6.16 Sustainability, greenhouse gas and climate change

This section provides a summary of the assessment of potential climate change impacts and greenhouse gas emissions during construction and operation of the proposal and identifies mitigation measures to address these impacts. A detailed assessment of climate change and greenhouse gas risks and impacts is presented in the technical working paper – greenhouse gas and climate change risk assessment (Appendix Q). This section also provides a summary of the sustainability objectives of the proposal and outlines specific targets to achieve these objectives.

6.16.1 Methodology

Sustainability

The sustainability assessment for the REF areas of the proposal broadly involved:

- Defining the sustainability context for the proposal within the broader context of NSW's objective of improving transport efficiency, and the relevant Transport policies and guidelines
- Reviewing the sustainability focus areas, associated objectives from the Great Western Highway Environment and Sustainability Policy and responding to how these focus areas apply to the proposal
- Identifying requirements for managing sustainability during detailed design, construction, and operation.

The assessment considered whole of life mitigation in response to the focus areas and objectives.

Greenhouse gas

Greenhouse gases are gases that when released into the atmosphere effectively trap heat influencing global temperatures. The release of greenhouse gases into the atmosphere is caused by both natural processes (such as bushfires) and human activities (e.g. burning fossil fuels and land clearing).

Since the industrial revolution the concentration of greenhouse gases, in parts per million, has rapidly increased, leading to an increase in the earth's average surface temperature and contributing to the phenomenon of 'climate change'.

Greenhouse gas emissions are reported as tonnes of carbon dioxide equivalent (tCO2-e) and categorised into three different scopes (either scope 1, 2 or 3) in accordance with the Greenhouse Gas Protocol (World Resources Institute, 2014), Intergovernmental Panel on Climate Change and Australian Government greenhouse gas accounting/classification systems.

The three emission categories (known as 'scopes') help differentiate between direct emissions from sources that are owned or controlled by a proposal, and upstream indirect emissions that are a consequence of proposal activities, but which occur at sources owned or controlled by another entity. The three greenhouse gas scopes are:

- Scope 1 emissions, also referred to direct emissions
- Scope 2 emissions, also referred to as indirect emissions
- Scope 3 emissions, includes all indirect emissions (not included in scope 2) due to upstream or downstream activities.

The objectives of the greenhouse gas assessment were to:

- Identify the likely sources of greenhouse gas emissions associated with the proposal
- Quantify the greenhouse gas emissions associated with each greenhouse gas source

- Identify opportunities (mitigation measures) to reduce greenhouse gas emissions.

The calculation of greenhouse gas emissions for this assessment was facilitated using the Transport Authorities Greenhouse Group's (TAGG) Carbon Gauge greenhouse gas assessment tool which automates many of the calculations, assumptions and default greenhouse gas emissions factors. Carbon Gauge was used to determine the fuel combustion, material requirements and vegetation clearance associated with the proposal. The tool was also used to calculate the projected electrical energy as well as maintenance fuel and materials requirements of the proposal during operation (with emissions factors updated from other sources as required).

Emissions associated with the change in traffic resulting from the proposal have been calculated in using 'Tool for Roadside Air Quality' (TRAQ). The total annual greenhouse gas emissions (CO_2e) have been calculated for the following scenarios:

- Existing 2021 – Emissions resulting from the existing road layout, with existing traffic levels in the year 2021
- Without proposal 2026 – Emissions resulting from the existing road layout, with predicted traffic levels in the year 2026 (year of opening)
- With proposal 2026 – Emissions resulting from the traffic using the roads constructed as part of the proposal in the year 2026 (year of opening)
- Without proposal 2036 – Emissions resulting from the existing road layout, with predicted traffic levels in the year 2036 (ten years after opening)
- With proposal 2036 – Emissions resulting from the traffic using the roads constructed as part of the proposal in the year 2036 (ten years after opening).

Climate change

Projections

Climate change projections are derived using general circulation models (often referred to as global climate models or GCMs), which simulate the ocean, atmospheric and land surface processes which influence climate. The models are run under historical conditions and with scenarios representing long-term trajectories for greenhouse gas emissions or their effect on radiative forcing.

