsw.gov.au/research-and-publications/publications-search/nsw-government-resource-efficiency-policy

Office of Environment and Heritage, 2016, *NSW Climate Change Policy Framework*, viewed 22 August 2022, https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Climate-change/nsw-climate-change-policy-framework-160618.pdf

Transport Authorities Greenhouse Group Australia and New Zealand, *GHG Assessment Workbook for Road Projects*, viewed 27 June 2022, https://roads-waterways.transport.nsw.gov.au/documents/about/environment/greenhouse-gas-assessment-workbook-road-projects.pdf

Transport for NSW, 2022a, *GWHUP – Blackheath to Little Hartley Sustainability strategy,* Transport for NSW

Transport for NSW, 2022b, *Future Transport Strategy 2056,* Transport for NSW

Transport for NSW, 2021a, *Transport Sustainability Plan 2021,* Transport for NSW

Transport for NSW, 2021b, *Katoomba to Blackheath Upgrade Review of Environmental Factors,* Transport for NSW

Transport for NSW, 2021c, *Little Hartley to Lithgow Upgrade Review of Environmental Factors,* Transport for NSW

Transport for NSW, 2021d, *Climate Risk Assessment Guidelines,* Transport for NSW

Transport for NSW, 2020a, *Transport Environment and Sustainability Policy*, Transport for NSW

Transport for NSW, 2020b, *TfNSW Enterprise Risk Management Standard,* TfNSW Enterprise Risk Management Team

Transport for NSW, 2020c, *Beyond the Pavement*, Transport for NSW

Transport for NSW, 2017, *NSW Sustainable Design Guidelines Version 4.0,* Transport for NSW

United Nations Framework Convention on Climate Change, *the Paris Agreement*, viewed on 27 June 2022, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

World Business Council for Sustainable Development and World Resources Institute, *GHG Protocol: A Corporate Accounting and Reporting Standard*, viewed 27 June 2022, https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

Annexure A

Risk rating criteria

Annexure A: Risk rating criteria

	Discrete events	Recurring events
Rare	May occur in exceptional circumstances within the asset's lifetime period if the risk is not mitigated	Has not occurred in the past 5 years – **OR** – Unlikely during the next 50 years
Unlikely	Has a 10-30% chance of occurring in the asset's lifetime if the risk is not mitigated	May have occurred once in the last 5 years – **OR** – May arise once in 25 to 50 years
Possible	Has a 40-60% chance of occurring in the asset's lifetime if the risk is not mitigated	Has happened during the past 5 years but not in every year – **OR** – May arise once in 25 years
Likely	Has a 60-90% chance of occurring within the asset's lifetime if the risk is not mitigated	Has happened at least once in the past year and in each of the previous 5 years – **OR** – May arise about once per year
Almost Certain	Has a greater than 90% chance of occurring within the asset's lifetime if the risk is not mitigated	Has happened several times in the past year and in each of the previous 5 years – **OR** – Could occur several times per year

Figure 7-1 Qualitative assessment for classifying risk likelihood in accordance with AS 5334:2013

RISK RATING MATRIX					
	Rare	Unlikely	Possible	Likely	Almost Certain
Extreme	15 - Medium	19 - High	22 - High	24 - Extreme	25 - Extreme
Major	10 - Low	14 - Medium	18 - Medium	21 - High	23 - Extreme
Moderate	06 - Low	09 - Low	13 - Medium	17 - Medium	20 - High
Minor	03 - Very Low	05 - Low	08 - Low	12 - Low	16 - Medium
Insignificant	01 - Very Low	02 - Very Low	04 - Low	07 - Low	11 - Low

Figure 7-2 Risk rating matrix.

DESCRIPTORS	Adaptive capacity[1]	Infrastructure service	Social/cultural	Governance	Environmental	Economy	Financial	Asset Value[2]
Extreme	Capacity destroyed, redesign required when repairing or renewing asset	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal of infrastructure by >90%.	Severe adverse human health effects, leading to multiple events of total disability or fatalities. Total disruptions to employees, customers or neighbours. Emergency response at a major level.	Major policy shifts. Change to legislative requirements. Full change of management control.	Very significant loss to the environment. May include localized loss of species, habitats or ecosystems Extensive remedial action essential to prevent further degradation. Restoration likely to be required.	Major effect on the local, regional and state economies	Extreme financial loss >90%	Extreme loss in asset value (>40%)
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service. Early renewal of Infrastructure by 50–90%	Permanent physical injuries and fatalities may occur, severe disruptions to employees, customers or neighbours	Notices issued by regulators for corrective actions. Changes required in management. Senior management responsibility questionable	Significant effect on the environment and local ecosystems. Remedial action likely to be required	Serious effect on the local economy spreading to the wider economy	Major financial loss 50-90%	Major loss in asset value (>5%)
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Early renewal of Infrastructure by 20–50%.	Frequent disruptions to employees, customers or neighbours. Adverse human health effects	Investigation by regulators. Changes to management actions required	Some damage to the environment, including local ecosystems. Some remedial action may be required	High impact on the local economy, with some effect on the wider economy	Moderate financial loss 10-50%	Moderate loss in asset value (2-5%)
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored	Localized infrastructure service disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 10–20%. Need for new/modified ancillary equipment	Short-term disruption to employees, customers or neighbours, Slight adverse human health effects or general amenity issues	General concern raised by regulators requiring response action	Minimal effects on the natural environment	Minor effect on the broader economy due to disruption of service provided by the asset	Additional operational costs Financial loss small, <10%	Small loss in asset value (<2%)
Insignificant	No change to the adaptive capacity	No infrastructure damage, little change to service	No adverse human health effects	No changes to management required	No adverse effects on natural environment	No effects on the broader economy	Little financial loss or increase in operating expenses	Negligible change in asset value

Figure 7-3. Qualitative assessment for classifying risk consequences in accordance with AS 5334:2013

Annexure B

Climate change risk register

Annexure B: Climate change risk register

				2030			2030 Residual risk rating (after mitigation and controls)			2090			2090 Residual risk rating (after mitigation and controls)		
Risk #	Element	Risk impact statement	Direct or indirect risk	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating
1	Temperature	Increased heat causing accelerated degradation of materials leading to increased maintenance and replacement	Direct	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low	Likely	Moderate	17 - Medium	Possible	Minor	08 - Low
2	Temperature	Increased temperatures lead to increased surface temperature of elements such as handrails and health and safety risk to construction and maintenance workers and passengers	Direct	Possible	Minor	08 - Low	Possible	Minor	08 - Low	Likely	Minor	12 - Low	Possible	Minor	08 - Low
3	Temperature	Increased exposure to higher temperatures affects the resilience of soil and vegetation and results in a loss of biodiversity and impacts to project landscaping	Both	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low	Likely	Major	21 - High	Likely	Moderate	17 - Medium
4	Temperature	High temperatures lead to an increase in private motorists which will increase traffic through the tunnel and increase emissions within the tunnel and put excess load on the ventilation system, leading to increased maintenance and possible failure	Direct	Possible	Moderate	13 - Medium	Unlikely	Moderate	09 - Low	Likely	Moderate	17 - Medium	Possible	Moderate	13 - Medium
5	Temperature	High temperatures lead to an increase in private motorists which will increase traffic through the tunnel increasing wear of road surface leading to increased maintenance (e.g., resurfacing)	Direct	Likely	Moderate	17 - Medium	Possible	Moderate	13 - Medium	Almost Certain	Moderate	20 - High	Likely	Moderate	17 - Medium
6	Temperature	Increased temperatures lead to power supply disruptions leading to interruption to transport services, traffic congestion or outages	Both	Possible	Moderate	13 - Medium	Possible	Moderate	13 - Medium	Likely	Moderate	17 - Medium	Possible	Moderate	13 - Medium
7	Temperature	Increase temperatures leads to more cooling days and an increase in energy consumption and carbon emissions	Direct	Likely	Minor	12 - Low	Likely	Minor	12 - Low	Almost Certain	Minor	16 - Medium	Almost Certain	Minor	16 - Medium
8	Temperature	Extreme heat days lead to potential failure of mechanical and electrical systems	Direct	Possible	Major	18 - Medium	Possible	Moderate	13 - Medium	Likely	Major	21 - High	Likely	Moderate	17 - Medium
9	Temperature	Increased temperatures lead to increased expansion and slacking between transmission lines decreases clearance from ground leading to increased health and safety incidents for workers and motorists	Direct	Possible	Minor	08 - Low	Possible	Minor	08 - Low	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low
10	Temperature	Increased temperatures lead to increased evaporation from hydrology systems impacting capacity of downstream swamps to act as retention basins leading to reputational impacts	Indirect	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low	Likely	Moderate	17 - Medium	Likely	Minor	12 - Low
11	Temperature	Increased extreme heat days leads to an increased risk of heat stress for construction and maintenance workers	Direct	Likely	Major	21 - High	Possible	Moderate	13 - Medium	Almost Certain	Major	23 - Extreme	Likely	Moderate	17 - Medium
12	Temperature	Increased temperatures lead to increased deterioration of road surfaces and increased safety risk for motorists	Direct	Unlikely	Major	14 - Medium	Unlikely	Major	14 - Medium	Possible	Major	18 - Medium	Unlikely	Major	14 - Medium
13	Drought	Increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to	Direct	Unlikely	Extreme	19 - High	Unlikely	Moderate	09 - Low	Possible	Extreme	22 - High	Possible	Moderate	13 - Medium

				2030			2030 Residual risk rating (after mitigation and controls)			2090			2090 Residual risk rating (after mitigation and controls)		
Risk #	Element	Risk impact statement	Direct or indirect risk	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating
		infrastructure within the tunnel and a health risk for workers and motorists													
14	Drought	Increased frequency and severity of drought conditions leads to increased dust build up in mechanical ventilation systems requiring additional maintenance	Direct	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low	Likely	Moderate	17 - Medium	Likely	Minor	12 - Low
15	Drought	Increased frequency and severity of drought conditions leads to increased dust storms creating visibility issues within the tunnel for motorists and increased health and safety impacts	Both	Unlikely	Major	14 - Medium	Unlikely	Moderate	09 - Low	Possible	Major	18 - Medium	Possible	Moderate	13 - Medium
16	Drought	Increased frequency and severity of drought conditions leads to increased water scarcity impacting water services in the project	Indirect	Unlikely	Minor	05 - Low	Unlikely	Minor	05 - Low	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low
17	Drought	Increased frequency and severity of drought conditions leads to increased risk of erosion and landslips from vegetation loss	Indirect	Unlikely	Moderate	09 - Low	Unlikely	Moderate	09 - Low	Possible	Major	18 - Medium	Possible	Major	18 - Medium
18	Drought	Increased frequency and severity of drought conditions leads to impacts on project landscaping	Direct	Likely	Moderate	17 - Medium	Likely	Minor	12 - Low	Likely	Major	21 - High	Likely	Moderate	17 - Medium
19	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to contamination of downstream receivers (groundwater dependent ecosystems, drinking water catchments etc.) leading to reputational impacts	Direct	Unlikely	Major	14 - Medium	Unlikely	Moderate	09 - Low	Possible	Major	18 - Medium	Possible	Moderate	13 - Medium
20	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to flooding of the carriageway leading to unsafe driving conditions	Direct	Possible	Major	18 - Medium	Possible	Minor	08 - Low	Likely	Major	21 - High	Possible	Moderate	13 - Medium
21	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to overloading of upstream detention basins and flooding impacts to the project site	Direct	Likely	Moderate	17 - Medium	Likely	Minor	12 - Low	Almost Certain	Moderate	20 - High	Almost Certain	Minor	16 - Medium
22	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to drainage issue over green roof covered ancillary structures and damage to property	Direct	Possible	Minor	08 - Low	Possible	Minor	08 - Low	Possible	Moderate	13 - Medium	Possible	Moderate	13 - Medium
23	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to corrosion of steel structures and decreased durability of other structural materials requiring additional maintenance or replacement	Direct	Possible	Moderate	13 - Medium	Possible	Minor	08 - Low	Likely	Major	21 - High	Likely	Moderate	17 - Medium
24	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events impacting traveller choices, reducing active transport such as walking and cycling and increasing traffic through the tunnel leading to congestion and reduced safety of motorists	Indirect	Likely	Minor	12 - Low	Possible	Minor	08 - Low	Almost Certain	Minor	16 - Medium	Likely	Minor	12 - Low
25	Extreme rainfall and flooding	Increased frequency and severity of extreme rainfall events leads to increased risk of landslides to new and	Indirect	Possible	Moderate	13 - Medium	Possible	Moderate	13 - Medium	Possible	Major	18 - Medium	Possible	Major	18 - Medium

				2030			2030 Residual risk rating (after mitigation and controls)			2090			2090 Residual risk rating (after mitigation and controls)		
Risk #	Element	Risk impact statement	Direct or indirect risk	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating
		existing embankments and damage to structures													
26	**Extreme rainfall and flooding**	Increased frequency and severity of extreme rainfall events leads to overloading capacity of downstream retention basins leading to downstream flood impacts	Indirect	Possible	Minor	**08 - Low**	Possible	Minor	**08 - Low**	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**
27	**Extreme rainfall and flooding**	Increased frequency and severity of extreme rainfall events leads to increased operational maintenance costs from water pumping and repairs	Direct	Likely	Minor	**12 - Low**	Likely	Minor	**12 - Low**	Almost Certain	Moderate	**20 - High**	Likely	Minor	**12 - Low**
28	**Extreme rainfall and flooding**	Increased frequency and severity of extreme rainfall events leads to flooding of surrounding access roads leading to reduced traffic and impacting operational profits	Both	Almost Certain	Minor	**16 - Medium**	Almost Certain	Insignificant	**11 - Low**	Almost Certain	Moderate	**20 - High**	Almost Certain	Minor	**16 - Medium**
29	**Increased storm intensity**	Increased storm intensity leading to damage to structures	Direct	Unlikely	Major	**14 - Medium**	Unlikely	Moderate	**09 - Low**	Possible	Major	**18 - Medium**	Possible	Moderate	**13 - Medium**
30	**Increased storm intensity**	Increased storm frequency and intensity leading to increased risk of lighting strike to pedestrians	Direct	Unlikely	Major	**14 - Medium**	Unlikely	Moderate	**09 - Low**	Unlikely	Major	**14 - Medium**	Unlikely	Moderate	**09 - Low**
31	**Increased storm intensity**	Increased storm frequency and intensity leading to increased risk of lighting strike to infrastructure and increasing repair and maintenance costs	Direct	Unlikely	Moderate	**09 - Low**	Unlikely	Minor	**05 - Low**	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**
32	**Increased storm intensity**	Increased storm intensity leading to damage to power supply infrastructure and service disruptions	Indirect	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**	Likely	Moderate	**17 - Medium**	Likely	Minor	**12 - Low**
33	**Increased storm intensity**	Increased storm intensity leading to safety risk to construction and maintenance workers	Direct	Possible	Moderate	**13 - Medium**	Possible	Moderate	**13 - Medium**	Likely	Major	**21 - High**	Likely	Moderate	**17 - Medium**
34	**Increased storm intensity**	Increased frequency and severity of storm events leads to overloading capacity of downstream retention basins leading to downstream flood impacts	Indirect	Possible	Minor	**08 - Low**	Possible	Minor	**08 - Low**	Likely	Minor	**12 - Low**	Likely	Minor	**12 - Low**
35	**Increased storm intensity**	Increased storm intensity leading to safety risk to travellers transitioning from outside to inside of tunnel and vice versa	Direct	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**	Possible	Major	**18 - Medium**	Possible	Moderate	**13 - Medium**
36	**Increased storm intensity**	Increased storm intensity leading to resulting in delays in construction and maintenance and reputational impacts	Indirect	Likely	Minor	**12 - Low**	Likely	Minor	**12 - Low**	Almost Certain	Minor	**16 - Medium**	Almost Certain	Minor	**16 - Medium**
37	**Increased storm intensity**	Increased intensity of extreme winds causing falling trees and debris leading to direct safety impacts for motorists	Direct	Likely	Minor	**12 - Low**	Possible	Minor	**08 - Low**	Almost Certain	Moderate	**20 - High**	Likely	Moderate	**17 - Medium**
38	**Increased storm intensity**	Increased intensity of extreme winds causing falling trees and debris on road or on essential infrastructure leading to safety impacts for motorists	Direct	Possible	Moderate	**13 - Medium**	Unlikely	Moderate	**09 - Low**	Possible	Major	**18 - Medium**	Unlikely	Major	**14 - Medium**
39	**Increased storm intensity**	Increased storm intensity leading to reduced driving visibility causing road accidents and traffic congestion	Direct	Possible	Major	**18 - Medium**	Unlikely	Major	**14 - Medium**	Likely	Major	**21 - High**	Possible	Major	**18 - Medium**
40	**Increased storm intensity**	Increased storm intensity leading to increased hail speed and size causing impact on vehicles at tunnel exits and entries	Direct	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**	Likely	Moderate	**17 - Medium**	Likely	Moderate	**17 - Medium**

				2030			2030 Residual risk rating (after mitigation and controls)			2090			2090 Residual risk rating (after mitigation and controls)		
Risk #	Element	Risk impact statement	Direct or indirect risk	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating	Likelihood	Consequence	Rating	Likelihood	Consequence	Residual rating
41	**Increased storm intensity**	Increased storm intensity diverting tunnel ventilation flow causing an increase in emission concentration	Direct	Possible	Minor	**08 - Low**	Possible	Minor	**08 - Low**	Likely	Minor	**12 - Low**	Likely	Minor	**12 - Low**
42	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to road closures, congestion and safety impacts to motorists	Direct	Possible	Major	**18 - Medium**	Possible	Moderate	**13 - Medium**	Likely	Major	**21 - High**	Likely	Moderate	**17 - Medium**
43	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to entry and exit of the tunnel becoming blocked and travellers becoming trapped inside the tunnel	Direct	Unlikely	Extreme	**19 - High**	Unlikely	Major	**14 - Medium**	Possible	Extreme	**22 - High**	Possible	Major	**18 - Medium**
44	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to a loss of biodiversity and impacts to project landscaping	Both	Likely	Moderate	**17 - Medium**	Possible	Moderate	**13 - Medium**	Likely	Major	**21 - High**	Possible	Major	**18 - Medium**
45	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to smoke inhalation risk for workers, travellers and fauna	Direct	Possible	Minor	**08 - Low**	Possible	Minor	**08 - Low**	Possible	Moderate	**13 - Medium**	Possible	Moderate	**13 - Medium**
46	**Bushfire Risk**	Increased frequency and intensity of bushfires impacting access to the project site leading to construction and maintenance delays	Direct	Unlikely	Moderate	**09 - Low**	Unlikely	Moderate	**09 - Low**	Unlikely	Major	**14 - Medium**	Unlikely	Major	**14 - Medium**
47	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to increased smoke and reduced performance of the tunnel ventilation system requiring increased maintenance	Direct	Possible	Minor	**08 - Low**	Possible	Minor	**08 - Low**	Likely	Minor	**12 - Low**	Likely	Minor	**12 - Low**
48	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to damage to infrastructure (e.g. noise walls, pavement) resulting in increased maintenance and decrease in operational safety	Direct	Unlikely	Extreme	**19 - High**	Unlikely	Moderate	**09 - Low**	Possible	Extreme	**22 - High**	Possible	Major	**18 - Medium**
49	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to damage to power infrastructure impacting tunnel operations	Indirect	Possible	Moderate	**13 - Medium**	Possible	Minor	**08 - Low**	Possible	Major	**18 - Medium**	Possible	Moderate	**13 - Medium**
50	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to increased strike risk for displaced fauna	Direct	Possible	Major	**18 - Medium**	Possible	Major	**18 - Medium**	Possible	Major	**18 - Medium**	Possible	Major	**18 - Medium**
51	**Bushfire Risk**	Increased frequency and intensity of bushfires leading to smoke pollution impacting road visibility and increasing safety risk to motorists	Direct	Possible	Major	**18 - Medium**	Possible	Moderate	**13 - Medium**	Possible	Extreme	**22 - High**	Possible	Major	**18 - Medium**
52	**Increased solar radiation**	Increased solar radiation leading to increased strike risk for fauna seeking shade	Direct	Possible	Major	**18 - Medium**	Unlikely	Major	**14 - Medium**	Likely	Major	**21 - High**	Possible	Major	**18 - Medium**
53	**Increased solar radiation**	Increased solar radiation leading to deterioration of tunnel surfaces and requiring additional maintenance	Direct	Likely	Minor	**12 - Low**	Possible	Minor	**08 - Low**	Almost Certain	Minor	**16 - Medium**	Likely	Minor	**12 - Low**
54	**Increased solar radiation**	Increased solar radiation leading to increased harmful UV effects to operations personnel	Direct	Likely	Moderate	**17 - Medium**	Possible	Minor	**08 - Low**	Almost Certain	Moderate	**20 - High**	Likely	Moderate	**17 - Medium**

Annexure C

Climate change adaptation actions

Annexure C: Climate change adaptation actions

As part of the project's design development, consideration has been given to avoiding, minimising or managing risks from future climate change, where possible.

As discussed in Section 2.3, climate change risks identified as extreme or high for the project are associated with an increase in the intensity and frequency of droughts, extreme temperatures and bushfires.

Adaptation options identified for consideration in the design of the project are shown in Table 1. These are to be reviewed and confirmed in the next phase of the design development.

Table 1 Summary of mitigation measures to be considered in the next stage of the design development

Adaptation measure	Project phase	Risk # addressed
Consider increasing albedo levels of concrete and other pavement structures during further design development and incorporate materials with high solar reflectivity to reduce degradation due to increased temperatures	Detailed design	1, 8
Consider incorporating contact materials with low heat conductive properties (touch point surfaces) and slip resistant materials during further design development to reduce risk of health and safety incidents for workers and motorists	Detailed design	1, 2, 33
Consider the selection of drought and heat-tolerant vegetation (prioritising native species) for project landscaping during further design development to reduce temperature and drought impacts	Detailed design	3, 17, 18, 44
Consider on-site irrigation or on-site detention systems during further design development to store water for irrigation of landscaped areas to minimise drought impacts	Detailed design	3, 17, 18, 44
Review the efficiency and capacity of the ventilation system to address the potential for bushfire smoke and dust to impact operations and lead to health and safety incidents	Detailed design	4, 14, 45, 47, 51
Consider including emergency back-up power supply and future services corridor in tunnel during further design development to supplement power infrastructure	Detailed design	6, 32, 49
During further design development, consider whether there is adequate ventilation and cooling to account for extreme high temperatures due to climate change for mechanical equipment that is susceptible to high temperatures	Detailed design	8,14
Consider designing roads, tunnel exits and entries to provide sufficient land clearance from potential hazards including vegetation debris	Detailed design	37, 38, 43
Consider designing to account for adequate drainage and stormwater removal and manage impacts to downstream water receivers including sensitive swamps	Detailed design	10, 20, 21, 26, 28, 34
During further design development, consider whether the project design allows for increased safety factor for wind load rating due to the projected increase in intensity and frequency of storms	Detailed design	29, 32, 35, 36, 41
During further design development, consider whether the project design allows for increased variable loads to manage structural fatigue	Detailed design	29, 32, 35, 36, 41
Consider conducting a fauna movement study to understand the specific risks to fauna due to climate events and develop	Detailed design	30, 45, 50, 52

Adaptation measure	Project phase	Risk # addressed
actions to mitigate these risks during further design development		
Consider designing to control traffic density and speed in accordance with Australian Design Rule 27A to manage vehicle emissions	Detailed design	4, 7, 41
Consider providing overhead shading (either built or natural canopy) for work areas of the project during construction and operations to limit exposure to direct sunlight and reduce ambient temperatures	Detailed design, construction	1, 6, 52, 54
Limit work hours during extreme heat and storm weather conditions to minimise health and safety incidents for workers	Construction	2, 9, 11, 33, 54
Consider options for providing incentives for ride sharing to reduce congestion through the tunnel	Operation	4, 6, 7, 24
Consider introducing regular organic fuel management plan to reduce bushfire risk around the project site	Operation	42, 43, 44, 45, 46, 47, 48, 49, 50, 51
Consider developing a resurfacing treatment plan as part of the regular maintenance plan for the project infrastructure to address impacts due to increased heat impacts	Operation	1, 2, 33
Consider providing adequate shading to operations personnel including safety work gear to minimise impacts from extreme heat	Operation	2, 9, 11
Consider regular fire safety system testing to address increased risk of fires	Operation	13
Develop a plan for managing impacts of extreme weather events on project infrastructure as part of operational maintenance plans to be prepared for the project	Operation	23, 24, 36, 46, 47, 48
Develop emergency response procedures that address increasingly severe weather events	Operation	20, 25, 28, 30, 32, 35, 37, 38, 39, 40 ,42, 43, 45, 51
Consider First Nations burning practices to be incorporated into operational maintenance plans to minimise risk of extreme bushfires	Operation	42, 43 44, 45, 46, 47, 48, 49, 50, 51
Consider the development of a rerouting network plan for implementation during severe weather conditions	Operation	20, 25, 28, 30, 32, 35, 37, 38, 39, 40 ,42, 43, 45, 51
Consider implementation of regular inspections for indicators that would trigger maintenance including blistering, flaking or peeling of protective coatings	Operation	1, 2, 4, 5, 14, 23, 27, 47, 48. 53

Annexure D

Key greenhouse gas assessment assumptions

Annexure D: Key greenhouse gas assessment assumptions

The proposed project remains subject to detailed design, and therefore high-level assumptions have been made where detail on the exact material types, construction methodology and resource requirements are unknown. Data and assumptions used for inputs into the CERT are detailed in Annexure D.

