NorthConnex

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Volume 1C

Environmental Impact Statement - Volume 1C

Main Volume Chapters 8 to 11
Appendix A - Director-General's Requirements
Appendix B - *Environmental Planning and Assessment Regulation 2000* Checklist
Appendix C - Geotechnical long section
Appendix D - Community communications framework

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In 2012, the NSW Government received an unsolicited proposal from Transurban and the Westlink M7 Shareholders (Sponsors) to design, construct, operate, maintain and finance a tolled motorway linking the M1 Pacific Highway at Wahroonga to the Hills M2 Motorway at the Pennant Hills Road interchange at West Pennant Hills, known as NorthConnex.

Roads and Maritime Services is the Proponent for the environmental impact statement and lodgement of an application for environmental and planning approval. Roads and Maritime is working with the Sponsors on the community consultation and public exhibition of this environmental impact statement.

8 Assessment of other issues

This chapter provides an assessment of the project's potential impacts that were not identified as key issues by either the Director-General's Requirements or the environmental risk analysis (**Chapter 10**).

The issues discussed in this chapter have either been directly identified by the project team or have emerged through the consultation process (see **Chapter 6**).

8.1 Land use and property

This chapter assesses land use and property impacts associated with the project. **Table 8-1** sets out the Director-General's Requirements as they relate to land use and property, and where in the environmental impact statement these have been addressed.

Table 8-1 Director-General's Requirements – land use and property

Director-General's Requirements	Where addressed
Impacts on directly affected properties and land uses, including impacts related to access, land use, property acquisition and amenity related changes.	Impacts to properties, land use, property acquisition and amenity impacts provided in **Section 8.1.2**. Further details regarding amenity related changes are provided in **Section 7.1** (Traffic and transport), **Section 7.2** (Noise and vibration) and **Section 7.3** (Air quality).

8.1.1 Existing environment

Regional context

The project is located in a major transport corridor for Sydney's northern and western suburbs. The area acts as an important link between the Hills district, the upper north shore and the north-western growth centres and is a key access point for the M1 Pacific Motorway. The project corridor passes through a number of suburbs including Baulkham Hills, Westmead, North Rocks, Carlingford, West Pennant Hills, Beecroft, Pennant Hills, Thornleigh, Normanhurst and Wahroonga.

The majority of the existing housing in the region is concentrated through the Ku-ring-gai and Hornsby local government areas. Historically, urban areas have been developed as settlements focused around the Northern and North Shore Railway Lines and the major road corridors of Pennant Hills Road, Pacific Highway and Beecroft Road, with outlying settlements around the Hawkesbury River and Pacific Highway extending to the north.

More recently, residential development has spread into outlying urban areas such as Cherrybrook, Castle Hill and Dural. Some urban consolidation has also occurred with medium and high density development within the Ku-ring-gai local government area and around the Hornsby town centre.

Several smaller local centres have established throughout the region, mainly focused around railway stations or on major roadways, including local centres along Pennant Hills Road such as at Thornleigh and Pennant Hills. Within the broader region Gordon and Epping provide larger town centres, whilst Hornsby has been identified as the region's principal centre.

The Draft North Subregional Strategy (Department of Planning, 2007) provides strategic planning direction at a regional level. This strategy identifies the need for an additional 21,000 homes within the region to provide for existing and future population growth. In order to protect the existing character of the North Subregion, including existing low density housing and outlying rural lands, future development is planned to be focused around the existing centres, particularly those along major transport routes such as railway lines and major roadways.

Local context

The majority of the project traverses three local government areas (LGAs) and is subject to the provisions of *The Hills Local Environmental Plan 2012* (Hills LEP), the *Hornsby Local Environmental Plan 2013* (Hornsby LEP), the *Ku-ring-gai Planning Scheme Ordinance 1971* (as amended) (Ku-ring-gai Planning Ordinance) and the *draft Ku-ring-gai Local Environmental Plan 2013* (draft Ku-ring-gai LEP). The main alignment tunnels traverse a variety of zonings within the three local government areas but surface works have only been proposed at discrete locations. Because of this, the local context is discussed separately for each surface site. Impacts to public utilities from the project works at each site are also outlined.

The local context for each site can be seen in **Figure 8-1** to **Figure 8-7**.

Windsor Road compound (C1)

A temporary construction compound would be established on the north-western corner of the Windsor Road / Hills M2 Motorway interchange. Surrounding land uses are predominately residential. Other land uses in the vicinity of the compound include the Our Lady of Lourdes school on the opposite side of Windsor Road and Baulkham Hills Pre School Kindergarten and a tyre retailer around 150 metres north of the site.

The compound site is unoccupied but has previously been used as a construction compound for the recently completed Hills M2 Motorway upgrade project. The site is zoned R3 Medium density residential under the Hills LEP.

The south-western side of the Hills M2 Motorway / Windsor Road interchange is located within the Parramatta LEP. Zonings in this area are primarily R2 Low Density Residential with a corridor of W1 Natural Waterways and E2 Environmental Conservation surrounding Toongabbie Creek. Land use zonings in the vicinity under the Hills LEP described in **Table 8-2**.

Table 8-2 Land use zonings under the Hills LEP surrounding the Windsor Road compound

Land use zoning	Features
R2 Low Density Residential	Located south of the Hills M2 Motorway on the eastern side Windsor Road.
R3 Medium Density Residential	The main land use zoning on the northern side of the Hills M2 Motorway.
R4 High Density Residential	Located around 50 metres north of the site along Windsor Road and on the southern western side of the Hills M2 Motorway / Windsor Road interchange.
RE1 Public Recreation	Several discreet locations within the local area.
SP2 Infrastructure	The Hills M2 Motorway and several minor sections of Windsor Road.

While a number of utilities are present around the site, these are not anticipated to be impacted by the works.

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Figure 8-1 Windsor Road construction compound local context

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Darling Mills Creek compound (C2)

A temporary construction compound would be established within the Hills M2 Motorway road corridor at the Darling Mills Creek viaduct. The primary land uses in the local area is residential. However the immediate surrounds of the site comprise native bushland.

The site is zoned SP2 Infrastructure under the Hills LEP and is located within the road corridor. Other land use zonings around the site are described in **Table 8-3**.

Table 8-3 Land use zonings under the Hills LEP surrounding the Darling Mills Creek compound

Land use zoning	Features
R2 Low Density Residential	The surrounding residential areas.
RE1 Public Recreation	Bushland areas on both sides of the Hills M2 Motorway.
E2 Environmental Conservation	Bushland areas on both sides of the Hills M2 Motorway.

While a number of utilities are present around the site, these are not anticipated to be impacted by the works.

Barclay Road compound (C3)

The Barclay Road compound would be located on the southern side of the Hills M2 Motorway on the corner of Barclay Road and Perry Street. The surrounding land uses are primarily residential with the exception of Muirfield Golf Course located directly south of the site on Barclay Road.

The site is zoned SP2 Infrastructure under Hills LEP and is located within the road corridor. Other land use zonings around the site are described in **Table 8-4**.

Table 8-4 Land use zonings under the Hills LEP surrounding the Barclay Road compound

Land use zoning	Features
R2 Low Density Residential	The surrounding residential areas.
RE1 Public Recreation	Several discreet areas in the vicinity.
RE2 Private Recreation	Muirfield Golf Course
E2 Environmental Conservation	Bidjigal Reserve to the west of the site.

While a number of utilities are present around the site, these are not anticipated to be impacted by the works.

Yale Close compound (C4)

The Yale Close compound would be located within the road reserve of the Hills M2 Motorway in the vicinity of the Yale Close overbridge. The primary land uses surrounding the site are residential on the southern side of the Hills M2 Motorway and natural bushland on the northern side of the Hills M2 Motorway. Other land uses in the local area include Muirfield High School around 100 metres west of the site and the Royal Institute for Deaf and Blind Children around 150 metres east of the site.

The site and the Hills M2 Motorway road corridor are zoned SP2 Infrastructure under the Hills LEP. Other land use zonings around the site are described in **Table 8-5**.

Table 8-5 Land use zonings under the Hills LEP surrounding the Yale Close compound

Land use zoning	Features
R2 Low Density Residential	The surrounding residential areas on the southern side of the Hills M2 Motorway.
RE1 Public Recreation	Bushland areas on the northern side of the Hills M2 Motorway.
E2 Environmental Conservation	Bushland areas on the northern side of the Hills M2 Motorway.

Whilst a number of utilities are present around the site, these are not anticipated to be impacted by the works.

Hills M2 Motorway integration works

Integration works for the Hills M2 Motorway would extend from the southern interchange at Pennant Hills Road through to Windsor Road in Baulkham Hills. The surrounding area is composed of a mixture of residential land uses and native bushland comprising Bidjigal Reserve which includes a public walking track passing underneath the Hills M2 Motorway at Darling Mills Creek viaduct. The integration works would occur largely within the suburb of North Rocks but would also pass through Carlingford and Baulkham Hills.

The integration works would occur largely within the road corridor, which is zoned SP2 Infrastructure. Other land use zonings around the site are described in **Table 8-6**.

Table 8-6 Land use zonings under the Hills LEP surrounding the Hills M2 Motorway integration

Land use zoning	Features
R2 Low Density Residential	The surrounding residential areas.
RE1 Public Recreation	Bushland areas on either side of the Hills M2 Motorway.
E2 Environmental Conservation	Bushland areas on either side of the Hills M2 Motorway.

The Hills M2 Motorway intelligent transport system (ITS) communication cables are located along the southern boundary of the motorway and are likely to be directly impacted by the works.

High voltage power lines cross the Hills M2 Motorway in the vicinity of Morton Avenue and in the vicinity of Gossell Grove. Direct impacts to these items have been avoided in the design of the project.

Figure 8-2 Hills M2 Motorway integration local context

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Southern interchange (C5)

The southern interchange would be situated at the intersection of Pennant Hills Road and the Hills M2 Motorway within the suburbs of Beecroft, Carlingford and West Pennant Hills. **Figure 8-3** shows the location of the proposed works. The local area is characterised by low density residential development. The area surrounding the interchange comprises Pennant Hills Golf Course located immediately to the east of Pennant Hills Road, a number of small parks, discrete areas of native vegetation and community facilities. Significant land uses in the area include several retail businesses located to the south of the Hills M2 Motorway on Carmen Drive and the West Pennant Hills Community Church around 500 metres to the west of the southern interchange.

The majority of project works would be within or adjacent to the road corridor, zoned as SP2 Infrastructure under the Hills LEP. The area proposed for the southern ventilation facility, the motorway control centre and the Pennant Hills Road on and off-ramps is zoned as R2 Low Density Residential. The project would also affect a small area on the northern side of the Hills M2 Motorway zoned as RE1 Public Recreation. The existing land use generally reflects this zoning with low density residential developments, however a commercial landscape supply business also operates at this location. The surrounding land zonings are described in **Table 8-7**.

Table 8-7 Land use zonings surrounding the southern interchange

Land use zoning	Features
R2 Low Density Residential (Hills LEP and Hornsby LEP)	The surrounding residential areas
RE1 Public Recreation (Hills LEP)	Discreet areas of parkland
RE2 Private Recreation (Hornsby LEP)	Pennant Hills Golf Course

Public utilities that would be impacted by works at the southern interchange include:

- Ausgrid power supply infrastructure at the Hills M2 Motorway.
- Overhead power lines at Eaton Road.
- Water mains at the Hills M2 Motorway and in the existing Pennant Hills Road northbound kerb lane.
- Sewer along Pennant Hills Road.
- Telecommunications infrastructure on the west side of Pennant Hills Road.
- Traffic lights at Pennant Hills Road, Copeland Road and Eaton Road.
- Red light camera at the Copeland Road / Eaton Road intersection.

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Figure 8-3 Southern interchange local context

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Wilson Road site (C6)

The Wilson Road compound would be utilised as an ancillary construction compound and would accommodate the Wilson Road tunnel support facility during operation. The site is located in a low density residential zone under the Hornsby LEP on the western side of Wilson Road between Killaloe Avenue and Pennant Hills Road. The surrounding area is largely composed of residential land uses. The urban landscape is well developed with mature vegetation including a patch of remnant bushland (classified as Blue Gum High Forest) located opposite the site at Ludovic Blackwood Memorial Sanctuary / Observatory Park. Other land uses in the area include:

- The Mount Saint Benedict Centre School, located around 100 metres south-west of the Wilson Road compound.
- White Lady Funerals, located around 300 metres to the east.
- A Sydney Water property containing two water tanks around 250 metres to the west.
- An electrical substation around 270 metres to the north-west.

Zonings for the local area surrounding the Wilson Road site are summarised in **Table 8-8**.

Table 8-8 Land use zonings under the Hornsby LEP surrounding the Wilson Road site

Land use zoning	Features
R2 Low Density Residential	The dominant land use zoning in the area.
R4 High Density Residential	Located around 500 metres east of the site on the northern and southern sides of Pennant Hills Road.
RE1 Public Recreation	Observatory Park located between Pennant Hills Road and Beecroft Road.
E3 Environmental Management	Located on the western side of Beecroft Road at the Beecroft Road / Pennant Hills Road intersection.
SP2 Infrastructure	The major roads in the area including Pennant Hills Road, Beecroft Road and Boundary Road as well as the Northern Railway Line.
B2 Local Centre	Located around 500 metres to the east of the site on the corner of Pennant Hills Road and Yarrara Road.
B5 Business Development	Located around 500 metres to the east of the site on the southern side of Pennant Hills Road.
B6 Enterprise Corridor	Located around 500 metres to the east of the site on the northern side of Pennant Hills Road.

A sewer line runs directly through the site and is likely to be directly impacted by the works.

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Figure 8-4 Wilson Road local context

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Trelawney Street site (C7)

The Trelawney Street compound would be utilised as an ancillary construction compound and would accommodate the Trelawney Street tunnel support facility during operation. The site is located on the eastern side of Pennant Hills Road between Trelawney Street and Loch Maree Avenue in Thornleigh. The site is generally zoned R2 Low Density Residential with developments reflecting this zoning. Two lots within the site are zoned B6 Enterprise Corridor and form part of the wider Thornleigh business enterprise corridor. These lots contain commercial properties.

The surrounding area features predominantly residential land uses as well as land use zones in which industrial, commercial and retail land uses are permissible. Non-residential land uses are largely located in the corridor between the Northern Railway Line and Pennant Hills Road in an area zoned as an enterprise corridor. The enterprise corridor extends from about 300 metres north of the Trelawney Street site south to around Thornleigh Railway Station dividing Thornleigh and roughly forming the town centre.

Several different commercial developments are located in the enterprise corridor zone including:

- Kennard's Storage.
- Ibis Hotel.
- Caltex and Shell service stations.
- Thornleigh Community Centre.
- Bunnings Warehouse.
- McDonald's restaurant.
- Thornleigh veterinary clinic.
- Other businesses, restaurants and general retail.

Brickpit Park is located 300 metres to the north-west of the Trelawney Street site and includes a putt-putt golf course, a golf driving range, a sports centre and a skate park. The Chinese and Australian Baptist Church is located on the southern side of Loch Maree Avenue opposite the Trelawney Street site.

The Trelawney Street site would be located in an area zoned for residential land uses with some retail / commercial land uses. Land use zonings around the site are summarised in **Table 8-9**.

Table 8-9 Land use zonings under the Hornsby LEP around the Trelawney Street site

Land use zoning	Features
R2 Low Density Residential	The majority of the area surrounding the Trelawney Street site.
RE1 Public Recreation	Several discrete locations within the local area.
SP2 Infrastructure	The Northern Railway Line and Pennant Hills Road.
B2 Local Centre	Located south of the Trelawney Street site around Thornleigh Railway Station.
B6 Enterprise Corridor	Located opposite the Trelawney Street site on the western side of Pennant Hills Road.
IN 1 General Industrial	Located north of the Trelawney Street site on the western side of the Northern Railway Line.

Whilst a number of utilities are present around the site, these are not anticipated to be directly impacted by the works.

Pioneer Avenue compound (C8)

The Pioneer Avenue compound would be located adjacent to the Northern Railway Line on Pioneer Avenue in Thornleigh. The local area is largely composed of industrial and commercial land uses, roughly bound by Duffy Avenue to the south, Sefton Road to the north, the Northern Railway to the east and a the residential area on Wild Ash Way to the west.

The area surrounding the commercial / industrial centre is predominately residential with other land uses including:

- Brickpit Park on the eastern side of the Northern Railway Line.
- Enterprise corridor to the south between Pennant Hills Road and the Northern Railway Line.

The site is zoned IN 1 General Industrial and is currently developed for this purpose. Land use zonings around the site are summarised in **Table 8-10**.

Table 8-10 Land use zonings under the Hornsby LEP around the Pioneer Avenue compound (C8)

Land use zoning	Features
R2 Low Density Residential	The majority of the area around the commercial / industrial centre.
RE1 Public Recreation	Several discrete locations within the local area.
SP2 Infrastructure	The Northern Railway Line and Pennant Hills Road.
IN 1 General Industrial	Surrounds the site west of the Northern Railway.
B6 Enterprise Corridor	Located south of the site on the western side of Pennant Hills Road.

A high voltage underground power line runs through the site and may potentially be impacted by construction works.

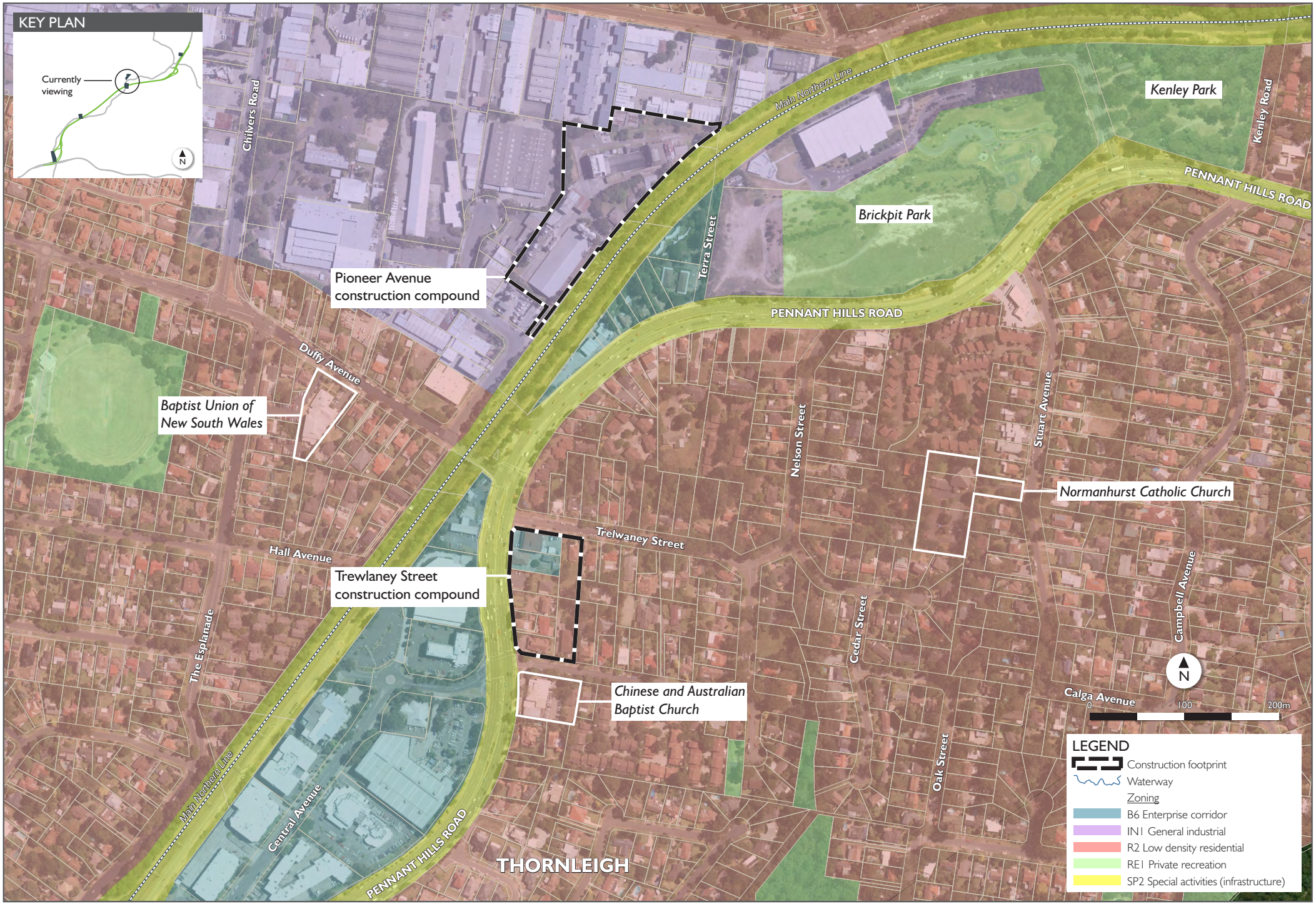

Figure 8-5 Trelawney Street local context

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Northern interchange compound (C9)

The northern interchange would be located at the Pennant Hills Road, M1 Pacific Motorway, Pacific Highway intersection. The suburban area is dominated by these major road corridors. Similarly to the other project sites, the surrounding area is made up largely of residential land uses. Other land uses in the vicinity of the northern interchange site include schools, places of worship, a hotel and various types of infrastructure.

The northern interchange site traverses the boundary between the Hornsby and Ku-ring-gai local government areas. Consequently the land zonings within each local government area have been described separately. The location of the local government area boundary is shown on **Figure 8-6**.

Land use zonings surrounding the site within the Hornsby local government area are mainly R2 Low Density Residential to the west of Pennant Hills Road and the area encompassed by Pennant Hills Road, the Pacific Highway and the M1 Pacific Motorway.

Land use zonings within the Ku-ring-gai local government area are described in **Table 8-11**.

Table 8-11 Land use zonings within Ku-ring-gai local government area around the northern interchange compound (C9)

Land use zoning (Ku-ring-gai Planning Ordinance)	Land use zoning (draft Ku-ring-gai LEP)	Features
2(h) Residential	R3 Medium Density Residential	Area encompassed by Pennant Hills Road, the Pacific Highway and the M1 Pacific Motorway.
2(h) Residential	R3 Medium Density Residential	Area around Kingsley Close.
2(d3) Residential 2(c) Residential 2(d) Residential	R4 High Density Residential R2 Low Density Residential	Area to the north of the Pacific Highway.
5 Special Uses A	SP2 Infrastructure	Abbotsleigh Senior School to the south of the Pacific Highway.

Public utilities that would be impacted by works at the northern interchange include:

- Sewer under the M1 Pacific Motorway.
- Traffic lights at M1 Pacific Motorway / Pennant Hills Road intersection.
- Street lighting for Pennant Hills Road.
- Telstra services on Pennant Hills Road.
- Water pipe on Pennant Hills Road.
- Gas main on Pennant Hills Road.
- Traffic lights at Pennant Hills Road / Pacific Highway intersection.

Bareena Avenue site (C10)

The Bareena Avenue site would be utilised as an ancillary construction compound and would accommodate the northern ventilation facility during operation. The Bareena Avenue site would be located on the corner of Bareena Avenue and Woonona Avenue on the western side of the M1 Pacific Motorway. The site is zoned as R2 Low Density Residential and the land use reflects this zoning.

The local area is characterised by low density residential development either side of the M1 Pacific Motorway with an area of higher density development on the northern edge of the Pacific Highway, Wahroonga. The residential areas are traversed by infrastructure corridors including the Pacific Highway, the M1 Pacific Motorway and the North Shore Railway Line. Other land uses in the area include a primary school on Woonona Avenue south, and several parks.

Within Hornsby local government area, on the western side of the M1 Pacific Motorway, the land use zoning surrounding the site is largely R2 Low Density Residential. This land use zoning extends as far west as the Pacific Highway on both the northern and southern sides of the North Shore Railway Line.

The land use zonings with the Ku-ring-gai local government area on the eastern side of the M1 Pacific Motorway are described in **Table 8-12**.

Table 8-12 Land use zonings within Ku-ring-gai local government area around the Bareena Avenue compound (C9)

Land use zoning (Ku-ring-gai Planning Ordinance)	Land use zoning (draft Ku-ring-gai LEP)	Features
2(d3) Residential 2(c) Residential 2(d) Residential	R4 High Density Residential R2 Low Density Residential	Area to the east of the M1 Pacific Motorway characterised by the presence of apartment buildings.
5 Special Uses A	SP2 Infrastructure	Abbotsleigh Junior School and a Sydney Water reservoir to the east of the M1 Pacific Motorway.

A sewer under the M1 Pacific Motorway would be impacted by the works at the Bareena Avenue compound.

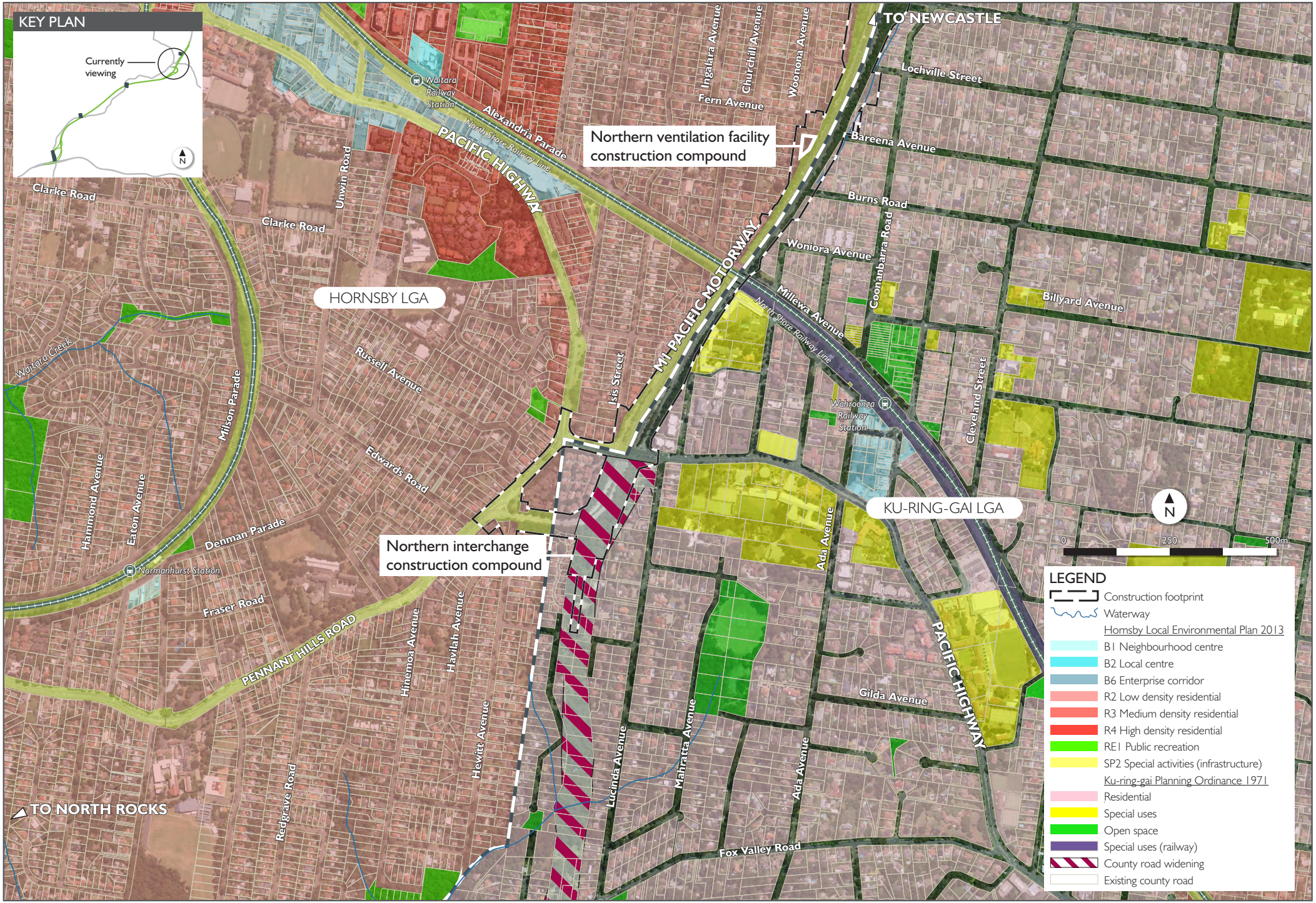

Figure 8-6 Northern interchange local context

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Junction Road compound (C11)

A temporary construction compound would be established adjacent to the M1 Pacific Motorway on the northern side of Junction Road. The surrounding land use is almost exclusively residential with the exception of the adjacent M1 Pacific Motorway.

