Chapter

26

Chapter 26

Climate change risk and greenhouse gas

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26 Climate change risk and greenhouse gas

This chapter assesses the potential impacts of climate change on the project and adaptation measures that have been incorporated into the design of the project. Greenhouse gas emissions generated by the construction and operation of the project are also assessed in this chapter. Detailed greenhouse gas calculations and climate change projections are provided in Appendix X (Climate change and greenhouse gas calculations).

The Secretary's environmental assessment requirements as they relate to climate change and greenhouse gas emissions, and where in the environmental impact statement these have been addressed, are detailed in Table 26-1.

The proposed environmental management measures relevant to climate change risk and greenhouse gas emissions are included in Section 26.2.5.

Table 26-1 Secretary's environmental assessment requirements – climate change risk

Secretary's requirement	Where addressed in EIS
Climate change risk	
1. The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	**Chapter 26**, and **Appendix X** (Climate change and greenhouse gas calculations), present a climate change risk assessment for the project in accordance with current guidelines as listed in **Section 26.1.1**.
2. The Proponent must quantify specific climate change risks with reference to either 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 incorporate specific adaptation actions in the design.	Climate change risks to the project are identified in **Section 26.1** and **Appendix X**, with reference to current climate change projections also presented in **Section 26.1.3**.

26.1 Climate change risk assessment

This section outlines the legislation, policies and climate change projections relevant to the project, assesses the risks of climate change to the project and outlines adaptations to manage those risks.

26.1.1 Legislative and policy framework

The climate change risk assessment has been conducted in line with the following relevant standards and current guidelines:

- *National Climate Resilience and Adaptation Strategy* (Department of the Environment and Energy, 2015)
- *NSW Climate Change Policy Framework* (Office of Environment and Heritage, 2016)
- *Environmental Sustainability Strategy* 2019-2023 (Roads and Maritime, 2019)

- Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure – A risk-based approach*
- Australian and New Zealand Standard AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*
- *Climate Change Impacts and Risk Management – A Guide for Business and Government* (Australian Government, 2006)
- *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime, in draft)
- *Guideline for Climate Change Adaptation*, Rev2.1: October 2011. (Australian Green Infrastructure Council, 2011).

26.1.2 Assessment methodology

The methodology for the climate change risk assessment was based on the Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure – A risk based approach*. This standard follows the International Standard ISO 31000:2009, *Risk management – Principles and guidelines* (adopted in Australian and New Zealand as AS/NZS ISO 31000:2009), which provides a set of internationally endorsed principles and guidance on how organisations can integrate decisions about risks and responses into its existing management and decision-making processes. The methodology was also guided by the draft *Technical Guide: Climate Adaptation for the Road Network* (Roads and Maritime (in draft)).

While adhering to the above guidance documents, the following key steps were carried out to complete the climate change risk assessment:

- Determination of the climate change context, including greenhouse gas emissions scenarios and projections, data on climate variables and past meteorological record
- Identification of the climate risks and assess the likelihood and consequence of each risk
- Identification of adaptation responses.

To assist with the determination of climate change context as well as the identification of climate change risks and the likelihood of such risks, a risk workshop was held with multidisciplinary members of the project team (ie members of the design and environmental assessment teams) early in the design phase. The preliminary risks identified at the workshop were then formalised in a risk register, and thorough risk descriptions, including cause, impact/consequence and current and proposed future treatment were identified.

A climate change risk update was subsequently carried out based on the design that forms the basis of this environmental impact statement. The update identified treatments that had been incorporated into the design since the initial climate change risk workshop, risk treatments to be implemented or investigated in future design stages, as well as some updates to risk ratings.

A hazard-receiver pathway model has been applied to identify and analyse risks to the project with respect to climate change. Climate or climate influenced attributes with potential to influence the project were identified (hazards), along with the component of the project, user or surrounding environment that would be impacted by the hazard (receivers).

The appropriate risk rating level was identified by:

- Determining the consequences of each risk occurring
- Determining the likelihood of each risk occurring
- Considering what is already inherent in the design, and the business as usual controls expected to be applied through design, construction, maintenance and operation

- Determining the residual risk, incorporating the above factors.

The risk assessment matrix in Appendix X was applied to produce risk ratings for the hazards and receivers identified.

26.1.3 Climate change projections

Climate change projections used for the climate change risk and adaptation assessment are summarised in Table 26-2.