The projections adopted for the assessment were those developed by NARCliM (NSW and ACT Regional Climate Modelling), a partnership led by the NSW government alongside the ACT and SA Governments as well as the Climate Change Research Centre at the University of NSW. The NARCliM model covers a number of meteorological variables, including air temperature, precipitation, wind speed, surface evaporation and soil moisture.

Risk assessment

The methodology for conducting this climate change risk assessment is based on the Australian Standard AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach. The risk assessment is intended to form part of a risk management process which involves communication and consultation with the design team, relevant stakeholders such as transport departments as well as regular monitoring and review of the risk assessment plan.

Risk analysis and evaluation was carried out through desktop assessment, and in liaison with other specialist studies (such as hydrology). The risk assessment involved the following steps:

- Identify the hazard and receptor
- Assess the potential exposure
- Identify existing controls and their effectiveness

- Identify the consequence rating corresponding to the maximum credible impact across the consequence categories (may be more than one), given the existing controls and their effectiveness
- Identify the likelihood of occurrence of those consequences at that level, considering business as usual controls and their effectiveness
- Determine the level of risk based on the intersection of the consequence and likelihood rating
- Determine any action (e.g. risk treatment) and escalation based on the level of risk
- Recommend next steps for detailed design to carry out prior to reconsideration of the level of consequence and likelihood (and therefore residual risk).

6.16.2 Existing environment

Sustainability

An Environment and Sustainability Policy has been developed to articulate the proposals commitment to sustainable outcomes. This policy has been reproduced below in Table 6-128, and captures the social and environmental sustainability objectives of proposal.

Table 6-128 Great Western Highway Upgrade Environment and Sustainability Policy

Great Western Highway Upgrade Environment and Sustainability Policy
This policy reflects a commitment in the delivery of the Great Western Highway Upgrade program to: • Align with, and support, Transport Environment and Sustainability Policy • Optimise sustainability outcomes, transport service quality, and cost effectiveness • Develop effective and appropriate responses to the challenges of climate change, carbon management, resource and waste management, land use integration, customer and community expectation, and heritage and biodiversity conservation • Be environmentally responsible, by avoiding pollution, enhancing the natural environment and reducing the proposal ecological footprint, while complying with all applicable environmental laws, regulations and statutory obligations • Be socially responsible by delivering a workforce legacy which benefits individuals, communities, the proposal and industry, and is achieved through collaboration and partnerships. To deliver on these commitments, the Great Western Highway Upgrade team will provide: Industry leadership • Implement coordinated and transparent decision making, by engaging with stakeholders and suppliers, encouraging innovation and demonstrating sustainability leadership • Explore new benchmarks for the transport infrastructure sector by requiring high standards from our designers, contractors and suppliers, building on experience gained through development of the Great Western Highway Upgrade. Community • Provide accessible, safe, and convenient access to transport infrastructure for users and all members of the community • Establish positive relationships with community and stakeholders to maximise opportunities to add value to local communities.

Land use integration and place making

- Create desirable places, promote liveability and cultural heritage, and optimise both community and economic benefit
- Balance transit oriented development opportunities with stakeholder expectations.

Embedding environmental and social sustainability

- Establish robust sustainability objectives and targets
- Maintain an environmental management system that is integrated into all our proposal activities
- Ensure thorough and open environmental assessment processes are developed and maintained
- Develop and maintain an environmental management framework to embed best practice pollution management and sustainable outcomes during construction
- Apply effective assurance processes to monitor performance against the proposal environment and sustainability objectives and identify appropriate reward or corrective action, as required
- Apply environment and sustainability specific processes to the procurement of delivery activities.

Accountability

- Undertake public sustainability reporting
- Hold employees and contractors accountable for proactively meeting their environmental and social sustainability responsibilities
- Provide appropriate training and resources necessary to meet our responsibilities.