The Junction Road compound site is located within the road corridor and would be zoned SP2 Infrastructure under the Ku-ring-gai Draft LEP. The primary zoning west of the M1 Pacific Motorway is R2 Low Density Residential under the Hornsby LEP.

The land use zonings within the Ku-ring-gai local government area to the east of the M1 Pacific Motorway are described in **Table 8-13**.

Table 8-13 Land use zonings within Ku-ring-gai local government area around the Junction Road compound (C11)

Land use zoning (Ku-ring-gai Planning Ordinance)	Land use zoning (draft Ku-ring-gai LEP)	Features
2(c) Residential	R2 Low Density Residential E4 Environmental Living	Area to the east of the M1 Pacific Motorway.
6 Open Space (a) Recreation Existing	RE1 Public Recreation	Carrington Park.

Whilst a number of utilities are present around the site, these are not anticipated to be impacted by the works.

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Figure 8-7 Junction Road construction compound local context

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8.1.2 Assessment of potential impacts

A key driver in the development of the preferred design was minimising the impacts on residential properties through land acquisition and changes in land use. The project, including the construction and operational disturbance footprints are predominately located within the purple corridor alignment option that was been identified during the 2004 report. As such, Roads and Maritime has already acquired a number of directly affected properties required for the project. However, a number of additional properties would be required for construction of the project.

Impacts on land use and property would occur from the commencement of construction. Potential impacts associated with construction and operation of the project would include:

- Temporary changes to land use and development through occupation of land during construction and alterations to property access.
- Permanent changes to land use and development through physical occupation of land required for operation of the project and consequential permanent alterations to surrounding property access.
- Longer-term changes to strategic land use and development planning as a consequence of the project including land use change facilitated by changes to amenity along the Pennant Hills Road corridor and in the event of development opportunities made available by the project (eg redevelopment of temporarily-affected land).

Land that would require acquisition for the project is referred to as directly affected land. Directly affected land would be acquired prior to commencement of construction and would involve:

- Partial acquisition where only part of the property would be required.
- Full acquisition, where the majority of a lot would be impacted.

All acquisition required for the project would be undertaken in consultation with the affected landowner and would be subject to the requirements of the *Land Acquisition (Just Terms Compensation) Act 1991*.

Property acquisition would be required for both temporary and permanent facilities. Land acquired for temporary facilities would only be required during construction and consequently has been discussed in the construction impacts section. Permanent facilities would require land throughout the operational life of the project and have been discussed within the operational impacts section.

The potential impacts to property associated with vibration and settlement from tunnelling works is described in **Section 7.8** (Hydrogeology and soils).

Construction

Temporary acquisition

Temporary ancillary construction facilities located outside of the road reserve such as those at the northern interchange would result in a temporary change to land use during construction. Temporary ancillary construction facilities would be located at the northern interchange compound (C9) at Eastbourne Avenue, the Junction Road compound (C11), the Pioneer Avenue compound (C8), the Windsor Road compound (C1), the Barclay Road compound (C3), the Yale Close compound (C4) and the Darling Mills Creek (C2) compound. Only Windsor Road, Pioneer Avenue and the northern interchange require temporary acquisition outside of the road corridor and have been assessed below. These facilities are outlined in more detail in **Chapter 5** (Project description)**.**

The properties that would be directly impacted by the temporary ancillary construction facility sites are detailed in **Table 8-14**. Four private properties would be required for temporary construction facilities in addition to eight properties previously acquired by Roads and Maritime. All four non-Roads and Maritime properties would be fully acquired.

Of the 12 affected properties, two are currently used for residential development, nine are currently undeveloped and one is developed for industrial purposes but is currently disused.

The Junction Road compound (C11) would not require land acquisition as the proposed site is within the existing M1 Pacific Motorway road corridor and is owned by Roads and Maritime. Similarly the Barclay Road (C3), Yale Close (C4) and Darling Mills Creek compounds (C2) would not require acquisition as they are located within the Hills M2 Motorway road corridor. There would not be any temporary acquisition for the southern interchange as the construction footprint aligns with the operational footprint (and therefore all properties would be permanently acquired) or the proposed works are contained with existing road reserves.

Table 8-14 Directly impacted properties – temporary construction facilities

Lot number	DP / SP number	Land use	Full / partial acquisition	Roads and Maritime owned	Construction facility / area
1	135976	Vacant (open space)	Full	Yes	Windsor Road compound (C1)
2	220508	Vacant (open space)	Full	Yes	
80	837675	Vacant (open space)	Full	Yes	
70	845947	Vacant (open space)	Full	Yes	
12	235680	Industrial	Full	No	Pioneer Avenue compound (C8)
8	16374	Vacant (open space)	Full	Yes	Northern interchange (C9)
13	285552	Residential	Full	No	
12	285552	Residential	Full	No	
2	455904	Vacant (vegetated)	Full	Yes	
1	455904	Vacant (vegetated)	Full	Yes	
2	524928	Vacant (open space)	Full	Yes	
911	811673	Vacant (vegetated)	Full	No	

Discussions have commenced and would continue with affected property owners regarding acquisition of or leasing the required land in the short term during the construction phase of the project. All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and the Land Acquisition Information Guide (Roads and Maritime, 2012c).

Properties leased for temporary construction facilities would be rehabilitated and returned to the land owner following completion of construction activities at each site. Roads and Maritime would investigate appropriate future uses for acquired properties, which may include landscaping, community facilities and / or sale.

Impacts on community facilities

The temporary construction facilities have generally been sited to avoid direct impacts to community facilities.

The bridge works required at Darling Mills Creek viaduct as part of the Hills M2 Motorway integration works would require short term closures of the public walking track along the creek to ensure safety of the public during construction. Appropriate signage would be erected during construction to advise the public during closures, including information regarding alternative walking routes.

Property access

Construction works and the establishment of temporary construction facilities may result in temporary impacts to existing property accesses. Where impacts to property accesses are unavoidable, consultation would be undertaken with the property owner and / or tenant to develop appropriate alternative access arrangements. This may involve provision of a temporary alternative access point.

Impacts on utilities

As described in **Section 8.1.1**, the project would impact on a number of existing utilities around and within the construction sites. These would be either protected in their current location or relocated at the commencement of construction works.

Impacts on surrounding development

The project would introduce construction sites within areas which are predominately zoned for and utilised as residential development. However, other land uses exist in the vicinity of the construction ancillary facilities including places of worship, businesses, schools and public recreation. These land uses may be more sensitive to the presence of a nearby construction site. Potential impacts such as noise, traffic and air quality associated with construction facilities have been mitigated as much as possible. Construction of the project is not likely to lead to land use changes or sterilisation of land. As such, the existing land uses surrounding construction sites would be able to continue during the construction phase.

Operation

Property acquisition

Permanent acquisition would be required for the following components of the project:

- Widening of road corridors.
- Operational surface facilities.
- The integration works to the Hills M2 Motorway.
- The tie-in works to the M1 Pacific Motorway.

A total of 56 residential, commercial and vacant properties, in addition to the 23 previously acquired by Roads and Maritime, would be directly impacted by permanent acquisition for the project (79 properties in total). A number of the Roads and Maritime properties are currently tenanted and usage within the project would require the current residents to relocate.

Of the 56 directly impacted properties, ten would require partial acquisition only, whilst 46 would be fully acquired. The majority of the land that would require full or partial acquisition is currently occupied by residential developments.

Table 8-15 provides a summary of the acquisitions required for the operational footprint of the project. These acquisitions are based on the current project design and may be subject to refinement in the future as detailed design work progresses. All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and the Land Acquisition Information Guide (Roads and Maritime, 2012c).

Table 8-15 Directly impacted properties – permanent operational footprint

Lot number	DP / SP number	Land use	Full / partial acquisition	Roads and Maritime owned	Operational facility / area
15	841778	Vacant (open space)	Full	No	Hills M2 Motorway integration works
9	873480	Vacant (open space)	Partial	No	
1	32472	Residential	Full	Yes	Motorway operations complex and southern interchange
1	34240	Residential	Full	Yes	
4	34450	Commercial	Full	No	
3	34450	Commercial	Full	No	
2	34450	Commercial	Full	No	
1	34450	Commercial	Full	No	
4	135600	Residential	Full	Yes	
3	135600	Residential	Full	Yes	
2	135600	Residential	Full	Yes	
1	135600	Residential	Full	No	
202	206130	Vacant (open space)	Full	Yes	
2	234245	Residential	Partial	No	
2	800355	Residential	Full	Yes	
1	800355	Residential	Full	Yes	
26	801997	Residential	Full	Yes	
33	825835	Residential	Full	Yes	
32	825835	Residential	Full	Yes	
31	825835	Residential	Full	Yes	
30	825835	Vacant (open space)	Full	Yes	
19	1017760	Vacant (open space)	Full	Yes	
18	1017760	Vacant (open space)	Full	Yes	
17	1017760	Vacant (open space)	Full	Yes	
16	1017760	Vacant (open space)	Full	Yes	
15	1017760	Vacant (open space)	Full	Yes	
14	1017760	Vacant (open space)	Full	Yes	
13	1017760	Vacant (open space)	Full	Yes	
12	1017760	Vacant (open space)	Full	Yes	
11	1017760	Vacant (open space)	Full	Yes	
10	1017760	Vacant (open space)	Full	Yes	
15	11685	Residential	Full	No	Wilson Road tunnel support facility
14	35528	Residential	Full	No	
13	35528	Residential	Full	No	
12	35528	Residential	Full	No	
-	41944	Residential	Full	No	

Lot number	DP / SP number	Land use	Full / partial acquisition	Roads and Maritime owned	Operational facility / area
112	1001146	Residential	Full	No	
111	1001146	Residential	Full	No	
22	1010137	Residential	Full	No	
21	1010137	Residential	Full	No	
20	1010137	Residential	Full	No	
34	5281	Residential	Full	No	Trelawney Street tunnel support facility
17	5281	Residential	Full	No	
17	262775	Commercial	Full	No	
16	262775	Commercial	Full	No	
15	262775	Residential	Full	No	
14	262775	Residential	Full	No	
12	262775	Residential	Full	No	
132	883467	Residential	Full	No	
131	883467	Residential	Full	No	
-	1836	Residential	Partial	No	Northern interchange
C	9921	Residential	Full	No	
A	9921	Residential	Full	No	
-	44036	Residential	Partial	No	
56	217127	Residential	Partial	No	
1	285552	Vacant (open space)	Partial	No	
12	285552	Residential	Full	No	
13	285552	Residential	Full	No	
B	384986	Residential	Full	No	
2	771102	Residential	Full	No	
1	771102	Residential	Full	No	
2	793127	Residential	Full	No	
8	868133	Residential	Full	No	
21	1006477	Residential	Full	No	
1	1045861	Residential	Full	No	
1	1050750	Residential	Full	No	
-	54471	Residential	Partial	No	M1 Pacific Motorway tie-in and northern ventilation facility
-	54857	Residential	Partial	No	
14	263707	Vacant (vegetated)	Full	No	
6	263707	Vacant (vegetated)	Full	No	
5	263707	Residential	Partial	No	
4	263707	Residential	Full	No	
9	706260	Residential	Full	No	
5	706260	Residential	Full	No	
1	847380	Residential	Full	No	
A	354779	Residential	Full	No	
19	866171	Residential	Partial	No	
18	866171	Vacant (vegetated)	Full	No	
2	1138943	Residential	Full	No	

Property access

One property would have some permanent physical change to external access arrangements. Existing vehicle access to a residential property adjacent to Bareena Avenue would require adjustment to accommodate the widening of the motorway.

Arrangements for altered property accesses would be subject to consultation with the affected property owner.

Impacts on existing and future developments

Across the project corridor, 45 residential properties would be permanently, fully acquired or have previously been fully acquired by Roads and Maritime for use as part of the project. This would result in a permanent change to the residential land use of these sites. Additionally, 12 lots which are currently undeveloped, but zoned R2 Low Density Residential, have previously been acquired by Roads and Maritime for the project. As such, these lots would no longer be available for future residential development opportunities.

One lot currently zoned public recreation adjacent to the Hills M2 Motorway would be fully acquired for the project resulting in the loss of this public space to the community.

Three lots which are currently undeveloped and vegetated would also be fully acquired. These lots are zoned for residential purposes under the Ku-ring-gai Planning Ordinance and as E2 Environmental Conservation or E4 Environmental living under the draft Ku-ring-gai LEP. Although the project would remove the future residential development potential of this land, this was already contemplated under the draft LEP. The potential ecological impacts arising from acquisition of this land are assessed in **Section 7.6** (Biodiversity).

Six properties comprising existing commercial developments would also be fully acquired for the project. Four of these commercial lots comprise one development, being a landscaping supply business near the southern interchange. This business is located within an area zoned for residential development and does not form part of a larger commercial centre. The other two commercial lots form part of the Thornleigh Enterprise Corridor, however they comprise the only two commercial developments within this corridor located on the western side of Pennant Hills Road. The acquisition of these two developments would not result in fragmentation of the enterprise corridor and is not anticipated to adversely affect the remaining commercial developments in the area. The economic and social impacts related to the acquisition of commercial properties are discussed further in **Section 7.7** (Social and economic).

Table 8-16 lists the lots which would be partially acquired, the relevant zoning of each lot, the residual lot size and whether this complies with the minimum lots sizes under the provisions of the relevant environmental planning instrument.

Table 8-16 Partially acquired properties – residual lot size

Lot number	DP / SP number	Land use zoning	Current land use	Minimum lot size (square metres)	Residual land size (square metres)
9	873480	R2 Residential (Hills LEP)	Residential	700	1,256
2	234245	R2 Residential (Hills LEP)	Residential	700	877
-	44036	R2 Residential (Hornsby LEP)	Residential	500	2,106
5	263707	2(c2) Residential (Ku-ring-gai Planning Ordinance) / R2 Residential (draft Ku-ring-gai LEP)	Residential	929 / 930	1,560
56	217127	R3 Residential (Hornsby LEP)	Residential	N/A	900
-	1836	R3 Residential (Hornsby LEP)	Residential	N/A	1,401
1	285552	2(h) Residential (Ku-ring-gai Planning Ordinance) / R3 Residential (draft Ku-ring-gai LEP)	Vacant (open space)	650 / 1,200	312
1	847380	R2 Residential (Hornsby LEP)	Residential	500	864
-	54471	2(c2) Residential (Ku-ring-gai Planning Ordinance) / R2 Residential (draft Ku-ring-gai LEP)	Residential	929 / 930	2,510
-	54857	2(c2) Residential (Ku-ring-gai Planning Ordinance) / R2 Residential (draft Ku-ring-gai LEP)1477	Residential	929 / 930	1,362
19	866171	2(c2) Residential (Ku-ring-gai Planning Ordinance) / R2 Residential (draft Ku-ring-gai LEP)	Residential	929 / 930	1,477

One residual lot would be below the minimum lot size contemplated under the Ku-ring-gai Planning Ordinance and under the draft Ku-ring-gai LEP. However, under the draft Ku-ring-gai LEP an exemption to minimum lot sizes would exist (if the draft LEP is made in its current form) for the subdivision of lots which are part of a strata or community title scheme. As this residual lot in question forms part of a community title scheme, future development potential of this land under the draft Ku-ring-gai LEP would be unaffected by the project.

All other residual lots would remain above the minimum lot size required by the relevant environmental planning instrument for development as a nominated permissible use on the affected land.

Land use compatibility and development potential

The project would introduce new surface operational ancillary facilities along the project corridor, mainly within areas developed and zoned for residential purposes. Wherever possible, these have been located immediately adjacent to the project and / or other arterial roads in order to limit the potential for impacts to surrounding land uses. For example, the motorway operations complex has been located immediately to the north of the Hills M2 Motorway and west of Pennant Hills Road.

The tunnel support facilities located on Wilson Road and Trelawney Street would be located within residential areas. These facilities would only be operated for air intake during low traffic speed conditions or to extract smoke in the unlikely event of an emergency within the tunnels. Additionally, they have been designed to integrate with the surrounding area and noise attenuation would be incorporated into the design of the facilities in order to meet the relevant guidelines (refer to **Section 7.2** Noise and vibration). As such, these elements of the project are not anticipated to affect the local development pattern or result in long-term land use changes.

On completion of the project, Roads and Maritime would investigate options for the use of residual land. This may include returning land to the community in the form of parks or recreational areas or selling land for redevelopment in accordance with the relevant existing land use zonings.

The project would also reduce the volume of traffic travelling on Pennant Hills Road, particularly heavy vehicles, resulting in improved local amenity in terms of noise and vibration, air quality and traffic. This improved local amenity could contribute to a reinvigoration of the corridor through improving the desirability over the longer-term for land uses such as residential and commercial developments (in particular retail).

The project would also facilitate future consideration of local embellishments including recreational facilities, cycling infrastructure, and public transport initiatives by the relevant authorities and infrastructure providers. These future opportunities, driven by improved amenity, do not form part of this project and would be subject to separate consideration by the relevant parties as appropriate.

8.1.3 Environmental management measures

The project has minimised the requirement for property acquisition by optimising the use of land already owned by Roads and Maritime, and locating operational elements within existing road corridors as much as feasible. The project also provides the potential to consider future development opportunities along the Pennant Hills Road corridor.

Mitigation and management measures would be implemented to avoid, minimise or manage impacts to land use and property. These mitigation and management measures are listed in **Table 8-17.**

Table 8-17 Environmental management measures - land use and property

Impact	No.	Environmental management measure	Timing
Construction			
Property access	LP1	Affected property owners would be consulted where temporary property access would be required.	Pre-construction and construction
	LP2	Affected property owners would be provided with advanced notification of relevant project schedules, construction works and changes to access arrangements.	Construction
	LP3	Community updates would be provided on changes to the local road network within the project area during construction.	Construction
Temporary lease or acquisition of property required for the project	LP4	Consultation would occur with the relevant property owners in relation to temporary land leases and acquisition of properties required temporarily for the construction of the project. Where acquisition is identified as the preferred option, this would be undertaken in accordance with the Land Acquisition Information Guide (Roads and Maritime, 2012c) and the *Land Acquisition (Just Terms Compensation) Act 1991.*	Construction
Community facilities	LP5	Appropriate signage would be provided advising of walking track closures and alternative walking routes.	Construction
Operation			
Acquisition of property required for the project	OpLP1	Land acquisition for the project would be undertaken in accordance with the Land Acquisition Information Guide (Roads and Maritime, 2012c) and the *Land Acquisition (Just Terms Compensation) Act 1991*.	Detailed design / pre-construction
Loss of land use and property access	OpLP2	Property accesses that are affected as a result of the project would be reinstated in consultation with the affected landowners including relocation if required.	Detailed design / construction

8.2 Hazards and risk

Environmental hazards resulting from the construction and operation of the project, and the identification of measures to avoid, mitigate or manage these risks, are addressed throughout **Chapter 7** and **Chapter 8** of this environmental impact statement.

Hazards arising from incidents during project construction and operation could pose a risk to the surrounding community, as well as that of the environment. Such potential risks and appropriate management measures are discussed below.

8.2.1 Assessment of potential impacts

Construction

During construction, the following hazards and risks may be associated with the project:

- Potential hazards resulting from accidental releases or improper handling and storage of dangerous goods and hazardous substances within construction sites.
- Potential hazards resulting from releases of hazardous substances from vehicles transporting dangerous goods and hazardous substances to and from the construction sites in the event of an accident.
- Workplace and public health and safety hazards, such as dangers to construction workers, road users and the general public.
- Potential rupture or interference with underground services.
- Potential risks from bushfires.

Storage and handling of dangerous goods and hazardous substances

The types of dangerous goods and hazardous substances that would be stored and used within the construction sites are outlined **Table 8-18** (construction sites are detailed in **Chapter 5** Project description). Minor quantities of other materials (less that 1,000 litres or 1,000 kilograms) may also potentially be used at the construction sites from time to time. Types and quantities of dangerous goods and hazardous substances stored and / or used within the project would be typical of tunnel construction projects of this scale.

While *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* (SEPP 33) does not apply to the project (refer to **Chapter 2** Assessment process), the principles of SEPP 33 have nonetheless been followed to consider potential hazards associated with the project. The screening thresholds specified in Hazardous and Offensive Development Application Guidelines: Applying SEPP 33 (Department of Planning, 2011) have been applied to inventories of dangerous goods to be stored at each construction site. These screening thresholds represent the level at which dangerous goods may present a credible off-site consequence requiring further, more detailed assessment of risks. Application of the screening thresholds is included in **Table 8-18.**

The storage, handling and use of dangerous goods and hazardous substances would be undertaken in accordance with the *Work Health and Safety Act 2011* (WHS Act), the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005) and relevant Australian Standards.

Table 8-18 Indicative dangerous goods and hazardous substances stored on-site during the construction period

Material	Australian Dangerous Goods Code class	Storage method	Construction site[1]						Assessment against Applying SEPP 33 inventory thresholds
			Southern interchange compound (C5)	Wilson Road compound (C6)	Trelawney Street compound (C7)	Northern interchange compound (C9)	Bareena Avenue compound (C10)	Junction Road compound (C11)	
Diesel	C1, PG III	Self bunded fuel tank	15,000L	15,000L	15,000L	15,000L	1,000L	3,000L	Diesel would not be stored with Class 3 materials and would therefore not be subject to the Applying SEPP 33 thresholds.
Lubricating and hydraulic oils and grease	C2	200L drums	3,000L	3,000L	3,000L	3,000L	1,000L	3,000L	Lubricating and hydraulic oils and grease would not be stored with Class 3 materials and would therefore not be subject to the Applying SEPP 33 thresholds.
Industrial grade oxygen	2.2	8.9m^3 cylinders	178m^3	178m^3	178m^3	178m^3	17.8m^3	178m^3	Industrial grade oxygen is a class 2.2 dangerous good and is therefore not subject to the Applying SEPP 33 thresholds.
Industrial grade acetylene	2.1	3.2m^3 cylinders (13 kg)	64m^3 (250kg)	64m^3 (250kg)	64m^3 (250kg)	64m^3 (250kg)	6.4m^3 (25kg)	64m^3 (250kg)	Individual cylinders containing acetylene would not trigger the Applying SEPP 33 thresholds (100kg). Maximum stored inventories (250 kilograms) would also be located more than 25 metres away from the nearest construction site boundary and would therefore also not trigger the Applying SEPP 33 thresholds if considered in aggregate.

Material	Australian Dangerous Goods Code class	Storage method	Construction site[1]						Assessment against Applying SEPP 33 inventory thresholds
			Southern interchange compound (C5)	Wilson Road compound (C6)	Trelawney Street compound (C7)	Northern interchange compound (C9)	Bareena Avenue compound (C10)	Junction Road compound (C11)	
Accelerator for shotcrete	3.2	1,000L intermediate bulk containers (IBC)	20,000L	20,000L	20,000L	20,000L	1,000L	N/A	Individual IBCs containing accelerator fluid would not trigger the Applying SEPP 33 thresholds (five tonnes). Maximum stored inventories (20,000litres) would also be located more than eight metres away from the nearest construction site boundary and would therefore also not trigger the Applying SEPP 33 thresholds if considered in aggregate.
General purpose Portland cement	N/A	20kg bags	1,000kg	5,000kg	5,000kg	5,000kg	1,000kg	1,000kg	General purpose Portland cement is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.
Road and joint sealants	N/A	12L boxes	240L	N/A	N/A	N/A	N/A	240L	Road and joint sealants are not dangerous goods and therefore do not trigger the Applying SEPP 33 thresholds.
Concrete curing compounds	N/A	1,000L IBC	6,000L	N/A	N/A	N/A	N/A	6,000L	Concrete curing compounds are not dangerous goods and therefore do not trigger the Applying SEPP 33 thresholds.
Pavement layers curing compound	N/A	1,000L IBC	3,000L	N/A	N/A	N/A	N/A	3,000L	Pavement layers curing compound is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.

Material	Australian Dangerous Goods Code class	Storage method	Construction site[1]						Assessment against Applying SEPP 33 inventory thresholds
			Southern interchange compound (C5)	Wilson Road compound (C6)	Trelawney Street compound (C7)	Northern interchange compound (C9)	Bareena Avenue compound (C10)	Junction Road compound (C11)	
Paint for tunnel roof	N/A	1,000L IBC	8,000L	N/A	N/A	N/A	N/A	8,000L	Paint for the tunnel roof is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.
Paints	N/A	50L drums	200L	N/A	N/A	N/A	N/A	200L	Paints are not dangerous goods and therefore do not trigger the Applying SEPP 33 thresholds.
Retardants for concrete	3 PGIII	205L drums	410L	N/A	N/A	N/A	N/A	410L	Retardants for concrete would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.
Epoxies	3 PGIII	20L drums	200L	N/A	N/A	N/A	N/A	200L	Epoxies would not trigger the Applying SEPP 33 thresholds (five tonnes) if considered as individual containers or in aggregate.
Coagulants	N/A	1,000L IBC	2,000L	2,000L	2,000L	2,000L	N/A	N/A	Coagulants are not dangerous goods and therefore do not trigger the Applying SEPP 33 thresholds.
Acids	8 PGII	1,000L IBC	2,000L	2,000L	2,000L	2,000L	N/A	N/A	Acids would not trigger the Applying SEPP 33 thresholds (25 tonnes) if considered as individual containers or in aggregate.
Bases	8 PGII	1,000L IBC	2,000L	2,000L	2,000L	2,000L	N/A	N/A	Bases would not trigger the Applying SEPP 33 thresholds (25 tonnes) if considered as individual containers or

Material	Australian Dangerous Goods Code class	Storage method	Construction site[1]						Assessment against Applying SEPP 33 inventory thresholds
			Southern interchange compound (C5)	Wilson Road compound (C6)	Trelawney Street compound (C7)	Northern interchange compound (C9)	Bareena Avenue compound (C10)	Junction Road compound (C11)	
									in aggregate.
Disinfectant	8 PGIII	500L IBC	1,000L	1,000L	1,000L	1,000L	N/A	N/A	Disinfectant would not trigger the Applying SEPP 33 thresholds (50 tonnes) if considered as individual containers or in aggregate.
Anti-scalent	N/A	100L drums	200L	200L	200L	200L	N/A	N/A	Anti-scalent is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.
Membrane preservative	8	10L drums	20L	20L	20L	20L	N/A	N/A	Membrane preservative would not trigger the Applying SEPP 33 thresholds (50 tonnes) if considered as individual drums or in aggregate.

[1] Quantities are indicative only.

The assessment of inventories of dangerous goods to be located at each construction site presented in **Table 8-18** demonstrates that the Applying SEPP 33 inventory thresholds would not be exceed for any material on any site. The storage and use of dangerous goods and hazardous materials on the project construction sites would therefore not pose an elevated risk of harm beyond the construction site boundary.

A register and inventory of the dangerous goods and hazardous substances to be stored on-site would be kept as part of the Pollution Incident Response Management Plan and Material Safety Data Sheets for each would need to be obtained prior to their arrival.

Storage would occur in accordance with supplier's instructions and may include bulk storage tanks, chemical storage cabinets / containers or impervious bunds. Impervious bunds would be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container. Storage areas would be located away from natural or built drainage lines to minimise the likelihood of pollutants entering any adjacent watercourses in the unlikely event of a spill or leak escaping the bunded area.

Implementation of environment management measures regarding the storage and handling of these dangerous goods and hazardous substances, as detailed in **Table 8-22**, would reduce the risk to the environment, construction personnel and the public.