The projections were developed for three periods, broadly reflecting the operating timeframes of different elements of the project:

- Year 2030: assets and systems with short operating timeframes, such as communications and other electronic systems, landscaping and road surfaces
- Year 2050: assets and systems with long operating timeframes, such as drainage structures and barriers/rails
- Year 2090: "permanent" assets, which would become fixed and ongoing features of project, such as: tunnel civil structures (including rock bolts), bridges, embankment culverts (and other inaccessible drainage), and buildings.

Projections were derived from the Intergovernmental Panel on Climate Change's Fifth Assessment Report (AR5, IPCC (2013) which are incorporated into the Climate Futures Tool by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Department of Environment and Energy. Projections are provided for a number of emissions and pathway scenarios for a range of climate parameters. The projections are based on the 'worst case' scenario (Representative Concentration Pathways 8.5), which reflects the highest emissions projected for the time period.

Table 26-2 Summary of climate change projections – Sydney region

Climate variable	Baseline (1986-2005)	2030	2050	2090
Temperature				
Mean minimum temperatures (°C) – annual	14.4	15.5	16.3	18.4
Mean maximum temperatures (°C) – annual	22.4	24.3	24.4	26.5
Days over 35°C – annual	3.5	5.6	5.9	11.3
Rainfall				
Mean precipitation (mm) – annual	1238	1206	1151	1049
Extreme rainfall events – max 1-day rainfall	Projected to increase 2 – 22%			
Extreme rainfall events – 20-year return level of max 1-day rainfall	Projected to increase 5 – 42%			

Climate variable	Baseline (1986-2005)	2030	2050	2090
Evapotranspiration				
Annual change in potential evapotranspiration (% change)	375mm (1961–1990)	4.2	No data	14.3
Fire regimes				
The number of days where the fire danger rating is 'severe' or 'extreme'	0.9	1.3	No data	2.1
Severe wind				
Average maximum daily wind speed (% change)	120 km/h	-0.2 to 1.9	1.8 to 3.2	0.3 to 5.7
Sea conditions				
Sea level rise (m)	0	0.14	-	0.66
Sea surface temperature (°C)	-	1.0	-	3.1
Atmospheric CO_2				
Atmospheric CO_2 concentration	401 ppm	-	-	940 ppm (2100)

26.1.4 Climate change risk evaluation

Climate change risks with a medium or high rating (based on the design presented in this environmental impact statement), prior to additional treatment measures being implemented, are summarised in Table 26-3 (ie 'initial rating'). These 'initial ratings' assume the incorporation of business as usual design, construction and operational controls.

Treatment methods have been identified and are proposed for those 'initial ratings', based on current design or proposed to be carried out as part of future investigations associated with the detailed design of the scheme. The 'final rating' (ie post-treatment), incorporating treatment options and further investigations, are also presented in Table 26-3.

Low risks identified during the assessment were not considered to require any additional risk treatment, as these risks are considered tolerable. As such, risks classified as 'low' or 'negligible' risks have therefore not been included in the table below.

In summary, the assessment of climate change risks identified the following risks prior to additional treatment:

- No extreme risks
- No high risk ratings
- Nine medium risk ratings.

Medium risks are anticipated in respect to increased ambient temperatures and heatwaves, rainfall and surface flooding, concrete carbonation and sea level rise.

Table 26-3 Climate change risk assessment

Risk ID	Hazard Category	Description	Initial Rating	Measures incorporated into the current design and business as usual practice	Proposed treatment or further investigation	Final Rating
7	**Increased ambient temperatures and heatwaves**	Increased occurrence of extreme heat events leading to a greater potential for adverse effects on infrastructure elements (ie the integrity of joints in retaining walls, noise walls and barriers) due to greater and more frequent variations in temperature ranges.	Medium	Standard tolerances for such installations as per Australian Standards.	No additional control.	**Low**
13	**Rainfall and surface flooding**	Subsurface structures and foundations (steel and concrete) could be impacted or damaged with changed groundwater levels due to lower than average annual rainfall.	Medium	Current design standards AS3735, AS2159, AS5100 provide the required guidance on the design and durability requirements.	No additional measures.	**Low**

Risk ID	Hazard Category	Description	Initial Rating	Measures incorporated into the current design and business as usual practice	Proposed treatment or further investigation	Final Rating
14	**Rainfall and surface flooding**	Increase in rainfall events leading to greater ground and stormwater flooding, potentially impacting the operation of water pumps associated with the project but also nearby water treatment plants.	Medium	Plant has been sized to accommodate deluge system which is beyond any climate change rainfall scenario.	No additional measures.	**Low**
25	**Concrete carbonation**	Exacerbated degradation of concrete structural elements associated with the project due to increased carbonation of concrete and exposure of reinforcement from a rise in average atmospheric temperatures or extreme heat events.	Medium	CO_2 diffusion modelling has been carried out with current CO_2 levels with an annual rate of increase; typically 440ppm with a rate of 2 ppm per year for Australian conditions, in accordance with international best practice probabilistic methods. Outcomes of this modelling have informed the design.	No additional measures.	**Low**