Transport for NSW Environment and Sustainability Policy

Under the Environment and Sustainability Policy Transport has the following interim sustainability targets:

Circular economy

- Maximise the use of recycled materials in accordance in accordance with existing specifications
- Look for opportunities for use of recycled materials
- Identify/estimate principle waste streams and identify re-use opportunities

Zero carbon

- Minimise energy use in operational assets
- Maximise use of lower emission materials in construction where appropriate

No net biodiversity loss

- Minimise construction footprints where appropriate and cost effective
- Maximise fauna connectivity opportunities
- Design cross-drainage structures for dual purpose fauna and drainage crossings where appropriate
- High quality revegetation and landscaping to reduce operational edge effects
- Provide biodiversity offsets for residual impacts

Future-proof for technology

- Design to allow for EV charging facilities at key points.

Sustainable procurement

- Include mandatory sustainability targets and strategy in procurement packages

- Enhance existing tender assessment to include consideration of above in non-price criteria.

Local employment and skills development

- Adopt Infrastructure Skills Legacy Program or similar outcomes
- Embrace Aboriginal Participation in Construction (APIC) Policy targets

Community spaces with community

- Where impacts to community spaces (e.g. parks, cycleways, footpaths), engage with the community to understand how the community perceives and uses these spaces, and to understand their future ambition.
- Enhance these where appropriate in design – look beyond the road infrastructure.

Aboriginal and local arts and cultural

- Adopt smoking ceremonies or similar for all key milestones / announcements
- Look for opportunities to embrace Aboriginal heritage and culture
- Look for opportunities to public celebrate Aboriginal culture in design
- Look for opportunities to incorporate local artists / art in community spaces and infrastructure spaces.

Climate change

The Central West and Orana Region, within which the proposal is located, has a highly variable climate. Annual and seasonal rainfall and temperatures vary over a wide range. The area is periodically subject to extreme weather and climatic events which may disrupt the community, threaten health and safety and damage infrastructure and the environment. The region's climate is also changing, with signs evident in records of temperature. Those and other changes are projected to continue as increasing atmospheric concentrations of greenhouse gases drive warming and other changes in the climate system.

Most of the seasonal patterns in rainfall are not projected to change significantly by 2030. Overall, summer, winter and spring will see some minor decreases, whilst Autumn is expected to increase by 14.7 per cent. Rainfall is expected to vary across summer with increases in the south west around Parkes and decreases around Coonabarabran. The greatest decreases in rainfall are found across the region during spring. Winter rainfall is primarily decreasing across the region. For 2070, the region is projecting increases in rainfall for summer, autumn and winter whilst spring is still maintaining a decrease of 5.8 per cent.

Table 6-129 Seasonal changes in rainfall (percentage change) for the Central West and Orana Region in response to projected climate change

Time period	2030 (2020 to 2039)	2070 (2060 to 2079)
Summer	-1.1 per cent	13.2 per cent
Autumn	14.7 per cent	13.5 per cent
Winter	-4.2 per cent	5.4 per cent
Spring	-7.6 per cent	-5.8 per cent

Source: Base data from BoM Station 063292. Projection data sourced from Climate Projects for NSW (NSW Government). Table includes projected changes in seasonal rainfalls for the 2030 and 2070 scenarios.

The increases are occurring across the region, with the greatest increase 0.95 degrees Celsius and 2.44 degrees Celsius during summer for the 2030 and 2070 scenario respectively. All models show there are no declines across the Central West and Orana Region.

Table 6-130 Seasonal changes in temperature (degrees Celsius) for the Central West and Orana Region in response to projected climate change

Time period	2030 (2020 to 2039)	2070 (2060 to 2079)
Summer	+0.95	+2.44
Autumn	+0.65	+2.04
Winter	+0.40	+1.65
Spring	+0.80	+2.30
Average	+0.70	+2.11

The Australian Rainfall & Runoff: A Guide to Flood Estimation 2019 (Geoscience Australia, 2019) provides guidance on estimating the increase in rainfall intensity with climate change. ARR 2019 details that an average temperature increase of 1 degree Celsius is in turn associated with a 5 per cent increase in the intensity of extreme rainfall events. Based on the projections in Table 6-130, the increase in rainfall intensity can be predicted. These are detailed in Table 6-131.