Transport of dangerous goods and hazardous substances

Dangerous goods and hazardous materials that would be transported to each construction are outlined in **Table 8-19**. Potential transportation hazards and risks have been considered through comparison of the type, quantity and frequency of dangerous goods and hazardous materials transportation with the thresholds presented in the Applying SEPP 33 guideline. In all cases, the transportation of dangerous goods and hazardous materials to project construction sites would be well below the Applying SEPP 33 thresholds. This indicates that risks associated with transport of dangerous goods and hazardous materials are unlikely to be significant.

Table 8-19 Dangerous goods and hazardous substances transported to construction sites

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Diesel	C1, PG III	Weekly	15,000L in bulk	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	Diesel is not a dangerous good and would not be transported with Class 3 dangerous goods. It is therefore not subject to the Applying SEPP 33 transportation thresholds.
			3,000L in bulk	• Junction Road compound (C11)	
			1,000L in bulk	• Bareena Avenue compound (C10)	
Lubricating and hydraulic oils and grease	C2	Weekly	3,000L in 200L drums	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9) • Junction Road compound(C11)	Lubricating and hydraulic oils and grease are not dangerous goods and would not be transported with Class 3 dangerous goods. They would therefore not be subject to the Applying SEPP 33 transportation thresholds.
			1,000L in 200L drums	• Bareena Avenue compound (C10)	

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Industrial grade oxygen	2.2	Weekly	178m^3 in 8.9m^3 cylinders	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9) • Junction Road compound (C11)	Industrial grade oxygen is not subject to the Applying SEPP 33 transportation thresholds.
			17.8m^3 in 8.9m^3 cylinders	• Bareena Avenue compound (C10)	
Industrial grade acetylene	2.1	Weekly	64m^3 in 3.2m^3 cylinders	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9) • Junction Road compound (C11)	Industrial grade acetylene would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (two tonnes, more than 30 times per week).
			6.4m^3 in 3.2m^3 cylinders	• Bareena Avenue compound (C10)	

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Accelerator for shotcrete	3.2	Weekly	20,000L in 1,000L IBCs	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9) • Junction Road compound (C11)	Accelerator for shotcrete would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (three tonnes, more than 45 times per week).
			1,000L in a single IBC	• Bareena Avenue compound (C10)	
General purpose Portland cement	N/A	Weekly	2,000kg in 20kg bags	• Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	General purpose Portland cement is not subject to the Applying SEPP 33 transportation thresholds.
			1,000kg in 20kg bags	• Bareena Avenue compound (C10)	
			500kg in 20kg bags	• Southern interchange compound (C5) • Junction Road compound (C11)	
Road and joint sealants	N/A	Monthly	240L in 12L boxes	• Southern interchange compound (C5) • Junction Road compound (C11)	Road and joint sealants are not subject to the Applying SEPP 33 transportation thresholds.

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Concrete curing compounds	N/A	Fortnightly	3,000L in 1,000L IBCs	• Southern interchange compound (C5) • Junction Road compound (C11)	Concrete curing compounds are not subject to the Applying SEPP 33 transportation thresholds.
Pavement layers curing compound	N/A	Monthly	3,000L in 1,000L IBCs	• Southern interchange compound (C5) • Junction Road compound (C11)	Pavement layers curing compound is not subject to the Applying SEPP 33 transportation thresholds.
Paint for tunnel roof	N/A	Weekly	4,000L in 1,000L IBCs	• Southern interchange compound (C5) • Junction Road compound (C11)	Paint for the tunnel roof is not subject to the Applying SEPP 33 transportation thresholds.
Paints	N/A	Monthly	50L in a single drum	• Southern interchange compound (C5) • Junction Road compound (C11)	Paints are not subject to the Applying SEPP 33 transportation thresholds.
Retardants for concrete	3 PGIII	Every two months	205L in a single drum	• Southern interchange compound (C5) • Junction Road compound (C11)	Retardants for concrete would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency.
Epoxies	3 PGIII	Monthly	40L in 20L drums	• Southern interchange compound (C5) • Junction Road compound (C11)	Epoxies would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (ten tonnes, more than 60 times per week).

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Coagulants	N/A	Weekly	1,000L in a single IBC	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	Coagulants are not subject to the Applying SEPP 33 transportation thresholds.
Acids	8 PGII	Every two months	1,000L in a single IBC	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	Acids would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (two tonnes, more than 30 times per week).
Bases	8 PGII	Every two months	1,000L in a single IBC	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	Bases would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (two tonnes, more than 30 times per week).

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Construction site destination	Assessment against Applying SEPP 33 transport thresholds
Disinfectant	8 PGIII	Monthly	500L in a single IBC	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound(C7) • Northern interchange compound (C9)	Disinfectant would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (two tonnes, more than 30 times per week).
Anti-scalent	N/A	Monthly	100L in a single drum	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound(C7) • Northern interchange compound (C9)	Anti-scalent is not subject to the Applying SEPP 33 transportation thresholds.
Membrane preservative	8	Monthly	10L in a single drum	• Southern interchange compound (C5) • Wilson Road compound (C6) • Trelawney Street compound (C7) • Northern interchange compound (C9)	Membrane preservative would not trigger the Applying SEPP 33 transportation thresholds for minimum transport load or transport frequency (two tonnes, more than 30 times per week).

[1] Quantities are indicative only.

Construction workplace hazards

Tunnelling works present a number of specific hazards to construction workers, members of the public and equipment, including partial or complete tunnel collapse with associated surface impacts, rock fall at cuttings, and exposure to airborne pollutants, such as dust during tunnelling and potential asbestos fibres during demolition works.

In accordance with the requirements of the Work Cover Code of Practice for Tunnels, work methods for excavation and support installation would ensure that no persons would be required to work under unsupported ground without an adequate overhead protection structure. Primary support for the project tunnels would be installed as the excavation progresses, as recommended by an appropriately qualified geotechnical or tunnel engineer. A 'Permit to Tunnel' system would also be developed and implemented to ensure that design, construction and survey are taken into consideration and ground support conditions modified if required before the excavation advances. This system requires the methodology and approach for any proposed tunnelling works to be reviewed and approved before the proposed work stage to proceed.

The structural integrity of the tunnel would be assured during construction through the implementation of appropriate construction methodology for the tunnelling conditions and ongoing tunnel support by way of rockbolts and / or shotcrete lining. The majority of the main alignment tunnels would be constructed at significant depth within Hawkesbury Sandstone with minimal risk of surface effects. For on and off-ramps, and where the main alignment tunnels come to the surface, tunnel components would be progressively constructed and stabilised to ensure that surface deformations do not occur.

The tunnel depth, generally around 20 metres to 60 metres below ground level with shallower sections approaching the portals, also enhances the structural integrity of the tunnel. The geology of the area was influential in determining the tunnel vertical alignment. Hawkesbury Sandstone is considered an excellent tunnelling and excavation medium as it is high strength with infrequent and relatively widely spaced defects. In comparison, Ashfield Shale is also of high strength but has a deeper soil profile, closer spaced defects (commonly affected by faulting) and the fresh shale can readily deteriorate on exposure. As a result, the tunnel has been designed to maximise the length of tunnel within Hawkesbury Sandstone and minimise the length within Ashfield Shale.

Rock fall hazards may occur around cuttings, the interchange dive structures and along the M1 Pacific Motorway tie-in works and the Hills M2 Motorway integration works. A rock fall could potentially injure construction personnel and cause damage to construction equipment. Steep slopes may pose an additional risk for construction personnel, who could slip and fall, or be injured by unsecured equipment. Standard construction practices and mitigation measures, including the use of appropriate personal protective equipment, properly secured equipment, safety fencing and overhead protection would minimise the risks associated with rock falls and steep slopes.

Tunnelling construction would generate dust within the tunnel at the cutting face. Dust generation may cause risks to human health of construction workers within the tunnel environment. The generation of dust within the tunnel would be minimised by wetting down the cutting face. Temporary fans and dry dust scrubbers would also be provided within the tunnel to remove dust from the working environment.

There is potential that demolition works, and the relocation of utilities, may encounter asbestos containing materials. If asbestos containing materials is disturbed or broken and the microscopic fibres become airborne, they can become a health risk if breathed into the lungs. Provided appropriate management measures are adopted prior to and during the demolition process, the risks associated with asbestos containing materials can be adequately controlled. The management of potential asbestos waste is described further in **Section 8.3** (Resource minimisation and waste management).

Underground services

The potential rupture of underground services when excavating could pose a hazard in the form of electrocution, release of sewage from a sewer main or fire if a gas main is impacted. The risk associated with these hazards would be minimised by undertaking utility checks (such as dial before you dig), consulting with the relevant service infrastructure providers and if required, relocating and / or protecting utilities in and around the project prior to the commencement of construction. Consultation with service infrastructure providers would commence during the design and continue during the construction to mitigate the risk of unplanned and unexpected disturbance of utilities. The relocation of utilities may result in short term outages of certain utilities to surrounding areas. Services which would be directly impacted and require protection and / or relocation are detailed in **Section 8.1** (Land use and property).

Bushfires

A bushfire risk assessment has been prepared in order to assess potential bushfire implications of the project. The assessment has been undertaken in accordance with the Bush Fire Risk Management Planning Guidelines for Bush Fire Management (RFS, 2008). Based on bushfire prone land mapping developed and published by the relevant local councils, the following construction sites would be located on or in proximity to bushfire prone land:

- The Junction Road compound and the M1 Pacific Motorway tie-in works on the east side of the existing M1 Pacific Motorway.
- The Hills M2 Motorway integration works.

Temporary construction sites and construction infrastructure would be generally less sensitive to bushfire risks than operational facilities, given the temporary nature of the construction sites and the absence of critical infrastructure within the sites. Notwithstanding, detailed design of temporary construction sites and particularly those in the locations listed above would be developed having regard to:

- Establishment of appropriate asset protection zones (APZ) within and around temporary construction sites.
- Provision of a principal and an alternative site access point, to be used in the event of an emergency.
- Use of fire resistant materials in the construction of site infrastructure where feasible and reasonable to do so, having regard to the relevant provisions of AS3959-2009: Construction of a Building in Bush Fire Prone Areas (Standards Australia, 2009).
- Storage and management of dangerous goods and hazardous materials in a safe, secure location consistent with the requirements of applicable Australia Standards.

Temporary construction sites would be maintained in a tidy and orderly manner, with the aim of minimising potential fuel loads in the event that the sites are affected by a bushfire.

If not properly managed, construction activities involving flammable materials and ignition sources (for example, welding) have the potential to increase fire and bushfire risks. These types of activities would be proactively managed to ensure that fire risks both within temporary construction sites and potentially affecting surrounding land are effectively minimised. High risk construction activities, such as welding and metal work, would be subject to a risk assessment on total fire ban days and restricted or ceased as appropriate.

Measures to mitigate and manage bushfire risks would be developed and included as part of site-specific hazard and risk management measures within Construction Environmental Management Plan.

Operation

During operation, the following potential hazards and risks may be associated with the project:

- Hazards resulting from accidental releases or improper handling and storage of dangerous goods and hazardous substances in the water treatment plant, located within the motorway operations complex adjacent to the southern interchange.
- Hazards resulting from releases of hazardous substances from vehicles transporting dangerous goods and hazardous substances to and from the motorway operations complex in the event of an accident.
- Accidents and incidents within the main alignment tunnels or on and off-ramp tunnels.
- Accidents and incidents on surface roads, including improvements to traffic safety on Pennant Hills Road.
- Risks from electric and magnetic fields from the project substations.
- Risks from bushfires.

Storage and handling of dangerous goods and hazardous substances

Dangerous goods and hazardous materials would be stored and used during operation of the water treatment plant, located within the motorway operations complex adjacent to the southern interchange (refer to **Figure 5-11**). The types and quantities of dangerous goods and hazardous materials to be stored on-site during operation are summarised in **Table 8-20.** Additional small quantities of other materials may be required on-site from time to time to support occasional maintenance activities.

Comparison of the types and quantities of dangerous goods and hazardous materials to be stored on-site with the thresholds in the Applying SEPP 33 guideline demonstrates that operational inventories would not pose a significant risk of harm beyond the site boundary.

Table 8-20 Indicative dangerous goods and hazardous substances stored on-site during operation

Material	Australian Dangerous Goods Code class	Storage method[1]	Assessment against Applying SEPP 33 inventory thresholds
Coagulant	N/A	10,000L feed tank in an undercover bunded area.	Coagulant is not subject to the Applying SEPP 33 thresholds.
Polymers	N/A	10,000L feed tank in an undercover bunded area.	Polymers are not subject to the Applying SEPP 33 thresholds.
Acid	8 PGII	10,000L feed tank in an undercover bunded area.	Acid would not trigger the Applying SEPP 33 thresholds (25 tonnes).
Base	8 PGII	10,000L feed tank in an undercover bunded area.	Base would not trigger the Applying SEPP 33 thresholds (25 tonnes).

[1] Quantities are indicative only.

Transport of dangerous goods and hazardous substances

Dangerous goods and hazardous materials that would be transported to the project during operation are outlined in **Table 8-21**. Transportation of both acid and base (alkaline) materials to the project during operation exceeds the quantity thresholds for these materials under the Applying SEPP 33 guideline, but the frequency of transportation falls well short of the frequency threshold. This indicates that risks associated with transport of dangerous goods and hazardous materials are unlikely to be significant.

Table 8-21 Dangerous goods and hazardous substances transported during operation

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity[1]	Assessment against Applying SEPP 33 transport thresholds
Coagulant	N/A	Every eight months	10,000L	Coagulant is not subject to the Applying SEPP 33 transportation thresholds.
Polymers	N/A		10,000L	Polymers are not subject to the Applying SEPP 33 transportation thresholds.
Acid	8 PGII	Every four months	10,000L	Acid would exceed the volume threshold but not the transport frequency threshold under the Applying SEPP 33 guideline (two tonnes, 30 times per week).
Base	8 PGII		10,000L	Base would exceed the volume threshold but not the transport frequency threshold under the Applying SEPP 33 guideline (two tonnes, 30 times per week).

[1] Quantities are indicative only.

Incidents in the project tunnels

The nature of the project means that there is an inherent risk of vehicle collision associated with its operation. The potential for incidents and accidents to occur is a function of:

- The design of the project.
- The type and volumes of traffic using the project.
- Driving conditions, including light conditions and meteorology.
- Human factors, including compliance with road rules, attention to driving conditions and fatigue.
- Vehicle failure and breakdown.

The project has been designed to provide for efficient, free flowing traffic with physical capacity to accommodate predicted traffic volume. The preferred design has incorporated all feasible and reasonable design measures including in relation to geometry, pavement, lighting and signage, consistent with current Australian Standards, road design guidelines and industry best practice. In doing so, the design of the project has been developed to inherently minimise the likelihood of incidents and accidents.

To minimise the likelihood of an incident associated with over height vehicles within the tunnel an over height detection system has been included in the project comprising:

- Electronic over height detectors prior to the tunnel portals.
- Vehicle presence detectors.
- Warning signs with lanterns installed that would light up upon detection of an over height vehicle.

Detectors would be installed prior to divergence points to the tunnels to allow over height vehicles to divert to an alternative route. Secondary detectors would also be installed after the divergence point to detect over height vehicles that have not diverted. The detection of over height vehicles would be alarmed to the motorway operator and the nearest camera switched onto the incident monitors so that the operator can control traffic management devices such as moveable physical barrier and portal variable message signs to stop the vehicle from entering the tunnel.

Notwithstanding, human factors in particular cannot be entirely removed during operation of the project and there would remain a residual risk of incidents and accidents, albeit the likelihood of such events would be low.

In the event of incidents and accidents, the project has been designed to meet appropriate fire and life safety requirements. The key fire and life safety aspects included in the project are:

- Wide shoulders to accommodate breakdowns and access by recovery and emergency vehicles.
- Each project tunnel would be one directional, reducing the risk of vehicle accidents through head-on collisions and simplifying smoke management and egress requirements.
- The transport of dangerous goods and hazardous substances would be prohibited through the main alignment tunnels and on and off-ramp tunnels, reducing the risk of very large fires or the release of toxic materials.
- State of the art CCTV and audible systems to detect incidents and manage evacuation processes.
- Emergency pedestrian exits from the main alignment tunnels and on and off-ramp tunnels.
- Multiple pedestrian cross passages between the main alignment tunnels.
- Two cross passages between the main alignment tunnels for emergency vehicles.
- Automatic fire and smoke detection within the tunnels.
- A ventilation system designed to manage emergency situations.
- Longitudinal ventilation would direct smoke in the direction of traffic flow from the fire source towards an emergency smoke extraction point or tunnel portal.
- A water deluge system would be activated manually or automatically at the fire source.
- Structures, linings and services would be fire hardened to protect them prior to the activation of the deluge system, or in the event that the deluge system fails.
- In the event of an incident, approaching traffic would be prevented from entering both the incident main alignment tunnel and the non-incident main alignment tunnel.
- Occupants involved in the fire event, or upstream of the fire source, would be instructed to stop their vehicles, and exit in the opposite direction along the carriageway (as this region would be protected by the smoke management system), or through an exit door to a cross passage leading to the non-incident main alignment tunnel.
- Occupants downstream of the fire source would be encouraged to continue driving out of the tunnel. If this is not possible and they are forced to evacuate on foot, egress would be provided via an exit door to a cross passage leading to the non-incident carriageway.
- Emergency services would be able to reach the fire source via the non-incident tunnel (by vehicle or foot), or from the upstream direction in the incident tunnel (by foot).

The project has been designed to minimise the likelihood of and manage incidents within the tunnel in accordance with the following standards:

- Australian Standard AS4825 – Tunnel fire safety.
- National Fire Protection Association (NFPA) 502 - Standard for Road Tunnels, Bridges and Other Limited Access Highways.
- Permanent International Association of Road Congress (PIARC) including:
  - Systems and equipment for fire and smoke control in road tunnels, 2007.
  - Road tunnels: Vehicle emissions and air demand for ventilation, 2012.
  - Fire and Smoke Control in Road Tunnels, 1999.
  - Operational Strategies for Emergency Ventilation, 2008.

During emergency conditions the ventilation system would extract smoke from the tunnel. Depending on the location of the incident, smoke would be emitted from one or more of the following locations:

- The southern ventilation facility.
- Wilson Road tunnel support facility.
- Trelawney Street tunnel support facility.
- The northern ventilation facility.
- The tunnel portals.

Emergency smoke extraction would be achieved through management of the project's ventilation system for a short duration until such time as the tunnel deluge system and / or emergency services have extinguished the fire.

Incidents on surface roads

As with underground components of the project, surface roads and infrastructure have been designed to provide an efficient and safe road network.

An important road safety opportunity facilitated by the project is an overall improvement in road safety performance of Pennant Hills Road, as a consequence of reduced traffic volumes (particularly heavy vehicles).

Pennant Hills Road currently carries large volumes of traffic with a large proportion of these vehicles being heavy vehicles, given the corridor's importance as a national freight corridor. Between 2008 and 2013, the section of Pennant Hills Road north of the Hills M2 Motorway had a total of 980 crashes, with one fatal and 342 injury crashes. Around half of these accidents were a result of rear-end collisions.

Due the anticipated reduction in heavy vehicles utilising Pennant Hills Road, the project would improve travelling conditions on Pennant Hills Road and the surrounding network, which would result in the following traffic related benefits:

- Improved traffic flow and intersection performance.
- Reduced crash rates.
- Improved road safety for pedestrians, cyclists and motorists.
- Improved travel times for bus services and motorists.

These traffic related benefits would result in an improved road safety environment and a reduction in incidents along this corridor.

Further details of the expected changes in traffic volumes on existing and new road infrastructure is provided in **Section 7.1** (Traffic and transport). Impacts and improvements to noise and air quality / and human health risks are discussed in **Section 7.2** (Noise and vibration), **Section 7.3** (Air quality) and **Section 7.4** (Human health) respectively.

Electric and magnetic fields

The Interim Guidelines on Limits of Exposure to 50 / 60 Hz Electric and Magnetic Fields (National Health and Medical Research Council, 1989) has remained an important Australian guideline on limits of exposure to power frequency and magnetic fields, despite the fact that the guideline has been rescinded and never replaced. In 1996, the Australian Radiation Protection and Nuclear Safety Agency with its responsibility for the management and review of the National Health and Medical Research Council's Radiation Health Series publications, released Draft Radiation Standard - Exposure Limits for Magnetic Fields (Australian Radiation Protection and Nuclear Safety Agency, December 2006). The Draft Radiation Standard drew on a large body of scientific research into the possible health effects of electromagnetic fields undertaken since 1989, and proposed a series of exposure standards to replace the National Health and Medical Research Council Interim Guidelines from 1989.

The Draft Radiation Standard also expanded on the National Health and Medical Research Council Interim Guidelines to include the entire Extreme Low Frequency range from 0 Hz to 3 kHz, whereas the National Health and Medical Research Council Interim Guideline only ever covered 50Hz / 60 Hz. While the Draft Radiation Standard has never been finalised and published, the exposure limits it presents are typically applied when considering electric and magnetic fields from new developments. The Draft Radiation Standard suggests the exposure limits for the general public (including vulnerable groups) and for the controlled activity or controlled circumstance (where exposure to electric and magnetic fields may reasonably be expected to exceed the public exposure reference level).

The project would include the provision of four aboveground substations located at the:

- Motorway operations complex.
- Wilson Road tunnel support facility.
- Trelawney Street tunnel support facility.
- Northern ventilation facility.

The detailed design of the project substations would ensure that the exposure limits for the general public suggested by the Draft Radiation Standard would not be exceeded at the boundary of the substation sites.

Bushfires

Based on bushfire prone land mapping developed and published by the relevant local councils, the following operational facilities would be located on or in proximity to bushfire prone land:

- The M1 Pacific Motorway tie-in works on the east side of the existing M1 Pacific Motorway and the northern ventilation facility.
- The Hills M2 Motorway integration works.

Most of the project's operational infrastructure is invulnerable to bush fire attack due to its incombustible nature (road surface materials, retaining walls, road barriers) and / or location underground. Infrastructure critical to the ongoing safe operation of the project, including the motorway operations complex, would be located outside of bushfire prone areas.

As with the development of designs for temporary construction sites, operational infrastructure would be subject to detailed design taking into account:

- Establishment of appropriate asset protection zones (APZ) within and around operational facilities.
- Provision of a principal and an alternative site access point, to be used in the event of an emergency.
- Use of fire resistant materials in the construction of site infrastructure where feasible and reasonable to do so, having regard to the relevant provisions of AS3959-2009: Construction of a Building in Bush Fire Prone Areas (Standards Australia, 2009).
- Storage and management of dangerous goods and hazardous materials in a safe, secure location consistent with the requirements of applicable Australia Standards.

In the event of a bushfire affecting surrounding land, there is potential for smoke and embers to be drawn into the main alignment tunnels and ventilation system. Emergency planning and development of incident response plans for the operation of the project would include specific provisions relevant to the management of a bushfire with direct or indirect impacts on the project. Emergency planning for bushfires would consider:

- Trigger points and control strategies to prevent access in the event of a tunnel or road closure.
- Smoke ingestion into the tunnel complexes and operational ventilation systems form surface bushfires.
- Closure of aboveground parts of road infrastructure by emergency services due to bushfires in the vicinity of or impacting on the road system.

8.2.2 Environmental management measures

The project has been designed to provide for efficient, free flowing traffic with physical capacity to accommodate predicted traffic volume. The preferred design has incorporated all feasible and reasonable design measures including in relation to geometry, pavement, lighting and signage, consistent with current Australian Standards, road design guidelines and industry best practice. In doing so, the design of the project has been developed to inherently minimise the likelihood of incidents and accidents.

Construction of the project would require the storage and use of dangerous goods and hazardous substances. These would be transported to site, stored and used in accordance with manufacturer's instructions and Australian Standards. Tunnelling works would occur in accordance with the Work Cover Code of Practice for Tunnels, including the implementation of a 'permit to tunnel' process to ensure the ongoing structural integrity of the tunnels.

Environmental management measures relating to hazards and risk for the construction and operation of the project are provided in **Table 8-22.**

Table 8-22 Environmental management measures – hazards and risk

Impact	No.	Environmental management measure	Timing
Construction			
General	HR1	Site-specific hazard and risk management measures would be included within the Construction Environmental Management Plan (CEMP), which may include items such as: • Details of the hazards and risk associated with construction activities for both surface and subsurface works. • Procedures to comply with legislative and industry standard requirements. • Contingency plans, as required. • Site-specific Work Health and Safety plans and Safe Work Method Statements. • Training for relevant personnel (including subcontractors) and site inductions, including the recognition and awareness of site hazards and locations of relevant equipment.	Pre-construction / construction
Storage of dangerous goods and hazardous substances	HR2	Storage of dangerous goods and hazardous materials would occur in accordance with supplier's instructions and relevant Australian Standards and may include bulk storage tanks, chemical storage cabinets / containers or impervious bunds.	Construction

Impact	No.	Environmental management measure	Timing
	HR3	Storage, handling and use of dangerous goods and hazardous substances would be in accordance with the *Occupational Health and Safety Act 2000* and the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005).	Construction
	HR4	Secure, bunded areas would be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds would be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Construction
	HR5	Bunds would be provided around activities such as vehicle refuelling, servicing, maintenance or wash-down, where there is a potential for spills and contamination.	Construction
	HR6	Material Safety Data Sheets would be obtained for dangerous goods and hazardous substances stored on-site prior to their arrival.	Construction
Transportation of dangerous goods and hazardous substances	HR7	Transport of dangerous goods and hazardous substances would be conducted in accordance with relevant legislation and codes, including the *Road and Rail Transport (Dangerous Goods) (Road) Regulation 1998* and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2008).	Construction
Operation			
Fire and life safety	OpHR1	The fire and safety systems and measures adopted for the project would be equivalent to or exceed the fire safety measures recommended by NFPA502 (American), PIARC (European), AS4825 (Australian) and Roads and Maritime standards.	Detailed design
Storage of dangerous goods and hazardous substances	OpHR2	Storage of dangerous goods and hazardous materials would occur in accordance with supplier's instructions and relevant Australian standards and may include bulk storage tanks, chemical storage cabinets / containers or impervious bunds.	Operation
	OpHR3	Storage, handling and use of dangerous goods and hazardous substances would be in accordance with the *Occupational Health and Safety Act 2000* and the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005).	Operation

Impact	No.	Environmental management measure	Timing
	OpHR4	Secure, bunded areas would be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds would be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Operation
	OpHR5	Bunds would be provided around activities such as vehicle refuelling, servicing, maintenance or wash-down, where there is a potential for spills and contamination.	Operation
	OpHR6	Material Safety Data Sheets would be obtained for dangerous goods and hazardous substances stored on-site prior to their arrival.	Operation
Transportation of dangerous goods and hazardous substances	OpHR7	The transport of dangerous goods and hazardous substances would be prohibited through the main alignment tunnels and on and off-ramp tunnels.	Operation
Incident response	OpHR8	An Incident Response Plan would be developed and implemented in the event of an accident or incident.	Operation
	OpHR9	The response to incidents within the motorway would be managed in accordance with the memorandum of understanding between Roads and Maritime and the NSW Police Service, NSW Rural Fire Service, NSW Fire Brigade and other emergency services	Operation
Electric and magnetic fields	OpHR10	The detailed design of the project substations would ensure that the exposure limits for the general public suggested by the Draft Radiation Standard (Australian Radiation Protection and Nuclear Safety Agency, 2006) would not be exceeded at the boundary of the substation sites.	Detailed design

8.3 Resources and waste

Construction and operation of the project would generate waste streams which would require management and disposal in accordance with relevant state policies and guidelines. This chapter provides a description of each waste stream, expected quantities of waste materials where known, and applicable waste management strategies. Estimated requirements and potential sources of construction resources are also provided.

Table 8-23 sets out the Director-General's Requirements as they relate to resource management and waste minimisation and, where in the environmental impact statement these have been addressed.

Table 8-23 Director-General's Requirements – resource and waste

Director-General's Requirements	Where addressed
A Spoil Management Strategy detailing how spoil will be managed during construction, including likely volumes, likely nature and classification of excavated material, opportunities for recycling, potential disposal sites, stockpile management, and method of transportation.	Detailed description of spoil management during construction including likely volumes, nature classification, handling, reuse and disposal is provided in **Section 8.3.1**. Spoil routes are described in detail in **Section 7.1** (Traffic and transport).