Emissions source	Assumptions
Construction fuel use	• all fuel use from plant, equipment and vehicles is diesel. Petrol use from plant and equipment use would be negligible • precast concrete delivery and spoil haulage diesel use are included in scope 1 construction fuel use figures as it was assumed these vehicle movements fall within the operational control of the construction contractor • there is negligible difference in construction fuel use between ventilation scenarios.
Construction electricity	• estimated electricity requirements and operating hours include tunnelling and construction equipment and construction sites • all electricity is purchased from standard NSW grid electricity. Note, the CERT calculates emissions based on 2016 grid emissions factors. As such, an 'adjustment factor' has been applied so that the equivalent emissions from current 2021 NSW grid electricity is reported. The emissions factor used is a conservative assumption, as the emissions intensity of electricity is expected to reduce over time as renewable energy penetration increases in NSW • there is negligible difference in construction electricity between ventilation scenarios.
Construction materials	• quantities do not include materials that are associated with hired plant, equipment and buildings as these materials will be reused • all materials travel 124 km to site. This is the approximate distance between Sydney CBD and Little Hartley • concrete assumed to be Portland cement based, 40MPa strength grade; and asphalt assumed to be 'hot mix' and contain 0 per cent reclaimed asphalt pavement (RAP). Further assumptions relating to construction materials inputs are detailed in Annexure E • there is negligible difference in embodied carbon of materials between ventilation scenarios.
Waste	• emissions from transport and decomposition of construction and operation waste were not quantified as part of the study, as sufficient data is not currently available. Emissions from waste are classified as scope 3 emissions and reporting of these are optional under the GHG Protocol (World Business Council for Sustainable Development and World Resources Institute, 2015). Further, the majority of material exported from the project is expected to be tunnel spoil, which is captured under 'construction fuel use'. The remaining general waste is expected to be comparatively negligible.
Operational light vehicles and electricity	• estimated operational electricity is assumed to be sourced from standard NSW grid electricity. While the 2021 NSW grid emissions factor was used for operational grid electricity over the asset life, future emissions from operational electricity are expected to reduce as renewable energy penetration increases in the NSW electricity grid. This has the potential to significantly reduce the emissions associated with operational electricity use over the asset life • axial fan energy consumption under the ventilation outlet option was estimated based on the best available information. The ventilation modelling involves conservative assumptions regarding minimum traffic

Emissions source	Assumptions
	flow and traffic induced airflow, leading to conservative estimates of axial fan energy consumption • building services are powered exclusively from electricity without gas appliances.
Maintenance	• the project contract nominates minimum design life periods for each component of the project. These were assigned to each item in the bill of quantities to determine the quantity of materials required to be replaced over the nominal 100-year asset life. • construction plant and equipment requirements were used to estimate fuel use requirements from maintenance activities • there no anticipated material difference in maintenance plant and equipment fuel use requirements between ventilation scenarios.
Land clearing	• land clearing area and vegetation types were based on Appendix H (Technical report – Biodiversity) of the EIS.
Fugitive emissions	• fugitive emissions were based on: - tunnel spoil quantities provided by the project technical advisor - initial estimates on the proportion of coal content within the tunnelled areas. Note this is subject to coal seam gas sampling scheduled for after detailed design and may be highly variable. The most conservative figure, i.e. highest proportion of coal content, of the range provided by the geotechnical team was used in the GHG assessment - The fugitive emission factor for open cut coal mining in the NGA 2021. Note that the tunnelling would more likely resemble underground mining, however emissions factors are not published as they are measured on a mine-specific basis. The fugitive emission factor for open cut coal mining is the best factor available at the time of writing and is expected to be more conservative compared to an emission factor from underground mining or tunnelling. Emissions may vary greatly from the value calculated • all fugitive emissions were allocated to the construction phase; however, it is anticipated that a proportion would occur during operation. There is currently not enough information available to quantify the allocation of fugitive emissions between construction and operation.
Road users (net change in vehicle tailpipe emissions)	• GHG emissions estimates from road users were modelled based on outputs from the air quality modelling, outlined in Appendix E (Technical Report – Air Quality) of the EIS. The GHG emissions included in the assessment are the difference in emissions between tailpipe emissions with and without the project. This includes vehicles travelling on the existing Great Western Highway, in the tunnel, and on surrounding surface roads. The geographical scope of the modelling is outlined in Appendix E – Technical Report – Air Quality • modelled GHG emissions estimates with and without the project were provided in project opening year (2030) and ten years into operation (2040). Emissions were linearly interpolated between the modelled years. Beyond 2040, traffic movements and fleet makeup are difficult to predict. A simple assumption that emissions stay the same from 2040 onward was made • traffic emissions modelling does not account for the uptake of electric vehicles as a conservative assumption. As electric vehicle penetration increases, emissions per vehicle would be expected to reduce compared to the estimates in this assessment • detailed assumptions related to the GHG modelling for road users are provided in Annexure E

Annexure E

CERT data and assumptions

Carbon Estimate & Reporting Tool

NSW Government | Transport for NSW

Project details

			User comments
Project name	Great Western Highway Blackheath to Little Hartley		
Project value			
Primary project type	Civil infrastructure		
Secondary project type	Civil infrastructure		
State/Territory where the project is constructed	New South Wales		Note: This informs the electricity emission factor
Project geographical scale, primary	10.4	other, please specify km	
Project geographical scale, secondary			
Expected construction start date	1 January 2022		Approximate dates at time of writing
Expected construction date of completion	1 January 2032		Approximate dates at time of writing

Note: The CERT tool can deal with a maximum construction period of five years

Project description

The Australian and NSW governments are investing $4.5 billion towards upgrading around 34 kilometres of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program). Once upgraded, over 95 kilometres of the Great Western Highway will be two lanes in each direction between Emu Plains and Wallerawang.
The Upgrade Program comprises the following components:
•Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade): upgrade and duplication of the existing surface road corridor with intersection improvements and a new pedestrian bridge (approved)
•Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the surface road network east of Blackheath (approved (TBC))
•Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the surface road network at Little Hartley (approved (TBC))
•Great Western Highway Blackheath to Little Hartley: construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel (the project).
Transport for NSW (Transport) is seeking approval under Division 5.2, Part 5 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) to upgrade the

User comments

Define your GHG assessment and mitigation requirements

Select all that apply — *Enter reduction target(s) below for selected items*

- ☐ SDG v3.0
- ☐ I&S Corporate target
- ☐ TSR
- ☐ ISCA
- ☐ Other Contract Requirement
- ☐ Other (please specify in user comments)

User comments

Maximum GHG reduction target you are required to achieve: **0.0%**

Please note: ISCA Ene-1 credit covers construction and operational emissions and requires a % reduction against an ISCA verified base case. Therefore the reduction targets and data in both tools may not be directly comparable.

If you have set an internal (informal) GHG reduction target, you can enter this here to keep track of progress towards this target.
Internal GHG % reduction requirement

Contact information

	Primary contact	*Secondary contact (if applicable)*
Person(s) that entered the data		
Position		
Organisation		
Contact details		
Address		
City		
State		
Postcode		
Telephone or mobile contact number		
E-mail		

User comments

	Site address	*Project location*
Address		
City		
State		
Postcode		

Data validation

Optional: describe type of validation

Data validated by	*[Name]* *[Position]* *[Organisation]*	
Signature		Date signed
Sign-off by	*[Name]* *[Position]* *[Organisation]*	
Signature		Date signed

User comments

For internal use by I&S only!

Report validated and accepted by — *[Name]* *[Position]*

NSW Government | Transport for NSW

Date accepted

TfNSW comments

Data input CDR

Carbon Estimate & Reporting Tool

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Project	Great Western Highway Blackheath to Little Hartley
Reporting period	CDR (or equivalent) design
Date of data entry	

Materials

Concrete & reinforcement	Quantity	Unit	Transport scenario	Evidence / data source / comments
Ready mixed concrete	478855.5	m^3	User defined	See 'Sheet for notes (Materials)'.
Reinforcement steel bars - Australian products	13901	tonnes	User defined	See 'Sheet for notes (Materials)'.
Reinforcement steel mesh - Australian products		tonnes		
Reo steel: low relaxation strand and wire - Australian products		tonnes		
Precast concrete	1374408.5	tonnes	User defined	See 'Sheet for notes (Materials)'. Make conservative estimate to assume reinforcement rate of bridges, as precast elements will primarily be structural elements (tunnel segments)

Steel	Quantity	Unit	Transport scenario	Evidence / data source / comments
Structural steel, beams and columns - Australian products	16245	tonnes	User defined	See 'Sheet for notes (Materials)'.
Structural steel, hot rolled coil - Australian products	403	tonnes	User defined	See 'Sheet for notes (Materials)'.
Structural steel, merchant bar - Australian products		tonnes		
Structural steel, plate - Australian products	9	tonnes	User defined	See 'Sheet for notes (Materials)'.
Galvanised steel - Australian products	5617	tonnes	User defined	See 'Sheet for notes (Materials)'.
Total steel rails (heavy & light)	-	track m		

Asphalt & Aggregates	Quantity	Unit	Transport scenario	Evidence / data source / comments
Asphalt	62,777	tonnes	User defined	See 'Sheet for notes (Materials)'.
Coarse aggregates	20562	m3	User defined	See 'Sheet for notes (Materials)'.
Recycled (coarse) aggregates				
Ballast				
Sand				
Manufactured sand				
Recycled crushed glass				

Piping	Quantity	Unit	Transport scenario	Evidence / data source / comments
Reinforced concrete pipes	1	m	User defined	Total mass of pipes input as 1m of pipe. This does not reflect the length of piping on the project, but does reflect the total mass of piping on the project. See 'Sheet for notes (Materials)'.
Steel pipe and tube	1	m	User defined	Total mass of pipes input as 1m of pipe. This does not reflect the length of piping on the project, but does reflect the total mass of piping on the project. See 'Sheet for notes (Materials)'.
HDPE pipes	1	m	User defined	Total mass of pipes input as 1m of pipe. This does not reflect the length of piping on the project, but does reflect the total mass of piping on the project. See 'Sheet for notes (Materials)'.
PVC pipes	1	m	User defined	Total mass of pipes input as 1m of pipe. This does not reflect the length of piping on the project, but does reflect the total mass of piping on the project. See 'Sheet for notes (Materials)'.
Other pipes	If other materials are used for piping, then define these under 'Additional materials' below			

Timber	Quantity	Unit	Transport scenario	Evidence / data source / comments
Timber, Structural (softwood)	0.4	m3	User defined	See 'Sheet for notes (Materials)'.
Timber, Structural (hardwood)				
Timber, MDF / Particleboard				
Timber, Plywood				
Timber, Cross-Laminated Timber (CLT)				

Other materials	Quantity	Unit	Transport scenario	Evidence / data source / comments
Aluminium	22	tonnes	User defined	See 'Sheet for notes (Materials)'.
Glass	1280.4	m^2	User defined	See 'Sheet for notes (Materials)'.
Ceramics (e.g. tiles)		tonnes		
Electrical cables	200.0	m	User defined	Total mass of each cable input as 100m of cable. This does not reflect the length of cable on the project, but does reflect the total mass of cable used on the project. See 'Sheet for notes (Materials)'.

Additional materials	Quantity	Unit	Material Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Bitumen	226	t	384.5	Emission factor sourced from IS Materials Calculator
Paint	78	t	2552.3	Emission factor sourced from IS Materials Calculator
WTP Chemicals	1259	t	664.4	Emission factor sourced from IS Materials Calculator
Cement Fibreboard	4591	t	1211.3	Emission factor sourced from IS Materials Calculator
uPVC sheet	45	t	2515.0	Emission factor sourced from IS Materials Calculator

Transport mode(s) for Additional materials	Quantity (tonnes)	Avg. Distance (km)	Transport task	Unit	Evidence / data source / comments
Rigid truck	6,198.9	124	768,662	tkm	Assume all materials travel 124km from Sydney to Little Hartley by rigid truck. (https://goo.gl/maps/LQ2BH8W9h6ZY4sNJ7)
Articulated truck			0	tkm	
Shipping			0	tkm	
Train			0	tkm	

Materials - Mitigation calculator

Change in material quantities (e.g. through value engineering exercise or a material exchange)	Quantity (tonnes)	Distance to site (km)		Material that is being avoided or replaced (e.g. through value engineering exercise)	Quantity (tonnes)	Distance (km)	Net mitigation (t CO_2e)	Evidence / data source / comments
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	
			replaces				0.0	

Change in material quantities (e.g. through value engineering exercise or a material exchange)	Quantity (tonnes)	Distance to site (km)	Emission factor (kg CO_2e/tonne)		Material that is being avoided or replaced (e.g. through value engineering exercise)	Quantity (tonnes)	Distance (km)	Emission factor (kg CO_2e/tonne)	Net mitigation (t CO_2e)	Evidence / data source / comments
				replaces					0.0	
				replaces					0.0	
				replaces					0.0	
				replaces					0.0	
				replaces					0.0	
				replaces					0.0	

total mitigation 0.0 t CO_2e

Energy use

Energy use	Quantity	Unit	Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Electricity use, on-site total	673331.3	MWh	960	See 'Sheet for notes (Energy)'
Diesel consumption for site vehicles	26648.0	kL	2849	See 'Tunnel Plant - Diesel', 'Precast and Spoil - Diesel'
Diesel consumption for stationary plant and equipment	419.9	kL	2849	See 'Civil Plant - Diesel', 'Tunnel Plant - Diesel'
Diesel consumption for mobile plant and equipment	18274.4	kL	2849	See 'Civil Plant - Diesel', 'Tunnel Plant - Diesel'
Total of other fuels consumed on-site in site vehicles, stationary and mobile plant	0.0	kL		

Energy use - Mitigation calculator

Energy use related mitigation measures	Quantity	Unit	Emission factor (kg CO_2e/unit)	Net mitigation (t CO_2e)	Evidence / data source / comments
On-site renewable energy generation			0.0	0.0	*On-site generation can only be claimed if the generated electricity is consumed within the project and you are not selling any renewable energy certificates*
Change in electricity use			0.0	0.0	
Change in diesel consumption for site vehicles			0.0	0.0	
Change in diesel consumption for stationary plant			0.0	0.0	
Change in diesel consumption for mobile plant			0.0	0.0	
Change in other fuels			0.0	0.0	
Change in use of biodiesel			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			Total net mitigation	0.0	**t CO_2e / year**

Construction energy use related offset measures	Quantity	Unit	Offset Emission factor (kg CO_2e/unit)	Offsets mitigation (t CO_2e)	Evidence / data source / comments
Green Power / renewable electricity purchased			0.0	0.0	
Green energy certificates			0.0	0.0	
Carbon offsets		t CO_2e	1000.0	0.0	
			Total offsets mitigation	0.0	**t CO_2e / year**

Waste generated

Waste related emissions	Quantity	Unit		Evidence / data source / comments
Transport of waste to landfill	0.0	tonnes	assumes 50 km to landfill site	
Construction and demolition waste to landfill: inert waste (concrete, masonry, glass, metals)				
Construction and demolition waste to landfill: timber, vegetation waste				
Construction and demolition waste to landfill: mixed waste				

Waste - Mitigation calculator

Waste related mitigation measures	Quantity	Unit	Emission reduction factor (kg CO_2e/unit)	Net mitigation (t CO_2e)	Evidence / data source / comments
Transport of waste to recycling centre	0.0	tonnes	assumes 22 km to recycling centre		
Waste to off-site recycling centre					
"Waste" re-used on-site					
				0.0	
				0.0	
				0.0	
				0.0	
				0.0	

Land use / Vegetation clearing

Land use / Vegetation clearing related emissions	Quantity	Unit			Evidence / data source / comments
Total area of vegetation cleared	-	ha			
Total emissions due to carbon sequestration loss			-	t CO_2e	
Extra emissions from fuels used for clearing and grubbing (Australian methodology)			-	t CO_2e	
Total street trees cleared	-	trees			
Total emissions due to carbon sequestration loss			-	t CO_2e	

Revegetation - Land use Mitigation calculator

Carbon sequestration related mitigation measures

Sequestration from revegetation of the project site is not included in line with the Australian method outlined in the TAGG 2013 Workbook.

Link to TAGG 2013 Workbook

Revegetation related sequestration	Quantity	Unit			Evidence / data source / comments
Total area of revegetation	-	ha			
Net sequestration due to revegetation			-	t CO_2e	
Total street trees planted	-	trees			
Net sequestration from additional street tree planting			-	t CO_2e	

End of Main data entry

Go back to the top

Operational energy

Carbon Estimate & Reporting Tool

Legend
- Concrete — Click text to go to calculator
- 250.0 — Calculated result
- Cell for user input
- Cell for user commentary

Project	Great Western Highway Blackheath to Little Hartley
Reporting period	Energy use modeled over asset lifetime
Date of data entry	

Operational energy totals - BASE CASE

Asset service life **100** years

	Quantity	Unit		Quantity	Unit
Annual operational energy use	1,192.7	GJ/year	Total operational energy use over asset life	119,272	GJ
Annual operational greenhouse gas emissions; scope 1	83.7	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 1	8,373	t CO_2e
Annual operational greenhouse gas emissions; scope 2	0.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 2	0	t CO_2e
Annual operational greenhouse gas emissions; scope 3	4.3	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 3	429	t CO_2e
Annual operational greenhouse gas emissions; total	88.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; total	8,802	t CO_2e

Copy Base Case data to Forecast Optimised

Base Case - Estimated BAU energy use

Project	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
TOTAL project						
Annual electricity consumption		kWh/year	Electricity	See 'Notes (Operational energy)'	0	GJ/year
Annual diesel consumption	30.89944	kL/year	Diesel	See 'Notes (Operational energy)'	1192.718	GJ/year
Annual natural gas consumption			Natural gas		0	GJ/year
Annual LPG consumption			LPG		0	GJ/year
Annual petrol consumption			Petrol / ULP		0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0	GJ/year
					1192.7	GJ/year

WARNING!!! EITHER fill in the project totals above OR fill in the breakdown per project element below. When values are entered for the total project (above) the breakdown (below) is disregarded!

Breakdown into project elements	Quantity	Unit	Energy source	Evidence / data source / comments		
[Enter project element]						
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year
					0	GJ/year

Subtotals [Enter project element]				
Electricity	0.0	GJ/year	0.0	t CO_2e/year
Diesel	0.0	GJ/year	0.0	t CO_2e/year
Natural gas	0.0	GJ/year	0.0	t CO_2e/year
LPG	0.0	GJ/year	0.0	t CO_2e/year
Petrol / ULP	0.0	GJ/year	0.0	t CO_2e/year
Petrol / Ethanol (10%) blend	0.0	GJ/year	0.0	t CO_2e/year

0.0 GJ/year

Add another project element | Hide any following project elements

Base Case - Estimated BAU use of synthetic gases

Synthetic gases - refrigerants and other gases with high global warming potentials (GWPs)

E.g. refrigerants used in HVAC; gases used in switch gear and circuit breakers. Define the refrigerant gas and determine its GWP

Location (e.g. building, rolling stock, switch gear, etc.)	*Quantity*	*Unit*	*Synthetic gas*	*GWP**	*Evidence / data source / comments*
		kg/year			
		kg/year			
		kg/year			
		kg/year			
		kg/year			

Default leakage rates for synthetic gases	Source: NGA 2016	
Equipment type	*HFCs*	*SF_6*
Commercial air conditioning - chillers	0.09	
Commercial refrigeration - supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.0089

* A list of GWP factors for common greenhouse gases is provided on the "Formulas and background" worksheet.

If your refrigerant is not on this list, it is likely that it consists of a mix of different gases. The GWP of the mix can be calculated based on the GWPs of the individual constituents.

Click here to go to the GWP list

Base Case - Optional reporting

Optional - other scope 3 emissions

	Quantity	Unit	Energy source		
Employee business travel					0
Employees commuting to/from work					0

User defined scope 3 emissions	Quantity	Unit	Energy density (GJ/unit)	Emission factor (kg CO_2e/unit)			
						0	
						0	
						0	
						0.0	GJ/year
						0.0	t CO_2e/year

Optional - secondary effects of asset delivery or operation

	Quantity	Unit	Energy source			
				e.g. induced traffic growth	0	
				e.g. exports of fossil fuels associated with port construction	0	
					0	
					0	
					0	
					0.0	GJ/year
					0.0	t CO_2e/year

Base Case - Mitigation

Mitigation is not captured under the Base Case.

End of data entry

Go back to the top

Operational energy

Carbon Estimate & Reporting Tool

Transport for NSW

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Operational energy totals: Forecast – Optimised

100 year asset service life

	Quantity	Unit			Quantity	Unit
Annual operational energy use	64,475.8	GJ/year		Total operational energy use over asset life	6,447,581	GJ
Annual operational greenhouse gas emissions; scope 1	0.0	t CO_2e/year	includes mitigation	Total operational greenhouse gas emissions over asset life; scope 1	0	t CO_2e
Annual operational greenhouse gas emissions; scope 2	15,044.4	t CO_2e/year	includes mitigation	Total operational greenhouse gas emissions over asset life; scope 2	1,504,436	t CO_2e
Annual operational greenhouse gas emissions; scope 3	2,149.2	t CO_2e/year	includes mitigation	Total operational greenhouse gas emissions over asset life; scope 3	214,919	t CO_2e
Annual green power, offsets and certificates purchased	0.0	t CO_2e/year		Total green power, offsets and certificates purchased	0	t CO_2e
Annual operational greenhouse gas emissions; total	17,193.5	t CO_2e/year		Total operational greenhouse gas emissions over asset life; total	1,719,355	t CO_2e

Forecast – Optimised: Estimated optimised energy use

Project	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
TOTAL project						
Annual electricity consumption	17909947.44	kWh/year	Electricity	See 'Notes (Operational energy)'	64475.81	GJ/year
Annual diesel consumption			Diesel		0	GJ/year
Annual natural gas consumption			Natural gas		0	GJ/year
Annual LPG consumption			LPG		0	GJ/year
Annual petrol consumption			Petrol / ULP		0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0	GJ/year
					64475.8	GJ/year

Breakdown into project elements	Quantity	Unit	Energy source	Evidence / data source / comments		
[Enter project element I]						
[please specify]				e.g. traction power, rolling stock	0	GJ/year
[please specify]				e.g. lighting, HVAC, vertical transport	0	GJ/year
[please specify]				e.g. signalling, communications, fire, hydraulics	0	GJ/year
[please specify]				e.g. tunnel power, ventilation	0	GJ/year
[please specify]				e.g. retail, front-of-house, back-of-house	0	GJ/year
[please specify]				e.g. miscellaneous power	0	GJ/year
[please specify]				e.g. diesel for emergency back-up generators	0	GJ/year
[please specify]				e.g. diesel for vessels	0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year

Subtotals [Enter project element I]				
Electricity	0.0	GJ/year	0.0	t CO_2e/year
Diesel	0.0	GJ/year	0.0	t CO_2e/year
Natural gas	0.0	GJ/year	0.0	t CO_2e/year
LPG	0.0	GJ/year	0.0	t CO_2e/year
Petrol / ULP	0.0	GJ/year	0.0	t CO_2e/year
Petrol / Ethanol (10%) blend	0.0	GJ/year	0.0	t CO_2e/year

0.0 GJ/year

Forecast – Optimised: Estimated optimised use of synthetic gases

Synthetic gases - refrigerants and other gases with high global warming potentials (GWPs)

E.g. refrigerants used in HVAC; gases used in switch gear and circuit breakers. Define the refrigerant gas and determine its GWP

Location (e.g. building, rolling stock, switch gear, etc.)	*Quantity*	*Unit*	*Synthetic gas*	*GWP**	*Evidence / data source / comments*
		kg/year			
		kg/year			
		kg/year			
		kg/year			
		kg/year			

Default leakage rates for synthetic gases	Source: NGA 2016	
Equipment type	***HFCs***	***SF_6***
Commercial air conditioning - chillers	0.09	
Commercial refrigeration - supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.0089

* A list of GWP factors for common greenhouse gases is provided on the "Formulas and background" worksheet.

If your refrigerant is not on this list, it is likely that it consists of a mix of different gases. The GWP of the mix can be calculated based on the GWPs of the individual constituents.

Click here to go to the GWP list

Forecast – Optimised: Optional reporting

Optional - other scope 3 emissions

	Quantity	Unit	Energy source		
Employee business travel					0
Employees commuting to/from work					0

User defined scope 3 emissions	Quantity	Unit	Energy density (GJ/unit)	Emission factor (kg CO_2e/unit)			
						0	
						0	
						0	
						0.0	GJ/year
						0.0	t CO_2e/year

Optional - secondary effects of asset delivery or operation

	Quantity	Unit	Energy source			
				e.g. induced traffic growth	0	
				e.g. exports of fossil fuels associated with port construction	0	
					0	
					0	
					0	
					0.0	GJ/year
					0.0	t CO_2e/year

Forecast – Optimised: Operational energy Mitigation calculator

Operational energy use related mitigation measures	Quantity	Unit	Emission factor (kg CO_2e/unit)	Mitigation achieved (t CO_2e)	Evidence / data source / comments		
On-site renewable energy generation			0.0	0.0	On-site generation can only be claimed if the generated electricity is consumed within the project and you are not selling any renewable energy certificates	0	GJ/year
Change in electricity use			0.0	0.0		0	GJ/year
Change in diesel consumption for site vehicles			0.0	0.0		0	GJ/year
Change in diesel consumption for stationary plant			0.0	0.0		0	GJ/year
Change in diesel consumption for mobile plant			0.0	0.0		0	GJ/year
Change in other fuels			0.0	0.0		0	GJ/year
Use of biodiesel			0.0	0.0		0	GJ/year
			0.0	0.0		0	GJ/year
			0.0	0.0		0	GJ/year
			0.0	0.0		0	GJ/year
			0.0	0.0		0	GJ/year
			0.0	0.0		0	GJ/year
			Total mitigation achieved	0.0	**t CO_2e / year**	0.0	GJ/year

Operational energy use related offset measures	Quantity	Unit	Offset Emission factor (kg CO_2e/unit)	Offsets purchased (t CO_2e)	Evidence / data source / comments		
Green Power / renewable electricity purchased			0.0	0.0		0.0	GJ/year
Green energy certificates			0.0	0.0		0.0	GJ/year
Carbon offsets		t CO_2e/year	1000.0	0.0			
			Total offsets purchased	0.0	**t CO_2e / year**		

End of data entry

Go back to the top

Maintenance

Carbon Estimate & Reporting Tool

Project	Great Western Highway Blackheath to Little Hartley
Reporting period	Maintenance modeled over asset lifetime
Date of data entry	

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Maintenance totals - BASE CASE

Asset service life 100 years

	Quantity	Unit			Quantity	Unit
Annual Routine Maintenance energy use	717.1	GJ/year		Total Routine Maintenance energy use over asset life	71,706	GJ
Annual Routine Maintenance GHG emissions; scope 1	50.3	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; scope 1	5,034	t CO_2e
Annual Routine Maintenance GHG emissions; scope 2	0.0	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; scope 2	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 3	375.6	t CO_2e/year	*(includes materials)*	Total Routine Maintenance GHG emissions over asset life; scope 3	37,561	t CO_2e
Annual Routine Maintenance GHG emissions; total	426.0	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; total	42,595	t CO_2e

Copy Base Case data to Expected Actual

Base Case - Estimated BAU ROUTINE MAINTENANCE (RM) material & energy use

Average annual energy use for Routine Maintenance (RM)

Energy for RM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
Annual electricity consumption			Electricity		0.0	GJ/year
Annual diesel consumption			Diesel		0.0	GJ/year
Annual natural gas consumption			Natural gas		0.0	GJ/year
Annual LPG consumption			LPG		0.0	GJ/year
Annual petrol consumption			Petrol / ULP		0.0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0.0	GJ/year
					0.0	GJ/year

Average annual materials use for Routine Maintenance (RM)

Additional materials required for Routine Maintenance	Quantity	Unit	Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Protective coatings, paints			0.0	
Rubberised bitumen for road maintenance	1760	kg/year	0.8	Bitumen input as routine maintenance, as there is no option for input under major preventative maintenance. See 'Sheet for notes (Materials)'.

