10.6 Air quality

A *M2 Motorway widening – Air quality impact assessment* report was prepared by Heggies Pty Ltd, dated February 2009 and a summary is presented below.

10.6.1 Existing environment

The M2 Motorway spans approximately 21 kilometres from Baulkham Hills to North Ryde and is, in several sections, in close proximity to a number of medium density residential areas mainly in the form of suburban detached dwellings with a small number of multi-unit developments. The eastern end of the M2 corridor also has light industrial uses. The M2 Motorway traverses a largely urban environment. As such background air quality in the vicinity of the M2 Motorway is largely governed by regional background air quality. Regional air quality is subject to factors such as seasonal variations, wind and temperature effects, varying potential pollutant sources such as vehicular emissions and industry and event type pollutant loads such as bushfires. Consequently, regional air quality can be highly variable in nature.

The contribution of vehicular emissions to atmospheric pollutant loads in the urban environment has been decreasing in recent years and is expected to continue to do so. Fuel and vehicle emissions standards have been becoming progressively more stringent due to government regulations and would continue to do so into the future. This is expected to lead to a large fall in vehicular emissions, which would have a follow on effect on overall air quality, particularly in urban environments such as the current study area.

NSW DECCW Action for Air (2009) sets out the NSW Government's 25-year air quality management plan for Sydney, the Illawarra and the Lower Hunter, and introduces a wide range of measures to reduce air pollutants from a wide range of sources. Vehicle exhaust emission standards for motor vehicles are prescribed under the Australian Design Rules (ADR), which implemented via the *Motor Vehicle Standards Act 1989*. Australian emission standards are now aligned with international standards (referred to as 'Euro standards').

Objective 3 of Action for Air: Make cars, trucks and buses cleaner, outlines the implementation timetable for vehicle emission standards in Australia as set out in Table 110.

Table 110 Implementation timetable for vehicle emission standards in Australia

Emission standards for light duty petrol vehicles		Emission standards for heavy duty diesel vehicles	
Standard	Implementation dates	Standard	Implementation dates
Euro 2	2003-2004	n/a	n/a
Euro 3	2005-2006	Euro 3	2002-2003
Euro 4	2008-2010	Euro 4	2007-2008
Euro 5	n/a	Euro 5	Proposed 2010-2011

Source: DECCW 2009

The development of ADRs, is summarised below, which is taken from the RTA website:

- ADR 79/00 (Emissions Control for Light Vehicles) introduced Euro 2 emission standards for new light vehicles operating on diesel from 1 January 2002, and for new light vehicles operating on petrol, Liquefied Petroleum Gas (LPG) and Natural Gas (NG) vehicles from 1 January 2003.
- ADR 80/00 (Emission Control for Heavy Vehicles) introduced Euro 3 emission standards for new heavy vehicles operating on diesel, LPG and CNG from 1 January 2002; for new heavy vehicles operating on petrol from 1 January 2003.
- ADR 79/01 introduced Euro 3 emission standards for light vehicles operating on petrol, LPG or NG from 2005 and for light vehicles operating on diesel fuel from 2006.
- ADR 80/01 introduced Euro 4 emissions standards for heavy vehicles operating on petrol from 2005 and for heavy vehicles operating on diesel, LPG and NG from 2006.
- ADR 80/02 (Euro 4) was implemented for heavy vehicles which run on diesel, liquefied petroleum gas or natural gas from January 2007 for new model vehicles and from 29 February 2008 for existing models of vehicle.
- ADR 79/02 (Euro 4) was implemented for new model light petrol, LPG and NG vehicles from July 2008 and from July 2010 for light vehicles.
- ADR 80/03 (Euro 5) will be implemented for new model heavy vehicles with a GVM greater than 3.5 tonnes, which run on diesel, liquefied petroleum gas, petrol or natural gas from 2010 and from 2011 for heavy vehicles.

Table 111 Euro emission standards for passenger cars (Category M1), g/VKT

Tier	CO	Hydrocarbons	NOx	Particles
Diesel				
Euro 3	0.64	-	0.50	0.05
Euro 4	0.50	-	0.25	0.025
Euro 5	0.50	-	0.18	0.005
Euro 6	0.50	-	0.08	0.005
Petrol				
Euro 3	2.3	0.20	0.15	
Euro 4	1.0	0.10	0.08	
Euro 5	1.0	0.10	0.06	0.005
Euro 6	1.0	0.10	0.06	0.005

Source: http://www.dieselnet.com

Action for Air makes the following comment in regard to effect of implementing vehicle emission standards and fuel standards:

> *"Taken together, the new fuel and vehicle emission standards are expected to lead to a significant fall in emissions."*

Despite the expected increases in VKT, motor vehicle emissions of carbon monoxide, VOCs and NOX in the Greater Metropolitan Region are forecast to fall by 62%, 40% and 55%, respectively, from 2002 to 2020 (DOTARS, 2004).

The emission factors provided by DECCW used in this assessment for light and heavy vehicles assume no improvement in vehicle exhaust standards to the assessment year of 2021. In reality, improvements in engine and fuel technology, together with the continued implementation of the vehicle exhaust emission standards across Australia would deliver a substantial reduction in vehicle exhaust emissions. In view of the foregoing, it is considered that this assessment represents a highly conservative scenario for the 2021 roadway emissions.

DECCW has established ground level air quality impact assessment criteria for key air pollutants to achieve appropriate environmental outcomes and to minimise associated risks to human health as published in the 2005 document, the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (the Approved Methods). A summary of the impact assessment criteria is given in Table 112 and Table 2 of Technical Paper 11.

For the purposes of this assessment, the key pollutants of interest are:

- Nitrogen dioxide (NO2).
- Carbon monoxide (CO).
- Particulate matter less than 10 microns in aerodynamic diameter (PM10).

A discussion of other potential air pollutants and their relevance to the current assessment is provided below.

Sulphur dioxide (SO_2) is generated by road related sources. SO_2 emissions from road traffic exhaust emissions is primarily controlled by the regulation of the sulphur content in diesel fuels, which has been systematically reduced since 2001 under the *Fuel Standard (Automotive Diesel) Determination 2001* DEWHA (2001). Under this determination, sulphur content in diesel fuel is now regulated to 10 parts per million (ppm), from 500ppm in 2002 and 50ppm in 2006.

Air pollution associated with lead-based fuels has historically been of concern in urban environments. However, since the removal of lead from fuel, lead is no longer likely to be a pollutant of concern and is not considered in this assessment.

Table 112 Air quality impact assessment criteria specified by DECCW

	Averaging Period	Concentration		Source
		pphm	µg/m³	
Sulphur dioxide (SO2)	10 minutes	25	712	NHMRC (1996)
	1 hour	20	570	NEPC (1998)
	24 hours	8	228	NEPC (1998)
	Annual	2	60	NEPC (1998)
Nitrogen dioxide (NO2)	1 hour	12	246	NEPC (1998)
	Annual	3	62	NEPC (1998)
Photochemical oxidants (as ozone)	1 hour	10	214	NEPC (1998)
	4 hours	8	171	NEPC (1998)
Lead	Annual	-	0.5	NEPC (1998)
PM10	24 Hours	-	50	NEPC (1998)
	Annual	-	30	EPA (1998)
PM2.5	24 hours	-	25	DECCW (2004) - NEPM
	Annual	-	8	DECCW (2004) - NEPM
Total suspended particulates (TSP)	Annual	-	90	NHMRC(1996)
		Maximum Increase (g/m2/month)	Maximum Total (g/m2/month)	
Deposited dust	Annual	2	4	NERDDC (1998)
		ppm	mg/m³	
Carbon monoxide (CO)	15 minutes	87	100	WHO (2000)
	1 hour	25	30	WHO (2000)
	8 hours	9	10	NEPC (1998)

Ozone is commonly associated with photochemical smog in urban environments. Ozone is not specifically considered in this assessment because it is a secondary pollutant, formed by the action of sunlight on NO_2 and volatile organic compounds. Hence, the measurement of NO_2 would reveal if ozone concentrations are likely to be a concern. Ozone is also a regional rather than a local phenomenon.

Total Suspended Particles (TSP) and dust are both measures of airborne particulates, like PM_{10}. Hence, the modelled PM_{10} air quality would reveal if it is likely that TSP or dust are likely to exceed their criteria. Additionally, the criteria for these larger particles (TSP and Dust) are set only for nuisance prevention rather than health protection. Consequently, only the pollutants NO_2, CO and PM_{10} have been examined in this assessment.

Particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$) is generated by road related sources. Such particulates are increasingly of concern due to potential inhalations and respiratory system impacts. At this time there are no set standards or goals for particulate matter as $PM_{2.5}$. Advisory goals only are provided in the Air NEPM (DECCW 2004). Similarly there is limited data for atmospheric $PM_{2.5}$

levels and emissions factors for vehicles. Given the increasing focus of $PM_{2.5}$ it is included in this assessment. The air quality standards for pollutants relevant to this assessment are summarised in Table 113.

Table 113 Project ambient air quality goals

Pollutant	Averaging Time	Maximum Allowable Level
NO_2	1-hour	12 pphm
CO	8-hours	9 ppm
PM_{10}	24-hour	50 µg/m^3
$PM_{2.5}$ [1]	24-hour	25 µg/m^3

Note 1: Advisory goals only

Abbreviations: pphm = parts per hundred million ($1x10^{-8}$)

ppm = parts per million ($1x10^{-6}$)

µg/m3 = microgram (g x 10-6) per cubic metre

For the purposes of assessing the potential cumulative air quality impacts from the project, an estimation of ambient air quality concentrations is required. The closest DECCW monitoring station to the M2 Motorway is located in the grounds of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Lindfield Laboratories at West Lindfield, approximately 1.5 kilometres east-southeast of the intersection of Lane Cove Road and the M2 Motorway. Hourly monitoring data from the most complete calendar year available, 2004, was sourced from the DECCW. In accordance with advice from the DECCW Atmospheric Science department, data recorded at the Lindfield station was deemed to be the most appropriate to quantify the existing air quality environment in the vicinity of the M2 Motorway, regardless of the large spatial distance the roadway covers.

No specific data for $PM_{2.5}$ is available from the CSIRO Laboratories at West Lindfield. PM_{10} and $PM_{2.5}$ data from other locations in Sydney has been assessed (Liverpool and Lucas Heights, and Magdala Park in North Ryde). From this data a factor has been developed to apply to PM_{10} data to estimate an approximate background level for $PM_{2.5}$ for the purpose of this assessment. The site-specific ambient air quality concentrations adopted for the purposes of this assessment are summarised in Table 114.

Table 114 Ambient air quality environment

Air Quality Parameter	Averaging Period	Assumed Background Ambient Level
NO_2	1-hour maximum	1.4 pphm[1]
CO	8-hour maximum	4.7 ppm
PM_{10}	24-hour maximum	42.3 µg/m^3
$PM_{2.5}$	24-hour maximum	19.0 µg/m^3

Note 1: Assumed to be the 75^{th} percentile of hourly measured concentrations, refer Section 10.6.1.

Within the tunnel itself, operator experience, based on monitoring of CO levels in the tunnel, indicates that CO concentrations in the eastbound tunnel can typically be 7 – 8 ppm and up to 9 – 10 ppm in the morning peak. Concentrations of CO can reach 20 ppm, at which point ventilation is required. However, this occurs very rarely and these concentrations are not sustained. Examination of in-tunnel carbon monoxide monitoring data for a typical traffic week day shows that maximum 1 minute CO concentrations experienced were 10 ppm.