8.3.1 Assessment of potential impacts

Construction resource consumption

Construction materials

Large quantities of materials would be required for the construction of the project. Wherever possible, construction materials would be sourced from within the Sydney region. However, due to the project's location within a suburban area, construction materials are unlikely to be available within the immediate area. As such, extraction and procurement of select materials such as concrete, steel, asphalt, polypropylene and copper is likely to be required from quarries, manufacturers and suppliers outside the project area.

Approximate required quantities and potential sources for each material are detailed in **Table 8-24.**

Table 8-24 Resource requirements

Material	Estimated quantity required
Plain shotcrete	41,000 cubic metres
Steel fibre reinforced shotcrete – concrete	221,000 cubic metres
Steel fibre reinforced shotcrete – steel	8,200 tonne
Polypropylene reinforced shotcrete – polypropylene	136 tonne
No-Fines – concrete	64,000 cubic metres
Base paving – concrete	66,4000 cubic metres
New jersey kerbs – concrete	26,000 cubic metres
Piles – concrete	59,000 cubic metres
Retaining walls – concrete	54,000 cubic metres
Bridges – concrete	1,300 cubic metres
Noise walls	1,400 cubic metres
Rock bolts	5,000 tonne
Reinforcing steel	5,280 tonne
Asphalt	25,000 tonne
Crushed aggregate	21,500 tonne
Conduit – PVC	810,000 metres
Copper cables	1,880 tonne
Concrete drainage pipes	18,000 metres

Construction resource requirements for the project are typical for a tunnelling project of this scale. Resource requirements may have an impact on resource availability within the local area over the construction period. The impact would be minor and limited to the construction period.

Water resources

Water would be required during construction activities, including for:

- Tunnelling activities such as cooling water and dust suppression.
- Surface works such as compaction of pavement materials and dust suppression.
- Concrete batching.
- Site offices and ablutions.

Higher quality water for some construction activities may be sourced from local drinking water supplies. Water from groundwater sources may also be used. The total volume of water required for construction of the project would be around 3,055 mega litres. Estimated volumes and potential supplies of water for each site, based on the construction program and the anticipated demand and supply sources at varying time throughout construction, are provided in **Table 8-25.**

Table 8-25 Water requirements

Source		Southern interchange compound (C5)	Wilson Road compound (C6)	Trelawney Street compound (C7)	Northern interchange compound (C9)	Road works	Total
Total potable water supply (mega litres)	Sydney Water mains	635	485	450	600	80	2,250
Total non-potable water supply (mega litres)	Collected rainwater	35	10	10	15	-	70
	Treated groundwater	190	160	150	235	-	735
Total		860	655	610	850	80	3,055

The volume of water required would be typical for tunnelling projects of this scale. It is anticipated that the local water supply network would have sufficient capacity to accommodate project water requirements.

Power

Power supply would be required during construction works, supplied to the majority of construction ancillary facilities. In particular, high voltage power would be required at the tunnel support sites. The power supply for each site would be sourced from outside the project corridor. **Table 8-26** summarises the power supply for temporary construction ancillary facilities including supply source, likely supply route and power demand. The construction power supply routes shown below are for information purposes only and do not form part of this assessment. Further assessment would be required in consultation with the relevant power supply authority.

Ancillary facilities which are not supporting tunnelling works, such as for the Hills M2 Motorway integration works, would not require access to high voltage power. These sites would be powered via diesel powered generators or a local connection to the mains infrastructure.

The location of power supply infrastructure is shown in **Figure 8-8** to **Figure 8-11**.

Table 8-26 Construction power supply

Construction site	Supply source substation	Distance to worksite (kilometres)	Supply route	Connected load (mega volt ampere)
Southern interchange compound (C5)	Pennant Hills Zone Substation	5	Victoria Road into Loftus Road then Pennant Hills Road to the southern interchange site	7
Wilson Road compound (C6)	Pennant Hills Zone Substation	0.5	Victoria Road into Loftus Road then to Killaloe Avenue and along Wilson Road to the site	5
Trelawney Street compound (C7)	Pennant Hills Zone Substation	4	Victoria Road across Loftus Road to Boundary Road then into Belamy Street. Up Stevens Street to Yarrara Road which becomes the Esplanade to Duffy Road. Along Duffy Road to Pennant Hills Road then to Loch Maree Avenue and into the site.	5
Northern interchange compound (C9)	Hornsby Zone Substation	4.5	Bridge Road to Sherbrook Road, Edgeworth David Avenue to the M1 Pacific Motorway corridor. Along the motorway corridor to the construction site	5

Note: These routes are indicative only and subject to change during detailed design and consultation with relevant power authorities.

Initial discussions with power supply authorities have confirmed that these substations have the required capacity to supply the site without impacting on the local supply network.

Figure 8-8 Location of power supply infrastructure for the southern interchange

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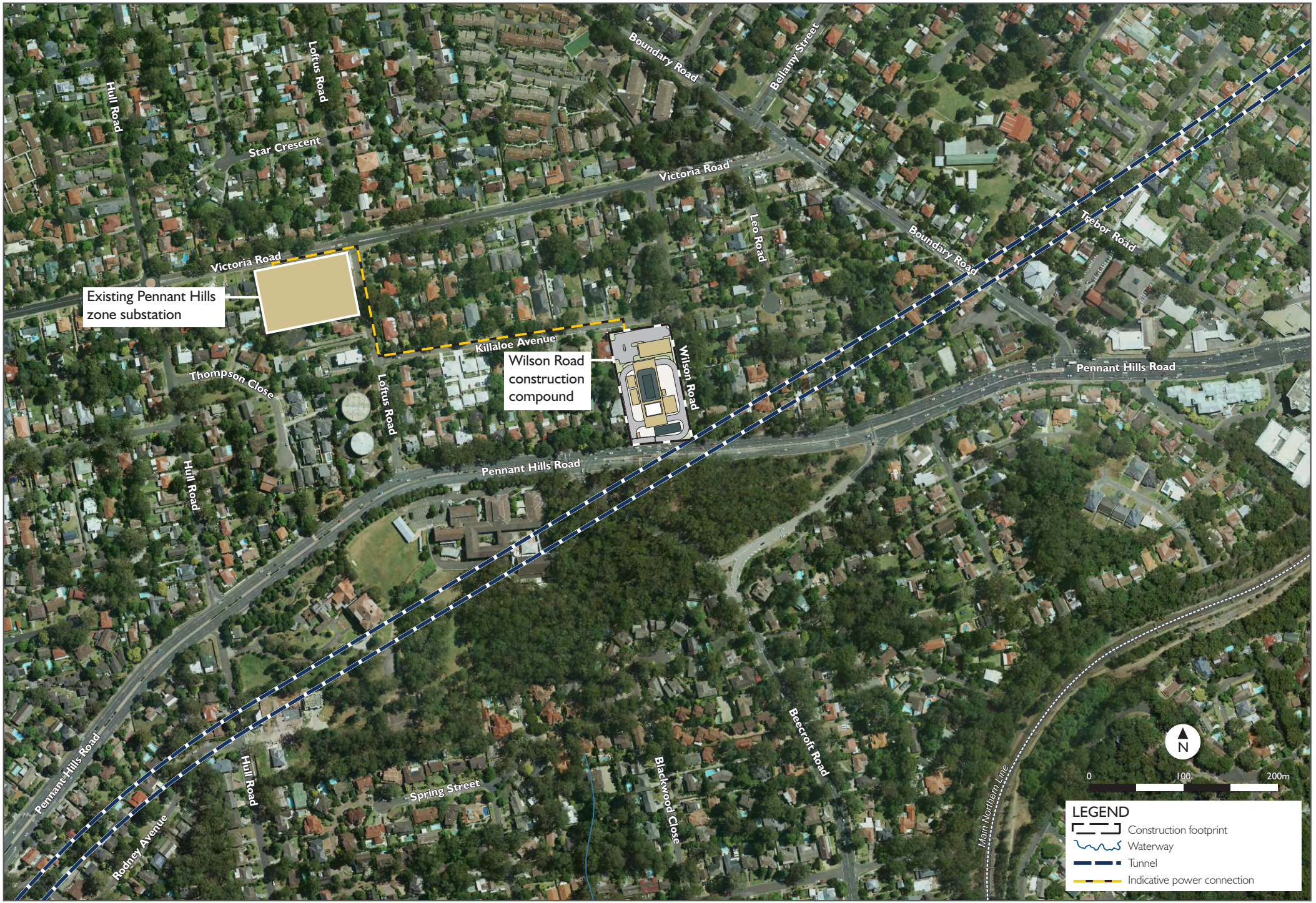

Figure 8-9 Location of power supply infrastructure for the Wilson Road compound

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Figure 8-10 Location of power supply infrastructure for the Trelawney Street compound

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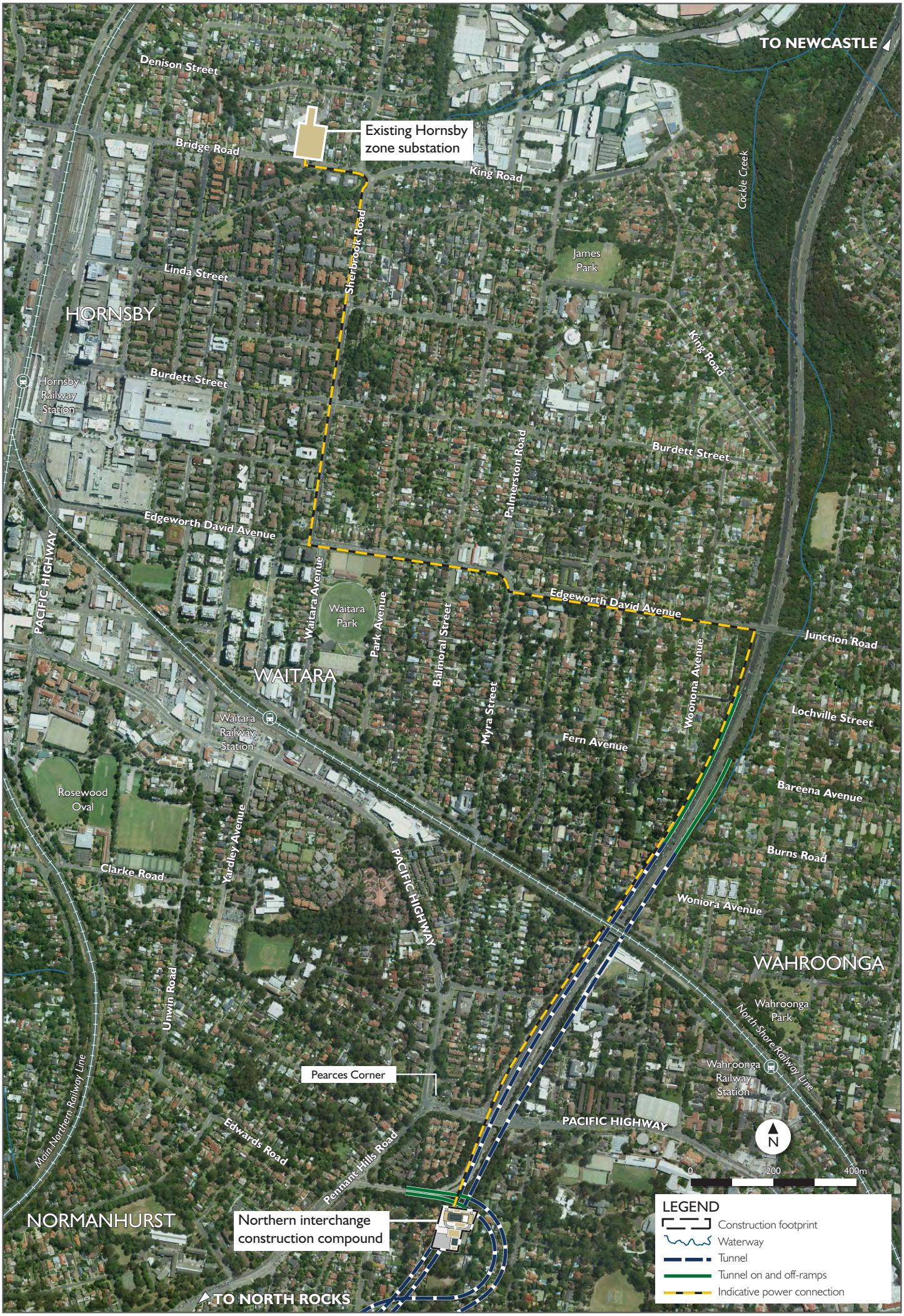

Figure 8-11 Location of power supply infrastructure for the northern interchange

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Construction waste management (non-spoil)

Solid wastes

Various waste streams would be generated during construction of the project, including construction and demolition waste, vegetation waste, packaging materials and liquid wastes. All wastes would be managed using the waste hierarchy approach of waste avoidance and waste re-use before consideration of waste disposal.

Should the generation of wastes be unavoidable or wastes unsuitable for re-use, disposal methods would be selected based on the classification of the waste material in accordance with the Waste Classification Guidelines (DECCW, 2009c). The Waste Classification Guidelines provide direction on the classification of waste, specifying requirements for management, transportation and disposal of each waste category. All wastes would be managed in accordance with the waste provisions contained within the *Protection of the Environment Operations Act 1997* and, where re-used off-site, would comply with relevant Environment Protection Authority resource recovery exemptions and requirements.

Wastes streams anticipated to be generated during construction of the project include:

- Excavated wastes, such as soil and rock, primarily from tunnelling and cutting including virgin excavated natural material.
- Wastewater from tunnel construction operations.
- Demolition wastes from existing structures that require removal (eg residential and commercial buildings):
  - Concrete, bricks, tiles, timber (untreated, treated), metals, plasterboard, carpets, electrical and plumbing fittings and furnishings (doors, windows).
- Hazardous waste (including asbestos).
- Vegetation waste from the removal of trees, shrubs and ground covers that are unable to be mulched and re-used within the project.
- General construction waste:
  - Timber formwork, scrap metal, steel, concrete, plasterboards and packaging material (crates, pallets, cartons, plastics and wrapping materials).
- Waste from operation and maintenance of construction vehicles and machinery (adhesives, lubricants, waste fuels and oils, engine coolant, batteries, hoses and tyres).
- General wastes from site offices (putrescibles, paper, cardboard, plastics, glass and printer cartridges).
- Wastewater from other sources including dust suppression and washdown and sewerage / greywater from construction compounds.

Potential adverse impacts arising from waste management associated with the project include:

- Excessive volumes of spoil directed to landfill due to inadequate recycling and re-use.
- Dust impacts due to incorrect storage, handling and disposal of spoil.

- Excessive volumes of waste directed to landfill due to excessive resource consumption and inadequate collection, classification and disposal of waste.
- Contamination of soil, surface and / or groundwater from the inappropriate storage, transport and disposal of liquid and solid waste.

Waste types and volumes generated during construction of the project would be typical of that produced on tunnel construction projects of this scale and would be appropriately managed through the implementation of standard management and mitigation measures (provided in **Table 8-31**). Existing metropolitan waste management facilities would have capacity to receive the waste streams generated by the project.

Demolition waste generated by the project has the potential to contain hazardous materials, in particular asbestos containing material. Management and disposal of asbestos containing material would be undertaken in accordance with:

- *Work Health and Safety Act 2011*.
- Code of Practice for the Safe Removal of Asbestos 2nd Edition (NOHSC, 2005a).
- Code of Practice for the Management and Control of Asbestos in Workplaces (NOHSC, 2005b).
- Protection of the Environment Operations (Waste) Regulation 2005 – clause 42 special requirements relating to asbestos waste.
- AS2601:2001 Demolition of Structures.

Removal of asbestos containing material would generally involve the following:

- Development of a site specific asbestos removal control plan.
- Establishing asbestos removal boundaries with appropriate security signage and barriers.
- Preparation of the work area.
- Use of the wet removal method where feasible and reasonable.
- Removal of asbestos containing material in sections and placement in suitably labelled and properly sealed asbestos waste containers.
- Decontamination of the workplace, tools and personal protective equipment.
- Disposal of asbestos waste at an appropriately licensed facility.

Waste management activities associated with the construction of the project are not considered to pose a significant risk to the environment with the implementation of standard measures (provided in **Table 8-31**) which would adequately address waste generation, storage, disposal and re-use.

Resource consumption and waste generated by the project would contribute to the emission of greenhouse gases during construction. The consideration of this impact and emission reduction opportunities are discussed further in **Section 8.4** (Greenhouse gas and climate change).

Wastewater

During construction, tunnelling works would result in significant volumes of wastewater requiring treatment and disposal. Water treatment methods and discharge water quality are described in **Section 7.9** (Surface water).

Water volumes generated during the construction phase of the project would vary based on construction activities that are taking place in the tunnel, the amount of groundwater infiltrating into the tunnel and the length of tunnel that has been excavated. The rate of groundwater infiltration is predicted to be around 1.7 litres per second per kilometre. Anticipated water discharge volumes at the relevant temporary construction ancillary facilities are summarised in **Table 8-27**. These volumes represent the total wastewater generation over the duration of the construction period (around four years).

Table 8-27 Indicative wastewater volume

Site	Wastewater volume (mega litres)
Southern interchange compound (C5)	575
Wilson Road compound (C6)	485
Trelawney Street compound (C7)	455
Northern interchange compound (C9)	705

Feasible and reasonable opportunities for wastewater re-use on-site or for construction purposes (such as dust suppression both in the tunnels and for surface works) or off-site (such as irrigation of Pennant Hills Golf Club or local parks) would be pursued. However, the generation of wastewater from tunnel construction would be significantly greater than the potential for re-use and, therefore, off-site discharge would be required.

Wastewater not used on-site would be discharged into the local stormwater system in accordance with the requirements of the local council and the Environment Protection Authority.

Construction waste management (spoil)

General spoil management

This section outlines the general approach to clean spoil management. The management of contaminated soil and details of a Spoil Management Strategy are provided in the following sections.

It is estimated that the project would generate about 2.6 million cubic metres of surplus spoil. The majority of spoil would be generated from excavation of the tunnels. As such, the primary facilities for receipt and dispatch of spoil would be the four tunnel support sites. Relatively smaller quantities of spoil would be generated by site preparation activities, excavation of dive structures, excavation of ventilation shafts, and cut and fill activities for the above ground components of the project. The indicative volume of spoil to be extracted and managed through each of the construction ancillary facilities is summarised in **Table 8-28.**

Table 8-28 Indicative spoil generation

Site	Spoil volume (cubic metres)
Hills M2 Motorway integration works	39,800
Southern interchange compound (C5)	613,900
Wilson Road compound (C6)	441,950
Trelawney Street compound (C7)	492,200
Northern interchange compound (C9)	743,150
Northern portals	281,200
TOTAL	2,612,200

Based on the depth of the tunnel and the local geology, the majority of excavated spoil material would be uncontaminated crushed sandstone and shale, classified as virgin excavated natural material. This would generally consist of mixed size crushed rock, ranging from shale and sand to lumps of rock.

The design of the project has taken into consideration the waste hierarchy by aiming to reduce the volume of excess spoil generated, as far as practical. Where possible and fit for purpose, spoil would be beneficially re-used as part of the project before alternative spoil disposal options such as other infrastructure projects or use as fill for disused quarries are pursued. These objectives would be further considered during the detailed design phase.

It is acknowledged, however, that the project has limited on-site requirements for fill and construction space for the long-term storage of spoil is constrained. As a result of the limited opportunities for on-site re-use of spoil, the majority of spoil generated would require disposal elsewhere. The following sites have been identified as having the capacity for spoil disposal:

- ADI site, St Marys – capacity of between two and 2.5 million cubic metres.
- Gosford Quarry – capacity of around 2.5 million cubic metres.
- Hornsby Quarry site – capacity of around 3.3 million cubic metres.
- CSR Quarry – capacity of around 1.16 million cubic metres.
- Defence precinct Schofields – capacity of around 500,000 cubic metres.
- Great Southern Rock (GSR) Quarry (Sandy Point Quarry) – currently an active quarry, the subject of a development application to extend and intensify quarrying activities. Anticipated capacity of around five million cubic metres.

These sites have a need for spoil or fill material and represent viable disposal / reuse locations. Other disposal/re-use sites may be used depending on need at the time spoil is generated.

Prior to leaving the construction site, excavated spoil would be classified in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c) to ensure it is appropriately reused within an approved development or disposed of at an appropriately licensed facility. In the case of spoil generated from the excavation of tunnels, spoil testing would cease following initial testing to verify that the excavated material is VENM. Spoil generated during surface excavations would be subject to ongoing sampling and classification in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c).

Spoil from tunnelling works would be transported from the tunnel face to the surface using dump trucks. At the surface, spoil would be stockpiled and handled within acoustic sheds with space for around one day's spoil production capacity. Spoil would then be loaded into haulage trucks within the acoustic shed and transported from the construction compounds by spoil trucks, along pre-determined haulage routes. The identification of these haulage routes, potential impacts arising from their use and appropriate management measures are described in **Section 7.1** (Traffic and transport).

Contaminated soil

A contamination due diligence assessment has been undertaken as part of this environmental impact statement (further details are provided in **Section 7.8** Hydrogeology and soils). This assessment identified the potential presence of contaminated material at the Pioneer Avenue compound (C8) associated with the former use of the site and the presence of fill of unknown origin.

There is also the potential to discover further contaminated soil during construction of the project either during surface works or from tunnelling activities.

In the event of discovery of previously unidentified area(s) of contaminated material, all relevant work would cease in the vicinity of the discovery. Relevant works would not recommence until the need for and scope of remedial action(s), if required, are identified in accordance with the requirements of the *Contaminated Land Management Act 1997*.

Spoil, including contaminated spoil, would be classified in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c). Depending on the extent of contamination, spoil would be considered for reuse either on the project site or at other approved development in line with resource recovery exemptions. Where reuse is not possible, spoil would be disposed of at an appropriately licensed facility.

Spoil management strategy

A formal Spoil Management Strategy would be developed and documented for the project prior to the commencement of soil disturbing works. The Strategy would take into account the progression of the detailed design of the project and specific conditions of approval that may be applied to the project. The broad parameters within which the Strategy would be developed are summarised in **Table 8-29.**

Table 8-29 Spoil Management Strategy broad parameters

Parameter	Strategy response
Spoil generation	2.6 million cubic metres (surplus spoil)
Spoil generation locations	Spoil would be generated at the following temporary construction sites: • Hills M2 Motorway integration works (39,800 cubic metres). • Southern interchange compound (C5) (613,900 cubic metres). • Wilson Road compound (C6) (441,930 cubic metres). • Trelawney Street compound (C7) (492,200 cubic metres). • Northern interchange compound (C9) (743,170 cubic metres). • Northern portals (281,000 cubic metres).
Spoil management hierarchy	Where feasible and reasonable, spoil would be managed according to the following hierarchy: • Avoidance of spoil generation through design and management. • Reuse of spoil within the project. • Beneficial reuse of spoil outside the project for site levelling, development or rehabilitation. • Disposal of spoil outside the project for a non-beneficial uses (landfilling).
On-site management	Spoil would be transported from the tunnel face to the surface by truck, where it would be stored in an acoustic shed at each temporary construction site with capacity to store up to one day's spoil generation from the site. Spoil would be loaded onto trucks within the acoustic shed prior to transport off-site.
Spoil testing	Spoil would be sampled, analysed and characterised according to the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c). In the case of spoil generated from the excavation of tunnels, spoil testing would be limited to initial testing to confirm that the excavated material is virgin excavated natural material.
Spoil quality	The majority of spoil that would be generated by the project is expected to meet the classification of virgin extracted natural material. There is some potential, particularly for spoil generated at the surface around current and historical development, that spoil may be classified as solid waste. More heavily contaminated materials are not expected to be encountered.
Spoil disposal locations	Excess spoil would be disposed of at a location that has appropriate approval or licences to accept the material. Alternative sites from those listed in this chapter may also be considered for spoil reuse / disposal subject to necessary environmental planning approvals being in place for those sites and the specific needs of the project. Solid waste and more highly contaminated materials would only be reused on-sites permitted to accept the materials, or otherwise directed to an appropriately licensed waste management facility.
Spoil transport	Spoil would be transported by truck. Spoil transport to the disposal site would be via Pennant Hills Road, the Hills M2 Motorway and the M1 Pacific Motorway. Transport beyond the Hills M2 Motorway and the M1 Pacific Motorway would be subject to the assessment and approval of those other sites to receive spoil materials.

Operation resource consumption

Water resources

The deluge system, which would form part of the fire and life safety system, would require a supply of water. The primary source of water for the system would be two fire water tanks located at the northern end of the project. Each tank would have capacity of 1,220 cubic metres and would have an infill line from the Sydney Water town mains network. The tanks would be designed to act as a buffer to ensure peak flow demands do not adversely impact the town mains network.

During operation water would also be required for landscaping irrigation at the interchanges and tunnel support facilities.

Power

An operational electricity supply would be required to supply power to the main alignment tunnels and associated mechanical and electrical equipment. It is essential that electrical power to the tunnels be provided as an uninterrupted supply for ventilation and other safety reasons. As such, two sources of supply would be required; each rated to supply the full load of the tunnel electrical systems. The power supply would be provided through two 66 kilovolt feeders supplied via a new switching station that would be located on the south-west side of the Pennant Hills Road / Hills M2 Motorway interchange (the Coral Tree Drive switching station which is further discussed in **Chapter 5**). The feeders would connect to a project supply substation on the other side of the motorway where the power supply would be stepped down to 22 kilovolt. From the project supply substation, power would be reticulated to another six substations along the project. Of the total seven project substations, three would be located underground and four would be located aboveground (incorporated into other operational ancillary facilities).

Initial discussions with power supply authorities indicate that these substations have sufficient capacity to supply the project without negative impacts on the local power supply.

The project has been designed to minimise energy consumption and maximise energy efficiency. Measures to increase energy efficiency are detailed in **Section 8.4** (Greenhouse gas and climate change). The anticipated energy consumption per kilometre of tunnel per annum, compared to other tunnels in Sydney is provided in **Table 8-30**.

Table 8-30 Tunnel energy consumption

Tunnel	Megawatt hour per kilometre per annum
NorthConnex	1,167
Eastern Distributor	1,375
M5 East Tunnel	6,750
Lane Cove Tunnel	2,139

Note: Eastern Distributor operates with managed portal emissions

Peak oil

Roads and Maritime are taking the view that it is prudent to consider that oil production may peak and then decline. This could increase the cost and reduce the availability of transport fuels and construction materials derived from oil. For transport, the solutions to the problem of "peak oil" are similar to those for climate change. Alternatives to fossil fuels need to be found and transport must become more energy efficient. There are moves to establish alternatives to oil as a fuel for transport and to improve energy efficiency. This would enable the economic benefits provided by road transport to continue to be delivered with a reduced need for fossil fuels. Similar action is being taken, through recycling and investigation of alternative materials, to reduce the need for construction products derived from fossil fuels.

Roads and Maritime is also participating with Austroads and industry in research and trials with the goal of developing more sustainable road construction materials and practices and reducing reliance on products derived from oil. As road transport is a significant and necessary element of the NSW economy, that also provides many social benefits, Roads and Maritime will continue to ensure that all potential impacts on this system, such as peak oil, are identified and action is taken to manage these risks.

With reference to the project, traffic modelling across the Sydney network indicated that the proposed project would result in increased travel speeds and shorter distance of the tunnel compared to the surface roads. This would result in an overall reduction in the quantity of fuel consumed by private and freight vehicles and a subsequent reduction in the quantity of emissions produced. As noted in **Section 8.4** (Greenhouse gas and climate change), it is estimated that by 2027, savings in operational road use emissions would be greater than the estimated emissions generated during construction of the project. Furthermore, it is estimated that operational emission savings from road use of around 68,600 Mt CO_2-e would be achieved by 2029 when compared against the 'do nothing' scenario.