Risk ID	Hazard Category	Description	Initial Rating	Measures incorporated into the current design and business as usual practice	Proposed treatment or further investigation	Final Rating
26	**Sea level rise**	Potential for key project elements (ie tunnel portals, ventilation and motorway control centres) to be flooded as a result of sea level rise, resulting in operational failure.	Medium	Key project elements are designed above PMF and above future projected sea level.	Flood modelling during detailed design would continue to use sea level rise projections and rainfall projections.	**Low**
36	**Rainfall and surface flooding**	Potential for key project elements (ie tunnel portals, ventilation and motorway control centres) to be flooded in extreme rainfall/stormwater events, resulting in operational failure.	Medium	Facilities have been designed to be immune in the PMF.	Flood modelling for detailed design would continue to use sea level rise projections and rainfall projections.	**Low**
44	**Rainfall and surface flooding**	Drainage channels and exits of culverts suffer increased scour as one per cent AEP storms (the design standard) are more severe as a result of climate change.	Medium	Preliminary scour protection identified.	The extent of scour protection would be refined during detailed design.	**Low**

Risk ID	Hazard Category	Description	Initial Rating	Measures incorporated into the current design and business as usual practice	Proposed treatment or further investigation	Final Rating
45	**Rainfall and surface flooding**	Design of drainage channels and culverts are not adequate in respect to climate change projections/predictions leading to induced flooding.	Medium	Culverts designed for one per cent AEP event, inclusive of climate change projections.	Sensitivity testing for climate change would carried out in the detailed design of drainage channels and culverts. Increased capacity would be provided where feasible and reasonable.	**Low**
46	**Rainfall and surface flooding**	The exacerbation of flooding (inclusive of climate change projections) in flood-risk areas surrounding the project as a result of the construction of new built form related to the project.	Medium	Sensitivity testing is carried out for climate change as required in the Secretary's environmental assessment requirements.	Detailed design would address any specific property impacts from flooding where feasible and reasonable.	**Medium**

26.1.5 Adaptation for climate change

Table 26-4 lists the actions that would be carried out during further design development to ensure climate change is addressed effectively.

Table 26-4 Environmental management measure – climate change risks

Ref.	Phase	Risks	Environmental management measure	Location
CC1	Design	Sea level rise, rainfall and flooding	The following actions will be carried out during further design development to ensure climate change is adequately addressed: a) Flood modelling will continue to use sea level rise projections and rainfall projections b) The extent of scour protection will be refined c) Sensitivity testing for climate change will be carried out for drainage channels and culverts. Increased capacity will be provided where feasible and reasonable d) Any specific property impacts from flooding will be addressed where feasible and reasonable.	WHT/WFU

Western Harbour Tunnel = WHT, Warringah Freeway Upgrade = WFU

26.2 Greenhouse gas

Atmospheric greenhouse gases absorb and re-radiate heat from the sun, trapping heat in the lower atmosphere and influencing global temperatures. This is known as the greenhouse effect and is linked to climate change.

The emission of greenhouse gases into the atmosphere occurs as a result of both natural processes (eg bushfires) and human activities (eg burning of fossil fuels to generate electricity).

This section outlines the legislation and policies relevant to the project, and the greenhouse gas emissions and potential impacts caused by the construction and operation of the project.

26.2.1 Legislative and policy framework

This assessment was prepared according to the principles and objectives outlined in the following legislation and policies:

- *Kyoto Protocol to the United Nations Framework Convention on Climate Change* (the Kyoto Protocol) (UNFCCC, 1998)
- *Doha Amendment to the Kyoto Protocol (UNFCCC, 2012)*
- *Paris Agreement (UNFCCC, 2015)*
- *National Greenhouse and Energy Reporting Act 2007 (Cth)*
- *Direct Action Plan (Australian Government, 2014)*
- *NSW Climate Change Policy Framework (OEH, 2016)*
- *Environmental Sustainability Strategy* 2019-2023 (Roads and Maritime, 2019).

26.2.2 Assessment methodology

The methodology for this greenhouse gas and energy assessment has been based on the following tools and protocols:

- *Greenhouse Gas Protocol: A Corporate Accounting and Reporting St*andard (World Council for Sustainable Business Development (WBCSD) and World Resources Institute (WRI & WBCSD, 2004)
- *Greenhouse Gas Assessment Workbook for Road Projects* (the TAGG Workbook) (Transport Authorities Greenhouse Group (TAGG), 2013)
- *Infrastructure Sustainability Materials Calculator* (Infrastructure Sustainability Council of Australia, 2016b)
- *Tools for Roadside Air Quality* (Roads and Maritime, 2005).