Base Case - Estimated BAU MAJOR PREVENTIVE MAINTENANCE (MPM) material & energy use

Average annual energy use for Major Preventive Maintenance (MPM)

Energy for MPM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
Annual electricity consumption			Electricity		0.0	GJ/year
Annual diesel consumption	19	kL/year	Diesel	See 'Notes (Maintenance)'	717.1	GJ/year
Annual natural gas consumption			Natural gas		0.0	GJ/year
Annual LPG consumption			LPG		0.0	GJ/year
Annual petrol consumption			Petrol / ULP		0.0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0.0	GJ/year
					717.1	GJ/year

Materials use associated with Major Preventive Maintenance (MPM)

Material/product replacement associated with Major Preventive Maintenance (MPM)	Total quantity of materials used at CDR stage	Product Service life (years)	% material that needs to be replaced at the end of each cycle	# of Replacements over asset life	Evidence / data source / comments	tonnes of material replaced
Coarse aggregates	34,955 t	1.0 years	2%	99.0	See 'Sheet for notes (Materials)'	73489.489
Recycled (coarse) aggregates	0 t	1.0 years	0%	99.0		0
Ballast	0 t	1.0 years	0%	99.0		0
Sand	0 t	1.0 years	0%	99.0		0
Manufactured sand	0 t	1.0 years	0%	99.0		0
Recycled crushed glass	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (I)	700,294 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	16343.76
Ready mixed concrete (II)	448,959 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	119634.35
Ready mixed concrete (III)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (IV)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (V)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (VI)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (VII)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (VIII)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (IX)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (X)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (XI)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (XII)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (XIII)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (XIV)	0 t	1.0 years	0%	99.0		0
Ready mixed concrete (XV)	0 t	1.0 years	0%	99.0		0
Precast concrete (I)	1,374,408 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	92.1984
Precast concrete (II)	0 t	1.0 years	0%	99.0		0
Precast concrete (III)	0 t	1.0 years	0%	99.0		0
Precast concrete (IV)	0 t	1.0 years	0%	99.0		0
Precast concrete (V)	0 t	1.0 years	0%	99.0		0
Precast concrete (VI)	0 t	1.0 years	0%	99.0		0
Precast concrete (VII)	0 t	1.0 years	0%	99.0		0
Precast concrete (VIII)	0 t	1.0 years	0%	99.0		0
Precast concrete (IX)	0 t	1.0 years	0%	99.0		0
Precast concrete (X)	0 t	1.0 years	0%	99.0		0
Precast concrete (XI)	0 t	1.0 years	0%	99.0		0
Precast concrete (XII)	0 t	1.0 years	0%	99.0		0
Precast concrete (XIII)	0 t	1.0 years	0%	99.0		0
Precast concrete (XIV)	0 t	1.0 years	0%	99.0		0
Precast concrete (XV)	0 t	1.0 years	0%	99.0		0
Reinforcement steel bars - Australian products	13,901 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	252.84607
Reinforcement steel bars - imported products	0 t	1.0 years	0%	99.0		0

Maintenance

Carbon Estimate & Reporting Tool

Project	Great Western Highway Blackheath to Little Hartley
Reporting period	Maintenance modeled over asset lifetime
Date of data entry	

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Maintenance totals - Forecast

Asset service life 100 years

	Quantity	Unit			Quantity	Unit
Annual Routine Maintenance energy use	0.0	GJ/year		Total Routine Maintenance energy use over asset life	0	GJ
Annual Routine Maintenance GHG emissions; scope 1	0.0	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; scope 1	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 2	0.0	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; scope 2	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 3	0.0	t CO_2e/year	*(includes materials and mitigation)*	Total Routine Maintenance GHG emissions over asset life; scope 3	0	t CO_2e
Annual Routine Maintenance GHG emissions; total	0.0	t CO_2e/year		Total Routine Maintenance GHG emissions over asset life; total	0	t CO_2e

Forecast – Estimated Optimised ROUTINE MAINTENANCE (RM) material & energy use

Average annual energy use for Routine Maintenance (RM)

Energy for RM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
Annual electricity consumption			Electricity		0.0	GJ/year
Annual diesel consumption			Diesel		0.0	GJ/year
Annual natural gas consumption			Natural gas		0.0	GJ/year
Annual LPG consumption			LPG		0.0	GJ/year
Annual petrol consumption			Petrol / ULP		0.0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0.0	GJ/year
					0.0	GJ/year

Average annual materials use for Routine Maintenance (RM)

Additional materials required for Routine Maintenance	Quantity	Unit	Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Protective coatings, paints			0.0	
Rubberised bitumen for road maintenance			0.0	

Forecast – Estimated Optimised MAJOR PREVENTIVE MAINTENANCE (MPM) material & energy use

Average annual energy use for Major Preventive Maintenance (MPM)

Energy for MPM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
Annual electricity consumption			Electricity		0.0	GJ/year
Annual diesel consumption			Diesel		0.0	GJ/year
Annual natural gas consumption			Natural gas		0.0	GJ/year
Annual LPG consumption			LPG		0.0	GJ/year
Annual petrol consumption			Petrol / ULP		0.0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0.0	GJ/year
					0.0	GJ/year

Materials use associated with Major Preventive Maintenance (MPM)

Material/product replacement associated with Major Preventive Maintenance (MPM)	Total quantity of materials used at CDR stage	Product Service life (years)	% material that needs to be replaced at the end of each cycle	# of Replacements over asset life	Evidence / data source / comments	tonnes of material rep
Coarse aggregates	34,955 t			0.0		0
Recycled (coarse) aggregates	0 t			0.0		0
Ballast	0 t			0.0		0
Sand	0 t			0.0		0
Manufactured sand	0 t			0.0		0
Recycled crushed glass	0 t			0.0		0
Ready mixed concrete (I)	700,294 t			0.0		0
Ready mixed concrete (II)	448,959 t			0.0		0
Ready mixed concrete (III)	0 t			0.0		0
Ready mixed concrete (IV)	0 t			0.0		0
Ready mixed concrete (V)	0 t			0.0		0
Ready mixed concrete (VI)	0 t			0.0		0
Ready mixed concrete (VII)	0 t			0.0		0
Ready mixed concrete (VIII)	0 t			0.0		0
Ready mixed concrete (IX)	0 t			0.0		0
Ready mixed concrete (X)	0 t			0.0		0
Ready mixed concrete (XI)	0 t			0.0		0
Ready mixed concrete (XII)	0 t			0.0		0
Ready mixed concrete (XIII)	0 t			0.0		0
Ready mixed concrete (XIV)	0 t			0.0		0
Ready mixed concrete (XV)	0 t			0.0		0
Precast concrete (I)	1,374,408 t			0.0		0
Precast concrete (II)	0 t			0.0		0
Precast concrete (III)	0 t			0.0		0
Precast concrete (IV)	0 t			0.0		0
Precast concrete (V)	0 t			0.0		0
Precast concrete (VI)	0 t			0.0		0
Precast concrete (VII)	0 t			0.0		0
Precast concrete (VIII)	0 t			0.0		0
Precast concrete (IX)	0 t			0.0		0
Precast concrete (X)	0 t			0.0		0
Precast concrete (XI)	0 t			0.0		0
Precast concrete (XII)	0 t			0.0		0
Precast concrete (XIII)	0 t			0.0		0
Precast concrete (XIV)	0 t			0.0		0
Precast concrete (XV)	0 t			0.0		0
Reinforcement steel bars - Australian products	13,901 t			0.0		0
Reinforcement steel bars - imported products	0 t			0.0		0

Reinforcement steel mesh - Australian products	0 t	1.0 years	0%	99.0		0
Reinforcement steel mesh - imported products	0 t	1.0 years	0%	99.0		0
Reo steel: low relaxation strand and wire - Australian produc	0 t	1.0 years	0%	99.0		0
Reo steel: low relaxation strand and wire - imported product	0 t	1.0 years	0%	99.0		0
Structural steel, beams and columns - Australian products	16,245 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	108.722
Structural steel, beams and columns - imported products	0 t	1.0 years	0%	99.0		0
Structural steel, hot rolled coil - Australian products	403 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	13
Structural steel, hot rolled coil - imported products	0 t	1.0 years	0%	99.0		0
Structural steel, merchant bar - Australian products	0 t	1.0 years	0%	99.0		0
Structural steel, merchant bar - imported products	0 t	1.0 years	0%	99.0		0
Structural steel, plate - Australian products	9 t	1.0 years	2%	99.0	See 'Sheet for notes (Materials)'	17.2
Structural steel, plate - imported products	0 t	1.0 years	0%	99.0		0
Galvanised steel - Australian products	5,617 t	1.0 years	2%	99.0	See 'Sheet for notes (Materials)'	9291.3531
Galvanised steel - imported products	0 t	1.0 years	0%	99.0		0
Steel rails - Australian products	0 t	1.0 years	0%	99.0		0
Steel rails - imported products	0 t	1.0 years	0%	99.0		0
Hot mix asphalt, 0% RAP (5.5% bitumen)	26,714 t	1.0 years	2%	99.0	See 'Sheet for notes (Materials)'	64546.3
Hot mix asphalt, 0-20% RAP	0 t	1.0 years	0%	99.0		0
Hot mix asphalt, 20-40% RAP	0 t	1.0 years	0%	99.0		0
Hot mix asphalt, 40-60% RAP	0 t	1.0 years	0%	99.0		0
Hot mix asphalt, >60% RAP	0 t	1.0 years	0%	99.0		0
Warm mix asphalt, 0% RAP (5.5% bitumen)	0 t	1.0 years	0%	99.0		0
Warm mix asphalt, 0-20% RAP	0 t	1.0 years	0%	99.0		0
Warm mix asphalt, 20-40% RAP	0 t	1.0 years	0%	99.0		0
Warm mix asphalt, 40-60% RAP	0 t	1.0 years	0%	99.0		0
Warm mix asphalt, >60% RAP	0 t	1.0 years	0%	99.0		0
Reinforced concrete pipes	606 t	1.0 years	0%	99.0		0
Steel pipe and tube - Australian products	6,453 t	1.0 years	0%	99.0		0
Steel pipe and tube - imported products	0 t	1.0 years	0%	99.0		0
HDPE pipes	16 t	1.0 years	2%	99.0	See 'Sheet for notes (Materials)'	31.724
PVC pipes	5,529 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	253.96678
Timber, Structural (softwood)	0 t	1.0 years	3%	99.0	See 'Sheet for notes (Materials)'	0.7105746
Timber, Structural (hardwood)	0 t	1.0 years	0%	99.0		0
Timber, MDF / Particleboard	0 t	1.0 years	0%	99.0		0
Timber, Plywood	0 t	1.0 years	0%	99.0		0
Timber, Cross-Laminated Timber (CLT)	0 t	1.0 years	0%	99.0		0
Aluminium	22 t	1.0 years	0%	99.0		0
Glass	38 t	1.0 years	0%	99.0	See 'Sheet for notes (Materials)'	1.08
Ceramics	0 t	1.0 years	0%	99.0		0
Power cables, Copper conductors	0 t	1.0 years	0%	99.0		0
Power cables, Aluminium conductors	0 t	1.0 years	0%	99.0		0
Power cables, Other conductors	0 t	1.0 years	0%	99.0		0

Additional or alternative materials required for Major Preventive Maintenance (MPM)	Quantity	Unit	Evidence / data source / comments

Base Case - Estimated BAU Maintenance Mitigation

Mitigation is not captured under the Base Case.

Reinforcement steel mesh - Australian products	0 t			0.0		0
Reinforcement steel mesh - imported products	0 t			0.0		0
Reo steel: low relaxation strand and wire - Australian produc	0 t			0.0		0
Reo steel: low relaxation strand and wire - imported product	0 t			0.0		0
Structural steel, beams and columns - Australian products	16,245 t			0.0		0
Structural steel, beams and columns - imported products	0 t			0.0		0
Structural steel, hot rolled coil - Australian products	403 t			0.0		0
Structural steel, hot rolled coil - imported products	0 t			0.0		0
Structural steel, merchant bar - Australian products	0 t			0.0		0
Structural steel, merchant bar - imported products	0 t			0.0		0
Structural steel, plate - Australian products	9 t			0.0		0
Structural steel, plate - imported products	0 t			0.0		0
Galvanised steel - Australian products	5,617 t			0.0		0
Galvanised steel - imported products	0 t			0.0		0
Steel rails - Australian products	0 t			0.0		0
Steel rails - imported products	0 t			0.0		0
Hot mix asphalt, 0% RAP (5.5% bitumen)	26,714 t			0.0		0
Hot mix asphalt, 0-20% RAP	0 t			0.0		0
Hot mix asphalt, 20-40% RAP	0 t			0.0		0
Hot mix asphalt, 40-60% RAP	0 t			0.0		0
Hot mix asphalt, >60% RAP	0 t			0.0		0
Warm mix asphalt, 0% RAP (5.5% bitumen)	0 t			0.0		0
Warm mix asphalt, 0-20% RAP	0 t			0.0		0
Warm mix asphalt, 20-40% RAP	0 t			0.0		0
Warm mix asphalt, 40-60% RAP	0 t			0.0		0
Warm mix asphalt, >60% RAP	0 t			0.0		0
Reinforced concrete pipes	606 t			0.0		0
Steel pipe and tube - Australian products	6,453 t			0.0		0
Steel pipe and tube - imported products	0 t			0.0		0
HDPE pipes	16 t			0.0		0
PVC pipes	5,529 t			0.0		0
Timber, Structural (softwood)	0 t			0.0		0
Timber, Structural (hardwood)	0 t			0.0		0
Timber, MDF / Particleboard	0 t			0.0		0
Timber, Plywood	0 t			0.0		0
Timber, Cross-Laminated Timber (CLT)	0 t			0.0		0
Aluminium	22 t			0.0		0
Glass	38 t			0.0		0
Ceramics	0 t			0.0		0
Power cables, Copper conductors	0 t			0.0		0
Power cables, Aluminium conductors	0 t			0.0		0
Power cables, Other conductors	0 t			0.0		0

Additional or alternative materials required for Major Preventive Maintenance (MPM)	Quantity	Unit	Evidence / data source / comments

Forecast – Estimated Optimised Maintenance Mitigation Calculator

Change in materials used for Routine Maintenance & Major Preventive Maintenance (MPM)	Quantity	Unit		Avoided/Replaced materials that would have been required for Routine Maintenance & Major Preventive Maintenance (MPM)	Quantity	Unit
			replaces			
			replaces			
			replaces			
			replaces			
			replaces			
			replaces			

Change in materials used for Routine Maintenance & Major Preventive Maintenance (MPM)	Quantity	Unit	Emission factor (kg CO_2e/tonne)		Avoided/Replaced materials that would have been required for Routine Maintenance & Major Preventive Maintenance (MPM)	Quantity	Unit
				replaces			
				replaces			
				replaces			
				replaces			
				replaces			

Forecast - Avoided annual energy use for Routine Maintenance & Major Preventive Maintenance (MPM)

Change in energy for RM & MPM	Quantity	Unit		Evidence / data source / comments	Energy conversion	
Change in annual electricity consumption			Electricity		0.0	GJ/year
Change in annual diesel consumption			Diesel		0.0	GJ/year
Change in annual natural gas consumption			Natural gas		0.0	GJ/year
Change in annual LPG consumption			LPG		0.0	GJ/year
Change in annual petrol consumption			Petrol / ULP		0.0	GJ/year
Change in annual E10 consumption			Petrol / Ethanol (10%) blend		0.0	GJ/year
					0.0	GJ/year

Table 14: Construction GHG emissions

	Emissions source	GHG emissions (tCO2e over construction period)				
		Scope 1	Scope 2	Scope 3	Total	% of total
	Fuel use					
	Diesel consumption for site vehicles (incl. segment delivery and spoil haulage)	72,209	0	3,703	75,912	5%
	Diesel consumption for stationary plant and equipment	1,138	0	58	1,196	0.1%
Fuel use	Diesel consumption for mobile plant and equipment	49,518	0	2,539	52,058	4%
	Electricity					
Electricity	Electricity consumption	0	525,198	47,133	572,332	41%
	Construction materials					
	Concrete	0	0	377,322	377,322	27%
	Steel	0	0	290,858	290,858	21%
	Asphalt	0	0	1,747	1,747	0.1%
	Other	0	0	199	199	0%
Construction materials	Transport of materials	0	0	19,482	19,482	1%
	Land Clearing					
Land Clearing	Land clearing	4,741	0	0	4,741	0.3%
	Fugitive Emissions					
	Fugitive emissions (methane gas from coal seams) during tunnelling	11,293	0	0	11,293	0.8%
	Total	**138,899**	**525,198**	**743,041**	**1,407,139**	**100%**

Table 15 Operation and maintenance GHG emissions: Ventilation Scenario 1 (ventilation outlets)

Emission source	GHG Emissions (tCO2e over 100-year asset life)			
	Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and operations vehicles)	8,373	3,484,778	313,166	3,806,316
Maintenance emissions (maintenance plant, equipment and materials)	5,034	0	37,561	42,595
Road users (net change in vehicle tailpipe emissions)	0	0	-298,929	-298,929
Total operations and maintenance emissions	**13,407**	**3,484,778**	**51,799**	**3,549,983**

Table 16 Operation and maintenance GHG emissions: Ventilation Scenario 2 (portal emissions)

Emission source	GHG Emissions (tCO2e over 100-year asset life)			
	Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and operations vehicles)	8,373	1,396,976	125,799	1,531,148
Maintenance emissions (maintenance plant, equipment and materials)	5,034	0	37,561	42,595
Road users (net change in vehicle tailpipe emissions)	0	0	-298,929	-298,929
Total operations and maintenance emissions	**13,407**	**1,396,976**	**-135,568**	**1,274,815**

Construction period (years)	7
Operations period (years)	100

Total scope 1 and 2 lifecycle emissions (MtCO2e)
4.16

NSW total emissions 2020 (MtCO2e)
132.408

Transport	Raod transport
25.9	23
0.195608	0.888031

GWH Central scope 1 and 2 annualised construction emissions (MtCO2e/yr)
0.09

GWH Central scope 1 and 2 construction emissions proportion of NSW annual emissions
0.07%

GWH Central scope 1 and 2 annualised operations and maintenance emissions - ventilation outlet (MtCO2e/yr)
0.03

GWH Central operations and maintenance emissions proportion of NSW emissions - ventilation outlet
0.03%

GWH Central scope 1 and 2 annualised operations and maintenance emissions - portal emissions (MtCO2e/yr)
0.01

GWH Central operations and maintenance emissions proportion of NSW emissions - portal emissions
0.01%

		Ventilation outlet		Portal emissions	
	LH2L (MtCO2e/yr)	Combined (MtCO2e/yr)	Combined (%)	Combined (MtCO2e/yr)	Combined (%)
Construction	0.032	0.127	0.096%	0.127	0.001
Operations	0.001	0.036	0.027%	0.015	0.011%

Ventilation outlet option vs portal emissions option (tCO2e):
2,275,168

	2020
	MtCO2e
QLD	159.202
NSW	132.408
VIC	83.274
WA	81.704
SA	25.376
NT	17.319
ACT	1.134
TAS	-3.733

https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-2020/state-and-territory-greenhouse-gas-inventories-2020-emissions

Table 1 Summary of Greenhouse Gas Emissions by project phase

Emission source	GHG Emissions (total t CO2e over project phase)			
	Scope 1	Scope 2	Scope 3	Total
Construction	138,899	525,198	743,041	1,407,139
Operation and Maintenance: Ventilation Scenario 1	13,407	3,484,778	51,799	3,549,983
Operation and Maintenance: Ventilation Scenario 2	13,407	1,396,976	-135,568	1,274,815

Carbon Estimate & Reporting Tool

Formulas, emission factors, data sources and other background information

Formulas

[illegible]

Data sources

[illegible]

Emission factors

Fuel combustion emission factors

Solid fuels	Energy content (GJ/t)	Emission factor, scope 1 (kg CO2-e/GJ)	Emission factor, scope 3 (kg CO2-e/GJ)	Emission factor, scope 1+3 (kg CO2-e/GJ)	Source	Notes	Emission factor, scope 1 (t CO2-e/t)	Emission factor, scope 3 (t CO2-e/GJ)
Bituminous coal	27	90.2	3.0	93.2	NGA 2016	All emission factors incorporate relevant oxidation factors [illegible]	2.4	0.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Biomass municipal and industrial materials, if recycled and combusted to produce heat or electricity	12.2	1.8	Not estimated	1.8	NGA 2016		0.0	Not estimated

Liquid fuels	Energy content (GJ/kL)	Emission factor, scope 1 (kg CO_2-e/GJ)	Emission factor, scope 3 (kg CO_2-e/GJ)	Emission factor, scope 1+3 (kg CO_2-e/GJ)	Source	Notes	Emission factor, scope 1 (t CO_2-e/kL)	Emission factor, scope 3 (t CO_2-e/kL)
Gasoline (other than for use as fuel in an aircraft)	34.2	67.8	3.6	71.4	NGA 2016	Density: 0.730 kg/L	2.3	0.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Biodiesel	34.6	0.3	Not estimated	0.3	NGA 2016	Density: 0.875 kg/L	0.0	Not estimated
Ethanol for use as a fuel in an internal combustion engine	23.4	0.3	Not estimated	0.3	NGA 2016	Density: 0.789 kg/L	0.0	Not estimated
Biofuels other than those mentioned in the items above	23.4	0.3	Not estimated	0.3	NGA 2016	Density: 0.875 kg/L	0.0	Not estimated
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Emission factors for the consumption of natural gas

Gases	Energy content (GJ/m³)	Emission factor, scope 1 (kg CO_2-e/GJ)	Emission factor, scope 3 (kg CO_2-e/GJ)	Emission factor, scope 1+3 (kg CO_2-e/GJ)	Source	Notes	Emission factor, scope 1 (t CO_2-e/m3)	Emission factor, scope 3 (t CO_2-e/m3)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]

Electricity emission factors

Electricity	Energy content (GJ/MWh)	Emission factor, scope 2 (kg CO_2-e/kWh)	Emission factor, scope 3 (kg CO_2-e/kWh)	Emission factor, scope 2+3 (kg CO_2-e/kWh)	Source	Notes	Emission factor, scope 2 (t CO_2-e/GJ)	Emission factor, scope 3 (t CO_2-e/GJ)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Material emission factors

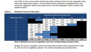
Material	Unit	Emission factor	Cement content	Source
Readymixed concrete, 20MPa or less	[illegible]	[illegible]	[illegible]	Formula for simplified concrete mix carbon footprint [illegible]
Readymixed concrete, 25MPa	[illegible]	[illegible]	[illegible]	Formula for simplified concrete mix carbon footprint [illegible]
Readymixed concrete, 32MPa	[illegible]	[illegible]	[illegible]	Formula for simplified concrete mix carbon footprint [illegible]
Readymixed concrete, 40MPa	[illegible]	[illegible]	[illegible]	Formula for simplified concrete mix carbon footprint [illegible]
Readymixed concrete, 50MPa	[illegible]	[illegible]	[illegible]	[illegible]
Readymixed concrete, 65MPa	[illegible]	[illegible]	[illegible]	[illegible]
Readymixed concrete, 80MPa	[illegible]	[illegible]	[illegible]	[illegible]
Readymixed concrete, more than 80MPa	[illegible]	[illegible]	[illegible]	[illegible]
Portland cement	kg CO_2-e/t	[illegible]		[illegible]
Fine aggregates	kg CO_2-e/t	[illegible]		[illegible]
Coarse aggregates	kg CO_2-e/t	[illegible]		[illegible]
Recycled (coarse) aggregates	kg CO_2-e/t	[illegible]		Sustainable Aggregates South Australia, CO2 Emission Factor Study [illegible]
Ballast	kg CO_2-e/t	[illegible]		Assumed same as for coarse aggregates
Sand	kg CO_2-e/t	[illegible]		[illegible]
Manufactured sand	kg CO_2-e/t	[illegible]		Assumed same as for recycled coarse aggregates
Recycled Crushed Glass	kg CO_2-e/t	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Material mitigation II	kg CO_2-e/unit	0		User defined
Material mitigation III	kg CO_2-e/unit	0		User defined
Material mitigation change I	kg CO_2-e/unit	0		User defined
Material mitigation change II	kg CO_2-e/unit	0		User defined
Material mitigation change III	kg CO_2-e/unit	0		User defined
Material mitigation change IV	kg CO_2-e/unit	0		User defined
Material mitigation change V	kg CO_2-e/unit	0		User defined
Material mitigation change VI	kg CO_2-e/unit	0		User defined
Material mitigation change VII	kg CO_2-e/unit	0		User defined
Material mitigation change VIII	kg CO_2-e/unit	0		User defined
Material mitigation change IX	kg CO_2-e/unit	0		User defined
Material mitigation change X	kg CO_2-e/unit	0		User defined
Material mitigation change XI	kg CO_2-e/unit	0		User defined
Material mitigation change XII	kg CO_2-e/unit	0		User defined
Plastic fibres (PP) for concrete reinforcement	kg CO_2-e/t	[illegible]		Australasian EPD [illegible]
Recycled plastic fibres (rPP) for concrete reinforcement	kg CO_2-e/t	[illegible]		Australasian EPD [illegible]
Protective coatings, paints	kg CO_2-e/t	[illegible]		[illegible]
Rubberised bitumen for road maintenance	kg CO_2-e/t	[illegible]		[illegible]