Operation waste management

Solid waste

Additional wastes would be generated during routine maintenance and repair activities required over time which may include mercury containing light globes used for the operation of the tunnel and ancillary facilities. Waste would also be generated from the operation of the motorway control centre. The type and volume of wastes generated would be dependent on the nature of the activity, but would predominantly consist of minor volumes of general office waste (paper, plastics, food waste), green waste, oil, road materials, as well as contaminated waste resulting from potential fuel spills and leaks. The volume and types of wastes would be typical of these types of facilities and could be accommodated by existing metropolitan waste management facilities.

With the implementation of standard work practices during routine maintenance and repair activities the overall impact of operational waste streams would be minimal.

Wastewater

As the main alignment tunnels would be drained, there would be an ongoing inflow of groundwater into the tunnels albeit relatively little. This would require the project to accommodate operational capture, removal, treatment and discharge of groundwater. The anticipated inflow of groundwater into the main alignment tunnels and on and off-ramp tunnels during the operational phase is anticipated to be around:

- 0.39 to 1.66 litres per second per kilometre for the first tunnel.
- 0.195 to 0.83 litres per second per kilometre for the second tunnel as the first tunnel would partially dewater the rock stratum.

This equates to a total of around 170 to 700 mega litres per year in total for two nine kilometres tunnels. However, there may be peak localised inflows in the order of three to five litres per second. The wastewater generation volumes are typical of existing tunnel projects of this scale within the Sydney region.

Captured groundwater would be treated at the water treatment plant located near the southern interchange. The operational water treatment plant would have a capacity to treat and dispose of up to 40 litres per second. Opportunities for reuse including irrigation of landscapes within the project, irrigation of Pennant Hills Golf Club and / or local parks would be considered in preference to discharge to the local stormwater system. The project has been designed to achieve a maximum water discharge quality equivalent to the 95 per cent protection level specified for freshwater eco-systems in accordance with ANZECC guidelines (ANZECC & ARMCANZ, 2000). The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during the detailed design phase.

Further information on groundwater inflow, drainage and treatment is provided in **Section 7.8** (Hydrogeology and soils) and **Section 7.9** (Surface water)**.**

8.3.2 Environmental management measures

Resource use and waste management impacts are commonly encountered on all road projects and can be managed and mitigated through the development of construction management plans and implementation of standard approaches.

The project would generate a significant volume of spoil from the tunnelling works. Various options are available with the capacity to receive this material. A Spoil Management Strategy would be developed to ensure this material is appropriately handled on the sites and disposed of including consideration of re-used and recycling options.

Measures to avoid, minimise or manage resource consumption and waste streams generated as a result of the project are detailed in **Table 8-31.**

Table 8-31 Environmental management measures – resources and waste

Impact	No.	Environmental management measure	Timing
Construction			
Resource consumption	RW1	Wherever feasible and reasonable, construction material would be sourced from within the Sydney region.	Pre-construction and construction

Impact	No.	Environmental management measure	Timing
	RW2	Unnecessary resource consumption would be avoided by making realistic predictions on the required quantities of resources, such as construction materials.	Construction
	RW3	Resource recovery, which includes re-use, recycling and reprocessing, would be applied to the management of construction waste and would include: • Recovery of resources for reuse. Waste materials generated by the project would be re-used either on-site or off-site where possible, including the re-use of top soil in landscape works, and the use of mulch for erosion and sediment controls. • Recovery of resources for recycling. Resources would be segregated for recycling such as paper, plastic, glass, aluminium cans and other recyclable materials generated during construction. These materials would then be sent to an appropriate recycling facility for processing. • Recovery of resources for reprocessing. Cleared vegetation would be mulched or chipped on-site and used for landscaping, in the absence of a higher beneficial use being identified.	Construction
Management of waste	RW4	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies including the *Protection of the Environment Operations Act 1997, Waste Avoidance and Resource Recovery Act 2001,* Waste Avoidance and Resource Recovery Strategy 2007 (DECC, 2007c) and the Waste Reduction and Purchasing Policy (RTA, 2009).	Pre-construction and construction
	RW5	A Waste Management Plan would be prepared as part of the Construction Environmental Management Plan detailing appropriate procedures for waste management.	Pre-construction and construction
	RW6	Wastes would be managed using the waste hierarchy principles of: • Avoidance of unnecessary resource consumption to reduce the quantity of waste being generated • Recover of resources for re-use on-site or off-site for the same or similar use, without reprocessing. • Recover of resources through recycling and reprocessing so that waste can be processed into a similar non-waste product and re-used. • Disposal of residual waste.	Construction

Impact	No.	Environmental management measure	Timing
	RW7	• Residual waste would be disposed of to a suitably licensed landfill or waste management facility where there are no other feasible and reasonable options for waste avoidance, re-use or recycling. Waste materials requiring removal from the site would be classified, handled and stored on-site in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c) until collection by a contractor for disposal.	Prior to / during construction
	RW8	Off-site re-use of waste would comply with relevant EPA resource recovery exemptions and requirements.	Construction
	RW9	An asbestos survey would be undertaken of buildings to be demolished as part of the project. The survey would be conducted by a suitably qualified person.	Construction
	RW10	Asbestos handling and management would be undertaken in accordance with: • Work Health and Safety Act 2011. • Code of Practice for the Safe Removal of Asbestos 2nd Edition (NOHSC, 2005a). • Code of Practice for the Management and Control of Asbestos in Workplaces (NOHSC, 2005b). • Protection of the Environment Operations (Waste) Regulation 2005 – section 42 special requirements relating to asbestos waste. • AS2601:1991 Demolition of Structures.	Construction
Excess spoil	RW11	A spoil management strategy would be developed prior to the commencement of construction and implemented during construction. The strategy would identify spoil disposal site and describe the management of spoil on -site and during off-site transport.	Pre-construction
	RW12	Where possible and fit for purpose, spoil would be beneficially re-used within the project before off-site re-use or disposal options are pursued.	Construction
	RW13	Before being transported from construction sites, excavated spoil would be classified in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c) to ensure appropriate reuse or disposal.	Construction
Wastewater	RW14	Feasible and reasonable opportunities for wastewater re-use on-site or for construction purposes would be pursued (such as dust suppression both in the tunnels and for surface works).	Construction

Impact	No.	Environmental management measure	Timing
	RW15	Wastewater not used on-site would be discharged into the local stormwater system in accordance with the requirements of an environment protection licence issued for the project.	Construction
Contaminated soil	RW16	In the event of discovery of previously unidentified area(s) of potentially contaminated material, all relevant work would cease in the vicinity of the discovery. Relevant works would not recommence until the need for and scope of remedial action(s), if required, are identified in accordance with the requirements of the *Contaminated Land Management Act 1997*.	Construction
Operation			
Management of waste	OpRW1	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies including the *Protection of the Environment Operations Act 1997, Waste Avoidance and Resource Recovery Act 2001,* Waste Avoidance and Resource Recovery Strategy 2007 (DECC, 2007c) and the Waste Reduction and Purchasing Policy (RTA, 2009).	Operation
	OpRW2	Any mercury containing light globes used for the operation of the tunnel and operational ancillary facilities would be recycled at an accredited recycling facility.	Operation
Operational water requirements	OpRW3	Opportunities for re-use of wastewater would be considered including irrigation of landscapes within the project, irrigation of Pennant Hills Golf Club and / or local parks in preference to discharge to the local stormwater system.	Operation
	OpRW4	In order to reduce demand on local water supplies, investigate options for providing water required for operation of the deluge system from wastewater produced through the tunnel drainage system where it meets appropriate quality parameters.	Operation

8.4 Greenhouse gas and climate change

This section outlines the legislative and policy framework for the control of greenhouse gas (GHG) emissions and climate change. It provides an assessment of the contributions of the project to climate change, due to the release of GHG emissions during the construction and operation stages and provides recommended mitigation measures to reduce GHG emissions.

This section also identifies the current climate change projections for the Sydney region and NSW more broadly, and examines the potential impact of these on the project. Where possible, this section identifies appropriate risk management and mitigation measures that would be provided as part of the project design to build the resilience of project infrastructure to changing climate conditions.

8.4.1 Existing environment

GHGs, such as carbon dioxide, are emitted into the Earth's atmosphere as a result of natural processes (eg forest fires) and human activities (eg burning of fossil fuels to generate electricity). GHGs absorb and re-radiate heat from the sun, trapping heat in the atmosphere which then influences global temperatures.

Since the industrial revolution there has been an increase in the amount of GHGs emitted from human activities, which has increased the global concentration of GHGs in the atmosphere.

The most recently published Australian National Greenhouse Accounts estimate Australian GHG emissions for 2011 to be 563.1 Mt CO_2-e as reported under the Kyoto Protocol (DIICCSRTE, 2013b). For the year 2010 to 2011, the annual NSW State GHG emissions totalled 159 Mt CO_2-e (DIICCSRTE, 2013c). The transport sector contributes approximately 14 per cent of Australia's total GHG emissions, with approximately 90 per cent of these emissions attributed to the combustion of fuel for road transport (Maddocks et al, 2010). Reducing the contribution of emissions from road transport would therefore have a significant impact on emissions reduction for the transport sector, and Australia's overall emissions profile.

An increase in the global concentration of GHGs has led to an increase in the Earth's average temperature (surface temperature) and has contributed to the phenomenon of 'climate change'. The State of the Climate 2012 (CSIRO and the Australian Bureau of Meteorology (BOM), 2012) confirms the long term warming trend over Australia's land and oceans, showing that in Australia, each decade has been warmer than the previous since the 1950s. Other observed trends include an increase in record hot days, a decrease in record cold days, ocean warming, sea-level rise and increases in global GHG concentrations. Due to long lag times associated with climate processes, even if GHG emissions are mitigated and significantly reduced, the warming trend is expected to continue for centuries (Intergovernmental Panel on Climate Change (IPCC), 2007).

The IPCC Fifth Assessment Report (IPCC, 2013) states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Certain current and predicted climate events and trends pose a risk to road infrastructure, by way of physical damage, accelerated deterioration of assets and reduced network capacity and road safety (Maddocks et al, 2010). As a result, it is important to understand the most likely and 'worst case' implications of climate change on high-value infrastructure, such as the project.

The two key responses to climate change are:

- Climate change mitigation: Reducing the amount of GHG emissions emitted into the atmosphere.
- Climate change adaptation: Adapting or reducing vulnerability to the physical impacts of climate change.

The following sections are structured in two parts:

- An assessment of GHG emissions estimated to be generated by the project (climate change mitigation).
- A climate change risk assessment for the operation and maintenance of project infrastructure (climate change adaptation).

8.4.2 Policy and planning setting

Increasing public concern and debate regarding the likelihood and magnitude of climate change impacts in Australia has resulted in a number of national and state policy commitments, addressing both GHG mitigation and climate change adaptation. These are outlined in the following sections.

GHG assessment

GHG emission requirements and considerations are included in a growing number of legislative and policy mechanisms in Australia (State and Federal) and internationally.

The Kyoto Protocol to the United Nation Framework Convention on Climate Change (the Kyoto Protocol) (UNFCCC, 1998) was signed in 1997 and Australia ratified the protocol in December 2007. The Kyoto Protocol's objective is to reduce GHG emissions through setting reduction targets for GHG emissions produced by ratifying countries. These targets are set using the ratifying countries' 1990 baseline emissions. Australia has committed to a target of 108 per cent of 1990 emission levels by the end of 2012. In December 2012, Australia signed the Doha Amendment (UNFCCC, 2012) to the Kyoto Protocol, agreeing to a second commitment period, from 1 January 2013 until 2020.

The Australian Government's climate change policies and regulations are managed by the Department of the Environment, and include:

- *The Energy Efficiency Opportunities Act 2006* (EEO Act).
- *The National Greenhouse and Energy Reporting Act 2007* (NGER Act).

The Australian Government has committed to a target of reducing carbon pollution by five per cent below 2000 emission levels by 2020 irrespective of what other countries do. The Government will review this position in 2015 at the Climate Summit in Paris as part of international negotiations regarding emissions reduction commitments prior to and post-2020.

The Australian Government's Direct Action Plan sets out how this five per cent reduction target will be achieved. The Emissions Reduction Fund Green Paper (Department of the Environment, 2013a), as part of the Direct Action Plan, aims to reduce Australia's GHG emissions by creating positive incentives to adopt better technologies and practices to reduce emissions.

In August 2013, the NSW State Government released the NSW Energy Efficiency Action Plan (Office of Environment and Heritage (OEH), 2013b), which provides a strategic management approach to improving energy efficiency, with a target for annual energy savings of 16,000 gigawatt-hours by 2020.

Climate change risk assessment

NSW 2021 – A Plan to Make NSW Number One (NSW Department of Premier and Cabinet, 2011) includes targets to minimise the impacts of climate change by ensuring that 'NSW is ready to deal with major emergencies and natural disasters' (Goal 28). In addition, the NSW Long Term Transport Master Plan (Transport for NSW, 2012a) promotes the need to ensure that transport infrastructure is 'able to withstand the predicted impacts of a changing climate'.

8.4.3 Assessment methodology

GHG assessment methodology

The methodology that has been used to develop the GHG inventory for the project has been based on relevant GHG reporting legislation and international reporting guidelines, including:

- The Greenhouse Gas Protocol A Corporate Accounting and Reporting Standard (World Council for Sustainable Business Development and World Resources Institute, 2005).
- *The National Greenhouse and Energy Reporting Act 2007*.
- Australian Standard AS ISO 14064.1:2006 Greenhouse Gas Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals (Standards Australia, 2006).
- Australian National Greenhouse Accounts: National Greenhouse Accounts Factors (NGA Factors) (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE), 2013a).
- Greenhouse Gas Assessment Workbook for Road Projects (the TAGG Workbook) (Transport Authorities Greenhouse Group (TAGG), 2013).

To calculate the GHG emissions associated with the construction, operation and maintenance of the project, the following steps were undertaken:

- Identify the assessment boundary and the sources of GHG emissions associated with the project (construction, operation and maintenance).
- Determine the quantity of each emissions source (fuel consumed, electricity, construction materials etc.) in line with the TAGG Workbook.
- Quantify the GHG emissions associated with each GHG source using equations specified in the NGA Factors (DIICCSRTE, 2013a).
- Present the GHG emissions associated with the project.
- Identify opportunities (mitigation measures) which may be implemented to reduce the GHG emissions associated with the project.

The TAGG Workbook provides a consistent methodology for estimating the GHG emissions for major activities that may contribute significantly to the overall emissions associated with a road project. The steps involved in undertaking a GHG assessment in accordance with the TAGG Workbook have been adopted for this assessment.

Appendix N provides a more detailed description of the GHG assessment methodology, including the calculation methods used to estimate the GHG emissions from liquid fuel combustion, electricity use, vegetation clearing, materials use and traffic use of the road post construction.

GHG emissions are reported in this assessment as tonnes of carbon dioxide equivalent (tCO_2-e).

GHG assessment boundary

The assessment boundary defines the scope of GHG emissions and the activities to be included in the GHG assessment. The TAGG Workbook considers the GHG assessment boundary of a road project to include all emissions sources that can be impacted by decisions made by designers, constructors, managers and/or operators of the road.

Emissions sources are categorised into three different scopes to delineate between 'direct emissions' from sources that are owned or controlled by the project and 'indirect emissions' that are a consequence of project activities but occur at sources owned or controlled by another entity. The three scopes are:

- **Scope 1** – direct emissions: GHG emissions generated by sources owned or controlled by the project, eg emissions generated by the use of diesel fuel by project-owned construction plant, equipment or vehicles.
- **Scope 2** – indirect emissions: GHG emissions from the generation of purchased electricity in project-owned or controlled equipment or operations. These GHG emissions are generated outside of the project's boundaries, eg the use of purchased electricity from the grid.
- **Scope 3** – indirect upstream emissions: GHG emissions generated in the wider economy due to third party supply chains as a consequence of activity within the boundary of the project, eg GHG emissions associated with the offsite mining, production and transport of materials used in construction or maintenance of the road.

GHG emissions associated with the project are assessed in terms of Scope 1, Scope 2 and Scope 3 emissions.

Climate change risk assessment methodology

The climate change risk assessment provided in this report has been undertaken in line with the following relevant standards and current guidelines:

- The risk assessment approach set out in AS/NZS ISO 31000:2009 Risk management – Principles and guidelines and ISO/IEC 31010 Risk management – Risk assessment techniques. Both build upon AS/NZ 4360:2004 Risk management and its application to climate change risks.
- The climate change projections used in this assessment have been derived and collated in accordance with AS 5334:2013 Climate change adaptation for settlements and infrastructure.
- The climate change impacts have been integrated into risk management in line with the methods recommended in Climate Change Impacts and Risk Management: A Guide for Business and Government (DEH, 2006) and Climate Change in Australia: Technical Report, Chapter 6: Application of Climate Projections in Impact and Risk Assessments (CSIRO and BOM, 2007).

The following key steps were undertaken to complete the climate change risk assessment (DEH, 2006 and AS 5334:2013):

- Identification of key climate variables (such as temperature, rainfall, extreme events) and the climate variability that differentiates regional climate zones.
- Identification of potential climate change scenarios, based on the latest climate science, that broadly identify how each climate variable may change over the design life of the project.
- Identification of climate-based risks that may impact on the project, as a result of climate change.
- Assessment of potential impacts of priority climate change risks based on the consequence and likelihood of each risk.
- Recommendation of broad actions to mitigate climate risks.

An assessment of the risk of climate change requires an understanding of the current climate using historical data for comparison with future climate scenarios. In order to assess the risk to the project posed by climate change, the current climate science and model projections have been investigated for the following parameters.

Time slices

Given the expected design life of road infrastructure, the proposed construction timeframe for the project and the available climate data, the time periods which were selected for assessment are 2030 and 2070. Climate change projections for 2030 were identified as appropriate for assessment of short term impacts of climate change on the project (around 10 years after opening to traffic). Although the project life is anticipated to be 100 years, much of the available climate change modelling only projects impacts up to the year 2070. Climate change projections for 2070 are relevant to the longer term operation and maintenance stages of the project.

Projections for 2050 have been used to inform the climate risk assessment, where data for 2030 or 2070 was not available.

Emissions scenarios

GHG emission scenarios estimate the quantity of GHG that may be released into the atmosphere in the future. The GHG emission scenarios used in this climate change risk assessment are A1B (moderate emissions) and A1FI (high emissions) as set out by the IPCC (2000). According to the Garnaut Climate Change Review (Maunsell, 2008), the A1B scenario provides the best estimate of annual warming over Australia relative to the climate of 1990. Projections for 2030 are therefore reported for the moderate A1B climate scenario. Scenario projections developed as part of the Garnaut Climate Change Review indicate potential emission paths greater than the A1FI high emissions scenario, suggesting that the increase of GHG emissions since 2000 was greater than that projected in the most fossil-fuel intensive A1FI emissions scenario. On this basis and adopting the precautionary principle, projections for 2070 are reported for the higher A1FI climate science scenario.

8.4.4 Assessment of potential impacts

GHG assessment

The GHG emission source data used to estimate the GHG emissions associated with construction, operation and maintenance of the project is provided in **Appendix N**. Assumptions have been made, where necessary, to provide a quantitative estimate of emissions.

Activities that would generate GHG emissions during construction of the project include:

- The combustion of diesel fuel for earthworks and construction activities using construction plant and equipment onsite.
- The combustion of diesel fuel for use in project vehicles.
- The combustion of diesel fuel for the transport of construction materials to site, and the transport of spoil from site.
- Electricity consumption to power construction plant, such as road headers, and project site offices.
- Clearance of vegetation.
- The embodied energy of construction materials, associated with the offsite mining and production of materials to be used in construction of the project.

Construction GHG emissions

It is estimated that the construction of the project would generate approximately 535,500 t CO_2-e. The breakdown of emissions by scope is provided in **Figure 8-12** and summarised as:

- 230,300 t CO_2-e direct Scope 1 GHG emissions.
- 69,800 t CO_2-e indirect Scope 2 GHG emissions.
- 235,400 t CO_2-e indirect Scope 3 GHG emissions.

The GHG emissions results from key emissions sources associated with construction are shown in **Table 8-32** and **Figure 8-12**. Detailed GHG assessment results are provided in **Appendix N**.

Table 8-32 Construction GHG emissions results

Emissions source		Scope 1	Scope 2	Scope 3	Total	% of total emissions
Fuel use (diesel) – mobile plant and equipment		95,638	-	7,261	102,899	19.22%
Fuel use (diesel) – transport of materials and waste to / from site		103,863	-	7,885	111,748	20.87%
Fuel use (petrol) – project light vehicles		14,777	-	1,170	15,947	2.98%
Vegetation clearance		16,048	-	-	16,048	3.00%
Electricity consumption		-	69,782	15,240	85,022	15.88%
Construction materials	Concrete	-	-	168,012	168,012	31.38%
	Cement	-	-	451	451	0.08%
	Steel	-	-	19,304	19,304	3.60%
	Aggregate	-	-	191	191	0.04%
	Asphalt	-	-	1,450	1,450	0.27%
	Copper	-	-	9,656	9,656	1.80%
	Plastic	-	-	1,655	1,655	0.30%
	Water	-	-	3,055	3,055	0.58%
Total		230,326	69,782	235,380	535,488	100%
% total		43%	13%	44%	100%	

The results demonstrate that the majority of GHG emissions, associated with the construction of the project, are attributed to indirect Scope 3 emissions (44 per cent), closely followed by direct Scope 1 emissions (43 per cent).

The embodied energy associated with the indirect offsite mining and production of materials which would be used for the construction of the project contributes the largest proportion of indirect Scope 3 emissions, accounting for 87 per cent of Scope 3 emissions (**Figure 8-13**). Concrete and, to a lesser extent, steel would contribute significantly to the emissions associated with construction materials. The high proportions of emissions associated with these materials are attributed not only to the quantity required for the construction of the project, but also the emissions-intensive processes involved in the extraction and production of these materials.

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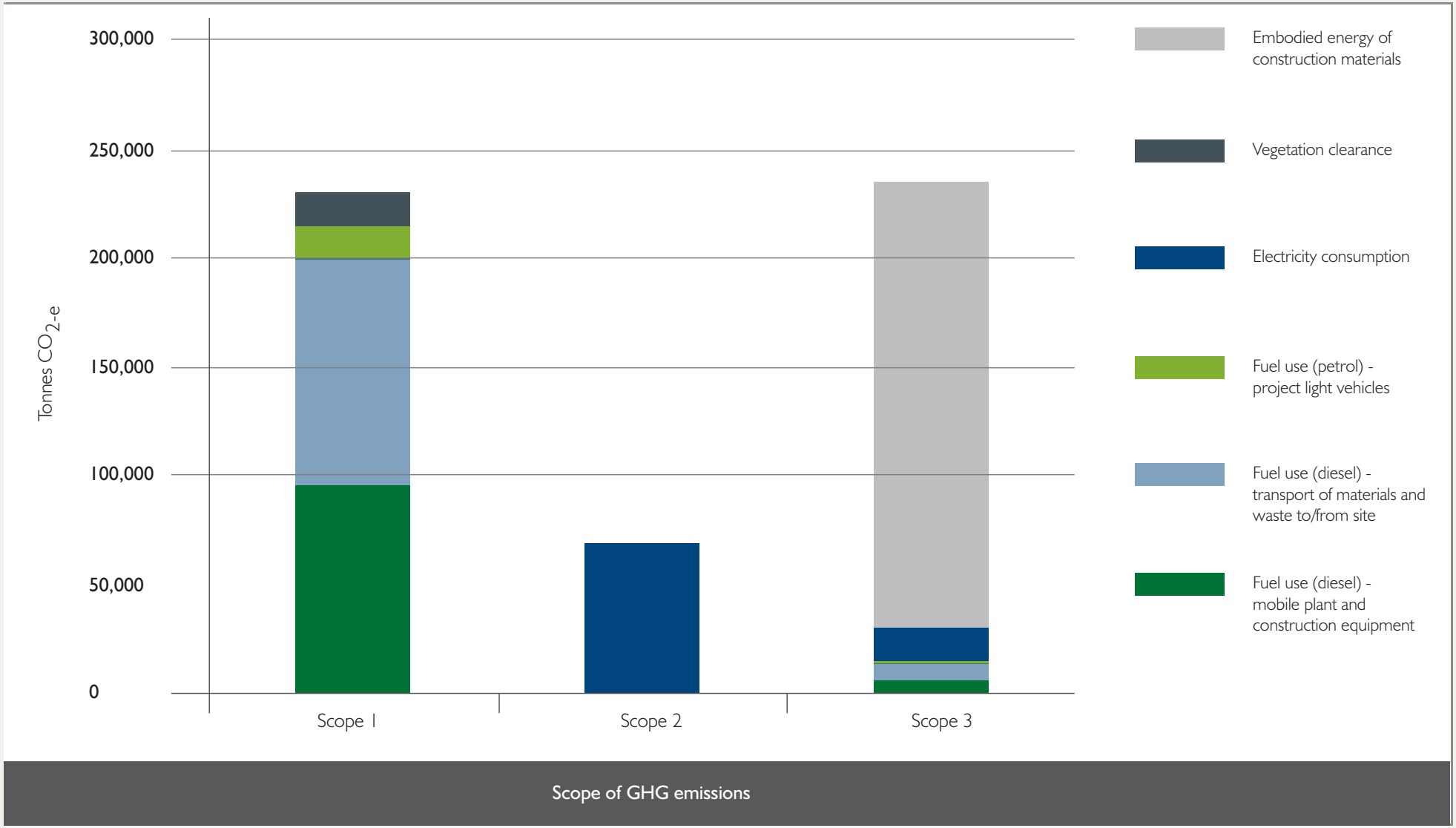

Figure 8-12 Construction greenhouse gas emissions by scope and emissions source

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Diesel fuel to operate construction equipment on site and for the transport of materials and waste to and from site would also contribute a major source of GHG emissions for the construction of the project, accounting for around 40 per cent of the total emissions.

The moderately high proportion of indirect emissions (16 per cent of the total GHG emissions) associated with the consumption of electricity is attributed to the use of road headers and lighting and ventilation requirements during the construction of the tunnel.

The total estimated GHG emissions from construction of the project are approximately 535,500 t CO_2-e, which equates to 0.10 per cent of the national GHG inventory for the year 2010 to 2011 and 0.34 per cent of the NSW GHG inventory for 2010 to 2011, as discussed in **Section 8.4.1**.

Operation and maintenance GHG emissions

Activities that would generate GHG emissions during the operation and maintenance stages of the project include:

- Road infrastructure operation: the use of electricity for powering tunnel lighting and ventilation, communications systems, control systems, computer and safety systems, electronic signage and other associated electrical systems.
- Road infrastructure maintenance: diesel fuel use for the operation of maintenance equipment and the use of materials for maintaining the road pavement.
- Vehicles using the project tunnel during operation: use of the tunnel during operation by traffic currently utilising the Pennant Hills Road alignment between the northern interchange with the M1 Pacific Motorway and the southern interchange with the Hills M2 Motorway (the operational traffic impact footprint) and the potential reduction of traffic volumes on Pennant Hills Road.

The estimated GHG emissions that would occur due to the operation and maintenance of the project, throughout its anticipated design life of 100 years, are presented in **Table 8-33**. These have been calculated according to the GHG assessment methodology summarised in **Section 8.4.3**, and the assumptions and inputs presented in **Appendix N**.

Table 8-33 Operation and maintenance GHG emissions results

Emissions source		Scope 1	Scope 2	Scope 3	Total
Operation					
Electricity consumption		-	18,391	4,016	22,408
Maintenance					
Fuel use (diesel) – mobile plant and equipment		5,611	-	426	6,037
Maintenance materials	Cement	-	-	772	772
	Steel	-	-	18	18
	Aggregate	-	-	400	400
Total maintenance emissions		5,611	-	1,616	7,227

Annual use of electricity for powering tunnel lighting and ventilation, communications systems, control systems, computer and safety systems, electronic signage and other associated electrical systems would incur 18,400 t CO_2-e indirect Scope 2 emissions and 4,000 t CO_2-e indirect Scope 3 emissions per year.