Greenhouse gas emissions are reported as kilotonnes of carbon dioxide equivalent (ktCO_2-e).

Emissions are categorised into three different scopes in accordance with the Greenhouse Gas Protocol.

The three greenhouse gas scopes are:

- Scope 1 emissions – direct emissions generated by the project, eg emissions generated by the use of diesel fuel in project construction plant, equipment or vehicles
- Scope 2 emissions – indirect emissions from the consumption of purchased electricity for project equipment or operation of the project
- Scope 3 emissions – all other indirect emissions (not included in Scope 2) generated as a consequence of the project, eg emissions associated with the mining, production and transport of materials used in construction.

26.2.3 Assessment of potential construction impacts

The primary sources of construction greenhouse gas emissions and the indicative Scope 1, 2 and 3 emissions are presented in Table 26-5 and Figure 26-1.

The construction stage of the project is expected to generate about 784 ktCO_2e of greenhouse gas emissions. As shown in Figure 26-1, about 50 per cent of emissions are expected to be contributed by construction materials, and about 26 per cent from terrestrial electricity consumption.

The estimated construction stage emissi2ons represent about 0.6 per cent of NSW emissions and about 0.15 per cent of Australia’s national emissions in 2016. Due to the indirect nature of Scope 3 emissions, a proportion of these emissions may be generated interstate or internationally. While these percentage contributions are small within the NSW and national contexts, the environmental management measures outlined in Section 26.2.5 will further minimise greenhouse emissions during the construction of the project.

Table 26-5 Indicative construction phase greenhouse gas emissions by scope

Emission source	Emissions ($ktCO_2e$)			
	Scope 1	Scope 2	Scope 3	Total
Diesel combustion (plant and equipment)	40	-	2	42
Diesel combustion (generators for marine construction)	28	-	1	29
Diesel combustion (transport of materials to terrestrial construction support sites)	-	-	216	16
Diesel combustion (transport of waste and spoil from terrestrial and harbour construction support sites)	-	-	77	77
Vegetation removal	Less than 1	-	-	Less than 1
Electricity consumption (terrestrial)	-	186	27	213
Construction materials	-	-	407	407
Total	**68**	**186**	**530**	**784**