Waste emission factors

Transport of waste to landfill	kg CO_2-e/t	[illegible]	[illegible]	[illegible]
Transport of waste to recycling centre	kg CO_2-e/t	[illegible]	[illegible]	[illegible]
[illegible]	kg CO_2-e/t	[illegible]		NGA 2016 [illegible]
Construction and demolition waste to landfill: timber, vegetation	kg CO_2-e/t	[illegible]		NGA 2016, table 42, wood
Construction and demolition waste to landfill: mixed waste	kg CO_2-e/t	[illegible]		NGA 2016, table 44, C&D waste

Land use emission factors

The land use emission factors are determined based on the vegetation class and maximum biomass class (maxbio)



[illegible]

Transport emission factors

Rigid truck	kg CO_2-e/tkm	[illegible]	[illegible]
Articulated truck	kg CO_2-e/tkm	[illegible]	[illegible]
Rail	kg CO_2-e/tkm	[illegible]	[illegible]
Shipping	kg CO_2-e/tkm	[illegible]	[illegible]

Material Densities

Literature: http://www.ambrsoft.com/Software/TRbGX/Images/DensityTable.jpg http://dlb.sa.edu.au/tsftfmoodle/pluginfile.php/3647/mod_resource/content/0/DensitiesTable.pdf http://www.engineeringtoolbox.com/density-materials-d_1652.html http://www.engineeringtoolbox.com/density-solids-d_1265.html http://www.anval.net/downloads/bulk%20density%20chart.pdf

[illegible]

Waste Densities

[illegible]

Construction and demolition waste to landfill: inert waste	1.16	Inert waste
Construction and demolition waste to landfill: timber, vegetation	0.195	Average of timber and vegetation waste
Construction and demolition waste to landfill: mixed waste	1.20	Mixed C&D waste

Equivalences

Australian GHG emissions per capita, 2013	23300	For the year to March 2014, national inventory emissions per capita (excluding LULUCF) were 23.3 t CO2-e per person. (Source: "Quarterly update of Australia's National Greenhouse Gas Inventory: March 2014", Commonwealth of Australia, Department of the Environment, 2014)

[illegible]

Material emission factors

[illegible]

Default transport scenarios

[illegible]

Energy conversions

Power conversions

Time conversions

Distance conversions

Area conversions

Weight conversions

Volume conversions

Transport activity conversions

Global Warming Potentials (GWPs)

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	SAR‡ (100-yr)	Global Warming Potential for Given Time Horizon 20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below	$1.4x10^{-5}$	1	1	1	1
Methane	CH_4	12	$3.7x10^{-4}$	21	72	25	7.6
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	$CClF_2CClF_2$	300	0.31		8,040	10,000	8,730
CFC-115	$CClF_2CF_3$	1,700	0.18		5,310	7,370	9,990
Halon-1301	$CBrF_3$	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435
Methyl bromide	CH_3Br	0.7	0.01		17	5	1
Methyl chloroform	CH_3CCl_3	5	0.06		506	146	45
HCFC-22	$CHClF_2$	12	0.2	1,500	5,160	1,810	549
HCFC-123	$CHCl_2CF_3$	1.3	0.14	90	273	77	24
HCFC-124	$CHClFCF_3$	5.8	0.22	470	2,070	609	185
HCFC-141b	CH_3CCl_2F	9.3	0.14		2,250	725	220
HCFC-142b	CH_3CClF_2	17.9	0.2	1,800	5,490	2,310	705
HCFC-225ca	$CHCl_2CF_2CF_3$	1.9	0.2		429	122	37
HCFC-225cb	$CHClFCF_2CClF_2$	5.8	0.32		2,030	595	181
Hydrofluorocarbons							
HFC-23	CHF_3	270	0.19	11,700	12,000	14,800	12,200
HFC-32	CH_2F_2	4.9	0.11	650	2,330	675	205
HFC-125	CHF_2CF_3	29	0.23	2,800	6,350	3,500	1,100
HFC-134a	CH_2FCF_3	14	0.16	1,300	3,830	1,430	435
HFC-143a	CH_3CF_3	52	0.13	3,800	5,890	4,470	1,590
HFC-152a	CH_3CHF_2	1.4	0.09	140	437	124	38
HFC-227ea	CF_3CHFCF_3	34.2	0.26	2,900	5,310	3,220	1,040
HFC-236fa	$CF_3CH_2CF_3$	240	0.28	6,300	8,100	9,810	7,660
HFC-245fa	$CHF_2CH_2CF_3$	7.6	0.28		3,380	1030	314
HFC-365mfc	$CH_3CF_2CH_2CF_3$	8.6	0.21		2,520	794	241
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	15.9	0.4	1,300	4,140	1,640	500
Perfluorinated compounds							
Sulphur hexafluoride	SF_6	3,200	0.52	23,900	16,300	22,800	32,600
Nitrogen trifluoride	NF_3	740	0.21		12,300	17,200	20,700
PFC-14	CF_4	50,000	0.10	6,500	5,210	7,390	11,200
PFC-116	C_2F_6	10,000	0.26	9,200	8,630	12,200	18,200
Perfluorinated compounds (continued)							
PFC-218		2,600	0.26	7,000	6,310	8,830	12,500
PFC-318		3,200	0.32	8,700	7,310	10,300	14,700
PFC-3-1-10		2,600	0.33	7,000	6,330	8,860	12,500
PFC-4-1-12		4,100	0.41		6,510	9,160	13,300
PFC-5-1-14		3,200	0.49	7,400	6,600	9,300	13,300
PFC-9-1-18		>1,000	0.56		>5,500	>7,500	>9,500
trifluoromethyl sulphur pentafluoride		800	0.57		13,200	17,700	21,200
Fluorinated ethers							
HFE-125		136	0.44		13,800	14,900	8,490
HFE-134		26	0.45		12,200	6,320	1,960
HFE-143a		4.3	0.27		2,630	756	230
HCFE-235da2		2.6	0.38		1,230	350	106
HFE-245cb2		5.1	0.32		2,440	708	215
HFE-245fa2		4.9	0.31		2,280	659	200
HFE-254cb2		2.6	0.28		1,260	359	109
HFE-347mcc3		5.2	0.34		1,980	575	175
HFE-347pcf2		7.1	0.25		1,900	580	175
HFE-356pcc3		0.33	0.93		386	110	33
HFE-449sl (HFE-7100)		3.8	0.31		1,040	297	90
HFE-569sf2 (HFE-7200)		0.77	0.3		207	59	18
HFE-43-10pccc124 (H-Galden 1040x)		6.3	1.37		6,320	1,870	569
HFE-236ca12 (HG-10)		12.1	0.66		8,000	2,800	860
HFE-338pcc13 (HG-01)		6.2	0.87		5,100	1,500	460
Perfluoropolyethers							
PFPMIE		800	0.65		7,620	10,300	12,400
Hydrocarbons and other compounds – Direct Effects							
Dimethylether		0.015	0.02		1	1	<<1
Methylene chloride		0.38	0.03		31	8.7	2.7
Methyl chloride		1.0	0.01		45	13	4

	Low estimate	High estimate	
Spoil quantity (tonnes)	6171142.8	6171142.8	Source: "BAM-RFI-GWHU-070-R2-REDUCED-SCOPE.xlsx"
% Coal	2%	3%	Source: initial estimate from geotechnical team. This is highly variable, and subject to coal seam gas sampling scheduled for mid 2023.
Coal quantity (tonnes)	123422.856	185134.284	Calculation
Fugitive emissions factor (t CO2e/t raw coal)	0.061	0.061	Source: NGAF 2021. Emissions factor for open cut mining used. Note that the tunnelling would more likely resemble underground mining, however emissions factors are not published as they are measured on a mine-specific basis.
Fugitive emissions (t CO2e)	7528.79422	11293.19132	Due to the above, the calculated fugitive emissions are likely to be highly inacurrate. Proper quantification of expected fugitive emissions should be undertaken after coal seam gas sampling is undertaken.

Quantities

Source document: BOQ provided by TA - "BAM-RFI-GWHU-066-067-R1.xlsx"

Based on 20% concept construction program and 80% concept design high level changes and reduction in scope

BAM-RFI-GWHU-066-067-R1.xlsx / **Calculation**

ID	RFI	Site	Material Class	Material	Element	Qty Total	Unit	CERT Material	CERT Unit	Initial quantit	Design Life (	Design Life	Maintenance	Note
1	067	Blackheath	Concrete	Concrete Blinding 20MPa	Site Establishment - Hardstandstands & Roads	526.75	m3	RM 20MPa	m3	526.75	Pavement - main c	40	1,053.50	
2	067	Blackheath	Concrete	Concrete 40MPa Insitu	Site Establishment - Hardstandstands and Footings	2,773.75	m3	RM 40MPa	m3	2,773.75	Pavement - main c	40	5,547.50	
3	067	Blackheath	Concrete	Concrete 40MPa precast	Site Establishment - workshop kelly blocks	10.98	m3	PC 40MPa	m3	10.98	Buildings - free sta	50	10.98	
4	067	Blackheath	Concrete	Concrete 40MPa Insitu	Site Establishment - Nib Walls and Sed Control	90.00	m3	RM 40MPa	m3	90.00	Accessible drainag	40	180.00	
5	067	Blackheath	Concrete	Concrete 40MPa Insitu	Site Establishment - Noise Wall Piles	294.05	m3	RM 40MPa	m3	294.05	Noise barriers	50	294.05	
6	067	Blackheath	Concrete	Concrete 40MPa Insitu	Site Establishment - Crane Pad	240.48	m3	RM 40MPa	m3	240.48	Buildings - CI	100	-	
7	067	Blackheath	Concrete	Concrete 40MPa Insitu	Site Establishment - Roads (External from Compound)	1,080.00	m3	RM 40MPa	m3	1,080.00	Pavement - local ro	20	4,320.00	
8	067	Blackheath	Steel	500 MPa reinforcement	Site Establishment All	501.60	t	Reinforcement steel bars - Australian products	t	501.60	Site establishment/	100	-	
9	067	Blackheath	Asphalt	AC20	Site Establishment - Parking, low traffic and sun valley rd	1,093.40	m3	Hot mix asphalt, 0% RAP (5.5% bitumen)	m3	1,093.40	Pavement - local ro	20	4,373.60	
10	067	Blackheath	Aggregates	DGB20	Site Establishment - All concrete areas	3,031.00	m3	Coarse aggregates	m3	3,031.00	Pavement - main c	40	6,062.00	
11	067	Blackheath	Aggregates	Riprap	Site Establishment - Access Tracks prior to hardstands	1,360.00	m3	Coarse aggregates	m3	1,360.00	Pavement - local ro	20	5,440.00	
12	067	Blackheath	Steel	250 MPa Steel	Site Establishment - Stores Containers	16.00	t	Galvanised steel - Australian products	t	16.00	Site establishment/	100	-	
13	067	Blackheath	Steel	250 MPa Steel	Site Establishment - Noise Walls Frames	67.00	t	Structural steel, beams and columns - Australian products	t	67.00	Noise barriers	50	67.00	
14	067	Blackheath	Steel	250 MPa Steel	Site Establishment - Wheel washes	7.50	t	Galvanised steel - Australian products	t	7.50	Site establishment/	100	-	
15	067	Blackheath	Steel	250 MPa Steel	Site Establishment - Temporary works	50.00	t	Galvanised steel - Australian products	t	50.00	Site establishment/	100	-	
16	067	Blackheath	Copper	Copper	Site Establishment - Cabling	0.63	t	6mm2 Cu LV Cable	t	0.63	Lighting and electri	20	2.54	
17	066 & 067	Blackheath	Piping - RCP	Reinforced Precast Concrete 40MPa	Site Establishment - Stormwater	213.84	t	Reinforced concrete pipes	t	213.84	Inaccessible draina	100	-	
18	066 & 067	Blackheath	Piping - HDPE	HDPE 200mm	Site Establishment - Water / Sewer / Internal	5.56	t	HDPE pipes	t	5.56	Accessible drainag	40	11.12	
19	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Site Establishment - Power & Services Reticulation	1.56	t	PVC pipes	t	1.56	Lighting and electri	20	6.23	
20	066 & 067	Blackheath	Piping - PVC	PVC 32mm	Site Establishment - Optic Fibre and Network Reticulation	0.22	t	PVC pipes	t	0.22	Lighting and electri	20	0.87	
21	066	Blackheath	Sprayed Bitumen	Class 170	Site Establishment - Asphalt	27,335.00	l	Bitumen	t	27.34	Site establishment/	100	-	Density bitume
22	066	Blackheath	Aluminium	Aluminium	Site Establishment	3.94	t	Aluminium	t	3.94	Site establishment/	100	-	
23	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Site Establishment	2,400.00	m2	Paint	t	2.40	Site establishment/	100	-	Assume 1mm th
24	066	Blackheath	WTP chemicals	WTP chemicals	Site Establishment (Entire Scope)	126,000.00	l	WTP chemicals	t	126.00	Site establishment/	100	-	Assume densit
25	066	Blackheath	Plastic Sheeting	Plastic Sheeting	Site Establishment	6,000.00	m2	uPVC sheet	t	7.74	Site establishment/	100	-	Assume uPVC sheet. Assume 1mm thickness. Density = 1.29 t/m3 https://polymeracademy.com/density-of-various-plastic/
26	067	Blackheath	Concrete	Concrete Blinding 20MPa	Cut and Cover	540.00	m3	RM 20MPa	m3	540.00	Tunnel	100	-	
27	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Piles	4,804.15	m3	RM 40MPa	m3	4,804.15	Tunnel	100	-	
28	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Capping Beam	622.72	m3	RM 40MPa	m3	622.72	Tunnel	100	-	
29	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Temporary Slab	464.25	m3	RM 40MPa	m3	464.25	Tunnel	100	-	
30	067	Blackheath	Concrete	Concrete 40MPa Shotcrete	Cut and Cover - Shotcrete Piles / Retaining Walls	1,711.37	m3	RM 40MPa	m3	1,711.37	Tunnel	100	-	
31	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Headwalls	359.93	m3	RM 40MPa	m3	359.93	Tunnel	100	-	
32	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Suspended Slab - Shell Beams, Columns & Footings	676.24	m3	RM 40MPa	m3	676.24	Tunnel	100	-	
33	067	Blackheath	Concrete	Concrete 40MPa precast	Cut and Cover - Suspended Slab - Precast	1,080.00	m3	PC 40MPa	m3	1,080.00	Tunnel	100	-	
34	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Suspended Slab - Stitch Pour	810.00	m3	RM 40MPa	m3	810.00	Tunnel	100	-	
35	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Roof - Shell Beams, Columns & Footings	1,264.40	m3	RM 40MPa	m3	1,264.40	Tunnel	100	-	
36	067	Blackheath	Concrete	Concrete 40MPa precast	Cut and Cover - Roof - Precast	1,080.00	m3	PC 40MPa	m3	1,080.00	Tunnel	100	-	
37	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Roof - Stitch Pour	810.00	m3	RM 40MPa	m3	810.00	Tunnel	100	-	
38	067	Blackheath	Concrete	Concrete 40MPa Insitu	Cut and Cover - Roof Upstand	46.80	m3	RM 40MPa	m3	46.80	Tunnel	100	-	
39	067	Blackheath	Steel	500 MPa reinforcement	Cut and Cover All	2,853.97	t	Reinforcement steel bars - Australian products	t	2,853.97	Tunnel	100	-	
40	067	Blackheath	Steel	500 MPa Steel	Cut and Cover - Anchors 32mm	36.52	t	Reinforcement steel bars - Australian products	t	36.52	Tunnel	100	-	
41	067	Blackheath	Steel	250 MPa Steel	Cut and Cover - Temporary works	200.00	t	Reinforcement steel bars - Australian products	t	200.00	Site establishment/	100	-	
42	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Cut and Cover - Power & Services Conduits	2.56	t	PVC pipes	t	2.56	Lighting and electri	20	10.25	
43	066	Blackheath	Glass	Glass	Cut and Cover	558.00	m2	Glass	m2	558.00	Tunnel	100	-	
44	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Cut and Cover	10,800.00	m2	Paint	t	10.80	Sign supports and	50	10.80	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
45	067	Blackheath	Concrete	Concrete Blinding 20MPa	Workshop	75.00	m3	RM 20MPa	m3	75.00	Buildings - free sta	50	75.00	
46	067	Blackheath	Concrete	Concrete 40MPa Insitu	Workshop - Base Slab	187.50	m3	RM 40MPa	m3	187.50	Buildings - free sta	50	187.50	
47	067	Blackheath	Steel	500 MPa reinforcement	Workshop All	52.50	t	Reinforcement steel bars - Australian products	t	52.50	Buildings - free sta	50	52.50	
48	067	Blackheath	Steel	250 MPa Steel	Workshop - Structural Steel	33.00	t	Structural steel, beams and columns - Australian products	t	33.00	Buildings - free sta	50	33.00	
49	067	Blackheath	Steel	250 MPa Steel	Workshop - Structural Steel	8.72	t	Structural steel, beams and columns - Australian products	t	8.72	Buildings - free sta	50	8.72	
50	067	Blackheath	Steel	250 MPa Steel	Workshop - Cladding & Roof	13.00	t	Structural steel, hot rolled coil - Australian products	t	13.00	Buildings - free sta	50	13.00	
51	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Workshop - Power & Services Conduits	0.24	t	PVC pipes	t	0.24	Lighting and electri	20	0.97	
52	066	Blackheath	Glass	Glass	Workshop	36.00	m2	Glass	m2	36.00	Buildings - free sta	50	36.00	
53	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Workshop	750.00	m2	Paint	t	0.75	Buildings - free sta	50	0.75	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
54	067	Blackheath	Concrete	Concrete Blinding 20MPa	Control Centre	150.00	m3	RM 20MPa	m3	150.00	Buildings - CI	100	-	
55	067	Blackheath	Concrete	Concrete 40MPa Insitu	Control Centre - Base Slab	525.00	m3	RM 40MPa	m3	525.00	Buildings - CI	100	-	
56	067	Blackheath	Concrete	Concrete 40MPa precast	Control Centre - Precast Walls GL	504.00	m3	PC 40MPa	m3	504.00	Buildings - CI	100	-	
57	067	Blackheath	Concrete	Concrete 40MPa Insitu	Control Centre - Suspended Slab, Underbeams, Columns & Footings	600.00	m3	RM 40MPa	m3	600.00	Buildings - CI	100	-	
58	067	Blackheath	Concrete	Concrete 40MPa precast	Control Centre - Precast Walls 1F	450.00	m3	PC 40MPa	m3	450.00	Buildings - CI	100	-	
59	067	Blackheath	Steel	250 MPa Steel	Control Centre - Structural Steel	22.00	t	Structural steel, beams and columns - Australian products	t	22.00	Buildings - CI	100	-	
60	067	Blackheath	Steel	250 MPa Steel	Control Centre - Structural Steel	5.87	t	Structural steel, beams and columns - Australian products	t	5.87	Buildings - CI	100	-	
61	067	Blackheath	Steel	250 MPa Steel	Control Centre - Cladding & Roof	27.00	t	Structural steel, hot rolled coil - Australian products	t	27.00	Buildings - CI	100	-	
62	067	Blackheath	Steel	500 MPa reinforcement	Control Centre All	451.37	t	Reinforcement steel bars - Australian products	t	451.37	Buildings - CI	100	-	
63	067	Blackheath	Steel	250 MPa Steel	Control Centre - Temporary works	20.00	t	Galvanised steel - Australian products	t	20.00	Site establishment/	100	-	
64	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Control Centre - Power & Services Conduits	0.44	t	PVC pipes	t	0.44	Lighting and electri	20	1.75	
65	066 & 067	Blackheath	Piping - PVC	PVC 32mm	Control Centre - Optic Fibre and Network Reticulation	0.04	t	PVC pipes	t	0.04	Lighting and electri	20	0.16	
66	066	Blackheath	Glass	Glass	Control Centre	240.00	m2	Glass	m2	240.00	Buildings - CI	100	-	
67	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Control Centre	3,000.00	m2	Paint	t	3.00	Buildings - CI	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
68	067	Blackheath	Copper	Copper	Control Centre - Cabling	1.11	t	6mm2 Cu LV Cable	t	1.11	Lighting and electri	20	4.44	
69	067	Blackheath	Concrete	Concrete Blinding 20MPa	Pump Room	15.00	m3	RM 20MPa	m3	15.00	Buildings - CI	100	-	
70	067	Blackheath	Concrete	Concrete 40MPa Insitu	Pump Room - Base Slab	37.50	m3	RM 40MPa	m3	37.50	Buildings - CI	100	-	
71	067	Blackheath	Steel	500 MPa reinforcement	Pump Room All	10.50	t	Reinforcement steel bars - Australian products	t	10.50	Buildings - CI	100	-	
72	067	Blackheath	Steel	250 MPa Steel	Pump Room - Structural Steel	6.50	t	Structural steel, beams and columns - Australian products	t	6.50	Buildings - CI	100	-	
73	067	Blackheath	Steel	250 MPa Steel	Pump Room - Structural Steel	1.78	t	Structural steel, beams and columns - Australian products	t	1.78	Buildings - CI	100	-	
74	067	Blackheath	Steel	250 MPa Steel	Pump Room - Cladding & Roof	3.50	t	6mm2 Cu LV Cable	t	3.50	Buildings - CI	100	-	
75	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Pump Room - Power & Services Conduits	0.09	t	PVC pipes	t	0.09	Lighting and electri	20	0.37	
76	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Pump Room	150.00	m2	Paint	t	0.15	Buildings - CI	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
77	067	Blackheath	Concrete	Concrete Blinding 20MPa	Fire Water Tanks	78.40	m3	RM 20MPa	m3	78.40	Buildings - free sta	50	78.40	
78	067	Blackheath	Concrete	Concrete 40MPa Insitu	Fire Water Tanks - Base Slab	274.40	m3	RM 40MPa	m3	274.40	Buildings - free sta	50	274.40	
79	067	Blackheath	Steel	250 MPa Steel	Fire Water Tanks - Tank Bases	3.98	t	Structural steel, hot rolled coil - Australian products	t	3.98	Inaccessible eleme	100	-	
80	067	Blackheath	Steel	250 MPa Steel	Fire Water Tanks - Tank Walls	18.10	t	Structural steel, hot rolled coil - Australian products	t	18.10	Inaccessible eleme	100	-	
81	067	Blackheath	Steel	250 MPa Steel	Fire Water Tanks - Tank Roof	5.07	t	Structural steel, hot rolled coil - Australian products	t	5.07	Inaccessible eleme	100	-	
82	067	Blackheath	Steel	250 MPa Steel	Fire Water Tanks - Temporary works	10.00	t	Structural steel, hot rolled coil - Australian products	t	10.00	Site establishment/	100	-	
83	067	Blackheath	Steel	250 MPa Steel	Fire Water Tanks - Piping	18.67	t	Steel pipe and tubing	t	18.67	Inaccessible eleme	100	-	
84	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Fire Water Tanks - Power & Services Conduits	0.18	t	PVC pipes	t	0.18	Lighting and electri	20	0.70	
85	066 & 067	Blackheath	Piping - PVC	PVC 32mm	Fire Water Tanks - Optic Fibre and Network Reticulation	0.04	t	PVC pipes	t	0.04	Lighting and electri	20	0.14	
86	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Fire Water Tanks	700.00	m2	Paint	t	0.70	Buildings - free sta	50	0.70	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
87	067	Blackheath	Concrete	Concrete Blinding 20MPa	Ventilation Building	295.00	m3	RM 20MPa	m3	295.00	Buildings - CI	100	-	
88	067	Blackheath	Concrete	Concrete 40MPa Precast	Ventilation Building - Retaining Walls	166.32	m3	PC 40MPa	m3	166.32	Retaining Walls	100	-	
89	067	Blackheath	Concrete	Concrete 40MPa Insitu	Ventilation Building - Base Slab - Shell Beams, Columns & Footings	4,730.57	m3	RM 40MPa	m3	4,730.57	Buildings - CI	100	-	
90	067	Blackheath	Concrete	Concrete 40MPa Insitu	Ventilation Building - Base Slab	737.50	m3	RM 40MPa	m3	737.50	Buildings - CI	100	-	
91	067	Blackheath	Concrete	Concrete 40MPa precast	Ventilation Building - Precast Walls	1,091.33	m3	PC 40MPa	m3	1,091.33	Buildings - CI	100	-	
92	067	Blackheath	Concrete	Concrete 40MPa Insitu	Ventilation Building - Roof - Shell Beams, Columns & Footings	1,385.54	m3	RM 40MPa	m3	1,385.54	Buildings - CI	100	-	
93	067	Blackheath	Concrete	Concrete 40MPa precast	Ventilation Building - Roof - Precast	590.00	m3	PC 40MPa	m3	590.00	Buildings - CI	100	-	
94	067	Blackheath	Concrete	Concrete 40MPa Insitu	Ventilation Building - Roof - Stitch Pour	442.50	m3	RM 40MPa	m3	442.50	Buildings - CI	100	-	
95	067	Blackheath	Concrete	Concrete 40MPa Insitu	Ventilation Building - Ventilation Stack	18.47	m3	RM 40MPa	m3	18.47	Buildings - CI	100	-	
96	067	Blackheath	Steel	500 MPa reinforcement	Ventilation Building All	1,891.45	t	Reinforcement steel bars - Australian products	t	1,891.45	Buildings - CI	100	-	
97	067	Blackheath	Steel	250 MPa Steel	Ventilation Building - Subs, transformers	90.00	t	Galvanised steel - Australian products	t	90.00	Buildings - CI	100	-	
98	067	Blackheath	Steel	250 MPa Steel	Ventilation Building - Dampers	680.00	t	Galvanised steel - Australian products	t	680.00	Buildings - CI	100	-	
99	067	Blackheath	Steel	250 MPa Steel	Ventilation Building - Temporary Works	50.00	t	Galvanised steel - Australian products	t	50.00	Buildings - CI	100	-	
100	066 & 067	Blackheath	Piping - PVC	PVC 100mm	Ventilation Building - Power & Services Conduits	6.19	t	PVC pipes	t	6.19	Lighting and electri	20	24.76	
101	066	Blackheath	Glass	Glass	Ventilation Building	223.20	m2	Glass	m2	223.20	Buildings - CI	100	-	
102	066	Blackheath	Coatings and Finishes	Coatings and Finishes	Ventilation Building	5,900.00	m2	Paint	t	5.90	Buildings - CI	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
103	067	Blackheath	Copper	Copper	Ventilation Building - Cabling	9.51	t	6mm2 Cu LV Cable	t	9.51	Lighting and electri	20	38.04	
104												#N/A	#N/A	
105												#N/A	#N/A	
106	067	Midpoint	Concrete	Concrete Blinding 20MPa	Site Establishment - Hardstandstands & Roads	355.00	m3	RM 20MPa	m3	355.00	Pavement - main c	40	710.00	
107	067	Midpoint	Concrete	Concrete 40MPa Insitu	Site Establishment - Hardstandstands and Footings	1,762.50	m3	RM 40MPa	m3	1,762.50	Pavement - main c	40	3,525.00	
108	067	Midpoint	Concrete	Concrete 40MPa precast	Site Establishment - workshop kelly blocks	5.49	m3	PC 40MPa	m3	5.49	Buildings - free sta	50	5.49	
109	067	Midpoint	Concrete	Concrete 40MPa Insitu	Site Establishment - Nib Walls and Sed Control	64.00	m3	RM 40MPa	m3	64.00	Accessible drainag	40	128.00	
110	067	Midpoint	Concrete	Concrete 40MPa Insitu	Site Establishment - Crane Pad	240.48	m3	RM 40MPa	m3	240.48	Buildings - CI	100	-	
111	067	Midpoint	Concrete	Concrete 40MPa Insitu	Site Establishment - Roads (External from Compound)	560.00	m3	RM 40MPa	m3	560.00	Pavement - local ro	20	2,240.00	
112	067	Midpoint	Concrete	Concrete 40MPa Insitu	Site Establishment - Shaft Apron	350.00	m3	RM 40MPa	m3	350.00	Tunnel	100	-	
113	067	Midpoint	Steel	500 MPa reinforcement	Site Establishment All	333.75	t	Reinforcement steel bars - Australian products	t	333.75	Site establishment/	100	-	
114	067	Midpoint	Asphalt	AC20	Site Establishment - Parking, low traffic and sun valley rd	280.00	m3	Hot mix asphalt, 0% RAP (5.5% bitumen)	m3	280.00	Pavement - local ro	20	1,120.00	
115	067	Midpoint	Aggregates	DGB20	Site Establishment - All concrete areas	2,138.00	m3	Coarse aggregates	m3	2,138.00	Pavement - main c	40	4,276.00	
116	067	Midpoint	Aggregates	Riprap	Site Establishment - Access Tracks prior to hardstands	720.00	m3	Coarse aggregates	m3	720.00	Pavement - local ro	20	2,880.00	
117	067	Midpoint	Steel	250 MPa Steel	Site Establishment - Stores Containers	16.00	t	Galvanised steel - Australian products	t	16.00	Site establishment/	100	-	
118	067	Midpoint	Steel	250 MPa Steel	Site Establishment - Wheel washes	7.50	t	Galvanised steel - Australian products	t	7.50	Site establishment/	100	-	
119	067	Midpoint	Steel	250 MPa Steel	Site Establishment - Temporary works	100.00	t	Galvanised steel - Australian products	t	100.00	Site establishment/	100	-	
120	067	Midpoint	Copper	Copper	Site Establishment - Cabling	0.25	t	6mm2 Cu LV Cable	t	0.25	Lighting and electri	20	1.01	
121	066 & 067	Midpoint	Piping - RCP	Reinforced Precast Concrete 40MPa	Site Establishment - Stormwater	77.76	t	Reinforced concrete pipes	t	77.76	Inaccessible draina	100	-	
122	066 & 067	Midpoint	Piping - HDPE	HDPE 200mm	Site Establishment - Water / Sewer / Internal	1.03	t	HDPE pipes	t	1.03	Accessible drainag	40	2.06	
123	066 & 067	Midpoint	Piping - PVC	PVC 100mm	Site Establishment - Power & Services Reticulation	0.73	t	PVC pipes	t	0.73	Lighting and electri	20	2.92	
124	066 & 067	Midpoint	Piping - PVC	PVC 32mm	Site Establishment - Optic Fibre and Network Reticulation	0.03	t	PVC pipes	t	0.03	Lighting and electri	20	0.13	
125	066	Midpoint	Sprayed Bitumen	Class 170	Site Establishment - Asphalt	7,000.00	l	Bitumen	t	7.00	Site establishment/	100	-	Density bitumen = 0.001 t/L (IS Materials Calculator)
126	066	Midpoint	Aluminium	Aluminium	Site Establishment	1.73	t	Aluminium	t	1.73	Site establishment/	100	-	
127	066	Midpoint	Coatings and Finishes	Coatings and Finishes	Site Establishment	1,400.00	m2	Paint	t	1.40	Site establishment/	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
128	066	Midpoint	WTP chemicals	WTP chemicals	Site Establishment (Entire Scope)	115,000.00	l	WTP chemicals	t	115.00	Site establishment/	100	-	Assume density WTP Chemicals = density of water = 1 t/m3
129	066	Midpoint	Plastic Sheeting	Plastic Sheeting	Site Establishment	4,000.00	m2	uPVC sheet	t	5.16	Site establishment/	100	-	Assume uPVC sheet. Assume 1mm thickness. Density = 1.29 t/m3 https://polymeracademy.com/density-of-various-plastic/
130	067	Midpoint	Aggregates	DGB20	Shaft - Piling Pad	120.64	m3	Coarse aggregates	m3	120.64	Inaccessible eleme	100	-	
131	067	Midpoint	Concrete	Concrete 40MPa Insitu	Shaft - Piles	502.65	m3	RM 40MPa	m3	502.65	Tunnel	100	-	
132	067	Midpoint	Concrete	Concrete 40MPa Insitu	Shaft - Capping Beam	92.47	m3	RM 40MPa	m3	92.47	Tunnel	100	-	
133	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Shaft - Shotcrete between Piles	258.29	m3	RM 40MPa	m3	258.29	Tunnel	100	-	
134	067	Midpoint	Concrete	Concrete 40MPa Insitu	Shaft - 2 x Ring Beams	125.10	m3	RM 40MPa	m3	125.10	Tunnel	100	-	
135	067	Midpoint	Concrete	Concrete 40MPa Insitu	Shaft - 500mm Secondary Lining	1,596.56	m3	RM 40MPa	m3	1,596.56	Tunnel	100	-	
136	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Shaft - Shotcrete Primary Lining	751.11	m3	RM 40MPa	m3	751.11	Tunnel	100	-	
137	067	Midpoint	Concrete	Concrete 40MPa Insitu	Base Slab	75.87	m3	RM 40MPa	m3	75.87	Pavement - main c	40	151.74	
138	067	Midpoint	Steel	500 MPa reinforcement	Shaft	478.53	t	Reinforcement steel bars - Australian products	t	478.53	Tunnel	100	-	