Emission estimates for the use of fuel and materials for the maintenance of the road pavement are based on the replacement of five per cent of the concrete pavement every 50 years, with only the top concrete layer requiring replacement (in accordance with 'typical' maintenance activities given in the TAGG Workbook).

The use of fuel and materials to undertake maintenance activities would result in around 5,600 t CO_2-e direct Scope 1 emissions and 1,600 t CO_2-e indirect Scope 3 emissions. The total quantity of GHG emissions associated with the above road maintenance activities would be approximately 7,200 t CO_2-e.

Operational road use emissions

GHG emissions generated during operation and maintenance of the project (eg lighting, ventilation and major road maintenance) are relatively small in comparison with indirect GHG emissions associated with the fuel consumption of vehicle traffic utilising the road.

To assess the indirect Scope 3 GHG emissions associated with fuel combustion of vehicle traffic utilising the project, and to evaluate any potential GHG emissions savings as a result of the project, road use was considered for two scenarios:

- The base case 'without project' scenario, assessing the future operational performance of Pennant Hills Road in its current condition.
- The 'with project' scenario, including the future operational performance of Pennant Hills Road as well as the operational performance of the project tunnel.

Traffic volumes were modelled for the years 2019 (the project opening year) and 2029 (the project opening plus ten years) as part of the traffic and transport assessment provided in **Section 7.1** and **Appendix E**. These future years were chosen as they provide an indication of road network performance immediately after the project opening (2019), and once traffic patterns have become accustomed to any changes brought about by the project (2029).

The base case scenario ('without project') was also assessed for these years in order to provide a baseline for comparison of GHG emissions. The results, detailed in **Table 8-34** and **Appendix E** indicate that the 'without project' scenario would generate around:

- 243,500 t CO_2-e for the year 2019
- 309,900 t CO_2-e for the year 2029.

The difference between total GHG emissions generated in the 'without project' and 'with project' scenarios was used to calculate the net GHG emissions savings attributable to operation of the project. **Table 8-34** indicates that the 'with project' scenario would generate less GHG emissions when compared to the base case 'without project' scenario, including around:

- 196,400 t CO_2-e for the year 2019 for the 'with project' scenario, resulting in a net reduction of GHG emissions of 47,100 t CO_2-e when compared to the 'without project' scenario for 2019
- 241,300 t CO_2-e for the year 2029 for the 'with project' scenario, resulting in a net reduction of GHG emissions of 68,600 t CO_2-e when compared to the 'without project' scenario for 2029.

Table 8-34 Scope 3 operational road use GHG emissions results

Route	GHG emissions				GHG savings	
	Without project		With project		Difference between scenarios	
	2019	2029	2019	2029	2019	2029
Pennant Hills Road	243,497	309,900	146,148	178,287	-97,349	-131,613
Project tunnel	0	0	50,230	63,039	50,230	63,039
Totals	243,497	309,900	196,379	241,327	-47,119	-68,574

Note: negative values indicate a savings in GHG emissions for the project compared to the 'without project' scenario.

The results demonstrate the benefits of road tunnel usage in urban areas, where travel along a more direct route at higher average speeds, results in a reduction of GHG emissions generated by road users. The GHG assessment results indicate the project would reduce GHG emissions by around 19 per cent in 2019 and around 22 per cent in 2029. The predicted reduction in GHG emissions as a result of the project is due to an improvement in vehicle fuel efficiency for most sections of Pennant Hills Road as well as the operational efficiency of the project tunnels. Vehicle fuel efficiency is anticipated to improve as part of the project based on:

- Increased average speeds on Pennant Hills Road due to reduced levels of congestion.
- Increased average speeds as a result of the operational efficiency of the project tunnels, which would minimise the number of intersections and the frequency of stopping.
- Reduced length of travel between the Hills M2 Motorway and the M1 Pacific Motorway.

The GHG emission saving of 47,100 t CO_2-e in the project opening year (2019) would represent around 0.008 per cent of the Australian National inventory and 0.03 per cent of the NSW inventory for the year 2010 to 2011 as discussed in **Section 8.4.1**.

Construction and operation of the project would generate GHG emissions, however, GHG emissions savings relative to the base case 'without project' scenario would result in an overall GHG emissions reduction for the project. **Figure 8-13** shows the cumulative GHG emissions and savings, from project construction commencing in 2015, to the operational road use of the project in 2029. **Figure 8-13** demonstrates that GHG emissions savings as a result of improved road performance of the project would offset emissions generated during construction by approximately 2027. The cumulative emissions savings shown in **Figure 8-13** exclude the annual contributions of operational emissions associated with project tunnel electricity use as emissions savings beyond 2029 were not able to be estimated. Emissions from major road maintenance are also excluded from **Figure 8-13** as these emissions are expected to occur on a 50 year basis, which would occur beyond the timeframe for which traffic volumes have been assessed.

Mitigation and management measures to reduce GHG emissions for the project are provided in **Section 8.4.5**.

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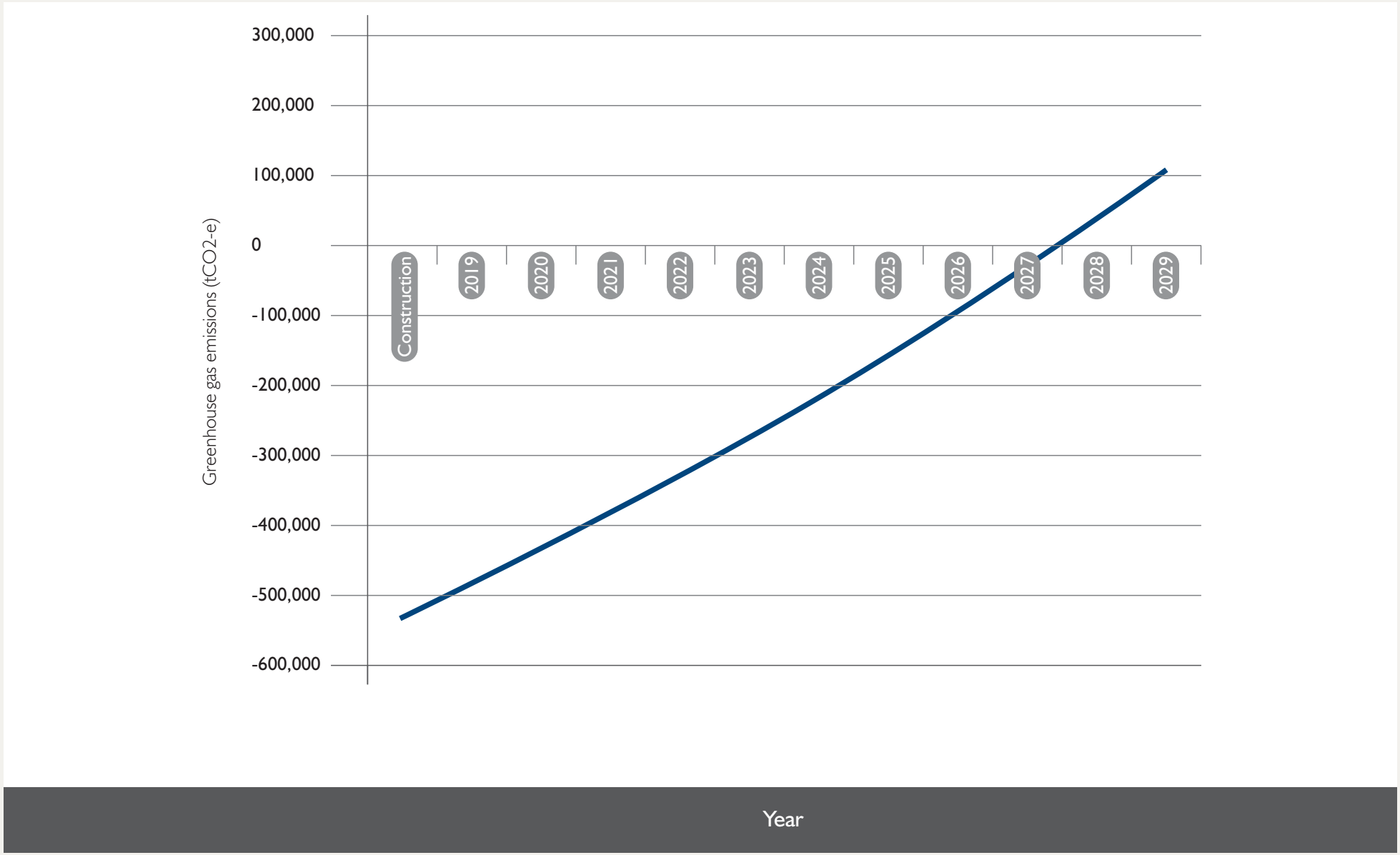

Figure 8-13 Greenhouse gas emissions savings

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Climate change risk assessment

Key climate variables

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction (IPCC, 2007). Consequently, climate change and the associated impacts can be expected to vary from region to region. The climate change assessment provided in this section is based on projections for the Sydney region. Projections for NSW more broadly are provided where data specific to the Sydney region was unavailable.

This assessment is based on the following factors regarding the broader context and nature of the project:

- The inland location of the project reduces the risk of impacts from sea level rise, however inland areas of the Sydney region are likely to experience higher temperatures compared with coastal areas.
- Flood impacts are likely to vary between regions as flood behaviour is highly influenced by local terrain and man-made infrastructure. Flood events in inland areas are influenced by rainfall behaviour, potential evaporation rates and soil moisture. Given the elevated topography of the project area, impacts from flooding are considered to be negligible however, localised flooding impacts may be associated with periods of heavy rainfall.
- The nature of the project, primarily comprising underground tunnel infrastructure, is likely to offer protection from a number climate impacts (eg solar radiation, rainfall, storm events), however the associated surface infrastructure including tunnel interchanges and project buildings are likely to be susceptible to these impacts.

Climate variables identified as potentially generating risks for the project include:

- Mean annual temperature change and extreme temperature events.
- Mean annual rainfall change and extreme rainfall events.
- Increased mean annual potential evaporation.
- Increased solar radiation.
- Extreme events, particularly storms (rainfall, hail, wind, dust, lightning), drought and bushfires.

Projections for these climate variables are presented in **Table 8-35** and summarised in the following section.

Climate change projections

Based on modelling undertaken by the CSIRO and BOM (2007), the Sydney region, and NSW more broadly, are projected to experience a warming trend, with an increase in the incidence of extreme temperature days over 35ºC. Annual average temperature in Sydney is likely to increase by around 0.9ºC by 2030 and 3.0ºC by 2070. The number of hot days per year in Sydney is projected to increase from 3.5 to 4.5 by 2030, under a moderate emissions scenario, and by up to 9.5 days per year by 2070 under a high emissions scenario.

NSW is likely to experience increased variability in rainfall throughout the year, with an annual average decrease of up to five per cent by 2030. Rainfall is likely to decrease in winter and spring, and increase in summer and autumn across most of NSW. The Sydney region is expected to follow this trend with an overall decrease in annual average rainfall of around three per cent by 2030 and eight per cent by 2070. The likelihood and intensity of extreme rainfall events is projected to increase for the Sydney region, with an increase of around five per cent by 2030 and an additional two per cent by 2070.

CSIRO and BOM (2007) projections show up to 20 per cent more drought months over most of Australia by 2030, with up to 40 per cent more droughts by 2070 across eastern Australia. Regional projections for NSW indicate more severe short term droughts in the northern parts of the state, with less severe medium and long term periods of drought. In the southern-most regions of the state, short, medium and long term periods of drought are all anticipated to increase in severity.

Increases in temperature and wind speed, decreases in mean annual rainfall and periods of prolonged drought are likely to increase the severity, frequency and duration of bushfire events in NSW. Very high to extreme fire danger days are projected to increase by between ten per cent and 50 per cent by 2050 (CSIRO and BOM, 2007).

Detailed projections for the Sydney region for 2030 under the A1B scenario and 2070 under the A1FI scenario, as described in **Section 8.4.3**, are presented in **Table 8-35**.

Table 8-35 Climate change projections for the Sydney region (CSIRO & BOM, 2007)

Climate variable	Baseline data (1990)	2030 projections (A1B)	2070 projections (A1FI)
Mean annual temperature	17 - 26ºC	+0.9ºC (+0.6 to +1.3ºC)	+3.0ºC (+2.1 to +4.3ºC)
Extreme temperature events (average days per year above 35ºC)	3.6	4.6 (3.9 to 5.3)	9.5 (5.0 to 13.9)
Extreme temperature events (average days per year above 40ºC)	0.3	0.7 (0.5 to 0.8)	1.9 (0.7 to 3.1)
Mean annual rainfall	1213mm	-3% (-9 to +3%)	-8% (-25 to +10%)
Extreme rainfall (change in 40 year 1 day rainfall total)	Not available	+5% (-3 to +12%)	+2% (-7 to +10%)
Rainfall intensity (change in 100 year – 2 hour event)	Not available	-10% (-15 to +5%)	+10% (+5 to +15%)
Rainfall intensity (change in 5 year – 2 hour event)	Not available	0% (-5 to +5%)	+10% (+5 to +15%)
Average annual potential evaporation	2.9mm	+3% (+2 to +5%)	+9% (+5 to +15%)
Solar radiation (milliJoules per square metre)	16.9	+0.3% (-1 to +1.9%)	+0.9% (-3.2 to +6.0%)

Note: Data in brackets represents the range of uncertainty associated with the magnitude of projections based on CSIRO & BOM (2007) modelled data, with the 10th to 90th percentile range presented in brackets below the median (50th percentile) value.

Potential climate change impacts and risks to the project

Road infrastructure is particularly vulnerable to very high temperatures, changes in soil moisture and the ground stability of sloping land forms (Thom et al, 2010). The increased frequency and intensity of extreme weather events, increased rainfall, bushfires and rising temperatures are already causing strain on existing road networks. Recent flood events and bushfire events in NSW have highlighted the susceptibility of the transport sector to extreme events (Thom et al, 2010). More extreme weather events are likely to damage road infrastructure and, by 2030, design criteria for extreme events are very likely to be exceeded more frequently (Thom et al, 2010).

Table 8-36 presents a high level desktop risk assessment of the projected climate change and associated impacts to key project components. Key risks to project tunnel and surface infrastructure components have been assessed in terms of low (acceptable), medium (tolerable), and high (undesirable) risks, as a result of impacts from projected climate change scenarios. In summary the climate risk assessment (**Table 8-36**) identifies one medium and seven low risks for tunnel infrastructure, and three medium and ten low risks for surface infrastructure.

The climate change risk assessment has been undertaken in line with relevant standards and current guidelines, as described in **Section 8.4.3**.

Table 8-36 Climate change risks and potential impacts

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
Tunnel infrastructure				
Increased temperatures and increased frequency and severity of extreme temperature days (days over 35 ºC)	Temperatures within the tunnel would be influenced by external surface temperatures as outside air would be drawn into the tunnel through the portals with the in-coming movement of vehicles and through mechanical ventilation fans. Higher temperatures are likely to be experienced within the tunnel as external surface temperatures increase, particularly on extreme temperature days. Increased temperatures may cause additional stress on infrastructure through heat expansion and the accelerated degradation of materials, particularly for road pavements.	Although temperatures within the tunnel are likely to be influenced by external surface temperatures, the underground location and drainage of groundwater inflows through the tunnel would provide a cooler environment compared with the surface and potential impacts associated with heat stress are anticipated to be less than those experienced on surface roads. In addition, there is sufficient knowledge and experience to demonstrate that bituminous and concrete road surfaces and concrete structures currently perform satisfactorily in Australia's extremely hot climates such as the tropical north and the dry inland where extreme weather conditions are similar to or more severe than predicted as a result of climate change for the Sydney region.	Low (acceptable)	Low (acceptable)
	Increased temperatures and extreme temperature days are likely to increase the risk of heat stress conditions for maintenance workers, which may lead to injury or, in a worst case scenario, fatality.	Management measures would be implemented to maintain safety of employees during operation and maintenance in line with current workplace health and safety practices, eg stop work procedures for extreme temperature thresholds.	Low (acceptable)	Medium (tolerable)
	Increased temperatures and extreme temperature days are likely to reduce the energy efficiency of electrical equipment including the use of tunnel ventilation fans, water treatment systems and electronic toll and surveillance systems during operation, increasing the consumption of electricity, and the risk of faults, equipment failure and power	The operation of mechanical and electric systems, particularly tunnel ventilation, during operation is anticipated to require significant amounts of electricity. Reductions in the efficiency of electrical equipment and systems as a result of increased temperatures would result in greater consumption of electricity and an increase in operational costs, as well as GHG emissions. However, efficiencies incorporated into the design, such	Low (acceptable)	Low (acceptable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
	outages.	as the consideration of mechanical and electrical systems with high energy efficiencies, would offset or otherwise reduce the impact of energy losses associated with temperature increases. The tunnel is also anticipated to maintain a cooler environment compared with surface temperatures and the likelihood of heat stress impacts on underground electrical equipment and systems is considered to be low. In addition, the design provides redundancy within the electricity network to minimise the risk of faults disrupting tunnel operation.		
	Increased temperatures and extreme temperature events may affect the efficiency and function of vehicles utilising the tunnel during operation, increasing the risk of vehicles overheating and breaking down. Higher temperatures may also result in an increased rate of fuel consumption due to the increased use of air conditioning and the reduced efficiency of vehicle engines, particularly for older models.	The tunnel is anticipated to maintain a cooler environment compared with surface temperatures and the likelihood of heat stress impacts on vehicles is considered to be low. Nonetheless, management measures would be implemented to maintain road safety in the event of breaking down vehicles (refer to **Section 8.2** Hazards and risk). For example, the main tunnel alignments would include provision of a 2.5 metre wide shoulder, which could be used to provide temporary accommodation for broken down vehicles and access for emergency vehicles. In addition, the tunnel would be equipped with automatic incident detection and motorist emergency equipment points would be positioned every 60 metres throughout the tunnel, with a direct telephone link to the motorway control centre.	Low (acceptable)	Low (acceptable)
Increased frequency, severity and	In the event of a bushfire or dust storm affecting the surrounding land, there is potential for smoke and embers, and / or dust	Emergency planning and development of incident response plans for the operation of the project would include specific provisions relevant to the management of	Low (acceptable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
duration of extreme events such as bushfires and storms	to be drawn into the main alignment tunnels and the tunnel ventilation system, reducing visibility, air quality and road safety within the tunnel.	a bushfire with direct or indirect impacts on the project. Management measures would be implemented to maintain road safety in the event of such extreme events, including the implementation of reduced speed limits during periods of reduced visibility, and as a worst case scenario, in the event that conditions within the tunnel are determined to be unsafe for road users, the tunnel would be temporarily closed and traffic diverted to other routes until conditions return to acceptable levels. **Section 8.2** (Hazards and risk), provides further discussion of the risks associated with bushfire events.		
Decreased rainfall and increased frequency, severity and duration of droughts	Decreased rainfall and surface runoff coupled with increased temperature and evaporation are likely to result in a reduction in soil moisture content. These impacts are likely to increase the risk of ground movement, which may result in the accelerated degradation of materials, structures, reinforcement and foundations, increased maintenance requirements and a reduction of the life expectancy of project infrastructure. Further stress caused by extreme climate events may trigger or contribute to structural failure through the cracking of embankments or tunnel walls.	There is sufficient knowledge and experience to demonstrate that bituminous and concrete road surfaces and concrete structures currently perform satisfactorily in Australia's extremely hot dry climates such as the dry inland areas where extreme weather conditions are similar to or more severe than those predicted as a result of climate change for the Sydney region.	Low (acceptable)	Low (acceptable)
	Decreased rainfall and surface runoff may lead to an increase in the salinity of soils, increasing the risk of corrosion of materials such as steel and concrete.	Existing road and tunnel infrastructure already cope with a range of soil profiles and standards and specifications are in place to ensure foundations perform to a high standard.	Low (acceptable)	Low (acceptable)
Periods of increased rainfall and	Periods of increased rainfall and an increased frequency and intensity of extreme rainfall events under climate change are likely to	The drainage system for the tunnel portals and approaches has been designed to accommodate inflows of a 100-year average recurrence interval (ARI) rainfall	Medium (tolerable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
increased intensity and frequency of extreme rainfall events	cause increased volumes of runoff which may result in localised flooding of the tunnel portals and approaches and increase the risk of overloading of the tunnel drainage system. Overloading of the tunnel drainage system may impact the asphalt and road foundation quality leading to a loss of strength and bearing capacity as well as accelerating the degradation of the road surface.	event. An additional allowance for the contribution of climate change related rainfall increases would be considered as part of the project's detailed design. Roads are designed to cope with a certain amount of overtopping. However with climate change, there may be changes in floodwater velocity and height which can increase the risk of damage. Inaccessible drainage elements, such as drainage culverts and pits are very difficult to modify once constructed.		
Surface infrastructure				
Increased temperatures, increased solar radiation, increased evaporation and increased frequency and severity of extreme temperature days (days over 35 ºC)	Increased temperatures, coupled with increased solar radiation and evaporation, are likely to cause additional stress on infrastructure through heat expansion and the accelerated degradation of materials, particularly for road pavements. Deterioration of materials, particularly asphalt and bitumen, would increase the risk of melting, cracking, or rutting of the road surface.	There is sufficient knowledge and experience to demonstrate that bituminous and concrete road surfaces and concrete structures currently perform satisfactorily in Australia's extremely hot climates such as the tropical north and the dry inland where extreme weather conditions are similar to or more severe than predicted as a result of climate change for the Sydney region.	Low (acceptable)	Low (acceptable)
	Increased temperatures, solar radiation and evaporation are likely to increase the risk of degradation and damage to structural materials of bridges, through the thermal expansion of bridge joints and paved surfaces.	The forecast increase in mean maximum and minimum temperature arising from climate change is within the range of temperatures presently experienced by bridge infrastructure across the state. Australian design standards allow for significantly hotter (hot inland desert) and cooler (Snowy Mountains) environments than predicted under climate change in the Sydney region.	Low (acceptable)	Low (acceptable)
	Increased temperatures and extreme temperature days are likely to increase the risk of heat stress conditions for maintenance workers, which may lead to injury or, in a worst case scenario, fatality.	Management measures would be implemented to maintain safety of employees during operation and maintenance in line with current workplace health and safety practices, eg stop work procedures for extreme temperature thresholds.	Low (acceptable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
	By 2070, the frequency and duration of heat wave events would increase significantly, with approximately 9.5 days per year above 35 ºC on average (**Table 8-35**), increasing the risk of heat stress related injury or fatality.			
	Increased temperatures and extreme temperature events may affect the efficiency and function of vehicles, increasing the risk of vehicles overheating and breaking down. Higher temperatures may also result in an increased rate of fuel consumption due to the increased use of air conditioning and the reduced efficiency of vehicle engines, particularly for older models.	Management measures would be implemented to maintain road safety in the event of breaking down vehicles (refer to **Section 8.2** Hazards and risk). The design includes provision of two incident response bays outside of the M1 Pacific Motorway portal and two incident response bays outside of the Hills M2 Motorway portal, which could be used to provide temporary accommodation for broken down vehicles. In addition, motorist emergency equipment points along the M1 Pacific Motorway and Hills M2 Motorway would provide a direct telephone link to the motorway control centre.	Low (acceptable)	Low (acceptable)
	Increased temperatures and extreme temperature days are likely to reduce the energy efficiency of electrical equipment and systems, increasing the consumption of electricity and the risk of faults, equipment failure and power outages. Increased temperatures are also likely to increase electricity consumption through an increased demand for air conditioning.	The project would draw power from the mains supply, through two separate feeders, designed to provide independent and reliable power sources for the project. The design provides redundancy within the reticulation network so that a single fault would not disrupt operations.	Low (acceptable)	Low (acceptable)
Increased frequency, severity and	An increased frequency and severity of bushfire events would increase risks to the health and safety of employees and the	Project buildings and infrastructure critical to the ongoing safe operation of the project, such as the Motorway Control Centre, would be located within an urban setting	Low (acceptable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
duration of extreme events such as bushfires	general public at the M1 Pacific Motorway tie-in and the Hills M2 Motorway integration works and within project operated buildings. Bushfires also increase the risk of damage to infrastructure through additional heat stress. Project areas mapped as on or in proximity to bushfire prone land include: Vegetated areas in proximity to the M1 Pacific Motorway tie-in works which mark the start of the vegetation contiguous with Ku-ring-gai Chase National Park. Vegetated areas including Darling Mills State Forest and the Cumberland State Forest located in proximity to the Hills M2 Motorway integration works.	and are not mapped within bushfire prone areas. The design of areas mapped within bushfire prone land, such as the M1 Pacific Motorway tie-in and the Hills M2 Motorway integration works, would take into account the establishment of appropriate asset protection zones (APZ), emergency access and egress, and the use of fire resistant materials. Most of the project's operational infrastructure would be relatively invulnerable to bush fire attack due to its incombustible nature (eg road surface materials, retaining walls, road barriers). Emergency planning and development of incident response plans for the operation of the project would include specific provisions relevant to the management of a bushfire with direct or indirect impacts on the project.		
Decreased rainfall and increased frequency, severity and duration of droughts	Decreased rainfall and surface runoff coupled with increased temperature and evaporation are likely to result in a reduction in soil moisture content. These impacts are likely to increase the risk of ground movement, which may result in the accelerated degradation of materials, structures, reinforcement and foundations, increased maintenance requirements and a reduction of the life expectancy of project infrastructure. Further stress caused by extreme climate events may trigger or contribute to structural failure eg through the cracking of embankment walls.	There is sufficient knowledge and experience to demonstrate that bituminous and concrete road surfaces and concrete structures currently perform satisfactorily in Australia's extremely hot dry climates such as the dry inland areas where extreme weather conditions are similar to or more severe than those predicted as a result of climate change for the Sydney region.	Low (acceptable)	Low (acceptable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
	Decreased rainfall and surface runoff may lead to an increase in the salinity of soils, increasing the risk of corrosion of steel reinforcement for concrete structures such as bridges.	Existing road and bridge infrastructure already cope with a range of soil profiles and standards and specifications are in place to ensure foundations perform to a high standard.	Low (acceptable)	Low (acceptable)
Periods of increased rainfall and increased intensity and frequency of extreme rainfall events	Periods of increased rainfall and an increased frequency and intensity of extreme rainfall events under climate change are likely to cause increased volumes of runoff which may result in temporary periods of localised flooding or overtopping of the road surface. Overloading of the drainage system and the subsequent overtopping of the road surface is likely to impact the asphalt and road foundation quality leading to a loss of strength and bearing capacity as well as accelerating the degradation of the road surface. Increased temperatures, solar radiation and evaporation cause the road surface to crack and become more brittle, which further reduces surface waterproofing. These impacts would be exacerbated by periods of extreme rainfall and localised flooding which have the potential to cause significant damage to roads eg through extensive potholing.	The drainage system has been designed to accommodate inflows of a 100-year ARI rainfall event. An additional allowance for the contribution of climate change related rainfall increases would be considered as part of the project's detailed design. Roads are designed to cope with a certain amount of overtopping. However with climate change, there may be changes in floodwater velocity and height which can increase the risk of damage. Inaccessible drainage elements, such as drainage culverts and pits are very difficult to modify once constructed.	Medium (tolerable)	High (undesirable)
	Periods of increased rainfall and an increased frequency and intensity of extreme rainfall events under climate change are likely to cause increased volumes of runoff which may result in temporary periods of localised	Flooding loads are well understood and are currently considered during bridge structural design which allows for the passage of a 100-year ARI rainfall event. An additional allowance for the contribution of climate change related rainfall increases would be considered as part of	Medium (tolerable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
	flooding or overtopping of bridges. Storm related damage and localised flood events as a result of extreme rainfall have the potential to cause significant damage to bridge infrastructure, such as the failure of abutments on bridges (foundations and supports are likely to be able to withstand storm events and localised flooding), resulting in significant costs associated with rebuilding and repair. An increase in the frequency and intensity of extreme rainfall events would increase the vulnerability of bridge infrastructure.	the project's detailed design. With climate change, there may be changes in floodwater velocity and height which can increase the risk of damage to bridge infrastructure. Bridges are difficult to modify once constructed.		
	Periods of increased rainfall and extreme rainfall events are considered to be the dominant factor in the occurrence of land slides, which can have implications on the maintenance and repair of roads as well as disruptions to road users through impaired access. Increased rainfall would also exacerbate dry soil conditions and increase the risk of land slip or rock fall hazards which may occur in areas of instability such as cuttings around the dive structures at the southern and northern interchanges.	Road foundations and embankments are designed to cope with a certain amount of runoff and potential overtopping. However with climate change, there may be changes in floodwater velocity and height which can increase the risk of damage. The drainage system has been designed to accommodate inflows of a 100-year ARI rainfall event. An additional allowance for the contribution of climate change related rainfall increases would be considered as part of the project's detailed design.	Medium (tolerable)	Medium (tolerable)

Climate change risk	Possible impacts / consequences	Evaluation of risk level	Risk rating for 2030	Risk rating for 2070
	The increased frequency and severity of extreme rainfall events may result in an increased malfunctioning of power supplies, communications systems and radio signal propagation.	Emergency management plans and procedures would be implemented as part of the project, so that in the event of an emergency, traffic controllers, working with the Police, Ambulance, Fire and other emergency services would respond to unplanned incidents on the road network.	Low (acceptable)	Low (acceptable)
	An increased frequency and severity of extreme rainfall events would increase risks to road user safety, particularly as the incidence of collisions increases in wet weather conditions (Austroads, 2004).	Management measures would be implemented to maintain road safety in the event of such extreme events, including the implementation of reduced speed limits during periods of extreme rainfall.	Low (acceptable)	Low (acceptable)

The risks to infrastructure described above may also generate knock-on effects or additional risks, such as (Maddocks et al, 2010):

- Risks to road user health and safety.
- Interruption or delays to commuter travel.
- Interruption or delays to commercial activities that depend on road transport, such as the movement of freight.
- Increased maintenance and replacement costs.
- Increased liability resulting from damage to road infrastructure.
- Higher insurance costs for road authorities.