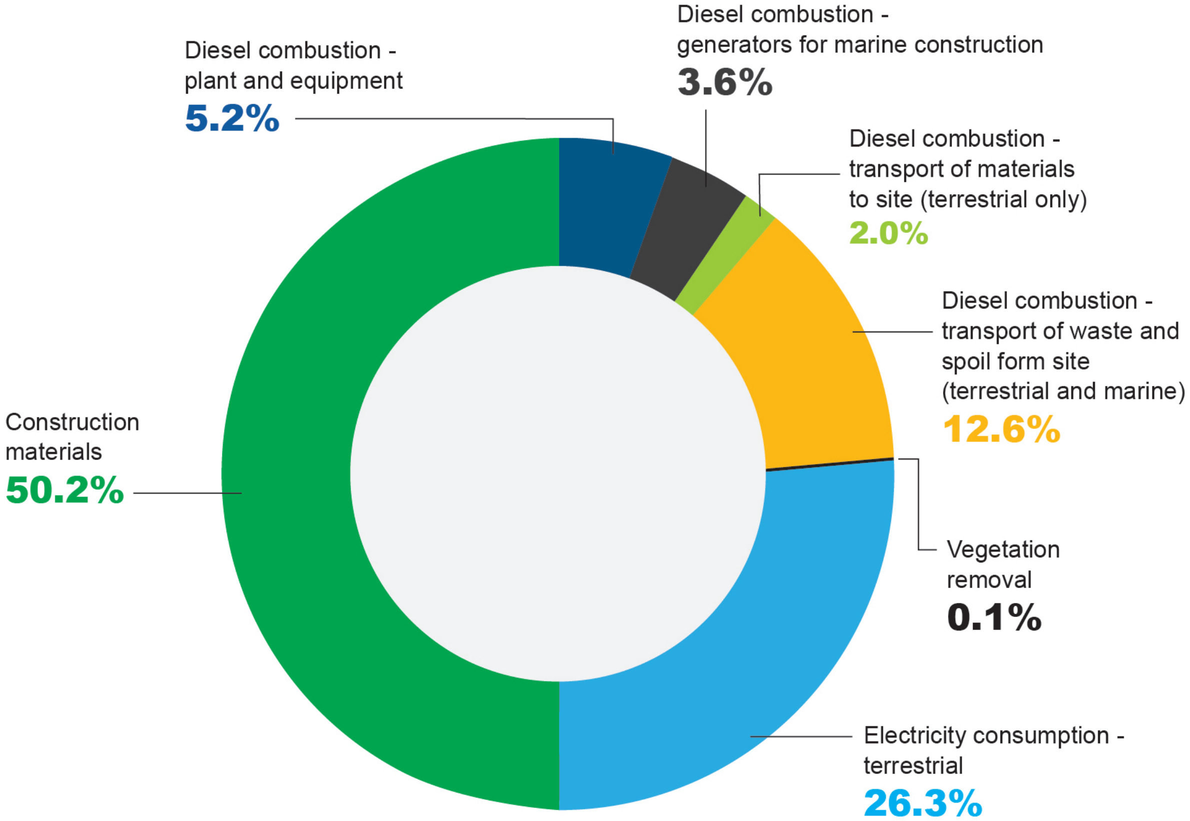

Figure 26-1 Estimated greenhouse gas emissions by source for construction

26.2.4 Assessment of potential operational impacts

The primary sources of operational greenhouse gas emissions and the indicative Scope 1, 2 and 3 emissions are presented in Table 26-6. Emissions estimates are provided for operational scenarios in 2027 (opening) and 2037 (10 years after opening).

Electricity

Operational greenhouse gas emissions would be associated with electricity consumption required to power operational infrastructure and facilities, including:

- Tunnel ventilation
- Surface and tunnel lighting
- Motorway control centre
- Wastewater treatment plant
- Substations.

Operational electricity consumption is projected to increase over time, due to the projected increase in traffic volumes using the roads, increasing tunnel ventilation requirements.

Maintenance

Greenhouse gas emissions generated from the maintenance of road infrastructure would be relatively small in comparison with other operational sources. Emissions would result from the use of diesel fuel maintenance vehicles and equipment, as well as being embedded in the construction materials used for maintenance activities.

Traffic

Operational greenhouse gas emissions would be associated with fuel consumed by vehicles using the road network. Greenhouse gas emissions are projected to increase as traffic numbers across the road network grow. However, the expected reduction in congestion as a result of the project and expected improvements in fuel efficiency and increases in electric vehicles are projected to result in improvements to the overall efficiency of emissions. The project would increase the number of road links across the network but would result in fewer vehicle stop and start movements, less congestion and a greater average vehicle speed, which would further increase the efficiency of vehicles and assist in reducing emissions. Table 26-6 outlines the difference between operation greenhouse gas emissions associated with traffic, with and without the project.

Emission estimates

The estimated operational emissions would represent about 0.04 per cent and 0.05 per cent of projected NSW emissions in 2027 and 2037 respectively, and 0.01 per cent of Australia’s projected national emissions in 2027 and 2037. While these percentage contributions are small within the NSW and national contexts, the environmental management measures outlined in Section 26.2.5 would be implemented to further minimise greenhouse emissions during the operation of the project.

Table 26-6 Indicative operational phase greenhouse gas emissions by scope

Source	Emissions ($ktCO_2e$)			
	Scope 1	Scope 2	Scope 3	Total
2027				
Operational electricity	-	32.3	4.7	36.9
Maintenance	0.53	-	0.47	1.0
Traffic (difference between existing levels and levels with the project)	-	-	20.6	20.6
Total	**0.53**	**52.9**	**4.7**	**58.5**
2037				
Operational electricity	-	34.4	5.0	39.4
Maintenance	0.53	-	0.47	1.0
Traffic (difference between existing levels and levels with the project)	-	-	31.7	31.7
Total	**0.53**	**66.1**	**5.47**	**72.1**

26.2.5 Environmental mitigation measures

Environmental management measures relating to greenhouse gas emissions are outlined in Table 26-7.

Table 26-7 Environmental management measures – greenhouse gas emissions

Ref.	Phase	Risks	Environmental management measure	Location
GHG2	Design	Energy efficiency	Energy efficiency will be considered during further design development with energy efficient systems installed where reasonable and practicable.	WHT/WFU
GHG1	Construction	Emission of greenhouse gases during construction	Greenhouse gas emissions will be managed and minimised as part of the Sustainability Management Plan which will be implemented to assist in achieving 'Design' and 'As Built' ratings of Excellent under the Infrastructure Sustainability Council of Australia rating scheme.	WHT/WFU

Western Harbour Tunnel = WHT, Warringah Freeway Upgrade = WFU

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