Table 6-131 Predicted increase in rainfall intensity in response to projected climate change

Time period	2030 (2020 to 2039)	2070 (2060 to 2079)
Increase in average temperature	+0.7 degrees Celsius	+2.11 degrees Celsius
Predicted Increase in Extreme Rainfall Intensity	3.5 per cent	10.6 per cent

Projections for days of extreme heat (i.e. days higher than 35 degrees Celsius) for the Central West and Orana Region are shown in Table 6-31. By 2030, it is expected the region will experience nearly 10 days a year over 35 degrees Celsius. By 2070, approximately 28 days will experience days of extreme heat.

Table 6-132 Average number of days exceeding 35 degrees Celsius for the Central West and Orana in response to projected climate change

Time period	1991 to 2021	2030 (2020 to 2039)	2070 (2060 to 2079)
Average number of days per year greater than 35 degrees Celsius	1.1	9.7	27.6

Over the course of the 21st century, the Central West and Orana Region is expected to become:

- Warmer: with increased average and extreme high temperatures, but fewer extreme cold temperatures.
- Wetter: rainfall is projected to increase. Increased annual rainfall is anticipated to result in wetter soil conditions, more run-off in water supply catchments and increased average river flows and groundwater recharge.
- Subject to more extreme weather conditions: hydrological cycles are projected to intensify with atmospheric warming, leading to more intense extreme rainfall events. Heatwaves would become more frequent, intense and prolonged. While extreme weather conditions may become more extreme, they may become less frequent.

6.16.3 Potential impacts

Sustainability

Six principles have been developed to govern environmental and socio-economic outcomes and performances for the proposal. The principles are designed to deliver on the Great Western Highway Environment and Sustainability Policy commitments and are set out in Figure 6-60.

Figure 6-60 Sustainability principles and objectives

Targets and initiatives have been developed to support the sustainability principles. These are outlined in Table 6-133. These initiatives and targets would be further refined as part of the design process.

Table 6-133 Sustainability initiatives and targets

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
Demonstrate leadership Deliver a world class road upgrade that is environmentally and socially conscious and	Embedding sustainability objectives into decision making	Integrate environmental and social principles into the proposal framework	●			●	●
		Establish collaborative working relationships with stakeholders	●	●	●	●	●
	Transparency and assurance	Develop performance targets across all sustainability focus areas	●	●	●	●	●

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
demonstrates innovation.		Develop a streamlined outcomes-focused approach to applying sustainability rating tools on the proposal	●				
		Obtain a high Infrastructure Sustainability rating for relevant infrastructure		●	●	●	
		Obtain a high Green Star rating for relevant infrastructure and precincts		●	●	●	
		Develop an assurance framework and reporting system to assist employees and contractors in reliably reporting against sustainability targets		●	●	●	
		Monitor sustainability performance and provide public sustainability reports			●	●	●
	Capture sustainability benefits	Document and evaluate environmental and social costs and benefits	●	●	●	●	●
		Adopt whole of life costing model to maximise benefits	●	●	●	●	●
	Encourage innovation that delivers sustainability benefits	Identify pathways to pilot new technology and approaches	●	●	●	●	●
		Identify opportunities to enable better sustainable approaches	●	●	●	●	●
		Engage with research organisations and look for opportunities to facilitate the uptake of new technologies and approaches	●	●	●	●	●
		Maximise the use of recycled materials in accordance in accordance with existing specifications (RAP / recycled		●	●	●	●

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
	Adopt circular economy principles	glass in asphalt pavement, fly-ash content / recycled glass in concrete)					
		Look for opportunities for use of recycled materials for construction		●	●	●	●
		Identify/estimate principle waste streams and identify re-use opportunities		●	●	●	●
	Emerging trends, approaches and priority areas for consideration	Prioritise blue (water related) and green (natural and designed greening such as landscaping/planting) infrastructure	●	●			
		Engage with local Aboriginal communities to develop integrate Aboriginal cultural values appropriately into design	●	●	●	●	
		Consider the future role of emerging technologies in relation to transport infrastructure and precinct development	●	●	●	●	
		Design to allow for EV charging facilities at key points	●	●			
Tackle climate change Integrate a comprehensive climate change response, and drive excellence in low carbon solutions	Infrastructure and operations will be resilient to the impacts of climate change	Identify all relevant climate change risks		●	●	●	
		Identify and implement adaptation measures to mitigate all very high, high and medium risks for the proposal	●	●	●	●	
		Identify sites vulnerable to flooding, and mitigate impacts where feasible	●	●	●	●	
		Ensure sensitivity testing is carried out on ventilation and air conditioning equipment		●	●	●	