For example, for a temperature increase of 2ºC to 3ºC Austroads (2004) predicts an average 17 per cent increase in road maintenance costs over most of Australia, based on predicted rates of pavement deterioration and assumptions around forecast traffic growth. By 2100, NSW is predicted to experience a 23 per cent increase in routine and periodic maintenance costs, including pothole patching, kerb and channel clearing, surface correction and resealing activities, and a 26 per cent increase in major rehabilitation or long term maintenance costs. Major maintenance or rehabilitation of the project road surface is anticipated to be required within 50 years of construction, occurring around 2070. **Table 8-35** indicates that a temperature increase of 3ºC is projected for 2070 under a high emissions scenario (CSIRO and BOM, 2007). As a result, project maintenance and rehabilitation costs are likely to be significantly greater than those expected under current climate scenarios and pavement deterioration rates.

Given the interconnected nature of climate variables, the risks identified are likely to occur in combination, resulting in amplified impacts on project infrastructure. Mitigation measures identified in **Section 8.4.5** are identified to minimise the risk of climate change impacts on the project.

8.4.5 Environmental management measures

Over the long term, the project has been shown to provide a net reduction in greenhouse gas emissions due to the provision of a free-flowing motorway standard alternative to Pennant Hills Road with improved travel times even accounting for the emissions during the construction period.

The design of the project has been optimised such that measures to reduce energy and resource requirements, and therefore GHG emissions, are inherent in the preferred tender design. The project design has been optimised to:

- Reduce the cross sectional area required to be excavated, which results in a reduction in spoil volumes and road header electricity consumption.
- Pass through a higher proportion of sandstone rock, as opposed to shale, reducing the number of rock bolts required and providing increased opportunities for the reuse of sandstone spoil at other developments.
- Reduce power consumption associated with tunnel ventilation by locating the ventilation facilities close to the main alignment tunnel portals thereby optimising the piston generated vehicle effect.
- Provide enhanced reflectivity and luminance so as to reduce the required level of lighting and associated power requirements within the tunnel.

- Provide large radius curves within the tunnel in order to allow consistent vehicle speeds to be maintained and reduce the need for vehicles to slow down on the approach to corners.
- Provide for long term performance and durability of the main tunnel alignments, the M1 Pacific Motorway, the Hills M2 Motorway and Pennant Hills Road and the associated local road network, increasing asset design lives and reducing the frequency of maintenance activities.

Environmental management measures relating to GHG mitigation and climate change adaptation for the construction and operation of the project are provided in **Table 8-37**.

Additional mitigation measures which would contribute to the reduction of GHG emissions or reduce the vulnerability of the project to climate change are provided in other sections of this environmental impact statement, including vegetation clearance (**Section 7.6** Biodiversity), waste reduction and recycling (**Section 8.3** Resource management and waste minimisation) and bushfire risk management (**Section 8.2** Hazards and risk).

Table 8-37 Environmental management measures – GHG and climate change

Impact	No.	Environmental management measure	Timing
Construction			
GHG emissions	GHG1	Emissions intensity of construction materials would be considered during procurement.	Procurement
	GHG2	Where feasible, recycled content road construction and maintenance materials such as recycled aggregates in road pavement and surfacing would be used.	Procurement
	GHG3	The fuel efficiency of the construction plant and equipment would be considered during selection.	Procurement / pre-construction
	GHG4	Project planning would be aim to minimise double handling of materials, long haulage distances and additional fuel use.	Prior to construction
	GHG5	Locally produced goods and services would be procured where feasible and cost effective to reduce transport fuel emissions.	Procurement / pre-construction
Climate change impacts	CC1	The risks of future climate change would be further considered during detailed design.	Detailed design
	CC2	Where high or medium risks to project infrastructure have been identified, the construction contractor would review existing design policies, specifications or practices to consider the impacts of climate change.	Detailed design
Operation			
GHG emissions	OpGHG1	The tunnel would be designed to minimise fuel use associated with motorist use of the road through the optimisation of design, for example the provision of a vertical alignment that allows consistent vehicle speeds to be maintained.	Detailed design

Impact	No.	Environmental management measure	Timing
	OpGHG2	Low carbon energy generation options would be investigated as part of the design process in order to reduce the demand on mains electricity where feasible.	Detailed design
	OpGHG3	A life cycle assessment would be undertaken as part of the detailed design in order to select mechanical and electrical systems with increased energy efficiencies, such as the tunnel ventilation system, water treatment systems and electronic toll and surveillance systems.	Detailed design
Climate change impacts	OpCC1	A stop work threshold (eg for extreme heat, storm events) for operation and maintenance activities would be implemented in line with current workplace health and safety practices.	Operation
	OpCC2	Emergency planning and management controls would be implemented during operation to reduce the risk of adverse climate impacts, maintain public safety and minimise congestion. For example, bushfire management would include measures to ensure safety such as reduced speed limits and temporary tunnel closures where required (refer to **Section 8.2** Hazards and risk).	Operation
	OpCC3	Maintenance regimes for road surface and other ancillary infrastructure would be developed to accommodate accelerated rates of asset degradation.	Operation
	OpCC4	The motorway operator would develop emergency response management plans in consultation with emergency management services, local governments and other relevant agencies to ensure better disaster management during extreme climate events.	Operation
	OpCC5	The motorway operator would monitor and review the performance of structures and materials in response to climate change related events. Where possible, the most cost-effective response would be to include adaptive measures in the regular maintenance of the project.	Operation

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9 Summary of environmental management measures

This chapter collates the environmental management measures for the project that were identified through the impact assessment process in **Chapter 7** and **Chapter 8**. All measures listed in **Table 9-1** would be incorporated into the Construction Environmental Management Plan and / or the operational framework for the project.

Table 9-1 Summary of environmental management measures

Impact	ID	Environmental management measure	Timing
Traffic and transport			
Construction			
General	TT1	A traffic management plan(s) (TMP) would be prepared as part of the construction environmental management plan(s) (CEMP). The TMP would include: • Signage requirements (eg temporary speed restrictions, changes to the road environment, traffic management controls deployed). • Lane possession and approval process during periods of online construction (eg line marking and temporary barriers). • Traffic control devices such as temporary traffic signals. • A local and regional communications strategy. This would include methods to provide advanced notice of any major or prolonged impacts (eg leaflets and local media), and real-time information regarding current impacts (eg variable message signs, radio traffic news). • Details of both the general approach to be used for access and egress to worksites (with consideration of minimum sight distances, maximum grade allowances, etc), and the specific controls required at selected locations (signage, barriers, signalling requirements). • Any specific provisions required to manage potential impacts to sensitive users such as schools, child care centres, health facilities, etc).	Pre-construction
Impacts to road network performance (delays) and safety	TT2	Construction methods and staging would be designed to minimise road closures, subject to other project constraints, and ensure that disruptions to existing traffic are minimised as much as feasible and reasonable.	Construction

Impact	ID	Environmental management measure	Timing
	TT3	Offline construction would be carried out wherever feasible and reasonable.	Construction
	TT4	Works which would significantly reduce the performance of the road network would be scheduled for periods of typically lower traffic volumes where feasible and reasonable.	Construction
	TT5	Where offline construction is not practical, and for tie-ins between online and offline sections of the project, construction sequencing and any temporary works identified would aim to minimise user delay while providing sufficient flexibility for the selected contractor to safely and efficiently construct the project.	Construction
	TT6	Signage would be used to clearly indicate the traffic controls in use. This could also include temporary speed restrictions and passing constraints if required to maintain road safety levels.	Construction
	TT7	In some instances lane closures would be implemented to remove road traffic from construction zones altogether. Where practical this is proposed to occur outside of peak periods including at night to maintain network capacity.	Construction
	TT8	Access to local roads / streets and properties would be maintained. If local roads / streets need to be closed (short or long term), arrangements would be made to provide access to properties of affected residents and their visitors.	Construction
	TT9	Road occupancy licences would be obtained for work that impacts traffic on existing roads.	Construction
Impacts to emergency services	TT10	The TMP would be developed in consultation with local emergency services and procedures would be implemented to maintain priority access and a safe environment for emergency vehicles to travel through construction areas.	Construction
	TT11	Local emergency services would be frequently updated on the staging and progress of construction works.	Construction
	TT12	Communication systems would be in place with traffic controllers to provide appropriate access and routes (eg gaps in concrete barriers, side-tracks, wide verges etc) for emergency vehicles to bypass queued traffic.	Construction
Operation			
Impacts to road safety	OpTT1	A road safety audit would be undertaken by qualified auditors as part of the detailed design, and again immediately prior to project opening, to examine the design from a road safety perspective and identify potential safety issues. This process would be undertaken in accordance with the Roads and Maritime Accident Reduction Guide Part 2: Road Safety Audits (RTA, 2005a).	Detailed design and prior to operation

Impact	ID	Environmental management measure	Timing
Noise and vibration			
Construction			
General	NV1	A Construction Noise and Vibration Management Plan(s) would be prepared and implemented, and would include the following: • Identification of nearby residences and other sensitive land uses. • Description of approved hours of work. • Description and identification of all construction activities, including work areas, equipment and duration. • Description of what work practices (generic and specific) would be applied to minimise noise and vibration. • A complaints handling process. • Noise and vibration monitoring procedures. • Overview of community consultation required for identified high impact works.	Pre-construction
Construction noise	NV2	Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise.	Construction
	NV3	Work would be undertaken during standard construction hours as far as feasible and reasonable.	Construction
	NV4	Noisy activities that cannot be undertaken during standard construction hours would be scheduled as early as possible during the evening and / or night-time periods.	Construction
	NV5	Particularly noisy activities such as the use of impact piling rigs, road and concrete saws, rockbreakers, would be scheduled around times of high background noise where feasible and reasonable to provide masking.	Construction
	NV6	Deliveries would be carried out during standard construction hours where feasible and reasonable.	Construction
	NV7	A protocol would be developed to identify the need for and provision of respite measures for residential receivers in accordance with the Interim Construction Noise Guidelines. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock breaking, rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as alternative accommodation.	Construction
	NV8	Appropriate plant would be selected for each task.	Construction

Impact	ID	Environmental management measure	Timing
	NV9	Alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable.	Construction
	NV10	Equipment would be regularly inspected and maintained to ensure it is in good working order.	Construction
	NV11	The distance between construction plant and noise sensitive receivers would be maximised as much as feasible and reasonable.	Construction
	NV12	Site access and egress points would be located as far as feasible and reasonable from noise sensitive receivers.	Construction
	NV13	Noisy equipment would be orientated away from residential receivers.	Construction
	NV14	Acoustic sheds would be erected at the ancillary construction facilities that would support 24 hour tunnelling activities, being: • Southern interchange compound (C5). • Wilson Road compound (C6). • Trelawney Street compound (C7). • Northern interchange compound (C8). The attenuation level of the acoustic sheds would be reviewed and optimised during the construction planning phase.	Construction
	NV15	Permanent noise barriers would be scheduled for completion as early as possible in order to mitigate construction noise.	Construction
	NV16	Where feasible and reasonable, the use of temporary noise hoardings would be considered where ancillary construction facilities are in proximity to sensitive receivers.	Construction
	NV17	Noise monitoring would be conducted at the commencement of construction activities and periodically during the construction program.	Construction
	NV18	A protocol would be developed to identify the need for and provision of respite measures for residential receivers in accordance with the Interim Construction Noise Guidelines. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock breaking, rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as alternative accommodation.	Construction

Impact	ID	Environmental management measure	Timing
Construction traffic noise	NV19	Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours and other relevant practices (ie minimising the use of engine brakes, and no extended periods of engine idling).	Construction
	NV20	Deliveries and spoil removal would be planned to avoid queuing of trucks around construction sites.	Construction
	NV21	Construction sites would be arranged to limit the need for reversing movements.	Construction
	NV22	Non-tonal reversing alarms would be used where feasible and reasonable, and taking into account the requirements of the Workplace Health and Safety legislation.	Construction
	NV23	The use of local roads for night-time spoil transport would be reviewed during construction planning.	Construction
Vibration impacts	NV24	Prior to the commencement of tunnelling or other vibration intensive works at each site, existing condition surveys would be undertaken on properties and structures within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface works.	Construction
	NV25	The safe working distances would be complied with where feasible and reasonable. This would include the consideration of smaller equipment when working in close proximity to existing structures.	Construction
	NV26	In the event that vibration intensive equipment would be used within the safe working distances for cosmetic damage, vibration monitoring would be undertaken to warn operators when vibration levels are approaching the peak particle velocity objective.	Construction
Operation			
Road noise impact	OpNV1	Feasible and reasonable mitigation measures would be developed and implemented to minimise noise impacts consistent with the requirements of the NSW Road Noise Policy and the Environmental Noise Management Manual. Specific noise mitigation measures for the project may include, where feasible and reasonable: • Low noise road surfaces. • Noise barriers. • At property acoustic treatments.	Detailed design

Impact	ID	Environmental management measure	Timing
	OpNV2	Operational traffic noise would be monitored at sensitive receivers between six months and one year after opening. If the traffic noise levels are above the predicted levels, consideration of additional feasible and reasonable mitigation measures would be undertaken.	Operation
Operational ancillary facilities	OpNV3	Operational ancillary facilities would be designed to meet project specific noise criteria derived in accordance with the NSW Industrial Noise Policy.	Detailed design
Air quality			
Construction			
General	AQ1	Site inductions and ongoing toolbox talks would be provided to make construction works aware of air quality control practices and responsibilities.	Construction
	AQ2	Construction activities would be modified, reduced or controlled during high or unfavourable wind conditions if they would potentially increase off-site dust emissions.	Construction
	AQ3	Measures would be implemented to control dust emissions, such as the use of water carts, sprinklers, sprays and dust screens. The frequency of use would be modified in response to weather conditions.	Construction
	AQ4	Dust extraction and filtration systems would be installed for tunnel excavation works.	Construction
	AQ5	Should odour emissions arise from the groundwater treatment plant or stockpiles, a management plan would be developed to identify and implement appropriate mitigation measures.	Construction
	AQ6	Disturbed areas would be stabilised as soon as practicable to prevent or minimise windblown dust.	Construction
	AQ7	Cutting of materials such as concrete or bricks would be undertaken in a manner that minimises the generation of dust, such as the wetting of the cutting face.	Construction
	AQ8	Controls, such as rumble grids or wheel wash facilities, would be implemented to minimise the tracking of dirt onto public roads.	Construction
	AQ9	Hardstand areas and surrounding public roads would be cleaned, as required.	Construction
	AQ10	Speed limits would be posted and observed by all construction vehicles on the construction site.	Construction
	AQ11	Loaded haulage trucks would be covered at all times on public roads and on-site where there is a risk of release of dust or other materials.	Construction
	AQ12	Haul trucks, plant and equipment would be switched off when not in operation for periods of greater than 15 minutes.	Construction

Impact	ID	Environmental management measure	Timing
	AQ13	Construction plant, vehicles and machinery would be maintained in good working order and in accordance with manufacturers' specifications.	Construction
Monitoring	AQ14	A formal dust observation program would be implemented during construction, involving daily reviews of weather forecasts, observations of meteorological conditions and on site dust generation. This would inform mitigation measures or alterations to construction activities to be implemented during unfavourable weather conditions (such as dry weather and strong winds).	Construction
Operation			
In-tunnel air quality monitoring	OpAQ1	A management framework would be developed and implemented to ensure that significant congestion is effectively managed and that acceptable in-tunnel air quality is maintained. The framework would include: • In-tunnel monitoring of carbon monoxide, nitrogen dioxide and / or visibility (extinction coefficient). • Monitoring of traffic conditions and traffic speeds within the main alignment tunnels, and upstream and downstream of the project. • Measures to limit and manage traffic entering the project tunnels in the event of significant congestion conditions that may lead to unacceptable in-tunnel air quality. This may include measures such as lane closures, rapid responses to incidents / breakdowns, and broader traffic network management. • Operational requirements to ensure that operation of the project's ventilation system reflects traffic volumes and in-tunnel air quality requirements. • Provision for the review of the management framework after a period of operation, once sufficient actual in-tunnel air quality and traffic data have been gathered. • Contingency measures in the event of elevated, unexpected in-tunnel air quality (including measures to manage emergency situations). • Provision for publication of relevant in-tunnel air quality performance data. • Review of the performance of smoky vehicle regulation / enforcement and whether additional or amended measures may be required.	Operation

Impact	ID	Environmental management measure	Timing
Local air quality monitoring	OpAQ2	Air quality in the vicinity of the project would be monitored for a specified time period following project opening. If pollutant concentrations contributed by the project are above predicted levels, additional feasible and reasonable mitigation measures would be considered to meet applicable predicted limits.	Operation
Health			
• Operational air quality mitigation and monitoring identified in Section 7.3 (Air quality). • Construction and operational noise and vibration mitigation measures identified in Section 7.2 (Noise and vibration).			
Urban design, landscape character and views			
Construction			
Visual amenity	V1	Existing vegetation around the perimeter of construction sites would be retained where feasible and reasonable.	Construction
	V2	The early implementation of noise walls and landscape planting around ancillary facilities would be investigated in order to provide visual screening and minimise noise impacts during the construction phase.	Construction
	V3	Elements within construction sites would be located to minimise visual impacts as far as feasible and reasonable, eg locating equipment back from site boundaries.	Construction
	V4	The design of acoustic sheds would aim to blend into the background where feasible and reasonable.	Pre-construction / construction
	V5	Design of site hoardings would consider the use of artwork or project information.	Pre-construction / construction
	V6	Regular maintenance would be undertaken of site hoardings and perimeter areas including the prompt removal of graffiti.	Construction
	V7	Revegetation / landscaping would be undertaken progressively.	Construction
Construction lighting	V8	Cut-off and directed lighting would be used and lighting location considered to ensure glare and light spill are minimised.	Construction
Landscaping	V9	Opportunities would be investigated to provide passive irrigation of landscaped areas at the operational ancillary facilities through use of directed overland flow paths.	Pre-construction / construction
	V10	Opportunities would be investigated to flatten landscape batters at the operational ancillary facilities to maximise plant response and maintainability.	Pre-construction / construction
Signage	V11	A signage strategy would be developed during detailed design. Potentially affected receivers would be consulted on the final signage in relation to the location and associated	Pre-construction / construction

Impact	ID	Environmental management measure	Timing
		impacts.	
Operation			
Visual amenity	OpV1	Street tree plantings and landscaping would be used to visually soften operational ancillary facilities.	Construction / post-construction
	OpV2	The urban design and landscaping along the Hills M2 Motorway integration works would be consistent with the recently completed Hills M2 Motorway Upgrade project.	Detailed design
	OpV3	The visual impact of noise walls would be reduced through high quality urban design treatments in accordance with *Noise Wall Design Guideline* (RTA, 2006a).	Construction / post-construction
Landscaping	OpV4	Landscaped areas would be maintained.	Operation
Operational lighting	OpV5	Cut-off and directed lighting would be used at the interchanges, Hills M2 Motorway integration, motorway operations complex and M1 Pacific Motorway tie-in to minimise glare and light spill to surrounding receivers.	Detailed design
Biodiversity			
Construction			
General	B1	A Flora and Fauna Management Plan would be developed for the construction phase of the project to identify potential impacts and mitigation measures.	Pre-construction
Clearing of native vegetation	B2	The disturbance and clearance of established vegetation would be minimised as far as feasible and reasonable.	Pre-construction and construction
	B3	Areas of vegetation to be retained would be protected from accidental damage.	Construction
	B4	Pre-clearing surveys would be undertaken by a suitably qualified ecologist to identify to presence of: • Hollow-bearing trees and other habitat features. • Threatened flora and fauna.	Construction
	B5	Where feasible and reasonable, topsoil and habitat elements (such as woody debris and bushrock) would be stored and reused onsite or in adjacent bushland. Cuttings or seed material may also be gathered from the construction footprint for landscaping plant stock.	Construction
Adverse impacts to riparian zones and aquatic habitats	B6	Temporary watercourse crossings would be designed in accordance with relevant guidelines including Fish and Fauna Friendly Waterway Crossing (Fairfull and Witheridge, 2003).	Construction
	B7	Viaduct and bridge structural elements would be located out of the waterway where feasible and reasonable.	Construction
	B8	Creeks, riparian zones or vegetated buffers disturbed by the project would be revegetated	Construction

Impact	ID	Environmental management measure	Timing
		with the restoration to pre-disturbance conditions.	
Spread of weeds and pathogens	B9	Weeds within the construction footprint would be actively managed prior to vegetation clearing. Cleared weed material would be disposed of to a facility licensed to receive green waste.	Construction
	B10	Machinery would be is cleaned prior to entering the project construction sites.	Construction
	B11	The identification of pathogens would be undertaken as part of pre-clearing inspections. In the event that pathogens are identified within the construction footprint, appropriate mitigation measures would be identified and implemented.	Construction
Loss of Epacris purpurascens	B12	Relocation of *Epacris purpurascens* species where identified within disturbance footprints, ideally to areas identified as a biodiversity offset and / or where future disturbance is unlikely.	Construction
Loss of hollow bearing trees	B13	The loss of hollow bearing trees would be mitigated by: • Relocation / replacement of existing nest boxes impacted by construction. • Nest boxes would be provided as replacement for hollow bearing trees impacted by construction.	Construction
Impact on culverts or buildings with potential threatened bat habitat	B14	A microbat management plan would be developed and implemented including: • Conduct monitoring of existing culverts and buildings commencing at least six months prior to construction / demolition commencing at each relevant culvert or building. • Maintaining appropriate exclusion zones and managing night works through the breeding and lactation period in the vicinity of identified microbat habitat. • Filling pipe joins in culverts identified as not being microbat habitat prior to passive exclusion (eg installation of one-way flaps at potential grab hole locations) to ensure alternative roosting locations are not created in culverts. • Minimising light spill and noise impacts into surrounding native vegetation.	Construction
Impacts on fauna due to draining of stormwater basins	B15	Surveys of stormwater basins would be undertaken by a suitably qualified ecologist prior to draining works to identify the potential presence of fauna. Appropriate fauna handling and release protocols would be established to remove fauna from waterbodies prior to draining works.	Construction
Operation			
General	OpB1	A management plan would be developed and implemented to identify and mitigate potential ongoing impacts including procedures for: • Management of weeds.	Operation

Impact	ID	Environmental management measure	Timing
		• Management of riparian areas associated with the discharge of treated water. • Maintenance of nest boxes.	
Social and economic			
Construction			
Traffic delays and road closures	SEc1	A community involvement plan would be developed and implemented to provide timely, regular and transparent information about changes to access and traffic conditions, details of future work programs and general construction progress throughout the construction phase of the project. Information would be provided in a variety of ways including letter box drops, media releases, internet site, signage and a hotline.	Pre-construction and construction
Reduced parking availability	SEc2	Where feasible and reasonable construction parking would be limited to facility sites to minimise the impact on public parking.	Construction
	SEc3	The need for parking restrictions around the Trelawney Street compound (C7) would be monitored and discussed with Hornsby Shire Council.	Construction
Reduced access to businesses	SEc4	Appropriate signage would be provided to ensure motorists' understanding of access to local businesses adjacent to construction works, including signage relating to parking for stopping motorists.	Construction
Impacts to business	SEc5	A business impact risk register would be maintained to identify and manage the specific impacts associated with construction related works for individual businesses.	Construction
	SEc6	The business stakeholder forum would continue to run throughout the detailed design and construction stages to ensure business concerns are addressed.	Construction
Hydrogeology and soils			
Construction			
General	HS1	A Construction Soil and Water Quality Management Plan would be prepared to manage surface and groundwater impacts during construction of the project.	Pre-construction and construction
Acid sulfate soils	HS2	If acid sulfate soils are encountered, they would be managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).	Construction
Contamination	HS3	A Construction Environmental Management Plan prepared for the project would include provisions to manage unexpected finds and hazardous materials identified during site preparation and / or construction works.	Pre-construction
	HS4	Potentially contaminated areas directly affected by the project would be investigated and managed in accordance with the requirements of the *Contaminated Land Management Act 1997* and Contaminated Sites: Guidelines for Consultants Reporting on Contaminated	Pre-construction

Impact	ID	Environmental management measure	Timing
		Sites (EPA, 1997).	
	HS5	Appropriate mitigation measures including stockpiling and management of potentially contaminated material would be undertaken at building demolition sites to prevent movement of material into receiving waters.	Construction
	HS6	If excavation and off-site disposal of soil is to take place in an area of potential contamination, further delineation and / or waste classification would be undertaken.	Construction
	HS7	Hazardous Materials Assessments would be undertaken, and Hazardous Materials Management Plans implemented, prior to and during the demolition of buildings. Demolition works would be undertaken in accordance with Australian and NSW WorkCover Standards.	Pre-construction and construction
Groundwater management	HS8	A groundwater monitoring plan would be prepared for the duration of the construction period. Parameters to be monitored would include groundwater levels and groundwater quality with field parameters, laboratory parameters and sample frequency to be developed prior to construction.	Pre-construction and construction
	HS9	A groundwater monitoring network to monitor groundwater levels and groundwater quality would be established during the construction phase. The groundwater monitoring network would contain monitoring wells along the project corridor intersecting groundwater in both Ashfield Shale and Hawkesbury Sandstone.	Construction
	HS10	Groundwater captured during construction would be tested, treated and discharged to meet the requirements of the project EPL.	Construction
	HS11	The management of groundwater and surface water inflow into the tunnels, including the design of capture, treatment and discharge methods would be undertaken in consultation with the Environment Protection Authority.	Construction
	HS12	Where available, and of appropriate chemical and biological quality, subject to a health risk assessment, stormwater, recycled water, groundwater inflows to tunnels or other water sources would be used in preference to potable water for construction activities, including concrete mixing and dust control.	Construction
	HS13	Compliance records of groundwater monitoring undertaken would be retained.	Construction
Ground movement	HS14	Further assessments would be undertaken during detailed design to determine the level of potential impact on structures and to identify feasible and reasonable mitigation and management measures required to minimise potential ground movement impacts.	Construction