Calculation (Summary)

ID	Material Class	Summary - Material	Initial quantit	Unit of Measure	Maint	Annualised Maintenance Qty %
1	Concrete	RM 20MPa	291789.4	m3	6810	0.02%
2	Concrete	RM 40MPa	187066	m3	49848	0.27%
3	Concrete	PC 40MPa	572670	m3	38	0.00%
4	Steel	Reinforcement steel bars - Australian products	13901	t	253	0.02%
5	Asphalt	Hot mix asphalt, 0% RAP (5.5% bitumen)	26714	m3	64546	2.44%
6	Aggregates	Coarse aggregates	20562	m3	43229	2.12%
7	Steel	Galvanised steel - Australian products	5617	t	9291	1.67%
8	Steel	Structural steel, beams and columns - Australian products	16245	t	109	0.01%
9	Copper	6mm2 Cu LV Cable	73	t	277	3.85%
10	Piping - RCP	Reinforced concrete pipes	606	t	0	0.00%
11	Piping - HDPE	HDPE pipes	16	t	32	2.02%
12	Piping - PVC	PVC pipes	5529	t	254	0.05%
13	Sprayed Bitumen	Bitumen	226	t	174	0.78%
14	Aluminium	Aluminium	22	t	0	0.00%
15	Coatings and Finishes	Paint	78	t	51	0.66%
16	WTP chemicals	WTP chemicals	1259	t	0	0.00%
17	Plastic Sheeting	uPVC sheet	45	t	0	0.00%
18	Glass	Glass	1280	m2	36	0.03%
19	Steel	Structural steel, hot rolled coil - Australian products	403	t	13	0.03%
20	Steel	Steel pipe and tubing	6453	t	24	0.00%
21	Other	Cement Fibreboard	4591	t	0	0.00%
22	Copper	1600mm2 Cu HV Cable	334	t	1335	4.04%
23	Steel	Structural steel, plate - Australian products	9	t	17	2.02%
24	Other	Timber, Structural (softwood)	0	m3	1	3.03%

139	067	Midpoint	Steel	250 MPa Steel	Shaft - Alimak	31.00	t	Galvanised steel - Australian products	t	31.00	Tunnel	100	-	
140	067	Midpoint	Steel	250 MPa Steel	Shaft - Ventilation Fans	7.20	t	Galvanised steel - Australian products	t	7.20	Inaccessible eleme	100	-	
141	067	Midpoint	Steel	250 MPa Steel	Shaft - Ventilation Ducting	42.00	t	Galvanised steel - Australian products	t	42.00	Inaccessible eleme	100	-	
142	066 & 067	Midpoint	Other	PVC	Ventilation Ventilation Bag	9.76	t	PVC pipes	t	9.76	Inaccessible eleme	100	-	
143	067	Midpoint	Steel	250 MPa Steel	Shaft - Kibble Frame	3.58	t	Galvanised steel - Australian products	t	3.58	Tunnel	100	-	
144	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Crosscut RH6 - Shotcrete	785.58	m3	RM 40MPa	m3	785.58	Tunnel	100	-	
145	067	Midpoint	Steel	500 MPa reinforcement	Crosscut RH6 - Bolts and Plates Crown	33.60	t	Reinforcement steel bars - Australian products	t	33.60	Tunnel	100	-	
146	067	Midpoint	Steel	500 MPa reinforcement	Crosscut RH6 - Bolts and Plates Walls	2.77	t	Reinforcement steel bars - Australian products	t	2.77	Tunnel	100	-	
147	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Crosscut RH12 - Shotcrete	509.48	m3	RM 40MPa	m3	509.48	Tunnel	100	-	
148	067	Midpoint	Steel	500 MPa reinforcement	Crosscut RH12 - Bolts and Plates Crown	21.75	t	Reinforcement steel bars - Australian products	t	21.75	Tunnel	100	-	
149	067	Midpoint	Steel	500 MPa reinforcement	Crosscut RH12 - Bolts and Plates Walls	2.99	t	Reinforcement steel bars - Australian products	t	2.99	Tunnel	100	-	
150	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Cavern - Maint and Breakdown Bay - Shotcrete	1,562.80	m3	RM 40MPa	m3	1,562.80	Inaccessible eleme	100	-	
151	067	Midpoint	Steel	500 MPa reinforcement	Cavern - Maint and Breakdown Bay - Bolts and Plates	99.02	t	Reinforcement steel bars - Australian products	t	99.02	Pavement - main c	40	198.03	
152	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Cavern - TBM Refirb - Shotcrete	336.50	m3	RM 40MPa	m3	336.50	Inaccessible eleme	100	-	
153	067	Midpoint	Steel	500 MPa reinforcement	Cavern - TBM Refirb - Bolts and Plates	18.39	t	Reinforcement steel bars - Australian products	t	18.39	Site establishment/	100	-	
154	067	Midpoint	Concrete	Concrete 40MPa Shotcrete	Cavern - VXP - Shotcrete	22.06	m3	RM 40MPa	m3	22.06	Inaccessible eleme	100	-	
155	067	Midpoint	Steel	500 MPa reinforcement	Cavern - VXP - Bolts and Plates	1.16	t	Reinforcement steel bars - Australian products	t	1.16	Pavement - main c	40	2.31	
156	067	Midpoint	Concrete	Concrete 40MPa Insitu	Shaft - Backfill Structure	659.52	m3	RM 40MPa	m3	659.52	Tunnel	100	-	
157	067	Midpoint	Concrete	Concrete 8MPa Insitu	Shaft - Flowable Fill	14,022.72	m3	RM 20MPa	m3	14,022.72	Tunnel	100	-	
158												#N/A	#N/A	
159												#N/A	#N/A	
160	067	Little Hartley	Concrete	Concrete Blinding 20MPa	Site Establishment - Hardstandstands & Roads	2,446.50	m3	RM 20MPa	m3	2,446.50	Pavement - main c	40	4,893.00	
161	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Site Establishment - Hardstandstands and Footings	12,372.50	m3	RM 40MPa	m3	12,372.50	Pavement - main c	40	24,745.00	
162	067	Little Hartley	Concrete	Concrete 40MPa precast	Site Establishment - workshop kelly blocks	21.95	m3	PC 40MPa	m3	21.95	Buildings - free sta	50	21.95	
163	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Site Establishment - Crane Pad	240.48	m3	RM 40MPa	m3	240.48	Buildings - CI	100	-	
164	067	Little Hartley	Steel	500 MPa reinforcement	Site Establishment All	1,508.14	t	Reinforcement steel bars - Australian products	t	1,508.14	Site establishment/	100	-	
165	067	Little Hartley	Asphalt	AC20	Site Establishment - Parking, low traffic areas	4,186.00	m3	Hot mix asphalt, 0% RAP (5.5% bitumen)	m3	4,186.00	Pavement - local ro	20	16,744.00	
166	067	Little Hartley	Aggregates	DGB20	Site Establishment - All concrete areas	9,786.00	m3	Coarse aggregates	m3	9,786.00	Pavement - main c	40	19,572.00	
167	067	Little Hartley	Aggregates	Riprap	Site Establishment - Access Tracks prior to hardstands	1,000.00	m3	Coarse aggregates	m3	1,000.00	Pavement - local ro	20	4,000.00	
168	067	Little Hartley	Steel	250 MPa Steel	Site Establishment - Stores Containers	16.00	t	Galvanised steel - Australian products	t	16.00	Site establishment/	100	-	
169	067	Little Hartley	Steel	250 MPa Steel	Site Establishment - Wheel washes	15.00	t	Galvanised steel - Australian products	t	15.00	Site establishment/	100	-	
170	067	Little Hartley	Steel	250 MPa Steel	Site Establishment - Water Tanks	165.88	t	Structural steel, hot rolled coil - Australian products	t	165.88	Site establishment/	100	-	
171	067	Little Hartley	Steel	250 MPa Steel	Site Establishment - Temporary works	200.00	t	Galvanised steel - Australian products	t	200.00	Site establishment/	100	-	
172	067	Little Hartley	Copper	Copper	Site Establishment - Cabling	0.82	t	6mm2 Cu LV Cable	t	0.82	Lighting and electri	20	3.30	
173	066 & 067	Little Hartley	Piping - RCP	Reinforced Precast Concrete 40MPa	Site Establishment - Stormwater	314.28	t	Reinforced concrete pipes	t	314.28	Inaccessible draina	100	-	
174	066 & 067	Little Hartley	Piping - HDPE	HDPE 200mm	Site Establishment - Water / Sewer / Internal	9.27	t	HDPE pipes	t	9.27	Accessible drainag	40	18.54	
175	066 & 067	Little Hartley	Piping - PVC	PVC 100mm	Site Establishment - Power & Services Reticulation	1.17	t	PVC pipes	t	1.17	Lighting and electri	20	4.67	
176	066 & 067	Little Hartley	Piping - PVC	PVC 32mm	Site Establishment - Optic Fibre and Network Reticulation	0.33	t	PVC pipes	t	0.33	Lighting and electri	20	1.32	
177	066	Little Hartley	Sprayed Bitumen	Class 170	Site Establishment - Asphalt	104,650.00	l	Bitumen	t	104.65	Site establishment/	100	-	Density bitumen = 0.001 t/L (IS Materials Calculator)
178	066	Little Hartley	Aluminium	Aluminium	Site Establishment	16.27	t	Aluminium	t	16.27	Site establishment/	100	-	
179	066	Little Hartley	Coatings and Finishes	Coatings and Finishes	Site Establishment	7,000.00	m2	Paint	t	7.00	Site establishment/	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
180	066	Little Hartley	WTP chemicals	WTP chemicals	Site Establishment (Entire Scope)	1,018,000.00	l	WTP chemicals	t	1,018.00	Site establishment/	100	-	Assume density WTP Chemicals = density of water = 1 t/m3
181	066	Little Hartley	Plastic Sheeting	Plastic Sheeting	Site Establishment	25,000.00	m2	uPVC sheet	t	32.25	Site establishment/	100	-	Assume PVC sheet. Assume 1mm thickness. Density = 1.29 t/m3 https://polymeracademy.com/density-of-various-plastic/
182	067	Little Hartley	Concrete	Concrete Blinding 20MPa	Dive	750.00	m3	RM 20MPa	m3	750.00	Tunnel	100	-	
183	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Dive - Temporary Slab	1,875.00	m3	RM 40MPa	m3	1,875.00	Tunnel	100	-	
184	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Dive - Temporary Works	300.00	m3	RM 40MPa	m3	300.00	Tunnel	100	-	
185	067	Little Hartley	Steel	500 MPa reinforcement	Dive All	585.00	t	Reinforcement steel bars - Australian products	t	585.00	Tunnel	100	-	
186	067	Little Hartley	Steel	250 MPa Steel	Dive - Temporary works	400.00	t	Steel pipe and tubing	t	400.00	Tunnel	100	-	
187	067	Little Hartley	Concrete	Concrete Blinding 20MPa	Ventilation Building & Structure	108.15	m3	RM 20MPa	m3	108.15	Buildings - CI	100	-	
188	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Walls and Columns	11,536.00	m3	RM 40MPa	m3	11,536.00	Buildings - CI	100	-	
189	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Suspended Slab	6,358.00	m3	RM 40MPa	m3	6,358.00	Buildings - CI	100	-	
190	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Roof Walls and Columns	1,495.20	m3	RM 40MPa	m3	1,495.20	Buildings - CI	100	-	
191	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Roof Suspended Slab	3,740.00	m3	RM 40MPa	m3	3,740.00	Buildings - CI	100	-	
192	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Ventilation Stack	18.47	m3	RM 40MPa	m3	18.47	Buildings - CI	100	-	
193	067	Little Hartley	Concrete	Concrete 40MPa Insitu	Ventilation Building & Structure - Headwalls	268.00	m3	RM 40MPa	m3	268.00	Buildings - CI	100	-	
194	067	Little Hartley	Steel	500 MPa reinforcement	Ventilation Building & Structure All	4,704.76	t	Reinforcement steel bars - Australian products	t	4,704.76	Buildings - CI	100	-	
195	067	Little Hartley	Steel	250 MPa Steel	Ventilation Building & Structure - Subs, transformers	90.00	t	Galvanised steel - Australian products	t	90.00	Buildings - CI	100	-	
196	067	Little Hartley	Steel	250 MPa Steel	Ventilation Building & Structure - Dampers	680.00	t	Galvanised steel - Australian products	t	680.00	Buildings - CI	100	-	
197	067	Little Hartley	Steel	250 MPa Steel	Ventilation Building & Structure - Temporary Works	50.00	t	Galvanised steel - Australian products	t	50.00	Buildings - CI	100	-	
198	066 & 067	Little Hartley	Piping - PVC	PVC 100mm	Ventilation Building & Structure - Power & Services Conduits	6.19	t	PVC pipes	t	6.19	Lighting and electri	20	24.76	
199	066	Little Hartley	Glass	Glass	Ventilation Building & Structure	223.20	m2	Glass	m2	223.20	Buildings - CI	100	-	
200	066	Little Hartley	Coatings and Finishes	Coatings and Finishes	Ventilation Building & Structure	6,800.00	m2	Paint	t	6.80	Buildings - CI	100	-	Assume 1mm thickness of paint. Density of paint = 1.3 t/m3 (IS Materials Calculator)
201	067	Little Hartley	Copper	Copper	Ventilation Building & Structure - Cabling	9.51	t	6mm2 Cu LV Cable	t	9.51	Lighting and electri	20	38.04	
202												#N/A	#N/A	
203												#N/A	#N/A	
204	067	Tunnel	Steel	250 MPa Steel	TBMs	5,000.00	t	Structural steel, beams and columns - Australian products	t	5,000.00	Site establishment/	100	-	
205	067	Tunnel	Steel	250 MPa Steel	TBM Backup Systems	3,600.00	t	Structural steel, beams and columns - Australian products	t	3,600.00	Site establishment/	100	-	
206	066 & 067	Tunnel	Other	Rubber, PVC, Urethane, Neoprene, Nylon, Nitrile, Polyester,	Conveyor Belt	1,337.70	t	PVC pipes	t	1,337.70	Inaccessible eleme	100	-	
207	067	Tunnel	Steel	250 MPa Steel	Conveyor Belt Frame, Supports and Idlers	6,465.55	t	Structural steel, beams and columns - Australian products	t	6,465.55	Site establishment/	100	-	
208	067	Tunnel	Steel	250 MPa Steel	Spoil Shed	160.00	t	Structural steel, hot rolled coil - Australian products	t	160.00	Embankment	100	-	
209	067	Tunnel	Steel	250 MPa Steel	Ventilation Fans	28.80	t	Galvanised steel - Australian products	t	28.80	Inaccessible eleme	100	-	
210	067	Tunnel	Steel	250 MPa Steel	Ventilation Frames	12.00	t	Galvanised steel - Australian products	t	12.00	Inaccessible eleme	100	-	
211	067	Tunnel	Steel	250 MPa Steel	Ventilation Ducting	56.00	t	Galvanised steel - Australian products	t	56.00	Inaccessible eleme	100	-	
212	066 & 067	Tunnel	Other	PVC	Ventilation Ventilation Bag	140.23	t	PVC pipes	t	140.23	Inaccessible eleme	100	-	
213	067	Tunnel	Concrete	Concrete 40MPa Precast	TBM Segment	522,023.41	m3	PC 40MPa	m3	522,023.41	Tunnel	100	-	
214	067	Tunnel	Concrete	Concrete 2MPa	TBM Grouting	49,079.30	m3	RM 20MPa	m3	49,079.30	Tunnel	100	-	
215	066 & 067	Tunnel	Other	Rubber	TBM segment gaskets	1,077.27	t	PVC pipes	t	1,077.27	Inaccessible eleme	100	-	
216	067	Tunnel	Steel	250 MPa Steel	TBM Steel Ramps	200.00	t	Structural steel, beams and columns - Australian products	t	200.00	Site establishment/	100	-	
217	067	Tunnel	Steel	250 MPa Steel	Temporary Works	177.13	t	Galvanised steel - Australian products	t	177.13	Site establishment/	100	-	
218	067	Tunnel	Concrete	Concrete 40MPa Precast	Back End Works - Invert Stone	42,084.90	m3	PC 40MPa	m3	42,084.90	Inaccessible eleme	100	-	
219	067	Tunnel	Concrete	Concrete 40MPa Precast	Back End Works - Services Pit & Drainage Pits	371.96	m3	PC 40MPa	m3	371.96	Inaccessible eleme	100	-	
220	067	Tunnel	Concrete	Concrete 40MPa Precast	Back End Works - Drainage Pipe	2,070.01	m3	PC 40MPa	m3	2,070.01	Inaccessible eleme	100	-	
221	067	Tunnel	Concrete	Concrete 8MPa Insitu	Back End Works - Flowable Fill	160,900.35	m3	RM 20MPa	m3	160,900.35	Inaccessible eleme	100	-	
222	066 & 067	Tunnel	Piping - Low Smoke Zero Halogen	LSZH 150mm	Ventilation Building & Structure - Power & Services Conduits	2,775.05	t	PVC pipes	t	2,775.05	Inaccessible eleme	100	-	
223	067	Tunnel	Concrete	Concrete 10MPa Insitu	Back End Works - RCC	62,447.19	m3	RM 20MPa	m3	62,447.19	Inaccessible eleme	100	-	
224	067	Tunnel	Concrete	Concrete 40MPa Insitu	Back End Works - CRCP	61,108.13	m3	RM 40MPa	m3	61,108.13	Inaccessible eleme	100	-	
225	067	Tunnel	Concrete	Concrete 40MPa Insitu	Back End Works - Barriers	11,902.80	m3	RM 40MPa	m3	11,902.80	Inaccessible eleme	100	-	
226	067	Tunnel	Steel	250 MPa Steel	Back End Works - Architectural Frames	834.74	t	Structural steel, beams and columns - Australian products	t	834.74	Inaccessible eleme	100	-	
227	067	Tunnel	Other	Compressed Fibre Cement	Back End Works - Architectural Panels	127,530.00	m2	Cement Fibreboard	t	4,591.08	Inaccessible eleme	100	-	Assume 20mm thick. Assume 1.8 t/m3 (http://cdn.ardexaustralia.com/nzpdf/Technical%20Bulletins/TP004.004_FCSheetPropertiesForTiles.pdf
228	067	Tunnel	Steel	250 MPa Steel	Ventilation Fans & Hangers	242.00	t	Galvanised steel - Australian products	t	242.00	Inaccessible eleme	100	-	
229	067	Tunnel	Steel	250 MPa Steel	Cabble Trays 600mm	1,700.40	t	Galvanised steel - Australian products	t	1,700.40	Lighting and electri	20	6,801.60	
230	067	Tunnel	Steel	250 MPa Steel	Cabble Trays 300mm	265.69	t	Galvanised steel - Australian products	t	265.69	Lighting and electri	20	1,062.75	
231	067	Tunnel	Steel	250 MPa Steel	Deluge Pipes 350mm	1,278.68	t	Steel pipe and tubing	t	1,278.68	Inaccessible draina	100	-	
232	067	Tunnel	Steel	250 MPa Steel	Deluge Distribution Pipes 150mm	3,964.40	t	Steel pipe and tubing	t	3,964.40	Inaccessible draina	100	-	
233	067	Tunnel	Steel	250 MPa Steel	Hydrant Pipes 200mm	779.04	t	Steel pipe and tubing	t	779.04	Inaccessible eleme	100	-	
234	067	Tunnel	Copper	Copper	HV - Copper	327.80	t	1600mm2 Cu HV Cable	t	327.80	Lighting and electri	20	1,311.20	
235	067	Tunnel	Copper	Copper	LV - Copper	43.56	t	6mm2 Cu LV Cable	t	43.56	Lighting and electri	20	174.24	
236	067	Tunnel	Other	PVC	Cross Passage - Waterproofing	84.15	t	PVC pipes	t	84.15	Inaccessible eleme	100	-	
237	067	Tunnel	Concrete	Concrete 40MPa Insitu	Cross Passage - Lining	22,724.39	m3	RM 40MPa	m3	22,724.39	Tunnel	100	-	
238	067	Tunnel	Steel	250 MPa Steel	Cross Passage - Deluge Manifolds	12.04	t	Steel pipe and tubing	t	12.04	Accessible drainag	40	24.08	
239	067	Tunnel	Copper	Copper	Cross Passage - Earthing Rods	5.85	t	1600mm2 Cu HV Cable	t	5.85	Lighting and electri	20	23.39	
240	067	Tunnel	Steel	250 MPa Steel	Cross Passage - Doors	8.60	t	Structural steel, plate - Australian products	t	8.60	Accessible drainag	40	17.20	
241	067	Tunnel	Other	PVC	Substations - Waterproofing	41.33	t	PVC pipes	t	41.33	Inaccessible eleme	100	-	
242	067	Tunnel	Concrete	Concrete 40MPa Insitu	Substations - Lining	7,132.31	m3	RM 40MPa	m3	7,132.31	Buildings - CI	100	-	
243	067	Tunnel	Steel	250 MPa Steel	Substations - Substations	60.00	t	Galvanised steel - Australian products	t	60.00	Buildings - CI	100	-	
244												#N/A	#N/A	
245												#N/A	#N/A	
246	067	Roadworks	Concrete	Concrete 40MPa precast	Stormwater Drainage - RCP 600mm DIAM	821.10	m3	PC 40MPa	m3	821.10	Inaccessible draina	100	-	
247	067	Roadworks	Concrete	Concrete 40MPa precast	Stormwater Drainage - Pits SO	176.45	m3	PC 40MPa	m3	176.45	Inaccessible draina	100	-	
248	067	Roadworks	Concrete	Concrete 40MPa Insitu	Kerbs and Gutters - SO	1,185.15	m3	RM 40MPa	m3	1,185.15	Pavement - main c	40	2,370.30	
249	067	Roadworks	Concrete	Concrete 40MPa Insitu	Kerbs and Gutters - No Fines	775.17	m3	RM 40MPa	m3	775.17	Pavement - main c	40	1,550.34	
250	066 & 067	Roadworks	Piping - PVC	PVC 100mm	Trench Drains - Drainage Pipe	9.75	t	PVC pipes	t	9.75	Lighting and electri	20	38.98	
251	067	Roadworks	Aggregates	DGB20	Trench Drains - Aggregate	1,607.76	m3	Coarse aggregates	m3	1,607.76	Inaccessible draina	100	-	
252	067	Roadworks	Concrete	Concrete 40MPa Insitu	Pavement	823.41	m3	RM 40MPa	m3	823.41	Pavement - main c	40	1,646.81	
253	067	Roadworks	Aggregates	DGB20	Pavement	499.56	m3	Coarse aggregates	m3	499.56	Pavement - main c	40	999.11	
254	067	Roadworks	Concrete	Concrete 40MPa precast	Reinforced Soil Walls - Precast Barrier panels	82.00	m3	PC 40MPa	m3	82.00	Embankment	100	-	
255	067	Roadworks	Steel	250 MPa Steel	Reinforced Soil Walls - Handrail	3.51	t	Galvanised steel - Australian products	t	3.51	Buildings - CI	100	-	
256	067	Roadworks	Steel	500 MPa Steel	Soil Nailing - Nails	113.60	t	Reinforcement steel bars - Australian products	t	113.60	Embankment	100	-	
257	067	Roadworks	Steel	250 MPa Steel	Soil Nailing - Handrail	8.32	t	Galvanised steel - Australian products	t	8.32	Embankment	100	-	
258	067	Roadworks	Concrete	Concrete 40MPa Shotcrete	Soil Nailing - Concrete	6,621.69	m3	RM 40MPa	m3	6,621.69	Embankment	100	-	
259	066	Roadworks	Sprayed Bitumen	Class 170	Pavement - Sprayed Bitumen	87,103.32	l	Bitumen	t	87.10	Pavement - main c	40	174.21	Density bitumen = 0.001 t/L (IS Materials Calculator)
260	067	Roadworks	Asphalt	AC20	Pavement - Asphalt	17,376.79	m3	Hot mix asphalt, 0% RAP (5.5% bitumen)	m3	17,376.79	Pavement - main c	40	34,753.58	
261	067	Roadworks	Asphalt	AC14	Pavement - Asphalt	3,777.56	m3	Hot mix asphalt, 0% RAP (5.5% bitumen)	m3	3,777.56	Pavement - main c	40	7,555.13	
262	067	Roadworks	Other	Timber	Signposts	0.43	m3	Timber, Structural (softwood)	m3	0.43	Timber furniture	30	1.29	
263	067	Roadworks	Steel	250 MPa Steel	Post and Rail Safety Barriers	575.57	t	Galvanised steel - Australian products	t	575.57	Sign supports and	50	575.57	
264	067	Roadworks	Steel	250 MPa Steel	Wire Rope Safety	56.36	t	Galvanised steel - Australian products	t	56.36	Site establishment/	100	-	
265	066	Roadworks	Concrete	Concrete 40MPa Insitu	Concrete	568.46	m3	RM 40MPa	m3	568.46	Pavement - main c	40	1,136.92	
266	067	Roadworks	Steel	250 MPa Steel	Signposts	1.33	t	Galvanised steel - Australian products	t	1.33	Sign supports and	50	1.33	
267	067	Roadworks	Steel	250 MPa Steel	Signs	2.41	t	Galvanised steel - Australian products	t	2.41	Sign faces	10	21.70	
268	066	Roadworks	Coatings and Finishes	Thermoplastic	Thermoplastic Line Marking	29,743.65	l	Paint	t	38.67	Sign supports and	50	38.67	Density of paint = 1.3 t/m3 (IS Materials Calculator)
269	066 & 067	Roadworks	Piping - PVC	PVC 100mm	Street Lighting	13.06	t	PVC pipes	t	13.06	Lighting and electri	20	52.26	
270	066	Roadworks	Concrete	Concrete 40MPa Precast	Cable Pits	33.50	m3	PC 40MPa	m3	33.50	Inaccessible eleme	100	-	
271	066	Roadworks	Concrete	Concrete 40MPa Insitu	Street Lighting Plinth	521.85	m3	RM 40MPa	m3	521.85	Sign supports and	50	521.85	
272	066	Roadworks	Steel	250 MPa Steel	Street Lighting Column	64.43	t	Galvanised steel - Australian products	t	64.43	Sign supports and	50	64.43	
273	067	Roadworks	Copper	Copper	Street Lighting Cabling	3.75	t	6mm2 Cu LV Cable	t	3.75	Lighting and electri	20	15.00	
274	067	Roadworks	Aggregates	DGB20	Cableway	298.58	m3	Coarse aggregates	m3	298.58	Inaccessible eleme	100	-	
275	066 & 067	Roadworks	Piping - PVC	PVC 100mm	Cableway	10.34	t	PVC pipes	t	10.34	Lighting and electri	20	41.36	
276	066 & 067	Roadworks	Piping - PVC	PVC 100mm	Cableway	10.34	t	PVC pipes	t	10.34	Lighting and electri	20	41.36	
277	066	Roadworks	Concrete	Concrete 40MPa Precast	Cableway	6.81	m3	PC 40MPa	m3	6.81	Inaccessible eleme	100	-	
278	066	Roadworks	Steel	250 MPa Steel	Security Fence	190.99	t	Galvanised steel - Australian products	t	190.99	Fences	20	763.98	
279	066	Roadworks	Concrete	Concrete 40MPa Insitu	Security Fence Footing	257.06	m3	RM 40MPa	m3	257.06	Fences	20	1,028.23	
280	066	Roadworks	Concrete	Concrete 40MPa Insitu	Bridges	-	m3	RM 40MPa	m3	-	Bridge structures	100	-	
281	066	Roadworks	Steel	250 MPa Steel	Bridges	-	t	Structural steel, beams and columns - Australian products	t	-	Bridge structures	100	-	
												#N/A	#N/A	