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
		Ensure emergency procedures adequately address extreme weather events				●	
		Protect sensitive construction equipment from the effects of extreme climate and weather			●	●	
		Continued engagement with key stakeholders to develop and implement appropriate responses to interdependent risks		●	●	●	
	Reduce energy use and carbon emissions	Identify and prioritise areas where the greatest reductions in carbon and energy can be achieved	●	●	●	●	
		Use energy efficient equipment, methods, and practices			●		
		Maximise use of lower emission materials in construction where appropriate	●	●	●	●	
		Local sourcing of materials where feasible	●	●	●	●	
		Minimise energy use in operational assets		●		●	
		Adopt enabling technology where feasible	●	●	●		
Manage resources efficiently	Minimise potable water use	Set targets and monitor potable water use		●	●	●	
		Integrate current best-practice water-efficient features, equipment and	●	●	●	●	

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
Achieve whole-of-life value through efficient use and management of resources		appliances at stations, stabling facility and construction sites					
		Avoid use of potable water for non-potable purposes if non-potable water is available	●	●	●	●	
		Set and implement targets for the use of non-potable water in concrete	●	●	●		
	Maximise non-potable water opportunities	Undertake a water balance to inform feasibility for reuse initiatives		●	●	●	
		Identify and implement opportunities for treatment and reuse on the proposal, including water from construction works, concrete batching, casting facilities		●	●		
		Connect to district recycled water networks where feasible	●	●	●	●	
		Harvest and reuse rainwater at permanent and temporary facilities where feasible	●	●	●	●	
	Minimise waste through the proposal lifecycle	Target 95 per cent construction and demolition waste recycling	●	●	●		
		Enable recycling of waste streams from site compounds	●	●	●		
		Plan for final disposal of operational assets		●	●		●
		Use modular, prefabricated and precast structural and finishing materials	●	●	●	●	
		Minimise the use of concrete and steel	●	●			

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
	Reduce materials consumption	Dematerialisation of components and finishes		●	●		
	Reduce embodied carbon and increase use of recycled materials	Undertake lifecycle assessments and minimise the embodied impacts of materials, through the selection of low carbon alternatives and considering durability and local sourcing	●	●	●		
		Minimise the embodied impacts of concrete through the adoption of proposal -wide supplementary cementitious materials use target and set targets for the use of alternate binder systems on non-structural elements		●	●		
		Minimise the embodied impacts of steel through maximising the use of recycled steel and steel produced using energy-reducing processes		●	●		
		Investigate and implement trials and pilot programs to demonstrate the viability of recycled alternatives		●	●		
		Engage with industry bodies to identify best practice low-impact alternative materials		●	●		
	Manage spoil effectively	Minimise volumes of excavation	●	●	●		
		Beneficial reuse of 100 per cent of usable spoil	●	●	●		
	Practice environmentally responsible sourcing	Source construction materials from environmentally responsibly sources where possible	●	●	●		

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
Drive supply chain best practice Collaborate with key stakeholders to drive a lasting legacy in workforce development, industry participation and sustainable procurement	Influence contractors, subcontractors and materials suppliers	Ensure procurement strategies are consistent with ISO:20400 Sustainable Procurement Guidelines	●	●	●	●	●
		Include mandatory sustainability targets and strategy in procurement packages	●				
		Enhance existing tender assessment to include consideration of mandatory sustainability targets and strategy in non-price criteria	●				
		Ensure supply chain sustainability objectives are adopted downstream	●	●	●	●	●
		Provide sustainability training to high impact suppliers		●	●		
	Increase supply chain transparency and responsibility	Adopt ethical governance principles and practices, including the use of Environmental Product Declarations and eco-labelling		●	●	●	●
		Conduct due diligence to ensure supply of materials and equipment align with human rights legislation and environmental standards	●	●	●	●	●
	Drive improvements in workforce development and industry participation	Increase diversity within the workforce and supply chain	●	●	●	●	
		Develop workforce skills which support skill shortages, transferable skills and new technologies	●	●	●	●	
		Increase local employment and participation of small and medium enterprises including Recognised Aboriginal Businesses	●	●	●	●	