10.6.2 Impact assessment

Operation impacts

An assessment of the potential impacts of the project was undertaken. The proposed upgrade is designed to accommodate an increased volume of traffic and therefore would affect air quality in proximity to the M2 Motorway. Air quality modelling has primarily been used in this study to predict incremental contributions of pollutants from the M2 Motorway at sensitive receptors based on provided future traffic projections for 2021. A number of residential, commercial, institutional and recreational receptors locations along the length of the M2 Motorway have been selected as suitably representative sites for input in the dispersion modelling process (total 65 sites). A list detailing the receptors adopted in this assessment is provided in Table 1 of the *Air Quality Impact Assessment* (Heggies 2010).

Two modelling scenarios have been undertaken to determine the air quality impact of the proposed project, specifically:

- Scenario 1 - 2021 'Do Nothing' configuration – current M2 Motorway configuration with corresponding predicted 2021 traffic predictions.
- Scenario 2 - 2021 'Upgrade' configuration – M2 Motorway post-upgrade configuration with corresponding predicted 2021 traffic predictions.

Cumulative concentrations of pollutants have also been assessed using background air quality data collected in the local area.

Air quality within the tunnel and associated with emission from the tunnel openings have also been assessed and are discussed in this section.

In order to adequately characterise the dispersion meteorology likely to be experienced along the M2 Motorway, meteorological observations recorded at the CSIRO Lindfield air quality monitoring station during 2004, concurrent with the NO_2 monitoring dataset, were obtained and processed using a dispersion model. The Air Pollution Model (TAPM) meteorological model (Version 3), developed by CSIRO, was used. The modelling revealed diurnal variations in average mixing depths (the height above the ground to which pollutants are mixed by turbulence in the air).

In order to determine the potential impact on air quality along the extent of the M2 Motorway, the transportation dispersion model CAL3QHCR, developed by the United States Environmental Protection Agency (USEPA), was used. Predicted daily total work-day traffic figures were provided for the M2 Upgrade project environmental assessment for both Scenario 1 and Scenario 2. Furthermore, the predicted distribution between passenger vehicles and heavy goods vehicles for each section of the M2 Motorway and an hourly traffic distribution profile, recorded at the M2 Motorway Toll Plaza in 2008, were provided by the M2 Motorway operator.

A highly conservative assessment of air quality impacts at key receptor locations has been undertaken. This assessment is likely to overestimate pollutant concentrations and air quality impacts associated with the M2 Upgrade project. A list of the conservative assumptions for the modelling assessment is presented in Table 115.

Table 115 Modelling assessment assumptions

Conservative assumption	Potential impact on assessment results
No vehicle emissions reductions applied between present day and 2021	In reality, technological and fuel efficiency improvements as currently implemented through government regulation would reduce emissions. As these emission improvements have not been factored in, the resultant predictions would likely be higher than actual future emission levels.
NO_X to NO_2 conversion assumed to be 10 percent of NO_X at distances up to 15 metres from kerbside and 20 percent at distances beyond 15 metres from kerbside.	In reality, this value is approximately 7.5 percent at source increasing to 20 percent at distances of several hundred metres from the roadway.
Elevation differences between roadway and receptors not accounted for[1]	This assumption would result in unobstructed flow of pollutants to receptors. In reality, topographical features and barriers such as noise walls or vegetation screens would act to obstruct the flow of pollutants to receptor and result in lower concentrations[2].
Tunnel portal emissions distributed along a 200 metre section of roadway	The assessment methodology assumes that pollutants emitted within the tunnel are released at the tunnel exits in the direction of travel. In reality, emissions in the tunnel would not be released from the tunnel exit. Also, the assessment methodology does not account for mixing of emissions from the tunnel exits with the ambient air for a distance of 200 metres past the tunnel exits, which in reality would cause some dilution of the pollutants present.

Note 1: With the exception of R46 and R47, which are elevated above the road at the eastern tunnel portal and are dealt with as a special case in the Air Quality Impact Assessment.

Note 2: Unquantifiable within the dispersion modelling assessment.

The predictions indicate that all modelled pollutant concentrations would meet current DECCW and NEPM air quality criteria as adopted by the NSW State Plan at the selected sensitive receptor locations. Due to the highly conservative nature of the assessment conducted, it is considered that the actual concentrations would be lower than those predicted under actual road operation. The targets adopted by the NSW State Plan require meeting the national air quality goals as specified in the NEPM for ambient air quality. The concentrations of air pollutants at all receptors are predicted to meet the NEPM standards even under the adoption of worst case assumptions. The maximum incremental 1-hour NO_2 concentration, due to the operation of the proposed upgrade, is predicted to be no greater than 7.3 pphm in Scenario 1 and 7.8 parts per hundred million (pphm) in Scenario 2 at selected receptor locations. With the addition of the assumed background concentration of 1.4 pphm, taken from the monitoring data from Lindfield for 2004, cumulative 1-hour maximum concentrations of NO_2 are likely to be 7.5 pphm for Scenario 1 and 7.8 pphm for Scenario 2, which are below the relevant DECCW criterion of 12 pphm (1-hour).

In the vicinity of the Norfolk Tunnel, predicted concentrations of air pollutants are higher than at any other point across the M2 Motorway. Indeed, the maximum predicted cumulative concentrations of NO2 in this area are approximately 65 percent of the DECCW criterion. However, it is considered that the method adopted to replicate portal emissions within this assessment is highly conservative. Conservative vehicle emission factors and assumptions have been used in the assessment methodology that would result in poor dispersion of airborne pollutants. Due to the combination of these factors, it is considered that the predicted pollutant concentrations at this location are higher than those likely to be experienced in reality.

The maximum incremental 8-hour CO concentration due to the operation of the proposed upgrade is predicted to be no greater than 0.6 ppm in either Scenario 1 or Scenario 2 at selected receptor locations. This is then added to the assumed background concentration of 2.8 ppm, taken from NSW DECCW Sydney Metropolitan area monitoring data for 2004, to give likely cumulative 1-hour maximum CO concentrations of 3.4 ppm for both scenarios, which is below the relevant DECCW criterion of 9ppm.

PM_{10} concentrations are also likely to be less than DECCW guideline concentration of 50µg/m3 (24-hours). Background maximum incremental 24-hour PM_{10} concentrations during the operation of the proposed M2 Upgrade project are predicted to be less than 5.5 micrograms per cubic metre and 5.0 micrograms per cubic metre during Scenario 1 ('no upgrade') and Scenario 2 ('upgrade') M2 configurations. With Scenario 1, the maximum 24-hour PM_{10} concentration of 5.5 micrograms per cubic metre is predicted at R47 (Devon Street, North Epping) and with Scenario 2 the maximum 24-hour PM_{10} concentration of 5.0 micrograms per cubic metre is predicted at R18 (Craig Avenue, Baulkham Hills) and R35 (Pennant Hills Golf Course).

With the addition of the assumed background PM_{10} concentration of 42.3 micrograms per cubic metre taken from the monitoring data from Lindfield for 2004, the predicted cumulative 24-hour maximum concentrations of PM_{10} are 47.8 micrograms per cubic metre for Scenario 1 and 47.3 micrograms per cubic metre for Scenario 2. These predictions are marginally below the DECCW criterion for PM_{10} of 50 micrograms per cubic metre. Relative contributions to the predicted overall concentrations in both scenarios are small compared to background levels. Also, the contributions due to the M2 Motorway are also likely to be over stated due to the conservative assumptions used in the modelling process.

Due to the limited data available regarding vehicle emissions PM2.5, it has not been specifically modelled in this assessment. Instead, a qualitative assessment has been undertaken to compare anticipated concentrations of $PM_{2.5}$ particles against the 24-hour National Environment Protection Council Measure for Air Toxics (NEPM, 2004) advisory standard of 25 micrograms per cubic metre averaged over 24 hours. A ratio of $PM_{2.5}$ to PM_{10} ratio of 0.45 was chosen, based on data measured at Magdala Park, North Ryde. This is considered to be worst case because the ratio is higher than other longer term monitoring data collected by the Australian Nuclear Science and Technology Organisation (ANSTO) in Sydney.

Calculations indicate that incremental concentrations of $PM_{2.5}$ arising from the M2 Upgrade project would be in the order of 2.5 micrograms per cubic metre (45 percent of 5.5 micrograms per cubic metre PM_{10}) during Scenario 1 and 2.3 micrograms per cubic metre (45 percent of 5.0 micrograms per cubic metre PM_{10}) during Scenario 2. Furthermore, adding the M2 Upgrade project component to the maximum 24-hour $PM_{2.5}$ background concentration of 19 micrograms per cubic metre results in a cumulative $PM_{2.5}$ concentration of 21.5 micrograms per cubic metre, which is still 3.5 micrograms per cubic metre below the NEPM advisory standard. It is background levels and not predicted emissions associated with the M2 Upgrade project that make the dominant contribution to the predicted $PM_{2.5}$ levels.

The results of the dispersion modelling of the M2 Motorway emissions of NO2, CO and PM_{10} show that for both the 2021 'Do Nothing' and 'Upgrade' scenarios, emissions generated by M2 Motorway traffic are unlikely to exceed relevant DECCW assessment criteria. Also, the results indicate that changes in air quality in the vicinity of the M2 Motorway as a result of the M2 Upgrade project are expected to be minor. Further, in accordance with the requirements of Action for Air, more stringent vehicle exhaust emission standards are likely to result in more efficient vehicles resulting in a decrease in emissions on a per vehicle basis.

Finally, the Scenario 1 'Do Nothing' configuration predictions are routinely lower than those for the Scenario 2 'Upgrade' configurations (by up to approximately 10 percent). However, it is predicted that traffic congestion in Scenario 1 would be greater than in Scenario 2 ('upgrade'), due to widening of the

M2 Motorway. Vehicle emissions from free flowing traffic are generally of better quality than the emissions during congested situations. Intermittent traffic congestion was not accounted for as such finer-scale traffic data cannot readily be handled by this screening level dispersion model. It is considered probable that, if the effect of congestion on air quality could be taken into account, air pollution concentrations for Scenario 2 'Upgrade' would be more comparable and potentially lower than for Scenario 1 'Do Nothing'.

In addition, although the M2 Motorway traffic volumes would increase, the traffic modelling (refer to Section 9.1) indicates that there would be a reduction in traffic on the surrounding arterial road network. Hence, any increased air emissions from vehicles travelling on the M2 Motorway would be offset in part by the reduction in emission on other routes due to less vehicles and improved driving conditions (reduced congestion) on these routes.

Within the Norfolk Tunnel, motorists may be exposed to elevated concentrations of pollutants for approximately one minute (the approximate maximum duration of time spent inside the tunnel). It is noted that pollutant emissions would vary depending on traffic flow, congestion and driving conditions within the tunnel. The continuous monitoring and the provision for ventilation controls maximum concentrations of CO in the tunnel. Thus, these are kept below the relevant DECCW criteria. No specific monitoring data for the other pollutants is available. However, due to the provision of ventilation it is considered that these pollutants would also be below DECCW criteria.

Whilst specific quantitative modelling has not been undertaken for CO or other key pollutants in the tunnel in the 2021 scenarios, it is considered unlikely this situation would change significantly due to the proposed upgrade and it is therefore unlikely that the DECCW criteria would be exceeded.