35,000.00
35.00
7.00

824.8
1250
0.65984 t CO2/t chem

23.09

Source: "220802 - EA Information - RFI068 R1 (1).pdf"				
ITEM	kW	Diversity over life	Operation hours	Power useage over life (MWh)
TBMs running	30,000	0.65	19655.4	383,280.4
TBMs idle	1,500	1.00	39480.6	59,220.9
Conveyors running	3,500	0.65	19655.4	44,716.1
Conveyors idle	1,167	0.65	39480.6	29,939.4
Main ventilation fans	1,800	0.50	59136.0	53,222.4
Back end works	1,000	0.50	59136.0	29,568.0
Emergency pumps	600	0.02	59136.0	709.6
Misc	500	0.50	59136.0	14,784.0
Cross passage operation	400	0.50	30744.0	6,148.8
Air compressors	400	0.20	59136.0	4,730.9
Cranes	400	0.50	8928.0	1,785.6
Office, crib and workshop	400	0.40	48180.0	7,708.8
Cooling water system	350	0.60	19655.4	4,127.6
Tunnel Lights	300	0.50	64896.0	9,734.4
Water system	250	0.60	59136.0	8,870.4
Pumps	200	0.80	59136.0	9,461.8
Grout system	150	0.60	59136.0	5,322.2
			Total	**673,331.3**

National Greenhouse Accounts Factors: 2021						
Table 46: Scope 2 and 3 emissions factors – consumption of purchased electricity by end users						
Financial year	**EF for scope 2**		**EF for scope 3**		**Full fuel cycle EF (EF for scope 2 + EF**	
	A	**B**	**C**	**D**	**E**	**F**
	kg CO_2-e/kWh	**kg CO_2-e/GJ**	**kg CO_2-e/kWh**	**kg CO_2-e/GJ**	**kg CO_2-e/kWh**	**kg CO_2-e/GJ**
NEW SOUTH WALES and AUSTRALIAN CAPITAL TERRITORY						
Latest estimate*	0.78	216	0.07	19	0.85	236

Component	SUB-01	SUB-02	SUB-03	SUB-04	SUB-05	SUB-06	SUB-07	SUB-08	Total	Diversity ove	Hours/day	kWh/day
Tunnel Lighting	159.6	59.1	54.52	57.65	54.16	54.52	54.52	122.18	616.22	1	24	14789.28
Base Level Lights (kW)	27.61	48.36	44.61	47.11	44.3	44.61	44.61	30.42	331.63	1	24	7959.12
Transition (Boost) Lights W	122.4							5.1	127.5	1	24	3060
Transition (Boost) Lights El	3.52							80.17	83.69	1	24	2008.56
Cross Passage Lighting	1.61	2.99	2.76	2.99	2.76	2.76	2.76	1.61	20.24	1	24	485.76
Other tunnel lighting (Emer	4.43	7.75	7.15	7.55	7.1	7.15	4.88		46.01	1	24	1104.24
Drainage (kW)	200						28		228	0.8	6	1094.4
Ventilation	3778	1666.67	1333.33	1666.67	1500	1500	1666.67	3777.78	16888.9	0.5	24	202666.8
Axial Fans	2778						2777.78		5555.56	0.5	24	66666.72
Jet Fans (Uphill)	666.7	1166.67	1000	1166.67	1000	1000	166.67	666.67	6833.35	0.5	24	82000.2
Jet Fans (Downhill)	333.3	500	333.33	500	500	500	500	333.33	3499.99	0.5	24	41999.88
Control Centre (kW)	266								266	0.4	24	2553.6
Backup Control Centre								50	50	0.02	24	24
Workshop	151.2								151.2	0.4	12	725.76
Water Treatment								162	162	0.6	24	2332.8
Fire pumps	400								400	0.02	24	192
General Substation and Pla	20	20	20	20	20	20	20	20	160	1	24	3840
ITS/Comms	61.35	101.45	94	101.45	94	94	94	61.35	701.6	1	24	16838.4
Electrical XP ITS/Comms	19.6	36.4	33.6	36.4	33.6	33.6	33.6	19.6	246.4	1	24	5913.6
Non-Electrical XP ITS/Com	32.55	60.45	55.8	60.45	55.8	55.8	55.8	32.55	409.2	1	24	9820.8
Tunnel Sub ITS/Comms	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	36.8	1	24	883.2
Portal Sub ITS/Comms	4.6							4.6	9.2	1	24	220.8

Maximum Demand

A preliminary maximum demand estimate has been prepared for the tunnel and summarised in table below.

Table 17 → Maximum Demand

	SUB-01	SUB-02	SUB-03	SUB-04	SUB-05	SUB-06	SUB-07	SUB-08	Note Ref
Tunnel Lighting	159.57	59.10	54.52	57.65	54.16	54.52	54.52	122.18	
Base Level Lights (kW)	27.61	48.36	44.61	47.11	44.30	44.61	44.61	30.42	1.
Transition (Boost) Lights WB (kW)	122.40							5.10	
Transition (Boost) Lights EB (kW)	3.52							80.17	
Cross Passage Lighting	1.61	2.99	2.76	2.99	2.76	2.76	2.76	1.61	2.
Other tunnel lighting (Emergency, signage, plant room lighting, etc.) (kW)	4.43	7.75	7.15	7.55	7.10	7.15	7.15	4.88	3.
Drainage (kW)	200.00							28.00	4.
Ventilation (kW)	3,777.78	1,666.67	1,333.33	1,666.67	1,500.00	1,500.00	1,666.67	3,777.78	
Axial Fans (kW)	2,777.78							2,777.78	5.
Jet Fans (Uphill) (kW)	666.67	1,166.67	1,000.00	1,166.67	1,000.00	1,000.00	1,166.67	666.67	6
Jet Fans (Downhill) (kW)	333.33	500.00	333.33	500.00	500.00	500.00	500.00	333.33	7.
Control Centre (kW)	266.00								8.

Civil Diesel Quantities

Source document: Diesel estimate provided by TA - "BAM-RFI-GWHU-070-R2-REDUCED-SCOPE.xlsx"
Based on 20% Concept Construction Program and 80% concept design high level changes

	Total diesel quantity (L)
Mobile Plant	2072556
Stationary Plant	19624

Pavement - main carriageway
Buildings - free standing
Accessible drainage elements
Noise barriers
Buildings - CI
Pavement - local roads
Site establishment/temporary works
Lighting and electrical equipment
Inaccessible drainage elements
Tunnel
Sign supports and road furniture
Inaccessible elements
Retaining Walls
0
Embankment
Timber furniture
Sign faces
Fences
Bridge structures

Activity **Quarter**

					Start Date	1-Jan-22	1-Apr-22	1-Jul-22	1-Oct-22	1-Jan-23	1-Apr-23	1-Jul-23	1-Oct-23	1-Jan-24	1-Apr-24	1-Jul-24	1-Oct-24	1-Jan-25	1-Apr-25	1-Jul-25	1-Oct-25	1-Jan-26	1-Apr-26	1-Jul-26	1-Oct-26	1-Jan-27	1-Apr-27	1-Jul-27	1-Oct-27	1-Jan-28	1-Apr-28	1-Jul-28	1-Oct-28	1-Jan-29	1-Apr-29	1-Jul-29	1-Oct-29	1-Jan-30	1-Apr-30	1-Jul-30	1-Oct-30	1-Jan-31	1-Apr-31	1-Jul-31	1-Oct-31	Total	Type
					End Date	1-Apr-22	1-Jul-22	1-Oct-22	1-Jan-23	1-Apr-23	1-Jul-23	1-Oct-23	1-Jan-24	1-Apr-24	1-Jul-24	1-Oct-24	1-Jan-25	1-Apr-25	1-Jul-25	1-Oct-25	1-Jan-26	1-Apr-26	1-Jul-26	1-Oct-26	1-Jan-27	1-Apr-27	1-Jul-27	1-Oct-27	1-Jan-28	1-Apr-28	1-Jul-28	1-Oct-28	1-Jan-29	1-Apr-29	1-Jul-29	1-Oct-29	1-Jan-30	1-Apr-30	1-Jul-30	1-Oct-30	1-Jan-31	1-Apr-31	1-Jul-31	1-Oct-31	1-Jan-32		
	Calendar Days					90	91	92	92	90	91	92	92	91	91	92	92	90	91	92	92	90	91	92	92	90	91	92	92	91	91	92	92	90	91	92	92	90	91	92	92	90	91	92	92		
	Working Days					58	63	69	62	58	63	69	62	59	63	69	62	58	63	69	62	58	63	69	62	58	63	69	62	59	63	69	62	58	63	69	62	58	63	69	62	58	63	69	62		
	Working Days Ratio					0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68		
	Day Shift Hours					10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10		
	Day + Night Shift Hours					20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
Blackheath																																														Total	Type
	Earthworks																																														
Blackheath	Wood chipper / Chainsaws - clearing	1		1/06/2026	1/07/2026																		6,181																							6,181	Mobile Plant
Blackheath	30t Excavator c/w rock hammer	1		1/06/2026	1/01/2027																		2,967	9,977	8,969																					#####	Mobile Plant
Blackheath	20t Excavator c/w rock hammer	1		1/06/2026	1/01/2027																		1,978	6,651	5,979																					#####	Mobile Plant
Blackheath	30t Off Road Dump trucks	2		1/06/2026	1/01/2027																		7,220	24,280	21,826																					#####	Mobile Plant
Blackheath	D9 Dozer	1																																													Mobile Plant
Blackheath	Grader	1		1/06/2026	1/08/2027																		2,909	9,780	8,792	8,138	8,813	3,289																		#####	Mobile Plant
Blackheath	CAT825 Compactor	1		1/06/2026	1/01/2027																		5,935	19,879	18,792																					#####	Mobile Plant
Blackheath	15t Vibrating Pad foot roller	1		1/06/2026	1/01/2027																		5,666	19,054	17,129																					#####	Mobile Plant
Blackheath	12t Vibrating smooth drum roller	1		1/06/2026	1/08/2027																		4,533	15,243	13,703	12,697	13,750	5,136																		#####	Mobile Plant
Blackheath	Road tip trucks		Per Traffic Spreadsheet																																												Mobile Plant
Blackheath	12,000lt water cart (road based)	1		1/06/2026	1/08/2027																		5,151	17,321	15,571	14,429	15,625	5,837																		#####	Mobile Plant
	Bored Piling																																														
Cut&Cover	Soilmec SR-45 or similar	2		1/09/2024	26/08/2025											8,134	22,423	20,777	22,500	15,183																										#####	Mobile Plant
Cut&Cover	Mobile Crane	1		1/09/2024	26/08/2025											2,858	7,879	7,301	7,906	5,335																										#####	Mobile Plant
Entry Ramp	Soilmec SR-45 or similar	2		1/06/2026	28/09/2026																		7,418	24,130																						#####	Mobile Plant
Entry Ramp	Mobile Crane	1		1/06/2026	28/09/2026																		2,606	8,479																						#####	Mobile Plant
	Soil Nailing																																														
Cut&Cover	Soil nail drill rig eg. BBURG HD910	1		31/08/2025	1/06/2026															1,564	4,173	3,867	2,807																							#####	Mobile Plant
Cut&Cover	Concrete pump for shotcreting	1		31/08/2025	1/06/2026															1,167	3,114	2,886	2,095																							9,262	Mobile Plant
Cut&Cover	Mobile Crane	1		31/08/2025	1/06/2026															2,953	7,879	7,301	5,300																							#####	Mobile Plant
Entry Ramp	Soil nail drill rig eg. BBURG HD910	1		30/09/2026	29/12/2026																			50	4,037																					4,088	Mobile Plant
Entry Ramp	Concrete pump for shotcreting	1		30/09/2026	29/12/2026																			38	3,013																					3,050	Mobile Plant
Entry Ramp	Mobile Crane	1		30/09/2026	29/12/2026																			95	7,622																					7,717	Mobile Plant
	Reinforced Soil Structure (Retaining Walls)																																														
RSS Walls	20t Excavators	2		1/06/2026	1/01/2027																		3,956	13,303	11,959																					#####	Mobile Plant
RSS Walls	Franna Crane	1		1/06/2026	1/01/2027																		1,792	6,024	5,416																					#####	Mobile Plant
RSS Walls	12 Roller + small tools	1		1/06/2026	1/01/2027																		2,266	7,621	6,851																					#####	Mobile Plant
	Concrete Works																																														
Cut&Cover	Generators, powersaws	1		31/08/2025	1/06/2026															1,681	4,485	4,155	3,016																							#####	Stationary Plant
Cut&Cover	Jackhammer, compressors	1		31/08/2025	1/06/2026															244	651	603	438																							1,936	Mobile Plant
Entry Ramp	Generators, powersaws	1		30/09/2026	29/12/2026																			54	4,338																					4,393	Stationary Plant
Entry Ramp	Jackhammer, compressors	1		30/09/2026	29/12/2026																			8	630																					638	Mobile Plant
	Drainage																																														
	20t Excavator c/w rock hammer	1		1/06/2026	1/01/2027																		989	3,326	2,990																					7,304	Mobile Plant
	Concrete Saw		Periodic Need																																												Mobile Plant
	Rock saw - cutting sandstone		Periodic Need																																												Mobile Plant
	Small compaction equipment	1		1/06/2026	1/01/2027																		1,813	6,097	5,481																					#####	Mobile Plant
	Road pavements																																														
	Grader		As noted in earthworks																																												Mobile Plant
	15t Vibrating smooth drum roller	0.5		1/05/2025	3/05/2027														1,383	2,286	2,055	1,905	2,063	2,286	2,055	1,905	725																			#####	Mobile Plant
	Bobcat	0.5		1/05/2025	3/05/2027														693	1,145	1,030	954	1,033	1,145	1,030	954	363																			8,347	Mobile Plant
	Asphalting																																														
	Asphalt profiler	1		30/07/2025	1/08/2027															493	648	600	650	721	648	600	650	243																		5,253	Mobile Plant
	Paver	1		30/07/2025	1/08/2027															334	438	406	439	487	438	406	439	164																		3,551	Mobile Plant
	Asphalt delivery		As req.																																												Mobile Plant
	12t Vibrating smooth drum roller	1		30/07/2025	1/08/2027															522	685	635	688	762	685	635	688	257																		5,556	Mobile Plant
	Misc Plant																																														
	Road sawing		Periodic Need																																												Mobile Plant
	Electric Rattle guns		Periodic Need																																												Mobile Plant
	MEWP's (scissor lifts or knuckle boom lifts)	2		1/06/2027	1/08/2028																						511	1,718	1,545	1,451	1,550	579														7,354	Mobile Plant
	Cranes - 100t or franna or	1		1/06/2027	1/08/2028																						4,170	14,023	12,607	11,840	12,650	4,725														#####	Mobile Plant
	Lighting Plants - periodically		Periodic Need																																												Mobile Plant
	Front end loader-IT28 or Cat924 or similar	1		1/06/2026	1/08/2028																		1,484	4,989	4,485	4,155	4,500	4,989	4,485	4,212	4,500	1,681														#####	Mobile Plant
Mid point Shaft																																															
	Site Establishment incl. road widening																																														
Site Est	Wood chipper / Chainsaws - clearing	1		1/07/2024	31/07/2024											6,778																														6,778	Mobile Plant
Site Est	30t Excavator c/w rock hammer	1		1/07/2024	1/12/2024											7,483	4,460																													#####	Mobile Plant
Site Est	D6 Dozer	1		1/07/2024	1/12/2024											6,319	3,766																													#####	Mobile Plant
Site Est	Grader	1		1/07/2024	1/12/2024											4,885	2,912																													7,796	Mobile Plant
Site Est	15t Vibrating Pad foot roller	1		1/07/2024	1/12/2024											7,621	4,543																													#####	Mobile Plant
Site Est	12t Vibrating smooth drum roller	1		1/07/2024	1/12/2024											6,097	3,634																													9,731	Mobile Plant
Site Est	Road tip trucks		Per Traffic Spreadsheet																																												Mobile Plant
Site Est	12,000lt water cart (road based)	1		1/07/2024	31/07/2024											4,519																														4,519	Mobile Plant
	Road pavements																																														
Site Est	Grader		As noted in earthworks																																												Mobile Plant
Site Est	15t Vibrating smooth drum roller	0.5		1/07/2024	1/12/2024											1,732	1,032																													2,765	Mobile Plant
Site Est	Bobcat	0.5		1/07/2024	1/12/2024											764	455																													1,219	Mobile Plant
	Misc Plant																																														
Misc	Front end loader-IT28 or Cat924 or similar	1		1/07/2024	1/09/2026											4,989	4,485	4,155	4,500	4,989	4,485	4,155	4,500	3,362																						#####	Mobile Plant
	Bored Piling																																														
Shaft	Soilmec SR-45 or similar	2		1/08/2024	30/10/2024											16,538	7,068																													#####	Mobile Plant
Shaft	Mobile Crane	1		1/08/2024	30/10/2024											5,811	2,484																													8,295	Mobile Plant
	Concrete Works to upper 20m																																														
Shaft	Generators, powersaws	1		30/09/2024	30/10/2024											54	1,414																													1,468	Stationary Plant
Shaft	Jackhammer, compressors	1		30/09/2024	30/10/2024											16	410																													426	Stationary Plant
Little Hartley																																															
	Earthworks																																															
Stage 1	Wood chipper / Chainsaws - clearing	1																																													Mobile Plant
Stage 1	30t Excavator c/w rock hammer	2																																													Mobile Plant
Stage 1	Misc Excavators - 20t	2																																													Mobile Plant
Stage 1	D9 Dozer	1																																													Mobile Plant
Stage 1	D6 Dozer	1																																													Mobile Plant
Stage 1	45t Excavator c/w rock hammer	1																																													Mobile Plant
Stage 1	40t Off Road Dump trucks	3																																													Mobile Plant
Stage 1	Grader																																														Mobile Plant
Stage 1	CAT825 Compactor	1																																													Mobile Plant
Stage 1	15t Vibrating Pad foot roller	1																																													Mobile Plant
Stage 1	12t Vibrating smooth drum roller	1																																													Mobile Plant
Stage 1	Watercart																																														Mobile Plant
Stage 2	30t Excavator c/w rock hammer	1		31/12/2024	28/02/2025												122	6,695																												6,817	Mobile Plant