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
		Inspire future talent and develop capacity in the sector	●	●	●	●	
		Provide opportunities for social enterprise		●	●	●	●
		Adopt Infrastructure Skills Legacy Program or similar outcomes	●	●	●		
		Embrace Aboriginal Participation in Construction (APIC) targets	●	●	●		
Value community and users Respond to community and user needs, promote heritage, liveable places and wellbeing for current and future generations	Protect and promote Aboriginal and non- Aboriginal heritage and culture	Avoid or minimise impacts to heritage	●	●	●		
		Identify and implement opportunities to enhance heritage and cultural values via design and interpretation	●	●	●		
		Develop partnerships with relevant stakeholders to identify heritage places and promote heritage values	●	●	●	●	
		Ensure key Aboriginal stakeholders are meaningfully engaged	●	●	●	●	
		Create opportunities for archaeological research and interpretation	●	●	●		
		Develop Aboriginal cultural design principles for the proposal and integrate into proposal outcomes	●	●	●	●	
		Adopt smoking ceremonies or similar for all key milestones / announcements			●	●	
		Design in accordance with best practice urban design principles	●	●			

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
	Prioritise community and user wellbeing	Incorporate Crime Prevention Through Environmental Design principles	●	●		●	
		Ensure efficiency and durability of built infrastructure that requires minimum expenditure in maintenance and upkeep	●	●	●	●	●
	Deliver community benefits	Ensure the community and local stakeholders are engaged and kept informed of proposal activities		●	●	●	●
		Where impacts to community spaces (eg parks, cycleways, footpaths), engage with the community to understand how the community perceives and use these spaces, and to understand their future ambition.	●	●			
		Provide information in ways that are easily accessible, taking into consideration dominate language groups	●	●	●	●	●
		Deliver initiatives that benefit local communities and provide positive social outcomes, enhance proposal design to incorporate community spaces		●	●	●	
		Look for opportunities to incorporate local artists / art in community spaces and infrastructure spaces	●	●	●	●	
Respect the environment Minimise impacts and take opportunities to provide	Minimise environmental impact	Target zero major pollution incidents			●	●	●
		Reduce sources of pollution through the development and implementation of a Construction Environmental Management Framework	●	●	●	●	
		Ensure environmental management plans and systems are in place		●	●	●	

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
environmental improvements		Avoid or minimise noise and vibration impacts	●	●	●	●	
		Early identification and management of soil and groundwater contamination issues	●	●	●	●	
		Design to minimise light spill in accordance with AS 4282-1997 Control of the obtrusive effects of oudoor lighting.	●	●	●	●	
		Develop an appropriate response to reduce air pollution	●	●	●	●	
		Develop appropriate responses to manage stormwater and groundwater contamination and runoff	●	●	●	●	
	Promote ecological functions and biodiversity	Avoid or minimise impacts to biodiversity, particularly with regard to endangered, vulnerable and threatened species, habitats and communities	●	●	●	●	
		Preserve ecological function through appropriate planning, management and financial controls	●	●	●	●	
		Contribute to the restoration and conservation of local ecological communities	●	●	●	●	
		Consider connectivity of existing ecosystems and impact on fauna movements	●	●	●	●	
	No net biodiversity loss	Minimise construction footprints where appropriate and cost effective	●	●	●		

Principle	Category	Sustainability initiatives and targets	Proposal life cycle phase				
			Planning	Design	Construction	Operation	End of life
		Maximise fauna connectivity opportunities	●	●	●		
		Design cross-drainage structures for dual purpose fauna and drainage crossings where appropriate	●	●			
		High quality revegetation and landscaping to reduce operational edge effects	●	●	●		
		Provide biodiversity offsets for residual impacts	●	●			
	Provide and promote green infrastructure	Use endemic species in landscaping and prioritise use of Aboriginal knowledge (six seasons) in asset management	●	●	●	●	