Construction impacts

Construction activities have the potential to impact on local air quality for sensitive receptors in proximity to project-related construction works. The air pollutants of main concern are fugitive dust emissions. Aspects of the upgrade with the potential to generate dust include:

- Demolition works.
- Civil engineering works.
- Road upgrades.
- Construction traffic.

Emissions from construction-associated traffic and equipment are expected to increase during the construction phase of the project. An increase in traffic is expected during the construction phase of the project, particularly heavy vehicle movements to, from and around the project work sites. A large amount of plant and equipment would also be required to facilitate construction, which have the potential to increase air emissions either directly or indirectly. Such emissions are expected to have only minor, localised and short-lived impacts of air quality in the study area.

10.6.3 Mitigation measures

No additional mitigation for operational air quality is required, since predictions for air quality indicate that modelled pollutant concentrations would meet current DECCW or NEPM air quality criteria at the selected sensitive receptor locations.

Mitigation measures for construction-associated activities are as follows. Dust emissions arising from construction activities can largely be controlled through operational and physical measures, which are routinely adopted as common practice during similar construction projects.

A number of safeguards and management practices can be used to protect the environment during construction activities. These include:

- Regular watering of unsealed access roads and exposed surfaces.
- Minimisation of exposed surfaces.
- Wind breaks composed of earth banks and other screens to protect small areas by reducing capacity of the wind to raise dust.
- Dust screening between construction activities and residential receptors.
- Progressive rehabilitation of exposed areas.
- Amending of dust-generating activities construction activities during adverse wind conditions.
- Installation of truck wheel washes, rumble grids or other measures to minimise tracking of dirt and generation of dust off site.
- Minimising the drop heights between front end loader buckets and the truck(s) being loaded.
- Introducing speed restrictions and designated transport routes for project traffic on unsealed surfaces.

The potential emissions from construction-associated traffic and equipment can be managed by:

- Limiting the amount of truck movements on- and off-site wherever practicable.
- Ensuring that vehicle queuing does not occur in local roads and adjacent to sensitive receptors such as residences.
- Ensuring adequate maintenance of trucks entering and leaving the site and emitting plant and equipment to reduce adverse impacts. Maintenance would be in accordance with the manufacturer's specification.

In order to manage the potential emissions during the project, an appropriate and adaptable air quality management strategy would be developed to support the various stages of construction and areas of work. The strategy would also outline air quality targets and the monitoring activities that would be conducted. Details of this overall air quality management strategy would be documented in the Construction Environmental Management Plan (CEMP) for the project. An outline of the CEMP is provided in the Construction Environmental Management Framework (refer to Appendix F).

10.7 Construction lighting impacts

A *Lighting Impact Assessment* report was prepared by Heggies Pty Ltd, dated January 2010 and a summary is presented below.

The objective of the assessment was to establish lighting levels at construction compound locations that are reasonably cost effective, provide sufficient illuminance levels and do not cause adverse light spill.

The assessment included the following elements:

- Establishment of relevant lighting criteria.
- Identification of surrounding sensitive receivers, such as residences, roads and traffic signalling systems.
- Assessment of impact on areas adjoining the compounds during the construction phase of the project, including:
  - Construction night-time light spill at residential properties.
  - Disability glare for road users.
  - Obtrusive glare from construction vehicle headlights at access points.
- Development of mitigation options to manage potential adverse effects of construction compound lighting.

The exact locations of the proposed compounds and the site boundaries may still be altered during the detailed design process.

10.7.1 Existing environment

The existing M2 Motorway interchanges and access ramps are currently lit during night time periods. The light is focussed on the carriageways and is often shielded from residences by noise walls and screening vegetation.

The current environment at the majority of the proposed compound sites is characterised by low levels of lighting. These sites are generally undeveloped areas with no lighting requirements. The exceptions are the Talavera Road and existing TIDC compounds which have either been developed or have previously been used as construction sites. These potential compound sites currently require or have recently required illumination.

Many of the construction compound sites are bordered by or are in close proximity to residential developments.

Assumptions and assessment criteria

Assumptions

Following the M2 Upgrade project, there would be additional lighting requirements at the new interchanges at Windsor Road, Christie Road and Herring Road only. Given that there is existing lighting along the M2 Motorway and at these interchanges, the increase in lighting would be negligible as a result of the M2 Upgrade project. This assessment therefore relates only to the lighting impacts during the construction phase.

The assumption has been made that lighting would be required during the winter months and during night-time periods (pre-sunrise and post-sunset) at certain compounds. Twenty-four hour construction activities have been proposed at 7 out of the 16 construction compounds assessed in this report. These compound sites include the Windsor Road, Beecroft Road (old bus ramp), Beecroft Road (tunnel), Toll Plaza, Christie Road, Macquarie Park and the existing TIDC compound. It is assumed that the remaining compound sites would be lit with localised security lighting during night time periods.

Where possible, lighting would be positioned away from residential development. This assumption has been used to determine the likely lighting arrangements assessed for each compound.

It is assumed that primary site lighting would consist of lighting towers. It is likely that each tower would be fitted with two or three 1500 Watt Metal Halide Floodlights, meaning each tower would produce 3000 or 4500 Watts of light.

Construction lighting criteria

Acceptable levels of light spill and glare at residential properties are governed by Australian Standard: *AS4282-1997 Control of the Obtrusive Effect of Outdoor Lighting*. AS4282 also specifies acceptable glare for other road users. The Standard states that the following assessment should be used to determine compliance:

Step 1: Time of Operation – much of the construction work for the project would be carried out during standard construction hours (7.00 am to 6.00 pm on weekdays and 8.00 am to 1.00 pm on Saturdays). Some work would be carried out at night time and there is the potential for nine compounds to be operational for 24 hours per day. These compounds are discussed in detail in Section 10.7.3.

Step 2: Relevant lighting limits – lower maximum lighting values would apply during curfew hours (11.00 pm – 6.00 am) for the construction compounds that operate 24 hours per day. The remaining compounds must comply with pre-curfew values.

Step 3: Calculation of light technical parameters – it is not possible to carry out such calculations and confirm compliance at this stage of the project without the provision of available photometric data for the specific luminaires to be used at the construction compounds.

Step 4: Determination of compliance – calculations are used to show whether or not residential receivers adjacent to the proposed construction compounds are likely to comply with the lighting criteria specified in Step 2.

Step 5: Documentation of installation – luminaires likely to be used for the installation are documented to the extent known.

10.7.2 Impact assessment

Outdoor lighting has the potential to have an adverse impact on the following:

- Residential houses – through both increased ambient light from light spill and glare from direct view of the light source.
- Transport system users – by a reduction in visibility caused by disability glare.
- Transport signalling systems – through disability glare.
- Astronomical Observations – due to sky glow from scattering of light from the installation and from direct light falling on the observatory.
- Native flora and fauna habitat intrusion.

The M2 corridor runs through areas of urban residential development located close to the M2 Motorway alignment. Obtrusive spill light from the night-time lighting required for safety reasons at the construction compounds has the potential to affect nearby residences and road users.

The effect of lighting impacts on native fauna is considered in Section 9.5. There are no astronomical observatories located close to the proposed construction compounds and hence are not covered within this report.

Assessment of light spill on residential areas

Without careful luminaire selection and, in some cases, further detailed modelling, there is potential that the lighting requirements set out in AS4282 may be exceeded at a number of locations impacted by construction compound lighting as summarised in Table 116.

Table 116 Potential lighting impacts at construction compounds

Proposed construction compound location	Potential obtrusive light spill	Potential for 24 hour operation	Details of impact
Windsor Road Compound	Yes	Yes	There exists potential for adverse light spill for certain residential properties north west and west of the compound from construction lighting and vehicle headlights.
Darling Mills Creek Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Barclay Road Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Devlins Creek Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Barombah Road Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Beecroft Road (Old bus ramp) Compound	Yes	Yes	There is potential for excessive light spill for surrounding residential properties, particularly those located to the south and east of the compound, from construction lighting.
Sutherland Road (Tunnel) Compound	Yes	Yes	There is a potential that the residential areas east and west of the compound may to be subjected to excessive light spill from the proposed compound lighting.
Somerset Road (Terrys Creek western end) Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.

Proposed construction compound location	Potential obtrusive light spill	Potential for 24 hour operation	Details of impact
Terrys Creek Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Vimiera Road Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Busaco Road Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Toll Plaza Compound	No	Yes	There are no residential properties located in the vicinity of the compound, therefore, there is no potential for adverse light spill.
Christie Road Compound	No	Yes	There are no residential properties located in the vicinity of the compound, therefore, there is no potential for adverse light spill.
Macquarie Park Compound	No	Yes	Limited potential for construction lighting or vehicle headlights to impact on residential properties.
Existing TIDC Compound	Yes	Yes	The residential area south of the compound has the potential for obtrusive spill light from the proposed construction lighting.
North Ryde Station Compound	No	No	Limited potential for construction lighting or vehicle headlights to impact on residential properties.

Impacts would occur at construction compound sites that have both the potential for obtrusive light spill and where 24 hour operations have been proposed. Therefore, compounds where surrounding residences are likely to experience an impact from lighting during construction include the Windsor Road, Beecroft Road (old bus ramp), Beecroft Road (tunnel) and existing TIDC compounds. These impacts would be mitigated as described in this report.

The impact at compound sites where 24 hour operation has not been proposed would be low, given that they would be lit only with localised security lighting through the night time period. The proposed security lighting would be limited to four 500 watt lights. These lights would not have sufficient luminance to impact on surrounding residences assuming that lights are positioned in suitable locations and directed away from residential properties.

Assessment of glare on the M2 Motorway

In some instances, lighting at the construction compound sites may be directed towards the M2 Motorway to avoid light spill onto residential receivers located behind the lighting installation. In such instances, there is potential to cause disability glare for users of the M2 Motorway. Adverse effects of light spill onto the M2 Motorway may include a reduction in the ability of drivers to discern objects and other road users.

10.7.3 Mitigation measures

Construction compound lighting

AS4282-1997: Control of the Obtrusive Effects of Outdoor Lighting sets out general principles that should be applied when designing outdoor light to mitigate adverse effect of the light installation. These would include, but are not limited to:

- Switch off lights when not required.
- Direct lights downwards as much as possible.
- Use luminaires that are aimed to minimise light spill, for example, full cut off luminaire where no light is emitted above the horizontal plane.
- Do not waste energy and increase light pollution by over-lighting.
- Minimise glare by keeping the main beam angle less than 70 degrees wherever practicable.
- Where possible, use floodlights with asymmetric beams so that front glazing can be kept at or near parallel to the surface being lit.
- Where practicable, direct site lighting away from sensitive receivers such as residential properties.
- Where possible, position site lighting away from the site boundary.

It is proposed that these standard mitigation measures be used when choosing and positioning floodlights for the construction compound sites to minimise the risk of light spill from the construction lighting. During the design stage of the project, this preliminary analysis would then be reviewed and sites would be identified where detailed modelling may be required to assist in the development of appropriate light spill management strategies.

Glare from construction vehicles

Excessive glare from vehicles entering and exiting the construction compounds would be minimised by utilising:

- Non-translucent barriers to shield residential developments located directly opposite access points.
- Hessian matting attached to the construction compound fencing to eliminate the potential of glare from vehicle headlamps. The minimum height of such matting would be based on the local topography and the distance of the closest sensitive receiver from the site.

Glare on the M2 Motorway

General mitigation measures that would be applied to manage glare from construction compound sites lighting on the M2 Motorway would include directing the floodlight towards the ground so the angle between the beam and the vertical is kept as small as possible.