Stage 2	Grader		See below																																											Mobile Plant
Stage 2	15t Vibrating Pad foot roller	1	31/12/2024	28/02/2025												186	10,228																												#####	Mobile Plant
Stage 2	12t Vibrating smooth drum roller	1	31/12/2024	28/02/2025												149	8,183																												8,332	Mobile Plant
Stage 2	Watercart		See below																																											Mobile Plant
Stage 3	30t Excavator c/w rock hammer	1	1/07/2027	1/08/2027																								2,101																	2,101	Mobile Plant
Stage 3	Grader	1	See below																																											Mobile Plant
Stage 3	15t Vibrating Pad foot roller	1	1/07/2027	1/08/2027																								6,420																	6,420	Mobile Plant
Stage 3	12t Vibrating smooth drum roller	1	1/07/2027	1/08/2027																								4,109																	4,109	Mobile Plant
Stage 3	Watercart		See below																																											Mobile Plant
Stage 4	30t Excavator c/w rock hammer	1	1/10/2029	30/12/2029																																	5,484								5,484	Mobile Plant
Stage 4	Grader	1	See below																																											Mobile Plant
Stage 4	15t Vibrating Pad foot roller	1	1/10/2029	30/12/2029																																	16,756								#####	Mobile Plant
Stage 4	12t Vibrating smooth drum roller	1	1/10/2029	30/12/2029																																	10,724								#####	Mobile Plant
Stage 4	Watercart		See below																																											Mobile Plant
Stage 4	Misc small plant	1	1/10/2029	30/12/2029																																	5,484								5,484	Mobile Plant
Stage 5	20t Excavator c/w rock hammer	1	1/01/2030	1/03/2030																																		2,270							2,270	Mobile Plant
Stage 5	Grader	1	See below																																											Mobile Plant
Stage 5	Misc small plant	1	1/01/2030	1/03/2030																																		3,405							3,405	Mobile Plant
Stage 5	Watercart		See below																																											Mobile Plant
Various loc'ns	Grader	1	30/09/2022	1/08/2027			106	8,782	8,138	8,813	9,769	8,782	8,249	8,813	9,769	8,782	8,138	8,813	9,769	8,782	8,138	8,813	9,769	8,782	8,138	8,813	3,292																		#####	Mobile Plant
Various loc'ns	12,000lt water cart (road based)	1	30/09/2022	1/08/2027			188	15,571	14,429	15,625	17,321	15,571	14,625	15,625	17,321	15,571	14,429	15,625	17,321	15,571	14,429	15,625	17,321	15,571	14,429	15,625	5,837																		#####	Mobile Plant
Various loc'ns	Grader	1	1/08/2027	1/03/2030																							1,943	2,635	2,475	2,644	2,931	2,635	2,441	2,644	2,931	2,635	1,600								#####	Mobile Plant
Various loc'ns	12,000lt water cart (road based)	1	1/08/2027	1/03/2030																							3,445	4,671	4,388	4,688	5,196	4,671	4,329	4,688	5,196	4,671	2,838								#####	Mobile Plant
	Bridge Construction																																													
Local Rd Bridge	Soilmec SR-45 or similar	1																																												Mobile Plant
Local Rd Bridge	Mobile Crane	1																																												Mobile Plant
Local Rd Bridge	Concrete works	1																																												Mobile Plant
Local Rd Bridge	Mobile Crane	1																																												Mobile Plant
Local Rd Bridge	Concrete pump for pouring elements	1																																												Stationary Plant
	Soil Nailing																																													
Tunnel Ent.	Soil nail drill rig eg. BBURG HD910	1	1/09/2024	1/05/2025											1,514	4,173	3,867	1,380																											#####	Mobile Plant
Tunnel Ent.	Concrete pump for shotcreting	1	1/09/2024	1/05/2025											1,130	3,114	2,886	1,030																											8,160	Mobile Plant
Tunnel Ent.	Mobile Crane	1	1/09/2024	1/05/2025											2,858	7,879	7,301	2,606																											#####	Mobile Plant
	Reinforced Soil Structure (Retaining Wall																																													
RSS Walls	20t Excavators	2																																												Mobile Plant
RSS Walls	Franna Crane	1																																												Mobile Plant
RSS Walls	12 Roller + small tools	1																																												Mobile Plant
	Drainage																																													
Road Drainage	20t Excavator c/w rock hammer	1	30/09/2022	31/12/2024			36	2,990	2,770	3,000	3,326	2,990	2,808	3,000	3,326	2,957																													#####	Mobile Plant
Road Drainage	Concrete Saw		Periodic Need																																											Mobile Plant
Road Drainage	Small compaction equipment	1	30/09/2022	31/12/2024			66	5,481	5,079	5,500	6,097	5,481	5,148	5,500	6,097	5,422																													#####	Mobile Plant
	Loader - CAT906 type size	1	30/09/2022	31/12/2024			72	5,979	5,541	6,000	6,651	5,979	5,616	6,000	6,651	5,914																													#####	Mobile Plant
	Road pavements																																													
	Grader		As noted in earthworks																																											Mobile Plant
	15t Vibrating smooth drum roller	0.5	30/09/2023	1/08/2027							38	3,114	2,925	3,125	3,464	3,114	2,886	3,125	3,464	3,114	2,886	3,125	3,464	3,114	2,886	3,125	1,167																		#####	Mobile Plant
	Bobcat	0.5	30/09/2023	1/08/2027							4	343	322	344	382	343	318	344	382	343	318	344	382	343	318	344	129																		5,305	Mobile Plant
	Asphalting																																													
	Asphalt profiler	1	29/09/2024	1/08/2027											16	648	600	650	721	648	600	650	721	648	600	650	243																		7,394	Mobile Plant
	Paver	1	29/09/2024	1/08/2027											21	876	811	879	974	876	811	879	974	876	811	879	328																		9,996	Mobile Plant
	Asphalt delivery		As req.																																											Mobile Plant
	12t Vibrating smooth drum roller	1	29/09/2024	1/08/2027											33	1,370	1,270	1,375	1,524	1,370	1,270	1,375	1,524	1,370	1,270	1,375	514																		#####	Mobile Plant
	Misc Plant																																													
	Road sawing		Periodic Need																																											Mobile Plant
	MEWP's (scissor lifts or knuckle boom lifts)	2	1/11/2029	3/03/2030																																	1,024	970							1,994	Mobile Plant
	Cranes - 100t or franna or …….	1	31/10/2029	1/06/2030																																	6,372	8,761	6,360						#####	Mobile Plant
	Lighting Plants - periodically		Periodic Need																																											Mobile Plant
	Front end loader-IT28 or Cat924 or similar	1	1/09/2024	1/06/2030											3,253	8,969	8,311	9,000	9,977	8,969	8,311	9,000	9,977	8,969	8,311	9,000	9,977	8,969	8,424	9,000	9,977	8,969	8,311	9,000	9,977	8,969	8,311	6,033							#####	Mobile Plant
	TOTAL						469	38,804	35,956	38,938	43,207	42,261	39,693	42,407	140,433	136,556	108,155	81,809	82,029	69,317	64,229	127,352	248,194	210,202	80,681	90,045	75,164	34,911	32,789	35,031	25,090	16,275	15,081	16,331	18,104	62,119	28,155	12,393							#####	
	l diesel	2,092,180																																												

Tunnel Diesel Quantities

Source document: Diesel estimate provided by TA - "BAM-RFI-GWHU-070-R2-REDUCED-SCOPE.xlsx"
Based on 20% Concept Construction Program and 80% concept design high level changes

	Total diesel quantity (L)
Mobile Plant	16201823
Stationary Plant	400252
Site Vehicle	3657685

ID	Activity		Qty	Start Date	End Date	Total	Type
1				Start Date		Total	Type
2					End Date		
3		Calendar Days					
4		Working Days					
5		Working Days Ratio					
6		Day Shift Hours					
7		Day + Night Shift Hours					
8							
9							
10							
11							
12	Blackheath						
13		**TBM Retrieval**					
14		Mobile Crane 400t for TBM recovery #1	1	1/04/2029	30/05/2029	1,363	Mobile Plant
15		Mobile Crane 400t for TBM recovery #2	1	1/06/2029	31/07/2029	1,453	Mobile Plant
16		EWPs - 120ft	3	1/04/2029	31/07/2029	19,810	Mobile Plant
17		Light Vehicles	5	1/04/2029	31/07/2029	3,829	Site Vehicle
18		Telehandler	2	1/04/2029	31/07/2029	28,455	Mobile Plant
19		Forklifts	1	1/04/2029	31/07/2029	3,131	Mobile Plant
20		Franna 25t	2	1/04/2029	31/07/2029	20,717	Mobile Plant
21		Welding / Cutting	2	1/04/2029	31/07/2029		Stationary Plant
22		Small Tools - grinders, rattle guns, drills	4	1/04/2029	31/07/2029		Stationary Plant
23							
24	Mid point Shaft						
25		**Shaft Excavation**					
26		Gantry Crane 50t	1	1/09/2024	17/09/2030		Mobile Plant
27		Excavators 30t	3	1/09/2024	15/05/2025	111,983	Mobile Plant
28		Excavators 8t	1	1/09/2024	15/05/2025	16,590	Mobile Plant
29		Front End Loader - Cat 980	1	1/09/2024	24/07/2026	102,427	Mobile Plant
30		Shotcrete Rig - Jacon Midjet	1	1/09/2024	15/05/2025	8,710	Mobile Plant
31		Bolting Rig - Hutte 904	1	1/09/2024	15/05/2025	13,894	Mobile Plant
32		Handheld rock bolter and air leg	1	1/09/2024	15/05/2025		Stationary Plant
33		Shaft stage shaft ground support, waterproofing and structure	1	1/09/2024	15/05/2025		Mobile Plant
34		Alimak	1	1/01/2025	30/06/2030		Mobile Plant
35		EWP - 120ft	1	1/09/2024	15/05/2025	10,058	Mobile Plant
36		Small Tools - grinders, rattle guns, drills	4	1/09/2024	15/05/2025		Stationary Plant
37		Compressor - 450 cuf/m	1	1/09/2024	24/07/2026	198,218	Stationary Plant
38		Light Vehicles	3	1/09/2024	24/07/2026	51,214	Site Vehicle
39		Telehandler	1	1/09/2024	15/05/2025	43,341	Mobile Plant
40		Franna 25t	1	1/09/2024	15/05/2025	42,073	Mobile Plant
41							
42							
43		**Cross Cut**					
44		Roadheader - Mitsuii SLB 300	1	15/05/2025	1/08/2025		Mobile Plant
45		Excavators 30t	1	15/05/2025	1/08/2025	16,020	Mobile Plant
46		Excavators 8t	1	15/05/2025	1/08/2025	7,120	Mobile Plant
47		Front End Loader - Cat 980	1	15/05/2025	1/08/2025	4,005	Mobile Plant
48		Shotcrete Rig - Jacon Midjet	1	15/05/2025	1/08/2025	2,804	Mobile Plant
49		Bolting Rig - Robodrill	1	15/05/2025	1/08/2025	1,869	Mobile Plant
50		Drilling Rig - Sandvik	1	15/05/2025	1/08/2025	1,836	Mobile Plant
51		EWP - 85ft	1	15/05/2025	1/08/2025	2,069	Mobile Plant
52		Bobcat	1	15/05/2025	1/08/2025	6,130	Mobile Plant
53		Dump Truck - AD30	1	15/05/2025	1/08/2025	12,238	Mobile Plant
54		Underground Agi - Jacon	1	15/05/2025	1/08/2025	4,673	Mobile Plant
55		Small Tools - grinders, rattle guns, drills	4	15/05/2025	1/08/2025		Stationary Plant
56							
57		**Cavern Excavation (includes substation)**					
58		Roadheader - Mitsuii SLB 300	2	1/08/2025	24/07/2026		Mobile Plant
59		Excavators 30t	2	1/08/2025	24/07/2026	141,558	Mobile Plant
60		Excavators 8t	2	1/08/2025	24/07/2026	62,915	Mobile Plant
61		Front End Loader - Cat 980	1	1/08/2025	24/07/2026	17,695	Mobile Plant
62		Shotcrete Rig - Normet Spraymec	1	1/08/2025	24/07/2026	24,773	Mobile Plant
63		Bolting Rig - Robodrill	1	1/08/2025	24/07/2026	16,515	Mobile Plant
64		Drilling Rig - Sandvik	1	1/08/2025	24/07/2026	16,220	Mobile Plant
65		EWP - 85ft	3	1/08/2025	24/07/2026	27,427	Mobile Plant
66		Bobcat	1	1/08/2025	24/07/2026	27,083	Mobile Plant
67		Dump Truck - AD30	3	1/08/2025	24/07/2026	162,202	Mobile Plant
68		Underground Agi - Jacon	2	1/08/2025	24/07/2026	41,288	Mobile Plant
69		Small Tools - grinders, rattle guns, drills	8	1/08/2025	24/07/2026		Stationary Plant
70		Swivel Telehanlder - Dieci Pegasus 40.25	1	1/08/2025	24/07/2026	61,637	Mobile Plant
71							
72		**Cavern Waterproofing and Lining (includes substation)**					
73		Shotcrete Rig - Normet Spraymec	1	24/07/2026	14/11/2026	8,241	Mobile Plant
74		EWP - 85ft	5	24/07/2026	14/11/2026	15,206	Mobile Plant
75		Bobcat	1	24/07/2026	14/11/2026	9,009	Mobile Plant
76		Underground Agi - Jacon	2	24/07/2026	14/11/2026	13,735	Mobile Plant
77		Small Tools - grinders, rattle guns, drills	8	24/07/2026	14/11/2026		Stationary Plant
78		Swivel Telehanlder - Dieci Pegasus 40.25	1	24/07/2026	14/11/2026	20,504	Mobile Plant
79							
80		**Shaft Demobilisation & Backfill**					
81		Mobile Crane 150t for demobilisation	1	19/06/2030	17/09/2030	3,389	Mobile Plant
82		Excavators 30t	2	19/06/2030	17/09/2030	38,583	Mobile Plant
83		Excavators 8t	1	19/06/2030	17/09/2030	8,574	Mobile Plant
84		Bogie Truck	1	19/06/2030	17/09/2030	8,574	Mobile Plant
85		Dump Truck - AD30	1	19/06/2030	17/09/2030	23,578	Mobile Plant
86		EWP - 120ft	2	19/06/2030	17/09/2030	16,076	Mobile Plant
87		Small Tools - grinders, rattle guns, drills	4	19/06/2030	17/09/2030		Stationary Plant
88		Light Vehicles	3	19/06/2030	17/09/2030	7,234	Site Vehicle
89		Telehandler	1	19/06/2030	17/09/2030	8,400	Mobile Plant
90		Franna 25t	1	19/06/2030	17/09/2030	8,154	Mobile Plant
91							
92	Tunnels						
93		**Tunnelling**					
94		Grout plant	1	1/03/2025	31/07/2029		Mobile Plant
95		Mobie concrete batch plant	1	1/03/2025	31/07/2029		Stationary Plant
96		Bentonite Silo	1	1/03/2025	31/07/2029		Mobile Plant
97		Pug Mill	1	1/03/2025	31/07/2029		Stationary Plant
98		Water Treatment Plant - 30 l/s	1	1/03/2025	31/07/2029		Stationary Plant
99		Chiller Plant for tbm cooling water	1	1/03/2025	31/07/2029		Stationary Plant
100		Water tanks - 1ML	2	30/08/2024	18/12/2030		Stationary Plant
101		Gantry Crane - 260t	1	2/10/2025	18/12/2030		Mobile Plant
102		Gantry Crane - 50t	1	2/10/2025	18/12/2030		Mobile Plant
103		Gensets - 250 kVa	1	1/06/2024	18/12/2030	35,731	Stationary Plant
104		Fans - 500kW	2	2/10/2025	18/12/2030		Stationary Plant
105		Forklift - Hyster 40t	1	2/10/2025	19/06/2030	276,473	Mobile Plant
106		TBMs - 14.7m OD	2	2/09/2025	31/07/2029		Mobile Plant
107		Multi Service Vehicle (MSVs) - Metalliance-tsi	4	2/09/2025	31/07/2029	660,470	Site Vehicle
108		Crew Transporters - Metalliance-tsi	2	2/09/2025	31/07/2029	194,256	Site Vehicle
109		Flatcar - Metalliance-tsi	2	2/09/2025	31/07/2029	194,256	Site Vehicle
110		Refuge Chamber	4	2/09/2025	1/01/2031		Stationary Plant
111		Spoil conveyor	2	2/09/2025	31/07/2029		Stationary Plant
112		Light Vehicle - Kubota ATV	10	2/09/2025	1/01/2031	752,550	Site Vehicle
113							
114		**Cross Passage & Substations - Excavation and Lining**					
115		liebherr 912 tunnel excavator	3	19/09/2026	26/03/2030	380,736	Mobile Plant
116		Brokk 400	5	19/09/2026	26/03/2030	40,101	Mobile Plant
117		Excavators - 8t	5	19/09/2026	26/03/2030	211,520	Mobile Plant
118		Dump Trucks - DP120 10t	5	19/09/2026	26/03/2030	930,687	Mobile Plant
119		Underground Agi - Jacon	3	19/09/2026	26/03/2030	222,096	Mobile Plant
120		Shotcrete Rig - Jacon Midjet	3	19/09/2026	26/03/2030	133,257	Mobile Plant
121		EWP - 85ft	5	19/09/2026	26/03/2030	163,928	Mobile Plant
122		Scissor Lifts - 20ft	5	19/09/2026	26/03/2030	163,928	Mobile Plant
123		Hiab	2	19/09/2026	26/03/2030	327,856	Mobile Plant
124		Bobcat	2	19/09/2026	26/03/2030	194,246	Mobile Plant
125		Concrete Trailer Pumps	2	29/10/2026	26/03/2030	68,267	Mobile Plant
126		Swivel Telehanlder - Dieci Pegasus 40.25	2	29/10/2026	26/03/2030	499,374	Mobile Plant
127		Telehandler - 7t	2	19/09/2026	26/03/2030	294,718	Mobile Plant
128							
129		**Tunnel BEW**					
130		Crusher - 50t	1	1/11/2025	12/03/2030	228,670	Mobile Plant
131		Screening	1	1/11/2025	12/03/2030	166,306	Stationary Plant
132		Dump trucks - AD30 ejector trays	8	8/01/2026	18/03/2030	######	Mobile Plant
133		Excavator - 12t	3	8/01/2026	18/03/2030	454,540	Mobile Plant
134		Bobcat (spreader bar)	3	8/01/2026	18/03/2030	208,710	Mobile Plant
135		Smooth drum roller	3	8/01/2026	18/03/2030	416,662	Mobile Plant
136		Compactor	3	8/01/2026	18/03/2030	638,250	Mobile Plant
137		Grader	2	8/01/2026	18/03/2030	178,028	Mobile Plant
138		Gravel paver	2	11/01/2027	12/03/2030	134,068	Mobile Plant
139		Bamtec roll truck - 10t rigid truck	2	11/01/2027	12/03/2030	238,388	Mobile Plant
140		Agis - 6/8 wheelers	8	18/04/2026	18/03/2030	663,449	Mobile Plant
141		Concrete CRCP paver	2	11/01/2027	12/03/2030	134,068	Mobile Plant

142		hiab trucks (conduits & pipes & reo))	3	24/03/2026	4/06/2030									4,617	56,250	62,357	56,057	51,943	56,250	62,357	56,057	52,650	56,250	62,357	56,057	51,943	56,250	62,357	56,057	51,943	39,560							951,313	Mobile Plant
143		telehandler (pits)	3	24/03/2026	31/12/2029									3,860	47,025	52,131	46,864	43,424	47,025	52,131	46,864	44,015	47,025	52,131	46,864	43,424	47,025	52,131	46,354									718,292	Mobile Plant
144		Barrier Slip form Machine - Gomaco 4400	1	10/03/2027	18/03/2030													1,190	5,273	5,845	5,254	4,935	5,273	5,845	5,254	4,869	5,273	5,845	5,254	4,111								64,221	Mobile Plant
145		Paving Grinding	1	11/04/2027	10/06/2030														4,693	5,845	5,254	4,935	5,273	5,845	5,254	4,869	5,273	5,845	5,254	4,869	4,056							67,265	Mobile Plant
146		hiab trucks (panels and framing)	3	10/03/2027	17/04/2030													6,349	28,125	31,179	28,029	26,325	28,125	31,179	28,029	25,971	28,125	31,179	28,029	25,971	4,945							351,558	Mobile Plant
147		Rigid truck with drilling platform	2	11/12/2026	4/06/2030												4,265	17,314	18,750	20,786	18,686	17,550	18,750	20,786	18,686	17,314	18,750	20,786	18,686	17,314	13,187							261,609	Mobile Plant
148		EWPs	20	8/01/2026	18/12/2030									39,600	46,500	51,549	46,341	42,939	46,500	51,549	46,341	43,524	46,500	51,549	46,341	42,939	46,500	51,549	46,341	42,939	46,500	51,549	39,289					926,836	Mobile Plant
149		Mobile Gantries	8	11/12/2026	19/06/2030												1,137	4,617	5,000	5,543	4,983	4,680	5,000	5,543	4,983	4,617	5,000	5,543	4,983	4,617	4,341							70,587	Mobile Plant
150		Light Vehicles	20	8/01/2026	18/12/2030									76,645	90,000	99,771	89,691	83,109	90,000	99,771	89,691	84,240	90,000	99,771	89,691	83,109	90,000	99,771	89,691	83,109	90,000	99,771	76,043					######	Site Vehicle
151		Tilt Trays Trucks	2	8/01/2026	18/12/2030									31,935	37,500	41,571	37,371	34,629	37,500	41,571	37,371	35,100	37,500	41,571	37,371	34,629	37,500	41,571	37,371	34,629	37,500	41,571	31,684					747,448	Mobile Plant
152		Telehandlers	4	8/01/2026	18/12/2030									53,396	62,700	69,507	62,485	57,899	62,700	69,507	62,485	58,687	62,700	69,507	62,485	57,899	62,700	69,507	62,485	57,899	62,700	69,507	52,976					######	Mobile Plant
153		Cable drum rollers	2	11/12/2026	4/06/2030												1,706	6,926	7,500	8,314	7,474	7,020	7,500	8,314	7,474	6,926	7,500	8,314	7,474	6,926	5,275							104,644	Mobile Plant
154		Small Tools - grinders, rattle guns, drills	20	8/01/2026	18/12/2030																																		Stationary Plant
155																																							
156																																							
157		**TOTAL**					445	50,507	136,459	126,444	124,957	225,132	330,118	731,441	957,779	978,988	1,040,915	1,016,195	1,134,812	1,258,662	1,131,498	1,062,726	1,135,391	1,258,662	1,131,498	1,048,453	1,193,226	1,229,763	1,064,528	872,777	372,190	410,178	236,013						
		l diesel	#######																																				

#######

TBM precast and Spoil Haulage Diesel Quantities

Source document: Diesel estimate provided by TA - "BAM-RFI-GWHU-070-R2-REDUCED-SCOPE.xlsx"
Based on 20% concept design and 80% concept design high level changes