Greenhouse gas

Emissions associated with the construction and operation (over a 100 year design life) of the proposal are outlined in Table 6-33. Overall, the proposal is estimated to result in the generation of:

- 129,422 kilotonnes of carbon dioxide equivalent (CO_2e) during the construction of the proposal
- 98,264 kilotonnes of carbon dioxide equivalent (CO_2e) during the operation of the proposal

Greenhouse gas emissions during the construction phase of the proposal has been projected to be predominately sourced from the embedded emissions of the materials used to construct the proposal, accounting for just over 60 per cent of the emissions of the construction phase. Fuel combustion accounts for about 20 per cent of construction phase emissions and vegetation clearance accounts for the remainder.

Traffic emissions dominate the emissions of the maintenance and operation phase of the proposal. Traffic related emissions account for approximately 66 per cent of emissions over the 100-year design life of the proposal, with the remainder generated by maintenance activities and the electricity consumption associated with street lighting.

When divided by scope, the overall emissions of the proposal are dominated by Scope 3 emissions as a result of the significance of traffic and embedded emissions. Scope 3 emissions account for 72 per cent of all emissions of the proposal, with the majority of the remainder Scope 1 emissions.

Given how significant a contribution traffic makes to the overall projected emissions for the proposal, it should be noted that due to potential future changes in technology regarding road vehicles in Australia, emissions projected from traffic may significantly decrease in the future. The modelling method used

assumes improved fuel efficiency in new models of cars in when predicting future emissions, however it does not yet account for the growing adoption of lower emission electric vehicles. It is likely that the increased production and adoption of electric vehicles is anticipated to mean that by 2026 and 2036 there would be a much greater number of electric vehicles using the proposal roads, hence resulting in lower traffic emissions than estimated.

Table 6-134 Greenhouse gas emissions from construction and operation of the proposal

Category	Emission source	Emissions (t CO2e)			
		Scope 1	Scope 2	Scope 3	Total
Construction					
Fuel consumption	Site offices and site vehicles	846	-	43	889
	Construction works	9,772	-	501	10,273
	Demolition and earthworks	12,387	-	635	13,023
	Vegetation removal	350	-	18	368
Materials	Aggregate	-	-	2,038	2,038
	Asphalt and bitumen	-	-	3,146	3,146
	Cement and concrete	-	-	41,613	41,613
	Steel	-	-	33,389	33,389
Vegetation clearance	Class C (Open forest)	4,636	-	-	4,636
	Class D (Open Woodland)	20,047	-	-	20,047
Operation					
Electricity	Street lighting	-	976	108	1,084
Maintenance	Full depth asphalt	14,802	-	19,002	33,804
Traffic	Traffic emissions	-	-	63,376	63,376

Climate change risk assessment

Climate change is anticipated to have direct and indirect impacts on the proposal. The types of impacts are relatively well understood however their severity and extent are uncertain. As such, risks need to be identified and assessed and strategies to treat them developed.

The combined direct and indirect impacts of climate change may contribute to one or more of the following categories:

- Accelerated infrastructure deterioration and increased maintenance requirement
- Safety incidents
- Increased frequency and/or duration of road closures
- Infrastructure loss (total or partial loss as a result of a severe weather event).

Eight risks are identified in Table 6-135 as having a medium risk rating prior to the implementation of environmental management measures. With the implementation of environmental management measures, two of these risks were reduced to minor.

Table 6-135 Climate change risks with an inherent risk rating of medium or higher