Directing the floodlight in a perpendicular direction to the road axis and hence perpendicular to the line of sight of drivers on the M2 Motorway.

10.8 Waste minimisation and management

This section provides an assessment of waste minimisation and management measures associated with the project.

10.8.1 Existing environment

As described in Section 1.5, the M2 Motorway is fully operational and is characterised by different environmental features. Waste is currently generated from ongoing road maintenance and repair activities and by users of the M2 Motorway. Maintenance wastes would include green wastes from trimmed vegetation, landscape areas, windblown leaves and debris, and vehicle oils and greases from maintenance vehicles. General litter can also be generated by road users utilising the M2 Motorway.

10.8.2 Impact assessment

The following section details types of solid and liquid waste expected to be generated during the construction and operation of the project. Inadequate collection, storage and disposal of waste generated during construction and operational activities may potentially lead to pollution of the surrounding environment, including soil and water. Solid waste, such as plastic bags, has the potential of being blown onto the M2 Motorway from neighbouring areas and causing litter nuisance and traffic disruption.

Activities that would generate waste during the construction period would include earthworks, drainage works, clearing and grubbing, associated upgrade works, bridge demolition and concrete trimming, restoration works on existing pavement, equipment maintenance, and site office activities. The key waste streams generated during these activities are summarised and presented in Table 117.

Waste streams that would be generated during the construction phase are:

- Green waste.
- General construction waste.
- Demolition concrete.
- Inert spoil.
- Potentially hazardous waste (including asbestos waste).
- Virgin Excavated Natural Material.
- General office waste such as paper, used printer cartridges, food waste, etc.

The management of waste is not considered a key issue given that standard measures are available to address waste generation, disposal and reuse in order to minimise potential impacts (refer to Section 10.8.3).

The Porters Creek landfill site is in the vicinity of the M2 Motorway corridor east of Lane Cove Road. There is no widening proposed as part of the M2 Upgrade project east of Lane Cove Road and there are no construction compounds located within the vicinity of the landfill. There would be no impact on or from the landfill site as a result of the project.

Table 117 Potential waste generated during construction

Waste	Quantity (t)	Classification per DECCW waste classification guidelines	Potential recovery/reuse	Disposal
Green waste from clearing and grubbing of vegetation	9,500	General Solid Waste (Non-Putrescible)	Timber would be collected and transported to nearby timber logging industry. Green waste would be sent to nearby composting facility or may be used as mulch onsite, where required and if appropriate.	Clear and grub subcontractor would remove timber and excess mulch to licensed facilities.
Demolition concrete	25,500	General Solid Waste (Non Putrescible)	Stockpiled and transported to on-site recycling centre and recycled for the project construction activities.	Stockpiled waste concrete would be transported to recycling centre as and when required for recycling and reuse.
Inert spoil	45,800	General Solid Waste (Non Putrescible)	Collected in designated collection areas and reused as much as practically possible. Where possible, excess spoil material would be transported to other projects that require suitable fill material.	Dedicated stockpile areas would be identified where excess material may be stored and after requirements of the project have been met, excess spoil would be transferred to other projects that require spoil.
Building rubble, demolition materials	4,603	General Solid Waste (Non Putrescible)	Collected in designated collection areas and reused as much as practically possible. Where possible, excess material would be transported to other projects that require it.	Dedicated stockpile areas would be identified where excess material may be stored and after requirements of the project have been met, excess material would be transferred to other projects that require it.
Asbestos	78	Special Waste	Would be recovered in sealed bags/containers and disposed by licensed contractors.	Waste must be stored on premises in an environmentally safe manner. Bonded asbestos material must be securely packaged at all times. Friable asbestos material must be kept in a sealed container. Asbestos-contaminated soils must be wetted down. Asbestos waste must be transported in a covered, leak-proof vehicle. Asbestos waste must be disposed of at a landfill site that can lawfully receive this waste.
Inert general solid waste (non-recyclable)	3,544	General Solid Waste (Non Putrescible)	Collected in bins.	General waste (non-putrescibles) would be stored in separate bins depending on the waste disposal method and waste collection contractor requirements. Bins/skips would be emptied on a regular basis such to prevent overflow of materials.

Waste	Quantity (t)	Classification per DECCW waste classification guidelines	Potential recovery/reuse	Disposal
Virgin Excavated Natural Material (VENM) – residual soil and shales	32,445	General Solid Waste (Non Putrescible)	VENM would be clearly identified and kept separated from other materials to ensure its potential for use is not affected.	Wherever possible, VENM would be used on the project and excess material would be transferred to other projects requiring VENM.
General office waste – paper, cardboard, used printer cartridges, and the like.	Cannot estimate at this point	General Solid Waste (Non Putrescible)	Office waste like paper, cardboard boxes, used printer cartridges would be recycled. Recycle computers and florescent bulbs, unless they are managed as a hazardous waste.	Recyclable office waste like paper, cardboard boxes, used printer cartridges would be segregated and stored separately from organic waste. A licensed waste collection contractor would collect the recyclable and organic waste. Bins/skips would be emptied on a regular basis to prevent overflow of materials.
Small quantities of hazardous waste from equipment and building maintenance activities.	Cannot estimate at this point	Hazardous	Hazardous waste would be clearly identified and stored separate from other waste materials for selective disposal.	Refer Hazardous Waste Management in Section 10.8.3.

10.8.3 Mitigation measures

General waste management

In order to minimise waste and maximise use of available resources, earthworks material would be reused on-site, as far as practically possible. Fill embankments, subgrade layers and other material would be reused on-site for batter extensions or in other suitable construction tasks. Topsoil would be reused for landscaping.

The total volume of green waste generated from clearing and grubbing activities is difficult to estimate as the vegetation cover varies along the different precincts of the proposed upgrade, and it is dependent upon the time of year within which this activity takes place. The proposed clearance area is approximately 145,000 square metres and at an average yield of around 0.09 cubic metres per square metre (based on clearing activities for similar projects). This would approximate to 13,050 cubic metres of green waste or 9,500 tonnes in total. It is proposed to transport timber to appropriate facilities such as the timber logging industry that can accept raw materials. Unsuitable material would be mulched, chipped or reused on-site for sediment filter fences and landscaping where appropriate. Suitable logs would be used to prevent access to construction areas.

Although contaminated waste is not expected to be encountered, waste that does not fall into any of the categories described in Table 117 would be chemically assessed to determine its classification. If any waste is deemed to be hazardous, restricted or general (non-putrescible) solid waste, the waste would be managed and disposed off in accordance with the DECCW Guidelines (refer to Table 117 for measures).

Waste generated during the operational phase would be limited to waste generated from road maintenance and road users. Maintenance wastes may include green waste (from adjacent vegetation and landscaped areas), demolition materials from pavement remediation, and oils and greases from maintenance vehicles. Litter may also be generated by road users using the M2 Motorway.

Maintenance wastes generated would be disposed of to an appropriate licensed facility. Waste generated by road users would be collected by the relevant maintenance organisation. Wastes would either be recycled or disposed of to an appropriate facility.

A Waste Management and Reuse sub plan would be prepared prior to the commencement of the construction period. This plan forms part of the CEMP, which is outlined in the Construction Environmental Management Framework (refer to Appendix F). These plans would address appropriate waste identification, handling, storage and disposal in accordance with the DECCW Guidelines.

Hazardous waste management

Hazardous waste would be stored so as to prevent or control accidental releases to air, soil, and water resources in the area. Storage provisions would include:

- Sufficient space between incompatibles or physical separation such as walls or containment bunds.
- A requirement that hazardous materials be stored in closed containers away from direct sunlight, wind and rain.
- A requirement that secondary containment systems be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment.

- Designing the available volume for secondary containment to be at least 110 percent of the largest storage container, or 25 percent of the total storage capacity (whichever is greater), in that specific location.
- Providing adequate ventilation where volatile wastes would be stored.

Hazardous waste storage activities would also be subject to special management actions, conducted by licensed contractors who have received specific training in handling and storage of hazardous wastes. Management actions would include:

- Provision of readily available information on chemical compatibility to employees, including labelling each container to identify its contents.
- Limiting access to hazardous waste storage areas to employees who have received proper training.
- Clearly identifying (label) and demarcating the area, including documentation of its location on a facility map or site plan.
- Conducting periodic inspections of waste storage areas and documenting the findings.
- Preparing and implementing spill response and emergency plans to address their accidental release.

Transportation

On-site and off-site transportation of waste would be conducted so as to prevent or minimise spills, releases, and exposures to employees and the public. Waste containers designated for off-site shipment would be secured and labelled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site, and be accompanied by a shipping paper (manifest) that describes the load and its associated hazards.

Monitoring

Monitoring activities associated with the management of hazardous and non-hazardous waste would include:

- Regular visual inspection of waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labelled and stored. Monitoring would include:
  - Inspection of construction plant and machinery for leaks, drips or other indications of loss.
  - Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors.
  - Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied).
  - Documenting results of testing for integrity, emissions, or monitoring stations (air, soil vapour, or groundwater).
  - Documenting changes to the storage facility, and any significant changes in the quantity of materials in storage.
- Regular audits of waste segregation and collection practices.
- Tracking of waste generation trends by type and amount of waste generated, preferably by facility departments.
- Characterising waste at the generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste, especially hazardous wastes.
- Keeping manifests or other records that document the amount of waste generated and its destination.

- Monitoring records for hazardous waste collected, stored, or transported would include:
  - Name and identification number of the material(s) composing the hazardous waste.
  - Physical state (solid, liquid, gaseous or a combination of one, or more, of these).
  - Quantity by weight, volume or number of containers.
  - Waste shipment tracking documentation to include, quantity and type, date dispatched, date transported and date received, record of the originator, the receiver and the transporter.
  - Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific manifest document numbers applicable to the hazardous waste.
  - Location of each hazardous waste within the facility, and the quantity at each location.

The environmental manager (or equivalent nominated by the site manager) would be responsible for waste monitoring, data collection and reporting as identified above.

10.9 Hazards and risks

Hazards and risks may be experienced during both construction of the project. An assessment of the hazards and risks to people and facilities that may be generated by the M2 Upgrade project is summarised in this section. A separate risk assessment has been prepared for potential impact to the environment (refer to Chapter 8).

Assessment methodology

Hazards and risks that may be generated by the project are related to:

- Storage and handling of dangerous goods.
- Construction activities.

There are a number of study approaches that may be used for the assessment of hazards and risks. In order to determine the most appropriate approach for the M2 Upgrade project, a preliminary assessment is made in accordance with the following published hazard and risk assessment guidelines:

- Multi level risk assessment
- *State Environmental Planning Policy No.33 – Hazardous and Offensive Developments* (SEPP 33).
- *Hazardous Industry Planning Advisory Paper* (HIPAP) No.6.

This preliminary assessment indicated that the likelihood of an incident occurring during construction is low, and that a qualitative hazard and risk assessment is the appropriate level of assessment for this project. The key reasons for this are:

- The quantity of dangerous goods that would be stored is relatively low and the threshold levels under SEPP 33 are unlikely to be exceeded.
- The operations associated with construction activities are well understood and have been demonstrated to be well managed on similar projects.

It should be noted that this assessment did not address hazard and risk associated with road safety or general public safety with regard to road traffic other then dangerous goods transportation.

10.9.1 Hazard identification

Dangerous goods

Table 118 details the type and quantity of dangerous goods expected to be stored on site during the construction stage of the project.