	Total diesel (L)
Site Vehicles (Delivery ar	22,990,355

Activity / **Quarter**

						Start Date	1-Jan-24	1-Apr-24	1-Jul-24	1-Oct-24	1-Jan-25	1-Apr-25	1-Jul-25	1-Oct-25	1-Jan-26	1-Apr-26	1-Jul-26	1-Oct-26	1-Jan-27	1-Apr-27	1-Jul-27	1-Oct-27	1-Jan-28	1-Apr-28	1-Jul-28	1-Oct-28	1-Jan-29	1-Apr-29	1-Jul-29	1-Oct-29	1-Jan-30	1-Apr-30	1-Jul-30	1-Oct-30	1-Jan-31	1-Apr-31	1-Jul-31	1-Oct-31
						End Date	1-Apr-24	1-Jul-24	1-Oct-24	1-Jan-25	1-Apr-25	1-Jul-25	1-Oct-25	1-Jan-26	1-Apr-26	1-Jul-26	1-Oct-26	1-Jan-27	1-Apr-27	1-Jul-27	1-Oct-27	1-Jan-28	1-Apr-28	1-Jul-28	1-Oct-28	1-Jan-29	1-Apr-29	1-Jul-29	1-Oct-29	1-Jan-30	1-Apr-30	1-Jul-30	1-Oct-30	1-Jan-31	1-Apr-31	1-Jul-31	1-Oct-31	1-Jan-32
	Calendar Days						91	91	92	92	90	91	92	92	90	91	92	92	90	91	92	92	91	91	92	92	90	91	92	92	90	91	92	92	90	91	92	92
	Working Days						59	63	69	62	58	63	69	62	58	63	69	62	58	63	69	62	59	63	69	62	58	63	69	62	58	63	69	62	58	63	69	62
	Working Days Ratio						0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68	0.64	0.69	0.75	0.68
	Day Shift Hours						10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Day + Night Shift Hours						20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Precast Deliveries																																						
	Load Location	Unload Location		Duration per trip	Start Date	Finish Date																																
	Wallerawang	Little Hartley (EPB)		2.36	15/10/2025	30/09/2027								187,562	204,990	221,988	246,089	221,226	204,990	221,988	243,414																	
	Wallerawang	Little Hartley (Single Shield)		2.36	30/09/2027	31/07/2029															3,745	309,717	290,892	310,783	344,525	309,717	286,985	310,783	112,345									
Spoil Haulage - Off Site																																						
Blackheath		20% concept design for excavation quantities																																				
	Construction Activity	Unload Location	Volume	Duration per trip	Start Date	Finish Date																																
	Site Establishment	Wallerawang	68,000	3.12	1/08/2024	30/05/2025			114,469	155,199	143,808	100,970																										
	Road Works	Wallerawang	55,000	3.12	19/05/2025	22/07/2027						22,639	53,111	47,745	44,241	47,909	53,111	47,745	44,241	47,909	12,123																	
	Cut and Covers	Wallerawang	75,034	3.12	1/02/2025	30/11/2025					104,026	171,842	190,499	111,686																								
	Road Works	Little Hartley	59,000	1.88	19/05/2025	7/06/2027						15,512	36,393	32,716	30,315	32,829	36,393	32,716	30,315	24,171																		
	Cut and Covers	Little Hartley	112,550	1.88	1/02/2025	30/11/2025					94,023	155,318	172,181	100,947																								
Mid point Shaft to Wallerawang																																						
	Load Location	Unload Location	Volume	Duration per trip	Start Date	Finish Date																																
	Site Establishment	Wallerawang	28,000	2.80	20/08/2024	15/11/2024			101,099	97,377																												
	Shaft & Adit Excavation	Little Harltey	83,000	1.64	10/09/2024	15/08/2025			22,524	88,706	82,196	89,012	48,265																									
	Cavern Excavation	Little Harltey	140,000	1.64	30/07/2025	24/07/2026							107,626	141,290	130,920	141,776	39,292																					
Tunnels to Wallerawang (Quantities Account for Tunnel Backfilling)																																						
	Load Location	Unload Location	Volume	Duration per trip	Start Date	Finish Date																																
	Tunnelling	Wallerawang	2,861,000	2.12	1/11/2025	31/07/2029								649,445	907,602	982,861	1,089,572	979,492	907,602	982,861	1,089,572	979,492	919,958	982,861	1,089,572	979,492	907,602	982,861	355,295									
	XPs and Substations	Wallerawang	82,000	2.12	19/09/2026	7/01/2030											4,620	31,845	29,507	31,954	35,423	31,845	29,909	31,954	35,423	31,845	29,507	31,954	35,423	31,845	1,967							
Little Hartley to Wallerawang																																						
	Load Location	Unload Location	Volume	Duration per trip	Start Date	Finish Date																																
	Site Establishment	Wallerawang	51,500	2.12	1/07/2024	5/03/2025			108,626	97,652	63,339																											
	Water Management	Wallerawang	15,000	2.12	1/09/2024	31/10/2024			42,472	38,181																												
	TOTAL		l diesel	22,990,355					389,189	477,114	487,393	555,292	608,076	1,271,392	1,318,068	1,427,363	1,469,078	1,313,024	1,216,655	1,308,883	1,384,278	1,321,053	1,240,760	1,325,598	1,469,520	1,321,053	1,224,095	1,325,598	503,064	31,845	1,967							

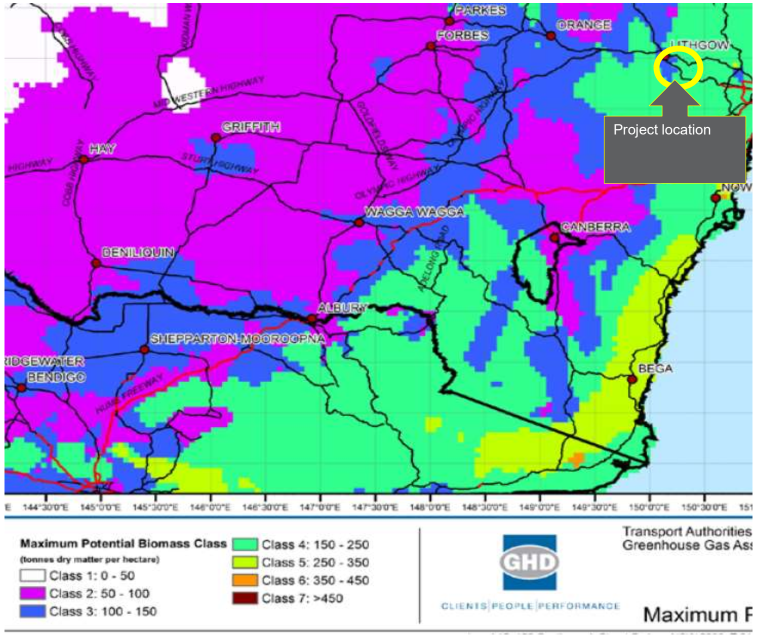
1/07/2024

Source document: Biodiversity Assessment - "Appendix.G.Biodiveristy.Credit.Reports"

BAM Credit Summary Report	TEC name	Area (ha)	Classification for Vegetation Emissions Methodology Vegetation Class	Name
Carex sedgeland of the slopes and tablelands	Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands Australian Alps bioregions	0.43	I	Grassland
Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin	Not a TEC	0.18	B	Eucalypt Tall Open Forest
Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin	Not a TEC	0.01	B	Eucalypt Tall Open Forest
Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion	Not a TEC	1.29	H	Heathlands
Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion	Not a TEC	0.5	H	Heathlands
Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Not a TEC	6.14	C	Open Forest
Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Not a TEC	0.86	C	Open Forest
Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Not a TEC	0.33	C	Open Forest

Summary

Vegetation Class	Area (ha)
I	0.43
B	0.19
C	7.33
H	1.79



Source: TAGG Workbook

	Emission factor (t CO_2-e/ha) Potential maximum biomass class						
Vegetation Class	1	2	3	4	5	6	7
A (Rainforest and vine thicket)		154	227	384	532	594	768
B (Eucalypt Tall Open Forest)			237	401	554	618	
C (Open Forest)	77	209	307	521	718	801	
D (Open Woodlands)	77	209	307	521			
E (Callitris Forest and Woodland)	80	217	316	538			
F (Mallee and Acacia Woodland and Shrubland)	106	287	419	713			
G (Open Shrubland)	113	305	442				
H (Heathlands)	115	309	446				
I (Grassland)	110	110	110	110	110	110	110

Determine the vegetation types	Look up the project location and determine the 'Maxbio' class	Area cleared (ha)	Emission factor (t CO_2e/ha)	Total emissions (t CO_2e)	Evidence / data sour
I (Grassland)	4	0.43 ha	110	47	
B (Eucalypt tall open forest)	4	0.19 ha	401	76	
C (Open forest)	4	7.33 ha	521	3,819	
H (Heathlands)	3	1.79 ha	446	798	
TOTAL Vegetation clearing emissions		9.74 ha		4,741 t CO2	

Source document: Biodiversity Assessment - "GHG Totals Summary_11Aug2022.xlsx" (modelling outputs undertaken by air quality specialist)

TOTAL OF TUNNEL AND ROADS				
Proj year	DataType	Pollutant	Project	Ann CO2-e (t)
2018	Average	CO2	N	23724
2030	Average	CO2	N	29777
2040	Average	CO2	N	33343
2030	Average	CO2	Y	25717
2040	Average	CO2	Y	30488
2018	Average	N2O	N	220
2030	Average	N2O	N	184
2040	Average	N2O	N	222
2030	Average	N2O	Y	133
2040	Average	N2O	Y	153

TUNNEL ONLY

Proj year	DataType	Pollutant	Project	Ann (kg)	Ann (t)	Ann CO2-e (t)
2030	Average	CO2	Y	15943857	15944	15944
2040	Average	CO2	Y	19383397	19383	19383
2030	Average	N2O	Y	293	0.3	78
2040	Average	N2O	Y	341	0.3	90

SURFACE ROADS ONLY

Proj year	DataType	Pollutant	Project	Ann (kg)	Ann (t)	Ann CO2-e (t)
2018	Average	CO2	N	23723640	23723.64	23724
2030	Average	CO2	N	29776637	29776.64	29777
2040	Average	CO2	N	33343209	33343.21	33343
2030	Average	CO2	Y	9772851	9772.851	9773
2040	Average	CO2	Y	11104954	11104.95	11105
2018	Average	N2O	N	829	0.8	220
2030	Average	N2O	N	694	0.7	184
2040	Average	N2O	N	837	0.8	222
2030	Average	N2O	Y	208	0.2	55
2040	Average	N2O	Y	238	0.2	63

^ emission factor years

Appendix 1 Greenhouse Gas Global Warming Potentials

The Global Warming Potential (GWP) is an index used to convert relevant non-carbon dio gases to a carbon dioxide equivalent (CO_2-e) by multiplying the quantity of the gas by its GWP in Table 32 below.

Table 32: Global Warming Potentials

Gas	Chemical formula	Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

Above were used in the CO2-e calcs.

	Project?						
	N	N	N	Y	Y	Y	
	Without Project			With Project			
Year	Surface	Tunnel	Total - without	Surface	Tunnel	Total - with	Difference
2030	29961	0	29961	9828	16022	25850	-4111
2031	30321	0	30321	9962	16367	26329	-3992
2032	30682	0	30682	10096	16712	26808	-3874
2033	31042	0	31042	10230	17057	27287	-3755
2034	31403	0	31403	10364	17402	27766	-3636
2035	31763	0	31763	10498	17748	28246	-3518
2036	32123	0	32123	10632	18093	28725	-3399
2037	32484	0	32484	10766	18438	29204	-3280
2038	32844	0	32844	10900	18783	29683	-3161
2039	33205	0	33205	11034	19128	30162	-3043
2040	33565	0	33565	11168	19473	30641	-2924
2041	33565	0	33565	11168	19473	30641	-2924
2042	33565	0	33565	11168	19473	30641	-2924
2043	33565	0	33565	11168	19473	30641	-2924
2044	33565	0	33565	11168	19473	30641	-2924
2045	33565	0	33565	11168	19473	30641	-2924
2046	33565	0	33565	11168	19473	30641	-2924
2047	33565	0	33565	11168	19473	30641	-2924
2048	33565	0	33565	11168	19473	30641	-2924
2049	33565	0	33565	11168	19473	30641	-2924
2050	33565	0	33565	11168	19473	30641	-2924
2051	33565	0	33565	11168	19473	30641	-2924
2052	33565	0	33565	11168	19473	30641	-2924
2053	33565	0	33565	11168	19473	30641	-2924
2054	33565	0	33565	11168	19473	30641	-2924
2055	33565	0	33565	11168	19473	30641	-2924
2056	33565	0	33565	11168	19473	30641	-2924
2057	33565	0	33565	11168	19473	30641	-2924
2058	33565	0	33565	11168	19473	30641	-2924
2059	33565	0	33565	11168	19473	30641	-2924
2060	33565	0	33565	11168	19473	30641	-2924
2061	33565	0	33565	11168	19473	30641	-2924
2062	33565	0	33565	11168	19473	30641	-2924
2063	33565	0	33565	11168	19473	30641	-2924
2064	33565	0	33565	11168	19473	30641	-2924
2065	33565	0	33565	11168	19473	30641	-2924
2066	33565	0	33565	11168	19473	30641	-2924
2067	33565	0	33565	11168	19473	30641	-2924
2068	33565	0	33565	11168	19473	30641	-2924
2069	33565	0	33565	11168	19473	30641	-2924
2070	33565	0	33565	11168	19473	30641	-2924
2071	33565	0	33565	11168	19473	30641	-2924
2072	33565	0	33565	11168	19473	30641	-2924
2073	33565	0	33565	11168	19473	30641	-2924
2074	33565	0	33565	11168	19473	30641	-2924
2075	33565	0	33565	11168	19473	30641	-2924
2076	33565	0	33565	11168	19473	30641	-2924
2077	33565	0	33565	11168	19473	30641	-2924
2078	33565	0	33565	11168	19473	30641	-2924
2079	33565	0	33565	11168	19473	30641	-2924
2080	33565	0	33565	11168	19473	30641	-2924
2081	33565	0	33565	11168	19473	30641	-2924
2082	33565	0	33565	11168	19473	30641	-2924
2083	33565	0	33565	11168	19473	30641	-2924
2084	33565	0	33565	11168	19473	30641	-2924
2085	33565	0	33565	11168	19473	30641	-2924
2086	33565	0	33565	11168	19473	30641	-2924
2087	33565	0	33565	11168	19473	30641	-2924
2088	33565	0	33565	11168	19473	30641	-2924
2089	33565	0	33565	11168	19473	30641	-2924
2090	33565	0	33565	11168	19473	30641	-2924
2091	33565	0	33565	11168	19473	30641	-2924
2092	33565	0	33565	11168	19473	30641	-2924
2093	33565	0	33565	11168	19473	30641	-2924
2094	33565	0	33565	11168	19473	30641	-2924
2095	33565	0	33565	11168	19473	30641	-2924
2096	33565	0	33565	11168	19473	30641	-2924
2097	33565	0	33565	11168	19473	30641	-2924
2098	33565	0	33565	11168	19473	30641	-2924
2099	33565	0	33565	11168	19473	30641	-2924
2100	33565	0	33565	11168	19473	30641	-2924
2101	33565	0	33565	11168	19473	30641	-2924
2102	33565	0	33565	11168	19473	30641	-2924
2103	33565	0	33565	11168	19473	30641	-2924
2104	33565	0	33565	11168	19473	30641	-2924
2105	33565	0	33565	11168	19473	30641	-2924
2106	33565	0	33565	11168	19473	30641	-2924
2107	33565	0	33565	11168	19473	30641	-2924
2108	33565	0	33565	11168	19473	30641	-2924
2109	33565	0	33565	11168	19473	30641	-2924
2110	33565	0	33565	11168	19473	30641	-2924
2111	33565	0	33565	11168	19473	30641	-2924
2112	33565	0	33565	11168	19473	30641	-2924
2113	33565	0	33565	11168	19473	30641	-2924
2114	33565	0	33565	11168	19473	30641	-2924
2115	33565	0	33565	11168	19473	30641	-2924
2116	33565	0	33565	11168	19473	30641	-2924
2117	33565	0	33565	11168	19473	30641	-2924
2118	33565	0	33565	11168	19473	30641	-2924
2119	33565	0	33565	11168	19473	30641	-2924
2120	33565	0	33565	11168	19473	30641	-2924
2121	33565	0	33565	11168	19473	30641	-2924
2122	33565	0	33565	11168	19473	30641	-2924
2123	33565	0	33565	11168	19473	30641	-2924
2124	33565	0	33565	11168	19473	30641	-2924
2125	33565	0	33565	11168	19473	30641	-2924
2126	33565	0	33565	11168	19473	30641	-2924
2127	33565	0	33565	11168	19473	30641	-2924
2128	33565	0	33565	11168	19473	30641	-2924
2129	33565	0	33565	11168	19473	30641	-2924
						Total	**-298929**

Traffic/tailpipe emissions modelling assumptions:

Parameter	Dependencies	Comment
Base Emission Factor	Source of Emission Factors	NSW EPA Air Emissions Inventory 2013 Calendar Year: On road mobile emissions air emissions inventory (AEI)
	Years of assessment (2021, 2030, 2040)	2021 scenario used 2016 base EF's 2030 scenario used 2026 base EF's 2040 scenario used 2036 base EF's
	Fleet mix (traffic composition)	Modelled based on traffic fleet mix as provided by traffic engineers for existing and future scenarios.
	Pollutants	Emission factors are calculated individually for each pollutant for entry into the model
	Vehicle class	Emissions vary by vehicle class, i.e.: light vs heavy vehicles. Light and heavy vehicles have been further spit according to the different sub-variants of the traffic fleet mix.
	Fuel type	Emissions vary by fuel type, i.e.: petrol vs diesel and emissions have been calculated to reflect variability in fuel usage across the fleet.
	Road type	Road type variability has been considered by the emissions calculations i.e.: congested traffic vs free flowing traffic for a given average speed
	Road grade	Variability in road grade affects emissions from vehicles on the road. Emissions rates have been calculated taking into consideration the road grade.
	Non-exhaust emissions	Not relevant for GHG
	Evaporative losses[1]	Not relevant for GHG
	Cold start emissions[1]	Additional emissions, due to the vehicles running "richer" (and other inefficiencies) before reaching normal operating temperature. - Not calculated due to vehicles being assumed at operating temperature when using a highway or major arterial roads.
Speed Factor	Source of Speed Factor data	AEI, 6th order polynomial calculations considering road type base speed, and modelled speed, per link, per hour of day. - CO2 used CO factors - N2O used NOx factors
	Traffic speed	Emission rates vary by vehicle speed. Data used in the modelling was based on expected average speed for a one-hour period for each road link.
Grade Factor	Source of Grade Factors	PIARC (2019), Road Tunnels: Vehicle Emissions and Air Demand for Ventilation - CO2 used CO factors - N2O used NOx factors
	Grade	Factor varies by road grade, i.e.: varies between -6% to 6%
Traffic Volume	Source of Traffic Volumes	Traffic numbers obtained from traffic modelling. Average day data used for calculations.
	Total volume	AADT data calculated for all road links and tunnel modelling scenarios. Data obtained from traffic model.
	Traffic data resolution	Weekday 24-hour cycle

[1] : These emissions are not included in the emission rate calculations

Transport for NSW

Operational vehicles: Assume 2 trucks and 4-5 utes, taking 6-10 trips a day for the length of the tunnel. Assume diesel vehicles. Assumptions provided by project technical advisors.

	Qty	trips/day	days/year	km/trip	Fuel use rate (kL/km)	Total annual fuel use (kL/yr)
Truck	2	10	365	10.4	1.22E-04	9.26224
Light vehicle	5	10	365	10.4	1.14E-04	21.6372
					Total	**30.89944**

Operational electricity: Source file: RFI-075 Daily Energy Usage Estimate.xlsx

System	Maximum Demand (kW)	% of max operating	Hrs per Day	kWh	Note
Base Level Lights (kW)	331.65	75%	24	5,969.70	50% lights assumed in interior zones at night
Transition (Boost) Lights WB (kW)	127.5	75%	12	1,147.50	Based on lighting level varying through day (photometer)
Transition (Boost) Lights EB (kW)	83.7	75%	12	753.30	Based on lighting level varying through day (photometer)
Cross Passage Lighting	20.24	25%	24	121.44	Based on strobes and exit lights being always on, 4x40W fluoros controlled based on door switch
Other tunnel lighting (Emergency, signage, plant room lighting, etc.) (kW)	53.16	10%	24	127.58	Based on wayfinding, MET, FET lighting always on, other (LV room, plantroom lighting) being on switch
Drainage (kW)	334	2.5%	6	50.10	Based on groundwater pumps at LH (10kW) running in cycles - other pumps only when rains / deluge testing / fire
Axial Fans (kW)	5555.56	55%	24	73,333.39	Based on 0 portal emissions 24 hours a day. Also conservative as SA don't provide flow rates for less than 200 vehicles per hour (which occurs for ~8 hours per day based on SA traffic profile)
Jet Fans (EB) (kW)	7833.35	3.7%	24	6,962.98	See "Ventilation Utilisation (2030)" tab - no jet fans required for emissions control for 'normal' traffic case considered by Stacey Agnew in vent modelling. Provision is for contraflow bank at exit portal and to exercise each fan for 2 hours once a week.
Jet Fans (WB) (kW)	4500	7.0%	24	7,578.95	See "Ventilation Utilisation (2030)" tab - no jet fans required for emissions control for 'normal' traffic case considered by Stacey Agnew in vent modelling. Provision is for contraflow bank at exit portal and to exercise each fan for 2 hours once a week.
Control Centre (kW)	266	100%	24	6,384.00	Bulk of building energy consuption will be associated with tunnel operations. Manned 24hrs a day.
Backup Control Room (kW)	50	100%	24	1,200.00	Bulk of building energy consuption will be associated with tunnel operations. Not normally manned.
Workshop (kW)	151.2	100%	10	1,512.00	Normally occupied through the day, minimal operations during the day
Water Treatment (kW)	162	50%	24	1,944.00	Assumed continuous groundwater throughput at 50% plant capactity. Not normally manned.
Fire pumps (kW)	400	0%	0	0.00	Operated during maintenance closures or during incidents only
General Substation and Plant Room Services (kW)	160	70%	24	2,688.00	Lighting assumed to be on switches, Air conditioning will cycle based on tunnel ventialltion and drainage operation
ITS/Comms (kW)	701.6	75%	24	12,628.80	Assumed some of redundant items to be lightly loaded.
Total Daily Consumption (normal day, free flowing traffic)				**122,401.74**	

			Annual		Over asset life	
			Scope 2	Scope 3	Scope 2	Scope 3
	kWh/day	kWh/year	tCO2-e/year	tCO2-e/year	tCO2-e	tCO2-e
Ventilation Scenario 1 (ventilation portals)	122,402	44,676,636	34,848	3,127	3,484,778	312,736
Ventilation Scenario 2 (no ventilation portals)	49,068	17,909,947	13,970	1,254	1,396,976	125,370

National Greenhouse Accounts Factors: 2021

Table 46: Scope 2 and 3 emissions factors – consumption of purchased electricity by end users

Financial year	EF for scope 2		EF for scope 3		Full fuel cycle EF (EF for scope 2 + EF for scope 3)	
	A	B	C	D	E	F
	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ	kg CO_2-e/kWh	kg CO_2-e/GJ
NEW SOUTH WALES and AUSTRALIAN CAPITAL TERRITORY						
Latest estimate*	0.78	216	0.07	19	0.85	236

Source: Table PS201.1 - Asset Design Life; Professional Services for Concept Design Scope and Requirements, PS201

Item No.	Asset	Short title	Minimum Design Life (years)	Plant and equipment diesel requirement (L)	Used in BOQ?	Whole of life diesel requirement (L)	
1	Inaccessible drainage elements	Inaccessible drainage elements	100		Y	0	
2	Drainage elements that are accessible for refurbishment and maintena	Accessible drainage elements	40	152174.7071	Y	304349	
3	Sign faces	Sign faces	10	53988	Y	485896	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
4	Sign support structures and other roadside furniture	Sign supports and road furniture	50	53988	Y	53988	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
5	Fences including fauna fences	Fences	20	53988	Y	215954	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
6	Lighting and electrical equipment	Lighting and electrical equipment	20	53988	Y	215954	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
7	Bridge structures, including underpasses, overpasses and wildlife tunr	Bridge structures	100		Y	0	
8	Retaining Walls including reinforced soil walls	Retaining Walls	100		Y	0	
9	Noise barriers, noise attenuation devices and headlight screens	Noise barriers	50	53988	Y	53988	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
10.1	Pavements - Main carriageway including ramps	Pavement - main carriageway	40	103859.0902	Y	207718	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
10.2	Pavements - Local roads	Pavement - local roads	20	25964.77254	Y	103859	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
11	Local Road embankment and support structures	Local road embankment	100				
12	Embankments including reinforced embankments	Embankment	100		Y	0	
13	Cut batters, including batter treatments	Cut batters	100				
14	Timber furniture	Timber furniture	30	53988	Y	161965	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
15	Assets not detailed within this table	Other	Typical industry values for similar assets of a high standard and quality				
16	Intersection capacity improvements	Intersection capacity improvements	10	63017			
17	Tunnels and Long Underpass structures, structural linings and ground	Tunnel	100		Y	0	
18	Inaccessible elements of drainage, fire protection, lighting, mechanical,	Inaccessible elements	100		Y	0	
19	Buildings - Free Standing Buildings	Buildings - free standing	50	53988	Y	53988	Assume 'Misc Plant' evenly split between remaining (yellow) sub-100 year design life components
20	Buildings - Buildings above civil infrastructure and buildings integral wi	Buildings - CI	100		Y	0	
	Site establishment/temporary works (use once - 100 year design life as	Site establishment/temporary works	100		Y	0	
					Total (L)	1857661	
					Annualised total (L)	18577	

Plant and Equipment	Fuel use requirement (L)
Blackheath	
Concrete Works	20303
Drainage	20696
Road pavements	25010
Asphalting	14359
Misc Plant	106848
Mid point Shaft	
Site Establishment incl. road widening	63017
Road pavements	3983
Misc Plant	39619
Little Hartley	
Drainage	131479
Road pavements	53442
Asphalting	33030
Misc Plant	231452