Cause, trigger or issue	Risk, hazard or opportunity	Potential consequence	Inherent risk rating	Environmental management measure	Residual risk
Increase in the frequency and intensity of severe rainfall events.	Extreme flood events at Boxes Creek may be too powerful for existing and extended culverts, leading to a failure of the culverts at that area.	Failure of culverts, inability for floodwater to continue downstream, increase in flooding upstream, floodwaters cross over the road, damaging road infrastructure and delaying traffic.	C	Review design conditions to confirm the size and type of culverts are capable of withstanding more intense floods under predicted climate change.	C
Increase in the frequency and intensity of severe rainfall events.	Increased ponding and water accumulation due to the construction of paved surfaces during construction and operation phases	Construction areas are overtopped with flooding, and ponding on roads cause construction delays and traffic accidents and delays during operation.	C	Storm water modelling to review climate change projections and flooding for 10 per cent, 20 per cent and 30 per cent increases on standard 100 year ARI event.	C
Increase in the frequency and intensity of severe rainfall events.	Sections of the designed road alignment may worsen localised flooding (such as the Kelly Street Service Road), which may be compounded by flood events becoming more frequent and intense.	Flooding damages in the locality may become worsened beyond what was originally expected due to the compounded effects the road design and climate change, leading to impacts both in and out of the proposal alignment.	C	Review climate change projections for the locality where climate change may compound flooding and determine if any changes are required for design.	D
Increase in the frequency and intensity of severe rainfall events.	Sections of the designed road which formerly permitted overtop flow are heighted, leading to the potential for worse upstream flooding, further exasperated by increased flood intensities.	Flood waters increasing in height by metres, failure or damage to culverts and embankment under the worst circumstances.	C	Review the design of the embankments and climate change projections to determine if any changes are required for design.	D
Increased temperatures and the more	Maintenance activities have to be	Delay in maintenance	C	Accept risk and use standard procedures	C

Cause, trigger or issue	Risk, hazard or opportunity	Potential consequence	Inherent risk rating	Environmental management measure	Residual risk
frequent incidence and severity of heatwaves.	postponed due to extreme heat.	activities causes a backlog in work.		for working in extreme heat.	
More severe fire weather and elevated fire weather conditions.	Increased local bushfires cause decreased visibility due to smoke effects	Road users suffer reduced visibility due to smoke effects resulting in accidents.	C	Accept risk and actively manage through road closures as appropriate.	C
More severe fire weather and elevated fire weather conditions.	Increased local bushfires destroy road signage or equipment.	Bushfires in the proximity of the proposal cause direct damage to road signage and other road furniture.	C	Design consideration should be provided for potential impacts to structures, utilities and fauna connectivity structures in bushfire prone areas. Where feasible, access to fire trails will be maintained.	C
Increased concentration of carbon dioxide in the atmosphere.	Carbonation occurs to a greater depth in concrete structures, allowing exposure and degradation of reinforcement. Retaining walls, piers and bridge deck elements are degraded quicker than anticipated shortening their design life.	Shorter design life results in greater levels of inspection and maintenance needed, increase asset operational costs.	C	Review standards for concrete cover of reinforcement to provide additional coverage as required.	C

6.16.4 Safeguards and management measures

Table 6-136 Safeguards and management measures – sustainability and climate change

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
GH01	Greenhouse gas emissions	Undertaking detailed modelling to ensure that cut and fill balances are managed to minimise any unnecessary movements of material;	Contractor	Detailed design	Appendix Q	All

No	Impact	Environmental safeguards	Responsibility	Timing	Reference	Locations
GH02	Greenhouse gas emissions	Review opportunities to specify biofuel use on construction plant and equipment based on site for long periods;	Contractor	Detailed design	Appendix Q	All
GH03	Greenhouse gas emissions	Review opportunities to use alternative materials in construction, such as fly ash as a supplementary cementitious material (to replace traditional Portland cement) and reclaimed aggregate;	Contractor	Detailed design and construction	Appendix Q	All
GH04	Greenhouse gas emissions	Specify high recycled content in steel use (where technically possible and cost effective).	Contractor	Detailed design	Appendix Q	All
GH05	Flooding	Findings of the CCRA will be used to inform further design considerations, mitigation measures and management plans regarding flooding in and around the proposal alignment.	Contractor	Detailed design	Appendix Q	All
GH06	Bushfire risk	Findings of the CCRA will be used to inform bushfire risk management measures and management plans.	Contractor	Detailed design	Appendix Q	All
GH07	Climate projections	Adopt consideration of climate projections, flooding and bushfire risks when developing the detailed design and material consideration	Contractor	Detailed design	Appendix Q	All

Other safeguards and management measures that would address sustainability and climate change impacts are identified in section 6.8 Hydrology and flooding.