Table 118 List of dangerous goods stored by the project

Dangerous goods stored	Quantity stored*
Diesel fuel	3x25kL tanks
Oils greases and lubricants	<500 L
Acetylene, dissolved (cylinders) – Class 2.1	eight cubic metres greater than ten metres from site boundary
Oxygen, compressed (cylinders) – Class 2.2 (5.1)	eight cubic metres
Bitumen – Class 3 PGIII (drums)	500 L
Paint and paint related materials – Class 3 PGII and III flammable liquid	500 L
Hydrated lime – non DG (Drums)	500 kg
Herbicides – Class 6.1 PG II	<100 L

** Note: the quantities indicated in the table represent the maximum amount that may be stored at individual sites. Individual sites are sufficiently separated such that each site can be considered as a separate facility for assessment purposes.*

It is anticipated that the storage and handling of dangerous goods (as listed in Table 118) would primarily occur within the main construction compound sites. Minor storage items would be located at other construction compound sites. Dangerous goods stored at other construction compound sites would comply with the minor storage provisions listed in the applicable Australian Standard for each specific dangerous good.

Hazard and risk associated with the storage and handling of dangerous goods has been assessed in Section 10.9.2.

Construction activities

The construction of the proposed M2 Upgrade project would require a number of potentially hazardous activities to be undertaken including, but not limited to, lifting of components and equipment using cranes, working at heights, working over carriageways on bridges, excavation activities and tunnel expansion.

As it is likely that these activities would be undertaken at a number of locations along the length of the M2 Motorway that is being upgraded, the hazards and risks associated with these activities were assessed based on the particular activity, rather that the location at which the activity may occur.

10.9.2 Hazard and risk assessment

A detailed hazard assessment was conducted using the hazard word diagram approach recommended in HIPAP No.6. The analysis assessed both dangerous goods and construction activities. The outcome of the assessment is summarised below.

Dangerous goods

The assessment considered potential hazard and risk resulting from bulk storage of dangerous goods at the main project compound and minor storage of dangerous goods at other construction compounds. The majority of potential hazards were determined to be of low risk with no off-site impact expected in the event of an incident.

The following incidents were identified as having the potential to impact off-site:

- Bulk fuel deliveries (diesel) – transfer of diesel fuel from road tanker to bulk tanks, fuel spill, ignition and fire.
- Dangerous goods deliveries – incident involving transport vehicle during minor deliveries to site, spill of dangerous goods and impact to the environment.
- Bulk fuel deliveries (diesel) – incident involving delivery truck and spill of fuel to the environment.
- Bulk fuel deliveries (diesel) – incident involving delivery truck and spill of fuel, ignition and fire.

A risk assessment was conducted for each of these potential incidents. The outcomes of the risk assessment are presented below.

Bulk fuel deliveries – fuel transfer incident

Diesel fuel would be stored and handled at the main project compound in three tanks, each of 25,000 litre capacity. The tanks would be double walled with a vapour space between the two walls of the tank. The vapour space would be fitted with leak detection such that an alarm would indicate when liquid is present within the annular space between the inner and outer walls. Hence, it would not be necessary to bund the tanks as the proposed design meets the requirements of AS1940.

In addition to the storage of diesel fuel it would be necessary to transfer the fuel from delivery road tankers to storage tanks and to fuel vehicles using a bowser type fuelling pump. In the event of fuel transfer, hose failure or premature coupling release, there is a potential for fuel to spill to the ground and escape offsite into the adjacent areas. Failure of the bowser hose is unlikely to occur, as filling nozzles are fitted with a number of safety features which include fuel shut off if the nozzle is dropped or turned upside down, and overpressure shut off if the vehicle tank is full.

Although the likelihood of an incident occurring is low, in the event that an incident did occur, it is likely that it would involve failure of a fuel tanker transfer hose. This would result in the spillage of diesel fuel and the formation of a pool at the spill point. In the unlikely event of ignition (noting that the flash point of diesel is well above ambient temperature), a pool fire would form. This may radiate heat to the surrounding areas causing damage and injury if sensitive land uses are close by.

By implementing the mitigation measures described in Section 10.9.3, fire impacts as a result of a fuel transfer incident would not exceed the acceptable risk criteria (DoP, 1992). In any event the site would be characterised as a low risk because the fuel transfer facilities would be located at least 18 metres from the site boundary fence, which is considered to be a sufficient distance to prevent heat radiation from impacting off-site.

Dangerous goods transport – truck incident (minor storage quantities)

Two forms of dangerous goods transport would be required to deliver goods to the site; package deliveries and bulk deliveries. Minor quantities of dangerous goods would be supplied in packages on smaller vehicles (for example, utilities, flat bed trucks, and the like), bulk deliveries of fuel would be supplied in 20,000 litre road tankers.

Potential for truck accidents, where smaller quantities of dangerous goods (packaged goods such as herbicides) are involved, would result in a localised impact and be low risk. Herbicides used at the sites for weed control are packaging group II materials, however, the quantities of these materials used are very small (less than100 litres) and the risk is therefore low.

The number of vehicles delivering minor quantities of dangerous goods to site would be low and the project construction period is limited. It is anticipated that the number of vehicles delivering minor quantities of dangerous goods to site would not exceed one per week on average. The increase in risk on the roads around the site would be negligible, based on the existing traffic delivering minor quantities of dangerous goods to industry in the areas adjacent to the M2 Motorway.

Dangerous goods transport – truck incident (bulk deliveries)

Bulk deliveries of diesel fuel would be transported to site as part of the requirements for site operations. It is noted that diesel fuel is not subject to SEPP 33 requirements and, therefore, may be eliminated from this assessment. However, for completeness, diesel transport has nevertheless been included in this assessment.

Diesel fuel would be transported to the main project site by 20,000 litre bulk tankers. The tankers would travel from the fuel supply depots in Sydney to the project site using local highways and roads. Fuel would not be transported on the M2 Motorway. The number of vehicles proposed for use in the project would only require diesel deliveries to the main project site around one to two times per week, which is a negligible increase in vehicle transportation.

In the event of an incident involving a road tanker, there is a potential for a spill of fuel leading to fire and heat radiation impact to the areas surrounding the spill. The quantity of fuel transported (20,000 litres) is considerable in volume and release of the full contents of the tanker would result in an extremely large pool surrounding the tanker. However, it is noted that fuel tankers are designed and constructed with compartments to minimise the total quantity of fuel that may be released in the event of an incident. The probability of the diesel igniting is also very low.

A review of the types and quantities of dangerous goods proposed to be stored at the site indicates that:

- The threshold levels published in SEPP 33 are unlikely to be exceeded.
- The types of dangerous goods are classified in the low risk category by the *Australian Dangerous Goods Code* (ADG, Ref.4).
- There is a low likelihood of incidents during construction.

Hence, the potential for impact to areas adjacent to the project area or to vehicles on the M2 Motorway, as a result of dangerous goods, is low. Standard mitigation measures would be implemented to reduce the risk of an incident. Specific mitigation measures are proposed where an incident has the potential to impact off-site. Mitigation measures are outlined in Section 10.9.4.

Construction activities

The proposed upgrade would require a number of potentially hazardous activities to be undertaken during construction. Although, the undertaking of these activities may result in potential incidents that may result in impact to people, facilities and adjacent public uses, the application of known risk reduction measures for road construction would minimise potential impacts. It is noted that during the original M2 Motorway construction, and during previous upgrades, there have been no major incidents recorded whereby impact to people and facilities occurred.

A risk assessment was conducted in relation to potentially hazardous construction activities. The results of the risk assessment are presented below.

The risk associated with accidents or incidents involving major construction activities are considered low and include:

- Crane operations have a potential risk to onsite personnel should there be an incident which involved a load falling from height.
- Working on bridges creates a potential hazard to construction personnel working at heights and to the general public in the event that objects fall from the bridge onto the carriageway and vehicles travelling along the M2 Motorway.
- A reduction in the lane width and changes to traffic management has the potential to cause collisions and impact on travellers of the M2 Motorway and construction personnel.
- Tunnel excavation has the potential to cause a hazard to travellers of the M2 Motorway during the use of the road header.

Standard mitigation measures and practices would be implemented to manage hazard and risk associated with construction activities. These measures are outlined in Section 10.9.4.

10.9.3 Mitigation measures

A number of mitigation measures have been considered to reduce the potential for risk and hazards to occur during the construction of the project. A summary of the key mitigation measures are addressed in this section.

Dangerous goods – general

Standard mitigation measures would be implemented to minimise general risks associated with the storage and handling of dangerous goods. These include:

- Dangerous goods risk assessments would be conducted for each storage area.
- Each storage area would be bunded to contain spills and isolated to contain fire to a localised area.
- Spill clean-up kits, including personal protective equipment, would be available at storage areas.
- Spill response personnel would be included in the incident response team.
- Regular inspections and audits of storage areas would be undertaken.
- Fire extinguishers would be available at storage areas and personnel would be trained in the use of this equipment.
- Storage would be designed to comply with the requirements of AS1940-2004 where relevant.

Dangerous goods – specific

Specific mitigation measures that would be implemented to manage and mitigate hazard and risk associated with dangerous goods related incidents that have the potential to impact off-site include diesel fuel and dangerous goods transport.

Diesel fuel

To prevent the spread of diesel fuel beyond the immediate spill area, the transfer point would be constructed with a concrete pad which includes a 'speed-hump' type bund to retain spill incidents. Hence, spills would be retained in the immediate area and would not escape offsite.

It is also proposed that the diesel fuel tank refuelling point and spill retention pad be no closer to the boundary of the main project compound than 18 metres. In addition, to assist with emergency response, in the event of a leak and fire incident, it is proposed that two fire extinguishers be installed close to the fuel transfer and fuelling area. One extinguisher would be of the dry powder type and one foam.

Dangerous goods transport

The analysis conducted in this study identified that:

- Each vehicle transporting the dangerous goods to site would contain the appropriate emergency response provisions (required under the *Australian Dangerous Goods Code*).
- Quantities of dangerous goods transported for minor stores would be low (both in total volume and package size).
- Drivers would be trained in emergency incident response.
- The number of vehicles delivering to site would be approximately one per week.

Based on this analysis the risks to roads around the project, from incidents involving the transport of minor quantities of dangerous goods, are considered low and there would be a negligible increase in the existing risk profile for the roads in the area adjacent to the project sites.

To reduce the potential for truck incidents, the works would maintain a limited number of deliveries and the project would only use registered fuel delivery companies for the supply of diesel fuel to the project. All companies would be required to demonstrate that they have the appropriate safety management systems in place, including compliance with the *Australian Dangerous Good Code*. This includes vehicle placarding, appropriate emergency procedure guides in the emergency information holder in the vehicle, driver training and emergency drills.

Based on the analysis conducted in this study, the risks to roads around the project, from incidents involving the transport of bulk diesel fuel, is considered low and there would be a negligible increase in the existing risk profile for the roads in the area adjacent to the main project site.

Construction hazards

The hazards and risks associated with accidents or incidents involving major construction activities are considered to be manageable through the implementation of standard mitigation measures and practices, including:

- Lift areas, excavations and areas under bridgeworks would be barricaded off to prevent access to hazardous areas.
- Equipment would be inspected in accordance with regulatory requirements.
- Loads would not be lifted over operating carriageways.
- Personnel would be required to wear personal protective equipment. This would include the use of harnesses when operating at height.
- Job safety analysis, safe work method statements and safety management plans would be developed and implemented.
- Traffic management measures would be undertaken to separate construction zones from operating carriageways and to control speed limits in the vicinity of the construction site.
- Relevant on-site personnel would be required to undertake an induction providing awareness of the key hazards associated with construction activities.

Based on the analysis and with implementation of the mitigation measures identified in this section, the potential hazards and risk that would be generated as a result of construction of the project are considered to be low and manageable.

10.10 Climate change

An *M2 Upgrade project Greenhouse Gas Inventory (Construction and Operation)* report was prepared by AECOM Pty Ltd, dated February 2010 and a summary is presented below.

10.10.1 Assessment framework

Rising concern of the likely impending climate change impacts in Australia has resulted in numerous national and state policy commitments addressing both mitigation and adaptation initiatives. This is reflected in the introduction of the *National Greenhouse and Energy Reporting Act 2007* (NGERS), the Carbon Pollution Reduction Scheme Bill and the potential introduction of a National Emissions Trading Scheme (NETS). During the environmental approvals process for infrastructure projects, the DoP increasingly requires that emissions are estimated to determine the impact of the project on the environment and provide some indication of whether the project would reduce long term operational emissions. During the approvals process it is prudent to consider climate change adaptation and mitigation to:

- Understand the impact that the project may have on climate change through the greenhouse gas (GHG) emissions associated with construction and operation.
- Understand the impact that projected climate changes may have on the project and how the project may respond to these changes through adaptation.
- Respond to community concerns about climate change and the environment.
- Ease the approvals process by providing transparent information about short-term increases and long-term potential decreases in GHG emissions that the project can deliver.

GHG emissions would be generated during the construction and operation of the project. A GHG emissions assessment was undertaken to estimate emissions associated with the construction and operation of the M2 Upgrade project (AECOM). Emissions associated with the following scenarios were assessed:

- Base case option – the project does not proceed.
- M2 Upgrade project option – the project is constructed.

Similarly, climatic changes would affect the M2 Upgrade project and associated infrastructure during its design life. A high level desktop assessment of projected climate changes and potential impacts to the upgrade is presented, based on the latest available information from the Intergovernmental Panel on Climate Change (IPCC, 2007), from the *Climate Change in Australia: Technical Report* (CSIRO and BOM, 2007), and resources such as the *Infrastructure and Climate Change Risk Assessment for Victoria* (Holper, P. et al., 2007).

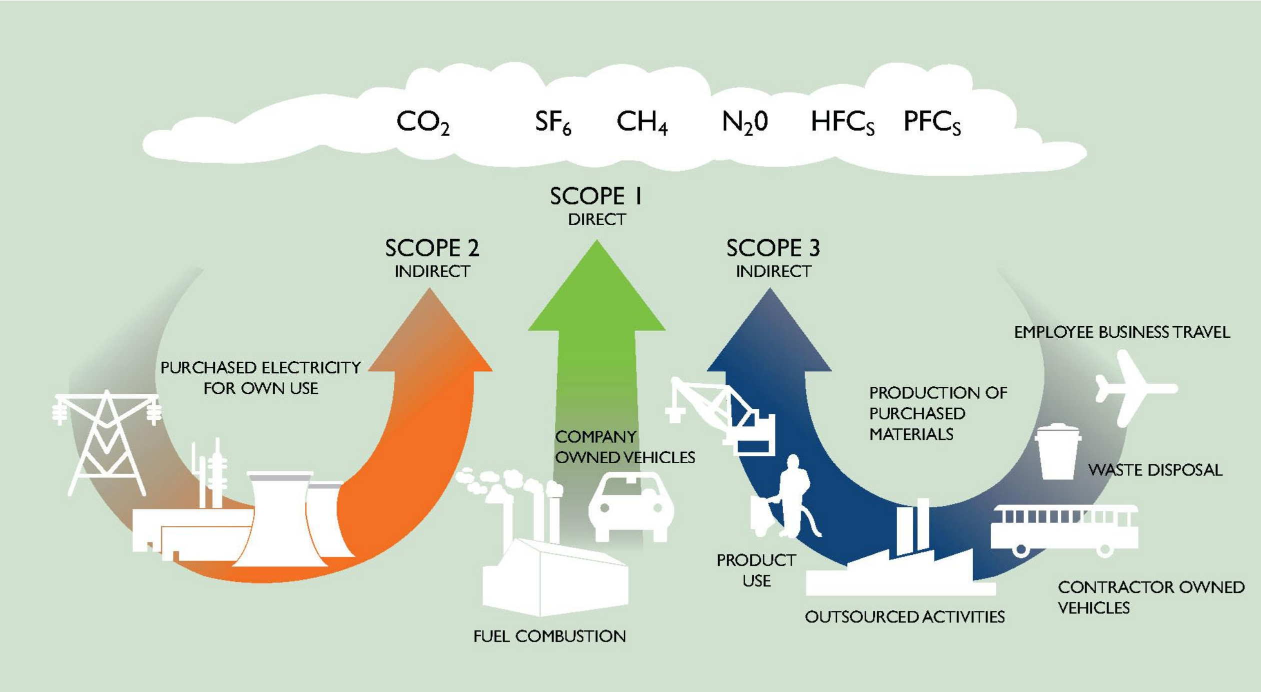
Climate change refers to both changed average conditions, such as temperature increases, and extreme events, such as increased frequency and intensity of storms. This assessment identifies new infrastructure items that would be affected in the future and recommends adaptation measures that would reduce asset damage.

10.10.2 Existing environment

Reducing GHG emissions is a key public concern and transport is a major contributor to GHG emissions in Australia. In 2006, Australia's net greenhouse gas emissions using the Kyoto accounting provisions were 576 million tonnes of CO_2-equivalent (Mt CO_2-e) (DCC, 2008). A relatively high level of car ownership in Australia has meant that transport contributes around 14 percent of Australia's emissions and is the second fastest growing source of emissions (Future Fuels Forum, 2008).. Of this, road travel contributes 89 percent of total transport GHG emissions.

The Intergovernmental Panel on Climate Change (IPCC) and Australian Government GHG accounting/classification systems categorises GHG emissions into three different scopes. In the context of this project, Scope 1 emissions are direct emissions generated by the project, Scope 2 emissions are indirect emissions generated outside of the project's boundaries to provide energy to the project and Scope 3 emissions are indirect, upstream emissions associated with the use of resources and the emissions generated by vehicles travelling on the road. These scopes are illustrated in Figure 42.

Figure 42 GHG emission scopes



Source: WBCSD and WRI, 2004

In the context of this project, the 'existing environment' for GHG emissions is the same as the 'do nothing' option where the project does not go ahead. This option constitutes the base case for emissions assessment and comparison. There would be no construction emissions under the base case 'do nothing' option. GHG emissions associated with the operation of the M2 Motorway without upgrade were calculated as part of the GHG assessment (AECOM, 2009). Emissions from the Greater Sydney network were estimated to be 13,878,664 tonnes CO_2-e per year (based on Sydney wide vehicle kilometres travelled). This figure is used to compare whether the project would result in emission savings.

Climate change

Australia and NSW have already experienced a range of observable climate changes and these changes are projected to continue. Under a 'do nothing' option, the M2 Motorway would be affected by future climate changes. This would require an increase in maintenance to respond to changed average conditions and may include emergency repairs in extreme events. The impacts discussed below would be the same for the 'do nothing' and the M2 Upgrade project options. Under the M2 Upgrade project, the proponent would have the opportunity to design and manage infrastructure so that it can withstand projected future conditions and reduce ongoing costs for more frequent maintenance or emergency repairs.

10.10.3 Impact assessment

Construction GHG emissions

Total predicted emissions associated with the construction phase of the project are approximately 113,000 tonnes CO_2-e. A summary of the factors that were considered in this calculation and the relative contributions of various sources to the total amount are described in Table 119 along with the GHG emissions generated from the construction of the project under each of the emission scopes.

Table 119 Construction to GHG emission sources

Scope	Description	Emissions (t CO_2-e)	Percentage of total emissions* (percent)	
Scope 1 – Direct Emissions	The onsite use of fuel by construction plant/equipment. The vegetation permanently cleared.	~19,400	17	
Scope 2 – Indirect Emissions	The onsite use of electricity purchased from the grid.	53	<1	
Scope 3 – Upstream Indirect Emissions	The embodied energy of construction materials.	~93,500	83	89
	The use of fuel for the transportation of construction/waste materials to/from the site.			9
	The indirect emissions associated with the generation of electricity purchased.			0.01
	The indirect emissions from the extraction, production and transport of fuels used by construction plant/equipment.			2
Total		~113,000	100	

** Note to table: Scope 3 emissions split to show percentage emissions for each sub type.*

Table 119 demonstrates that Scope 3 emissions constitute the majority of emissions associated with the construction of the project and of these the majority represents embodied energy in construction materials. Of the embodied energy contained in construction materials, the use of concrete and steel materials contributes to approximately 68 percent of the total construction GHG emissions.

Operational GHG emissions

It is estimated that the project would result in emission savings of approximately 46,000 tonnes CO_2-e per year compared to the base (do nothing) option for the first few years of operation. At this rate, by 2013, the estimated savings in operation emissions would be greater than the estimated emissions generated during construction. Over a thirty year period, total operational emission savings of around 1.75 Mt CO_2-e are estimated. A discussion of these results is provided below.

For operation emissions, two scenarios were considered:

- Base (do nothing) option – the project does not proceed.
- M2 Upgrade project option – the project is constructed.

The difference between estimated emissions under these two options would be the GHG emissions/reductions associated with the operation of the project.

Whilst the overall vehicle kilometres travelled in Sydney are not expected to change significantly as a result of the project, there are expected to be reduced travel times as peak period congestion is eased. By reducing congestion and stop-start driving on the M2 Motorway fuel consumption is expected to be reduced. New ramps under the M2 Motorway allow for more direct routes to be taken, reducing trip distances and associated GHG emissions. Sources of GHG emissions associated with the operational phase of the project are shown in Table 120.

Table 120 Operational GHG emission sources

Scope 1 – Direct Emissions	Scope 2 – Indirect Emissions	Scope 3 – Upstream Indirect Emissions
Fuel consumption by the M2 Motorway operator maintenance vehicles and equipment.	The onsite use of electricity purchased from the grid: • Lighting. • Traffic signals. • Communications. • Toll equipment. • Speed cameras.	• Full fuel cycle consumption by road users driving on the Sydney network (private vehicles). • Fuel consumption by maintenance vehicles and equipment other than those of the M2 Motorway operator. • Extraction, production and transport of fuel used by maintenance vehicles and equipment. • The indirect emissions associated with the generation of electricity purchased. • Embodied energy of materials used in repairs and maintenance works.

Source: AECOM, 2009

Table 121 shows the estimated savings of emissions generated by vehicle travel across the Sydney network resulting from the project, calculated from a comparison of the Base and M2 Upgrade project options in 2013. The results indicate that upgrading the M2 Motorway is expected to generate emissions savings of approximately 46,000 tonnes CO_2-e per year for the first few years of operation. Operational emission savings would balance out the construction emissions within the first few years of operation.

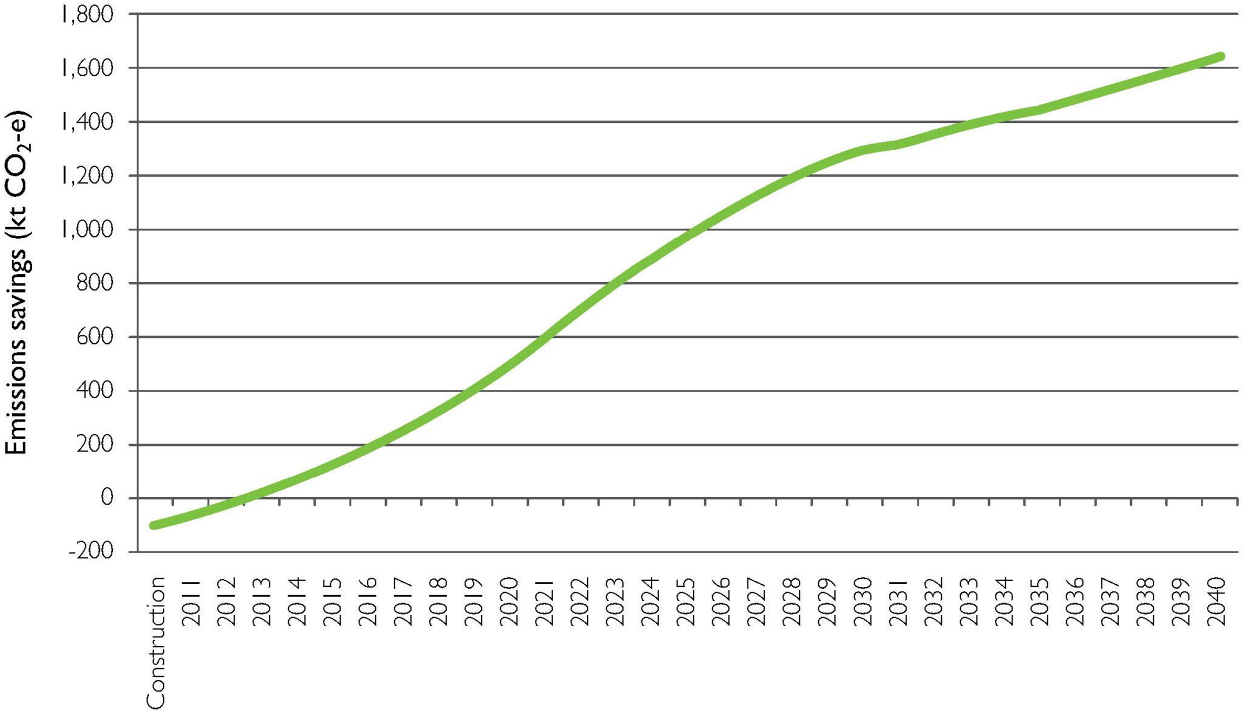
Table 121 Operational GHG emissions for each GHG scope in 2013

GHG Scope	Savings Emissions (t CO2-e)
1(direct emissions)	-2
2 (indirect emissions)	-541
3 (upstream indirect emissions)	46,181
Total	~45,600

Source: AECOM based on data provided by Hills M2, 2009

Cumulative GHG emissions and savings are shown in Figure 43 including construction emissions. The annual operational GHG savings are expected to decrease over time as vehicles become more fuel efficient and the M2 Motorway becomes congested and conditions become more like the current situation once again. Over a thirty year period, estimated cumulative operation emission savings total approximately 1.75 mega tonnes CO_2-e.

Figure 43 Cumulative GHG emissions savings including construction



Source: AECOM based on data provided by Hills M2, 2009

The majority of GHG emissions in the Sydney region are generated by private vehicles using the Sydney road network. Emissions from the combustion of fuels make up the bulk of Scope 3 emissions, whilst the emissions associated with electricity use and the embodied energy of materials/fuel used are relatively small in comparison.

Under the project the GHG emissions associated with the operation are reduced by approximately 1.75 mega tonnes CO_2-e over a thirty year period. This is primarily due to reduced peak period congestion and stop-start driving on the M2 Motorway, which reduces fuel consumption. This outweighs GHG emissions associated with electricity consumption (for additional lighting, tolls, traffic signals) and increased maintenance (fuel for vehicles and equipment and embodied energy in construction material).

Climate change projections

The project would have a 100+ year design life. The precise effects of climate change are unknown. However, research indicates a demonstrated change in Australia's climate and there is evidence that this change would continue despite carbon mitigation measures that may be adopted. The project would include road upgrade, tunnel widening, bridge widening and new access ramps. These items would be affected by projected changes in climatic conditions.

Climate projections prepared by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM) in 2007 (CSIRO and BOM, 2007) suggest that the future climate of eastern Australia would generally be characterised by:

- Higher average temperatures.
- More frequent occurrence of extreme temperatures (days over 35°C).
- Lower average rainfall.
- More intense extreme rainfall events.
- Higher evapotranspiration.
- Higher sea level and storm surge events.
- More frequent extreme fire danger days.

Projected climate changes from CSIRO and BOM are summarised in Table 122.

Table 122 Climate change projections

Variable	2007	2030	2070	Trend
Average annual mean temperature	-	Increase of annual mean temperature 1°C	Increase in annual mean temperatures of between 1.8°C and 3.5°C	Warmer average temperatures
Number of extremely hot days (over 35°C)	3.5 days per year	4.4 days per year	8.2 days per year	More extremely hot days
Rainfall – annual average	-	Decrease between two to five percent	Decrease between five and ten percent	Decreased precipitation
Evapotranspiration – annual average	-	Increase 2 percent	Increase between sixand ten percent	Increased evapotranspiration
Bushfire annual return period	5.5 years	3.3 years	1.0 years	More frequent bushfires

Small changes in annual and seasonal temperature and rainfall conditions can be associated with large changes in extreme weather events, such as heatwaves, storms, stronger winds, increased lightning and higher intensity rainfall, which are potentially of greater significance to infrastructure design, construction and operation than changes in average conditions. Changes in extreme weather events that are projected for eastern Australia include:

- An increase in the frequency of hot days and warm nights, and a decrease in the frequency of cold nights.
- An increase in both daily precipitation intensity (rain per rain-day) and the number of dry days, leading to longer dry spells interrupted by heavier rainfall events.
- El Niño events becoming drier and La Niña events becoming wetter (CSIRO and BOM, 2007).

Consistent with scientific literature on climate change risks, it can be expected that there would be changes in the flood, bushfire, and storm risk associated with the above changes in average climate conditions and extreme weather events.

Impacts to infrastructure

The *Infrastructure and Climate Change Risk Assessment for Victoria* (Holper, P. *et al.,* 2007), (CCRA) provides some insight into potential impacts from climate change. Given the global proximity and similarity in infrastructure design and construction techniques, the findings from this report are considered comparable to events that would occur in NSW as a result of projected climatic changes. Findings from the Report are shown in Table 123 below. The table indicates the level of risk for each infrastructure type for the 2030 and 2070 time horizons under low and high emission scenarios.

Risks to road, tunnel and bridge infrastructure associated with climate change in the 2030 and 2070 time horizons are generally moderate to high. Moderate risk issues would require change to design standards and increased ongoing maintenance of assets. High risk issues would require detailed research and planning at senior management level.

The CCRA found that road infrastructure would generally suffer moderate risk from climate change within the 2030 and 2070 time horizons under both low and high emissions scenarios. Under a high emissions scenario, road foundations would be at high risk of degradation by 2070. Roads would likely suffer asphalt degradation, road foundation degradation and flood damage. Bridges and tunnels would generally suffer moderate to high risks from climate changes within the 2030 time horizon and high risks within the 2070 horizon. Bridge structures would be at high risk under a high global emission scenario by 2030.

In general, impacts to road infrastructure are related to accelerated degradation of materials or one-off damages from extreme events including damages to infrastructure and property. These impacts lead to increase maintenance or repair costs. In catastrophic situations such as infrastructure failure related to extreme events, impacts may include major road accidents or loss of life. Given the above risk profile, these catastrophic events are considered unlikely in the timeframe considered (to 2070).

- Higher winds, increased intensity of storm events and extreme temperature events would cause damage to infrastructure, resulting in increased maintenance costs.
- Increased rainfall, which may exceed the capacity of the existing stormwater system and affect areas near existing waterways, would lead to flooding and associated damage to infrastructure and property.
- Extreme events may reduce road safety conditions and lead to higher likelihood of vehicle accidents.

Table 123 Transport infrastructure risk summary

Transport	Risk Scenario	Climate Variable	Rating			
			2030		2070	
			Low	High	Low	High
Roads	Asphalt degradation	Increased solar radiation. Increased temperature and heatwaves.	Moderate	Moderate	Moderate	Moderate
	Road foundations degradation	Increased variation in Wet/dry spells. Decrease in Available moisture.	Moderate	Moderate	Moderate	High
	Flood damage to roads	Increase in extreme daily rainfall. Increase in frequency and intensity of storms.	Moderate	Moderate	Moderate	Moderate
Bridges	Bridge structural material degradation	Increased Temperature and Heatwaves. Increased Solar Radiation.	Moderate	High	High	High
	Storm damage to bridges	Increase in extreme daily rainfall. Increase in frequency and intensity of storms. Increase in intensity of extreme wind.	Moderate	Moderate	High	High
Tunnels	Tunnel flooding	Increase in Extreme Daily Rainfall. Increase in frequency and intensity of storms.	Moderate	Moderate	High	High

Souorce: Holper. P, et al, 2007

10.10.4 Mitigation measures

Construction

Procurement

To reduce the environmental impact of the project, a sustainable procurement policy would be implemented during the construction and operational stages of the project. The M2 Motorway operator has developed a sustainable procurement policy and this may be reviewed and where applicable applied/tailored to the project to guide the procurement of materials for the construction and operation of the project.

A sustainable procurement policy would be developed for the project that considers the following factors during the purchasing decision making process:

- Whole life cycle of a product (maintainability, recyclable components).
- Environmental impacts.
- Social impacts (for example, OH&S of workers, labour conditions).
- Value for money.

Where appropriate and feasible, options that would be considered to reduce the GHG emissions associated with the upgrade during procurement include:

- Plan construction works to avoid double handling of materials where possible.
- Preferential use of locally sourced goods and services.
- Consider fuel efficiency when selecting construction plant and equipment and procure fuel efficient plant and equipment where feasible.
- Ensure construction equipment used is maintained to reduce energy efficiency losses associated with damaged or poorly maintained equipment.
- Assess the emissions intensity of the construction materials specified in the design of the project.
- Where practical, preferentially use/specify materials with lower GHG emissions factors.
- Use recycled aggregates in road pavement and surfacing (including crushed concrete, granulated blast furnace slag, glass, slate waste and fly ash).
- Consider purchasing Green Power.

Materials selection

A number of decisions can impact on the materials used for the upgrade. As 68 percent of the estimated construction GHG emissions are related to the use of concrete and steel, these materials in particular would be carefully selected. Consideration is needed for the availability of resources, use of finite resources, related waste reuse/recycling opportunities and landfilling and associated material embodied energy. Materials selection would focus on the availability of local and recyclable materials in order to minimise the energy requirements over the life cycle of these materials.

Recycling aggregates

Where possible, concrete waste and milled asphalt would be processed for incorporation back into the pavement construction (expected to be approximately 30,000 tonnes of material).

Recycled aggregates used in asphalt pavements can include crushed concrete, milled asphalt, granulated blast furnace slag, glass and fly ash.

Energy management

Energy management in construction has the objective of finding and implementing methods to reduce the total energy consumption in construction and operation. Energy efficiency measures that would be investigated include:

- Achieving a cut and fill balance, which would avoid significant energy consumption both directly in the form of haulage and indirectly in the form of embodied energy.
- Priority would be given to low embodied energy materials or recycled materials sourced from the construction site.
- Management of the energy consumption by design and construction teams. Specifically energy used to power operations including site offices' power and vehicle fleets' fuel.

Operation

Whilst it is estimated that the project would reduce GHG emissions by reducing congestion and fuel usage, there are still large volumes of GHG emissions generated from vehicles using the M2 Motorway. Reducing overall operational emissions would depend largely on improved vehicle fuel efficiency standards, which are implemented through increasingly stringent government regulation. The project includes measures to encourage the reduction of GHG emissions, such as transit lanes, which encourage higher occupancy in vehicles and the use of public transport.

Electricity emissions may be reduced through:

- Implementation of equipment with improved energy efficiency, for example, ensuring installation of the energy efficient lighting.
- Management of electricity consumption at tolling stations, such as reducing the number of lanes during off-peak periods.

Potential climate change adaptation responses

As road infrastructure can have a design and effective operational life of up to 100 years, planning, design, construction and maintenance would consider climate change adaptation measures to reduce the risks associated with impacts from projected climatic changes. Proactive consideration of adaptation strategies can decrease the risk of asset damage which would represent an economic and social cost. Specific climate change impacts and consequent design, construction and operation adaptation strategies would be considered during detailed design. Generally, adaptation strategies can be expected to fall into one of six categories:

- Suitable material selection.
- Design standards.
- Maintenance regimes.
- Technologies.
- Planning.
- Cultural change.

Mitigation and management

Measures to mitigate the impact of the project on climate change are discussed in Section 10.10.3 along with the GHG assessment. The following mitigation measures relate to adaptation of the project to mitigate and manage the effects of climate change on the project.

- Design standards would be reviewed in light of projected changes over the design life of the road upgrade. In particular, standards related to flooding and drainage, material selection and foundation materials would be reviewed and more stringent standards considered. This would reduce degradation and the cost of maintenance requirements and emergency repairs.
- It would be beneficial to hold a workshop with the design team prior to detailed design to identify areas where materials, design standards, maintenance and new technologies would be considered to improve the adaptability of the new infrastructure for changed climatic regimes over the projects design life.
- A value for money assessment would be undertaken on the project to determine whether each adaptation measure is worthwhile implementing at the design stage or whether it would be more beneficial to undertake ad-hoc repairs.

10.11 Cumulative impacts

10.11.1 Approach to assessment

Cumulative impacts occur when the potential impacts associated with an upgrade interact with other developments and activities to create combined effects.

A cumulative impact assessment has been undertaken to determine the combined effect of the project with other proposed activities within the region. It is difficult to assess the integrated impacts of different projects and the synergies through their construction phases in the context of this environmental assessment as the timing for construction of the relevant projects is unknown at this stage. Therefore, a higher level assessment has been performed which looks at impacts from a strategic perspective rather than on a project-by-project basis.

In order to assess the cumulative impacts associated with the project it is important to understand:

- The impact of the project.
- The other proposals in the region that may interact with the project.
- The spatial and temporal scale and limits of the assessment.

The potential impacts of the project are identified and assessed in detail in Chapters 9 and 10 and in the various Technical Papers (Volume 2). There are a range of other proposals in the region that have the potential to interact with the project. These proposals are listed in Section 10.11.2.

Given the extent of the project, only proposals that are located within the suburbs that lie adjacent to the M2 Motorway have been included in this assessment. Proposals outside these suburbs have only been considered if they are major developments within a broader regional context.

The proposals assessed were generally large-scale developments. Smaller proposals were considered if they lay directly adjacent to the M2 corridor. Proposals were considered if they were likely to be constructed at some point during the construction phase of the project or if the operational phase of the project would interact with the strategic aim of a proposal.

10.11.2 Other proposals and activities

Known proposals located in the vicinity of the M2 Motorway are listed in Table 124. These projects are in different stages of development and form the basis of the cumulative impact assessment.

Table 124 Proposals in the vicinity of the project

Proposal	Location	Brief description
North West Growth Centre	North western suburbs from Marsden Park to Kellyville	Water related services: • Drinking water distribution. • Wastewater pipelines. • Water Treatment Plant.
63-77 West Parade, West Ryde – Concept Application	West Ryde	• Residential development. • Commercial and retail areas. • Parking. • Services.
Northern Sydney Freight Line project (reference: *Metropolitan Transport Plan*)	Beecroft Road (rail overbridge)	Key features include: • Potential for widening of existing rail overbridge as part of Northern Sydney Freight Line project. • Timing of construction is unknown, unlikely to be within construction timeframe of M2 Upgrade project.
West Ryde Station	West Ryde	Key features include: • Demolition of existing structures. • Construction of four new residential buildings. • Car parking. • Landscape works.
Macquarie University – Concept Plan	Macquarie Park	Approval over a 25 year period for: • 400,000 square metre commercial space. • 61,200 square metre academic space. • 3,450 beds within the University Housing Precinct. • Upgrades to infrastructure and road network. • Landscaping. • Pedestrian and cycle network. • Additional car parking.
Macquarie University Private Hospital	Macquarie Park	Key features include: • Demolition of existing building on site. • Construction of new five storey building. • One storey underground car park. • Retail shops. • Loading dock area.
Macquarie University – Cochlear global	Macquarie Park	Development of purpose-built Cochlear Global Headquarter including: • A six or seven storey building. • Car parking. • Landscaping and associated amenities. • Rehabilitation of University Creek corridor within site.
Macquarie University – Library	Macquarie Park	Development of a new five storey library building. This project should be completed in Feb 2010 but has been included in case the project ran over time.

Proposal	Location	Brief description
Eastwood Shopping Centre – Mixed Use Development	Eastwood	Key features include: • Demolition of existing structures. • One commercial development of two storeys. • Four residential developments of four to eight storeys. • A childcare centre.
112-128 Talavera Road	Macquarie Park	A six to nine storey development.

10.11.3 Cumulative impact assessment

The proposed developments in the vicinity of the project can generally be characterised as commercial and residential developments with the majority being centred around Macquarie Park. There are no other known major road or transport developments proposed in the vicinity of the project.

The cumulative impacts of the project and other proposals within the region have been estimated, however, they remain relatively undefined given the uncertainty with regards to the timing of construction of the surrounding proposals. Therefore, further impact assessment would be required at such time that construction timeframes have been determined.

For the purpose of this assessment, the following issues are important in determining the potential cumulative impacts associated with the project and other known proposed developments:

- Traffic and transport:
  - Impacts during construction.
  - Impacts for the greater region once operational.
- Construction noise and vibration.
- Other issues:
  - Socio-economic.
  - Greenhouse gas and climate change.
  - Air quality.
  - Construction lighting.

Key issues not included in this assessment (such as surface water management, Aboriginal heritage, operational noise and vibration, flora and fauna and urban design and landscape) are not considered to have potential for cumulative impacts, as mitigation measures included in this environmental assessment are considered sufficient to avoid impact from the project.

Traffic and transport

Section 9.2 describes the construction traffic and transport impacts associated with the project. During construction, traffic impacts would occur as a result of construction vehicles utilising local roads as well as traffic disruptions caused by construction activities and lane closures.

The main area of impact from construction traffic would be around Macquarie Park. The project requires the widening of Talavera Road and the bridge over Christie Road. These works would require utilisation of local roads around Macquarie Park by construction vehicles.

Once the project is operational, there would be improved traffic flow and travel times for motorists along the length of the M2 Motorway. This would improve accessibility between Sydney's north west and the Sydney CBD thereby improving access to new residential developments in Sydney's north west. It would also facilitate access to new commercial precincts at West Ryde, Eastwood and Macquarie University.

Operational traffic impacts and broader scale impacts, such as the affect of the project on the Sydney Orbital network have been addressed in the Chapter 2 and Section 9.1.

Construction noise and vibration

Noise impacts to sensitive receivers during construction have been addressed in Section 9.4. While the impacts assessed in this section would be mitigated through measures discussed in Section 9.4.3, there is the potential for these impacts to be heightened if they coincide with noise impacts from other construction activities within the region.

Of particular interest in this instance would be the noise impact at Macquarie University. The University is an educational precinct and would be highly sensitive to noise impacts from construction activities. Students and staff at the University may be subject to noise impacts from construction of the project, Macquarie University Library and the Cochlear Global Headquarters.

It is also important to consider the noise impacts on proposed developments such as the Macquarie University Private Hospital. Consultation with the proponents of the proposed developments would be required to determine the construction staging of those proposals. In the event that the proposed developments are constructed and become operational during the M2 Upgrade project construction period, then these developments would become sensitive receivers and noise impacts would need to be addressed and mitigated at that time.

Other impacts

Socio-economic

Socio-economic impacts associated with the project have been discussed in Section 10.4.

Once the project is operational, decreased congestion and reduced travel times would increase accessibility of new and existing residential and commercial developments within the Sydney's north west. The new access ramps at Windsor Road would provide an integral link between these new large-scale residential development areas, the growing commercial precinct at Macquarie Park and the CBD. This would increase the accessibility of job opportunities for residents situated in the Sydney's north west.

The project would also improve the accessibility between the proposed commercial developments within Macquarie Park and West Ryde and the expanding residential areas in Sydney's north west. These proposed developments would be provided with an increased catchment area and greater accessibility to larger labour and trade markets.

Climate change and greenhouse gas emissions

Greenhouse gas emissions produced during construction of the project have been documented in Section 10.11. Resource use during construction of adjoining proposals would increase emissions from local resource suppliers. Transport of materials and workers would have a greater combined impact compared to each individual project.

Air quality

Dust emissions from the project have been discussed in Section 10.6. Cumulative impacts may be generated from dust emissions should the construction periods of the project and the proposed developments around Macquarie Park coincide. This impact would be of particular concern in the educational precinct of Macquarie University.

10.11.4 Mitigation measures

Liaison with relevant councils, project proponents and land holders would be required to determine the timing and location of developments that may coincide with the project. Specific mitigation measures would be determined at a later stage following this consultation. These may include:

- The preparation of TMPs, in consultation with local councils and project proponents, which address other proposed changes to traffic conditions that are likely to occur during construction.
- Coordination and management of construction traffic through the construction phase of the project. Measures to minimise construction traffic impacts would include:
  - Combined construction vehicle parking sites to minimise the loss of on-street parking and/or the size of construction sites.
  - Targeted communication with road users likely to be affected by multiple changes to traffic conditions (this would be done by radio broadcasts, signage, and the like).
  - Further consideration of measures to minimise congestion on local traffic routes, loss of parking spaces and changes to traffic conditions.
- Targeted consultation with sensitive receivers identified as noise-affected by the construction of the project and likely to be simultaneously affected by the construction of other projects.
- Discussions with proponents of nearby developments to identify measures to minimise cumulative noise impacts. Measures would include:
  - Undertaking particularly noisy activities at the same time (to minimise the duration of noise impacts) or at different times (to minimise the overall noise levels).
  - Consideration during the detailed design phase of measures to further reduce noise emissions from construction sites.
- Adjustment of construction staging to enable, where reasonable and feasible, construction not to occur in the same locations of other developments at the same time.
- Further consideration during the detailed design phase of measures to reduce noise impacts during construction of the project.
- Consideration by developers of the integration of mitigation measures for one project with another. For example, hoardings and noise barriers would be extended over time to minimise disruption and further reduce amenity or visual impacts.