Impact	ID	Environmental management measure	Timing
Operation			
General	OpHS1	Operations personnel would be competent and trained in systems and procedures.	Operation
Contamination	OpHS2	Procedures to address spills, leaks and tunnel washing would be developed and implemented during operation of the project.	Operation
Groundwater management	OpHS3	The project has been designed to achieve a maximum water discharge quality equivalent to the 95 per cent protection level specified for freshwater eco-systems in accordance with ANZECC guidelines. The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during the detailed design phase taking into consideration the current water quality of the receiving watercourses.	Detailed design
	OpHS4	Feasible and reasonable opportunities would be identified for the reuse of captured groundwater.	Operation
Surface water			
Construction			
General	SW1	A Construction Soil and Water Quality Management Plan would be prepared to manage surface and groundwater impacts during construction of the project.	Pre-construction and construction
Erosion and sedimentation	SW2	Progressive erosion and sediment control plans (ESCPs) would be prepared and implemented in advance of construction, including earthworks and stockpiling. ESCPs would be updated as required.	Pre-construction and construction
	SW3	Erosion and sediment controls, including sedimentation basins, would be designed, installed and managed in accordance with Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom, 2004) and Managing Urban Stormwater: Soils and Construction Volume 2D, Main Road Construction (DECC, 2008).	Pre-construction and construction
	SW4	A project soil conservationist would be engaged and consulted during construction to provide advice on erosion and sediment control design, installation and maintenance.	Pre-construction and construction
	SW5	Works would be programmed to minimise the extent and duration of disturbance to vegetation.	Pre-construction and construction
	SW6	Cleared native vegetation would be mulched for use in erosion and sediment control where feasible and reasonable, in accordance with the Environmental Direction Management of Tannins from Vegetation Mulch (Roads and Maritime, 2012b).	Pre-construction and construction
	SW7	Site induction and ongoing toolbox talks would be provided to project personnel, including relevant sub-contractors on soil erosion and sediment control requirements and practices	Construction

Impact	ID	Environmental management measure	Timing
		and their responsibilities.	
	SW8	Erosion and sediment control structures would remain installed and maintained until sufficient stabilisation is achieved.	Construction
	SW9	Soil and land rehabilitation would occur as soon as practicable following construction. This would include rehabilitation in stages as the construction process allows.	Construction and post construction
	SW10	Temporary stockpile locations for both site establishment and earthworks would be specified prior to the commencement of construction activities in that area. Diversion drains and erosion and sediment control measures would be in place prior to the commencement of any stockpiling activities. Material would only be stockpiled in designated stockpiling areas.	Pre-construction and construction
Protection of riparian areas	SW11	Scour protection and erosion protection measures would be implemented downstream of the watercourse crossings and surface water discharge points.	Pre-construction
	SW12	Where water is released into local creeks, outlet scour protection and energy dissipation would be implemented. The discharge point would be at the upstream end of a large pool where feasible and reasonable, to allow for slowing of water.	Pre-construction
Water efficiency	SW13	Water efficiency measures would be implemented with a focus on achieving water savings and targeting water recycling and re-use.	Pre-construction and construction
Dewatering	SW14	A specific Work Method Statement for dewatering and discharging from open exposed excavations and sediment controls would be prepared, in accordance with the Technical Guideline Environmental Management of Construction Site Dewatering (Roads and Maritime, 2011d).	Construction
	SW15	Water discharge quality would comply with the requirements of an environmental protection licence issued for the project.	Construction
Refuelling and storage of chemicals and fuels on-site	SW16	Where refuelling on-site is required, a Work Method Statement would be prepared and the following management practices would be implemented: • Refuelling would be undertaken on level ground and away from drainage lines, waterways and / or environmentally sensitive areas. • Refuelling would be undertaken within the designated refuelling areas with appropriate bunding and / or absorbent material. • Refuelling activities would be attended at all times. • Spill kits would be readily available and personnel trained in their use. A spill kit would be kept on the refuelling truck at all times.	Construction

Impact	ID	Environmental management measure	Timing
Localised flooding of receiving watercourses	SW17	The discharge of treated groundwater would be managed to ensure that discharge does not exceed the capacity of the downstream system.	Construction
Blocking of fish passage	SW18	Maintain the flow along the current Cockle Creek and Darling Mills Creek alignment through appropriate design.	Construction
	SW19	Design waterway crossings, structures, bridges and culverts to maintain fish passage with reference to the guidelines contained in Guidelines and Policies for Aquatic Habitat Management and Fish Conservation' (Smith and Pollard 1999), Why do fish need to cross the road? Fish passage requirements for waterway crossings (Fairfull and Witheridge, 2003) and Fish and Fauna Friendly Waterway Crossings (Fairfull & Witheridge, 2003).	Pre-construction and construction
Monitoring	SW20	A surface water quality monitoring program for the construction period would be implemented to monitor water quality upstream and downstream of the construction areas. The monitoring program would commence prior to commencement of any construction works and would build on available water quality data.	Pre-construction and construction
	SW21	Inspection of water quality mitigation controls (eg sediment fences, sediment basins) would be carried out regularly and following significant rainfall to detect any breach in performance.	Construction
Operation			
Operational Environmental Management Plan	OpSW1	The management of potential surface water impacts during the operation of the project would be detailed as part of an OEMP.	Operation
Contaminant spill	OpSW2	Procedures to quickly address any contaminant spill or accident would be developed prior to operation and implemented during operation project.	Operation
Water treatment and discharge	OpSW3	Treated tunnel water would be discharged to the local stormwater system. The project has been designed to achieve a maximum water discharge quality equivalent to the 95 per cent protection level specified for freshwater eco-systems in accordance with ANZECC guidelines (ANZECC & ARMCANZ, 2000). The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during the detailed design phase taking into consideration the current water quality of the receiving watercourses.	Detailed design
Water re-use	OpSW4	All feasible and reasonable opportunities for captured surface water reuse would be utilised in the first instance.	Operation
Increased water flow	OpSW5	On-site detention would be provided where required to mitigate impacts associated with increased impervious areas. This would involve the augmentation of existing basins and the construction of new basins.	Operation

Impact	ID	Environmental management measure	Timing
	OpSW6	The exact location of discharge to Blue Gum Creek or Darling Mills Creek would be further investigated during the detailed design phase. Additional mitigation measures such as stream bed and bank stabilisation, or re-sizing of existing drainage infrastructure would be determined at this stage based on the location of discharge.	Detailed design
Water quality	OpSW7	Water Sensitive Urban Design principles would be incorporated into the design to minimise impacts on the existing hydrologic regime. Such measures would include: Minimising increases in peak flows through the use of detention and retention measures as appropriate. Treating stormwater through a range of at source and end point measures that are integrated with the urban landscape.	Detailed design
Drainage maintenance	OpSW8	Operational drainage infrastructure would be regularly inspected and maintained.	Operation
Non-Aboriginal heritage			
Construction			
General	NAH1	In the event of an unexpected cultural heritage find, the Standard Management Procedure – Unexpected Archaeological Finds (Roads and Maritime, 2012d) would be followed. This would include notification to the NSW Heritage Branch.	Pre-construction and construction
	NAH2	Construction personnel would be made aware of non-Aboriginal heritage sites as part the site induction. These sites would be identified on sensitive area plans and in the CEMP.	Pre-construction and construction
Removal of heritage listed vegetation	NAH3	Feasible and reasonable options for the relocation of the two mature Canary Island Palms (I762) would be investigated. If the trees cannot be relocated: • Archival samples would be collected in accordance with NSW Royal Botanic Gardens collection procedures. • Options would be investigated to collect seed samples for later propagation. • Oral histories (if relevant) would be obtained.	Detailed design

Impact	ID	Environmental management measure	Timing
	NAH4	Feasible and reasonable options to avoid direct impacts to identified heritage listed vegetation along Woonona Ave, Wahroonga (I769) would be investigated during detailed design. If impacts cannot be avoided: • The street frontage would be revegetated in consultation with the landowner (Hornsby Shire Council). • Plantings that are representative species of the Blue Gum High Forest ecological community would be considered.	Detailed design
Construction vibration and / or ground settlement	NAH5	Where non-Aboriginal heritage items have been identified as having the potential to be impacted by construction vibration or ground settlement, the following would be implemented: • A ground settlement assessment would be undertaken during detailed design to confirm predicted impacts on heritage structures. • Completion of existing condition surveys prior to the commencement of construction for heritage items within the project corridor or that have been identified during detailed design to be within recommended safe working distances to surface works. A post-construction condition survey would also be undertaken of these items to identify if impacts have occurred. Additional feasible and reasonable mitigation and management measures to be implemented would be identified based on the above assessments. This would include the use of vibration monitoring where recommended maximum levels are predicted to be exceeded. The placement of vibration monitors would consider the heritage fabric of the item.	Pre-construction, construction and post-construction
Impacts to North Wahroonga heritage conservation area and Beecroft Cheltenham heritage conservation area	NAH6	Landscaping of ancillary infrastructure sites would be undertaken with consideration of the heritage values of the Wahroonga North heritage conservation area and Beecroft Cheltenham heritage conservation area.	Detailed design

Impact	ID	Environmental management measure	Timing
Impacts to heritage values due to changes in views (construction)	NAH7	The heritage values of items I771, I953, I956, I957 (including views and vistas from the items) would be considered during the detailed design of built elements of the project and the development of the landscaping plan.	Pre-construction
Removal of heritage listed structures	NAH8	The germination building at the Thornleigh Maltworks (A66) would be conserved. Prior to demolition of other structures: • A structural assessment of the germination structure would be conducted to ascertain the possible impact of the demolition of adjacent structures and to identify suitable mitigation methods to ensure the germination structure remains intact. Additional measures would be identified and implemented, if required, to treat the newly exposed surfaces of the germination structure to protect it from the elements as a result of the demolition of adjacent structures. • An archival recording of the industrial site would be undertaken to record the connection of the original structures to the modern upgraded structures. • An archaeological test excavation program would be undertaken to assess the archaeological potential of identifying evidence of the early malting industry in this area, and the relationship of the industrial to the urban site and evidence of the occupation of the Manager's house by the Chilvers family.	Pre-construction
Operation			
Impacts to heritage values due to changes in views (operation)	OpNAH1	The heritage values of items I771, I953, I956, I957 (including views and vistas from the items) would be considered during the detailed design of built elements of the project and the development of the landscaping plan.	Detailed design / Pre-construction
Aboriginal heritage			
Construction			
Impacts on culturally sensitive Aboriginal sites	AH1	The detailed design of the project would be developed to avoid direct impacts on ASA1 or ASA2 management zones. If direct impacts to ASA1 or ASA2 management zones cannot be avoided, a Stage 3 assessment would be conducted with reference to the Roads and Maritime PACHCI process (Roads and Maritime, 2011c).	Pre-construction and construction
	AH2	In the event that the project is required to extend outside the assessed construction footprint or study area, these additional areas would be assessed in accordance with PACHCI prior to the commencement of construction within those identified areas.	Pre-construction and construction

Impact	ID	Environmental management measure	Timing
Impacts on rockshelter sites	AH3	The identified rockshelter sites and overhangs located within 200 metres of the Hills M2 Motorway integration works should be clearly delineated prior to construction works.	Construction
Indirect impacts on rockshelter sites	AH4	During construction, vibration monitoring would be conducted for vibration intensive works within 50 metres of rockshelter sites and associated overhangs within management zone ASA2. The need for vibration monitoring would be informed by a preliminary screening of activities at this location to identify activities which have the potential for vibration at these areas of sensitivity.	Construction
Unexpected discovery of Aboriginal objects	AH5	If an Aboriginal object(s) is discovered during construction it would be managed in accordance with the standard management procedure: Unexpected Archaeological Finds (Roads and Maritime, 2012d), including: • Relevant works in the vicinity of the object(s), with the potential to directly or indirectly impact on the object(s), would cease. • The construction Environmental Representative, OEH and Registered Aboriginal Parties (RAPs) would be notified of the discovery. • A qualified archaeologist would be engaged to determine the nature, extent and scientific significance of the object(s). • Management recommendations would be developed in consultation with the qualified archaeologist, OEH and RAPs.	Construction
Unexpected discovery of human remains	AH6	If human remains are discovered during construction would be managed in accordance with the standard management procedure: Unexpected Archaeological Finds (Roads and Maritime, 2012d), including: • Relevant works in the vicinity of the remains, with the potential to directly or indirectly impact on the remains, would cease. • The construction Environmental Representative, OEH and NSW Police would be notified of the discovery. • Directions from the NSW Police and / or OEH, as relevant, would be followed depending on the nature of the remains and the outcomes of forensic investigations.	Construction
Land use and property			
Construction			
Property access	LP1	Affected property owners would be consulted where temporary property access would be required.	Pre-construction and construction

Impact	ID	Environmental management measure	Timing
	LP2	Affected property owners would be provided with advanced notification of relevant project schedules, construction works and changes to access arrangements.	Construction
	LP3	Community updates would be provided on changes to the local road network within the project area during construction.	Construction
Temporary lease or acquisition of property required for the project	LP4	Consultation would occur with the relevant property owners in relation to temporary land leases and acquisition of properties required temporarily for the construction of the project. Where acquisition is identified as the preferred option, this would be undertaken in accordance with the Land Acquisition Information Guide (Roads and Maritime, 2012c) and the *Land Acquisition (Just Terms Compensation) Act 1991.*	Construction
Community facilities	LP5	Appropriate signage would be provided advising of walking track closures and alternative walking routes.	Construction
Operation			
Acquisition of property required for the project	OpLP1	Land acquisition for the project would be undertaken in accordance with the Land Acquisition Information Guide (Roads and Maritime, 2012c) and the *Land Acquisition (Just Terms Compensation) Act 1991*.	Detailed design / pre-construction
Loss of land use and property access	OpLP2	Property accesses that are affected as a result of the project would be reinstated in consultation with the affected landowners including relocation if required.	Detailed design / construction
Hazards and risks			
Construction			
General	HR1	Site-specific hazard and risk management measures would be included within the Construction Environmental Management Plan (CEMP), which may include items such as: • Details of the hazards and risk associated with construction activities for both surface and subsurface works. • Procedures to comply with legislative and industry standard requirements. • Contingency plans, as required. • Site-specific Work Health and Safety plans and Safe Work Method Statements. • Training for relevant personnel (including subcontractors) and site inductions, including the recognition and awareness of site hazards and locations of relevant equipment.	Pre-construction / construction
Storage of dangerous goods and hazardous substances	HR2	Storage of dangerous goods and hazardous materials would occur in accordance with supplier's instructions and relevant Australian Standards and may include bulk storage tanks, chemical storage cabinets / containers or impervious bunds.	Construction

Impact	ID	Environmental management measure	Timing
	HR3	Storage, handling and use of dangerous goods and hazardous substances would be in accordance with the *Occupational Health and Safety Act 2000* and the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005).	Construction
	HR4	Secure, bunded areas would be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds would be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Construction
	HR5	Bunds would be provided around activities such as vehicle refuelling, servicing, maintenance or wash-down, where there is a potential for spills and contamination.	Construction
	HR6	Material Safety Data Sheets would be obtained for dangerous goods and hazardous substances stored on-site prior to their arrival.	Construction
Transportation of dangerous goods and hazardous substances	HR7	Transport of dangerous goods and hazardous substances would be conducted in accordance with relevant legislation and codes, including the *Road and Rail Transport (Dangerous Goods) (Road) Regulation 1998* and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission, 2008).	Construction
Operation			
Fire and life safety	OpHR1	The fire and safety systems and measures adopted for the project would be equivalent to or exceed the fire safety measures recommended by NFPA502 (American), PIARC (European), AS4825 (Australian) and Roads and Maritime standards.	Detailed design
Storage of dangerous goods and hazardous substances	OpHR2	Storage of dangerous goods and hazardous materials would occur in accordance with supplier's instructions and relevant Australian standards and may include bulk storage tanks, chemical storage cabinets / containers or impervious bunds.	Operation
	OpHR3	Storage, handling and use of dangerous goods and hazardous substances would be in accordance with the *Occupational Health and Safety Act 2000* and the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005).	Operation
	OpHR4	Secure, bunded areas would be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds would be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Operation
	OpHR5	Bunds would be provided around activities such as vehicle refuelling, servicing, maintenance or wash-down, where there is a potential for spills and contamination.	Operation
	OpHR6	Material Safety Data Sheets would be obtained for dangerous goods and hazardous substances stored on-site prior to their arrival.	Operation

Impact	ID	Environmental management measure	Timing
Transportation of dangerous goods and hazardous substances	OpHR7	The transport of dangerous goods and hazardous substances would be prohibited through the main alignment tunnels and on and off-ramp tunnels.	Operation
Incident response	OpHR8	An Incident Response Plan would be developed and implemented in the event of an accident or incident.	Operation
	OpHR9	The response to incidents within the motorway would be managed in accordance with the memorandum of understanding between Roads and Maritime and the NSW Police Service, NSW Rural Fire Service, NSW Fire Brigade and other emergency services	Operation
Electric and magnetic fields	OpHR10	The detailed design of the project substations would ensure that the exposure limits for the general public suggested by the Draft Radiation Standard (Australian Radiation Protection and Nuclear Safety Agency, 2006) would not be exceeded at the boundary of the substation sites.	Detailed design
Resources and waste			
Construction			
Resource consumption	RW1	Wherever feasible and reasonable, construction material would be sourced from within the Sydney region.	Pre-construction and construction
	RW2	Unnecessary resource consumption would be avoided by making realistic predictions on the required quantities of resources, such as construction materials.	Construction
	RW3	Resource recovery, which includes re-use, recycling and reprocessing, would be applied to the management of construction waste and would include: • Recovery of resources for reuse. Waste materials generated by the project would be re-used either on-site or off-site where possible, including the re-use of top soil in landscape works, and the use of mulch for erosion and sediment controls. • Recovery of resources for recycling. Resources would be segregated for recycling such as paper, plastic, glass, aluminium cans and other recyclable materials generated during construction. These materials would then be sent to an appropriate recycling facility for processing. • Recovery of resources for reprocessing. Cleared vegetation would be mulched or chipped on-site and used for landscaping, in the absence of a higher beneficial use being identified.	Construction

Impact	ID	Environmental management measure	Timing
Management of waste	RW4	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies including the *Protection of the Environment Operations Act 1997, Waste Avoidance and Resource Recovery Act 2001,* Waste Avoidance and Resource Recovery Strategy 2007 (DECC, 2007c) and the Waste Reduction and Purchasing Policy (RTA, 2009).	Pre-construction and construction
	RW5	A Waste Management Plan would be prepared as part of the Construction Environmental Management Plan detailing appropriate procedures for waste management.	Pre-construction and construction
	RW6	Wastes would be managed using the waste hierarchy principles of: • Avoidance of unnecessary resource consumption to reduce the quantity of waste being generated • Recover of resources for re-use on-site or off-site for the same or similar use, without reprocessing. • Recover of resources through recycling and reprocessing so that waste can be processed into a similar non-waste product and re-used. • Disposal of residual waste.	Construction
	RW7	Residual waste would be disposed of to a suitably licensed landfill or waste management facility where there are no other feasible and reasonable options for waste avoidance, re-use or recycling. Waste materials requiring removal from the site would be classified, handled and stored on-site in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c) until collection by a contractor for disposal.	Prior to / during construction
	RW8	Off-site re-use of waste would comply with relevant EPA resource recovery exemptions and requirements.	Construction
	RW9	An asbestos survey would be undertaken of buildings to be demolished as part of the project. The survey would be conducted by a suitably qualified person.	Construction
	RW10	Asbestos handling and management would be undertaken in accordance with: • Work Health and Safety Act 2011. • Code of Practice for the Safe Removal of Asbestos 2nd Edition (NOHSC, 2005a). • Code of Practice for the Management and Control of Asbestos in Workplaces (NOHSC, 2005b). • Protection of the Environment Operations (Waste) Regulation 2005 – section 42 special requirements relating to asbestos waste. • AS2601:1991 Demolition of Structures.	Construction

Impact	ID	Environmental management measure	Timing
Excess spoil	RW11	A spoil management strategy would be developed prior to the commencement of construction and implemented during construction. The strategy would identify spoil disposal site and describe the management of spoil on -site and during off-site transport.	Pre-construction
	RW12	Where possible and fit for purpose, spoil would be beneficially re-used within the project before off-site re-use or disposal options are pursued.	Construction
	RW13	Before being transported from construction sites, excavated spoil would be classified in accordance with the Waste Classification Guidelines: Part 1 Classifying Waste (DECCW, 2009c) to ensure appropriate reuse or disposal.	Construction
Wastewater	RW14	Feasible and reasonable opportunities for wastewater re-use on-site or for construction purposes would be pursued (such as dust suppression both in the tunnels and for surface works).	Construction
	RW15	Wastewater not used on-site would be discharged into the local stormwater system in accordance with the requirements of an environment protection licence issued for the project.	Construction
Contaminated soil	RW16	In the event of discovery of previously unidentified area(s) of potentially contaminated material, all relevant work would cease in the vicinity of the discovery. Relevant works would not recommence until the need for and scope of remedial action(s), if required, are identified in accordance with the requirements of the *Contaminated Land Management Act 1997*.	Construction
Operation			
Management of waste	OpRW1	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies including the *Protection of the Environment Operations Act 1997, Waste Avoidance and Resource Recovery Act 2001,* Waste Avoidance and Resource Recovery Strategy 2007 (DECC, 2007c) and the Waste Reduction and Purchasing Policy (RTA, 2009).	Operation
	OpRW2	Any mercury containing light globes used for the operation of the tunnel and operational ancillary facilities would be recycled at an accredited recycling facility.	Operation
Operational water requirements	OpRW3	Opportunities for re-use of wastewater would be considered including irrigation of landscapes within the project, irrigation of Pennant Hills Golf Club and / or local parks in preference to discharge to the local stormwater system.	Operation
	OpRW4	In order to reduce demand on local water supplies, investigate options for providing water required for operation of the deluge system from wastewater produced through the tunnel drainage system where it meets appropriate quality parameters.	Operation

Impact	ID	Environmental management measure	Timing
Greenhouse gas and climate change			
Construction			
GHG emissions	GHG1	Emissions intensity of construction materials would be considered during procurement.	Procurement
	GHG2	Where feasible, recycled content road construction and maintenance materials such as recycled aggregates in road pavement and surfacing would be used.	Procurement
	GHG3	The fuel efficiency of the construction plant and equipment would be considered during selection.	Procurement / pre-construction
	GHG4	Project planning would be aim to minimise double handling of materials, long haulage distances and additional fuel use.	Prior to construction
	GHG5	Locally produced goods and services would be procured where feasible and cost effective to reduce transport fuel emissions.	Procurement / pre-construction
Climate change impacts	CC1	The risks of future climate change would be further considered during detailed design.	Detailed design
	CC2	Where high or medium risks to project infrastructure have been identified, the construction contractor would review existing design policies, specifications or practices to consider the impacts of climate change.	Detailed design
Operation			
GHG emissions	OpGHG1	The tunnel would be designed to minimise fuel use associated with motorist use of the road through the optimisation of design, for example the provision of a vertical alignment that allows consistent vehicle speeds to be maintained.	Detailed design
	OpGHG2	Low carbon energy generation options would be investigated as part of the design process in order to reduce the demand on mains electricity where feasible.	Detailed design
	OpGHG3	A life cycle assessment would be undertaken as part of the detailed design in order to select mechanical and electrical systems with increased energy efficiencies, such as the tunnel ventilation system, water treatment systems and electronic toll and surveillance systems.	Detailed design
Climate change impacts	OpCC1	A stop work threshold (eg for extreme heat, storm events) for operation and maintenance activities would be implemented in line with current workplace health and safety practices.	Operation
	OpCC2	Emergency planning and management controls would be implemented during operation to reduce the risk of adverse climate impacts, maintain public safety and minimise congestion. For example, bushfire management would include measures to ensure safety such as reduced speed limits and temporary tunnel closures where required (refer to **Section 8.2** Hazards and risk).	Operation

Impact	ID	Environmental management measure	Timing
	OpCC3	Maintenance regimes for road surface and other ancillary infrastructure would be developed to accommodate accelerated rates of asset degradation.	Operation
	OpCC4	The motorway operator would develop emergency response management plans in consultation with emergency management services, local governments and other relevant agencies to ensure better disaster management during extreme climate events.	Operation
	OpCC5	The motorway operator would monitor and review the performance of structures and materials in response to climate change related events. Where possible, the most cost-effective response would be to include adaptive measures in the regular maintenance of the project.	Operation

10 Environmental risk analysis

A detailed environmental risk analysis was conducted as part of this environmental impact statement. This chapter outlines the environmental risk analysis process and identifies the key environmental issues.

Table 10-1 sets out the Director-General's Requirements as they relate to risk analysis and where these have been addressed in the environmental impact statement.

Table 10-1 Director-General's Requirements – environmental risk analysis

Director-General's Requirement	Where addressed
Notwithstanding the key issues identified for consideration, the EIS must include an environmental risk analysis to identify the potential environmental impacts associated with the infrastructure.	This chapter

10.1 Environmental risk analysis process

An environmental risk analysis has been carried out to identify and confirm the key environmental issues for the project. Key issues are those that may have major or moderate impacts (actual or perceived) and require detailed assessment to determine the level or severity of potential effects and to identify appropriate mitigation and management measures.

The environmental risk analysis process carried out for the project included:

- Preliminary environmental assessment carried out as part of the State significant infrastructure application report (AECOM, 2013g) and subsequent State significant infrastructure supplementary report (AECOM, 2014c) to help identify the key environmental issues and to inform the State significant infrastructure application.
- An assessment of the key issues identified in the Director-General's Requirements for the project (**Appendix A**).
- An environmental risk review to confirm the key environmental issues based on the results of the detailed investigations presented in this environmental impact statement.

These steps are described further in **Section 10.2** to **Section 10.4** below.

10.2 Preliminary environmental assessment

A preliminary environmental assessment was undertaken prior to the preparation of this environmental impact statement to inform the State significant infrastructure application for the project. The outcomes of this preliminary assessment identified the following key environmental issues for the project:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Biodiversity.
- Urban design, landscape character and visual amenity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.

The outcomes of the preliminary environmental assessment were documented in the State Significant Infrastructure Application Report, which was submitted to the Director-General of the then NSW Department of Planning and Infrastructure. The purpose of the application report was to assist the Director-General in identifying the environmental impact assessment requirements for the project, including the key issues to be addressed in the environmental impact statement.

10.3 Assessment of the key issues identified in the Director-General's Requirements

The key issues identified in the Director-General's Requirements are consistent with but add to the key issues identified in the State significant infrastructure application report. The Director-General's Requirements identified the following as the key issues to be addressed in the environmental impact statement for the project:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Health.
- Urban design, landscape character and visual amenity.
- Biodiversity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.
- Non-Aboriginal heritage.
- Aboriginal heritage.
- Community liaison.

The issues listed above have been assessed in detail as part of the preparation of this environmental impact statement. The results of this assessment are presented in **Chapter 7**, with stakeholder and community engagement detailed in **Chapter 6**.

10.4 Risk analysis framework

The environmental risk analysis has been undertaken in accordance with the principles of the *Australian and New Zealand standard AS/NZS ISO 31000: 2009 Risk Management – Principles and Guidelines*. The risk analysis involved:

- Ranking the risk of each identified potential impact by identifying the consequences of the impact and the likelihood of each impact occurring.
- Considering the probable effectiveness of the proposed mitigation measures to determine the likely residual risk of each impact.

The first step involved the identification of the consequence, should an impact occur. Definitions of the consequences used as a guide are provided in **Table 10-2**.

Table 10-2 Risk analysis consequence definitions

Consequence level	Definition
Catastrophic	Long term (greater than three months) and irreversible impacts. Resulting in a major prosecution under relevant environmental legislation.
Major	Medium term (between one month and three months) and potentially irreversible impacts. Resulting in a fine or equivalent penalty notice under relevant environmental legislation.
Moderate	Moderate and reversible impacts, or medium term (between one and three months).
Minor	Minor and reversible, or short term impacts (less than one month)/
Insignificant	Minor, negligible impacts.

The next step in the risk analysis involved an assessment of the likelihood of the consequence, considering the frequency of activities that are to occur. The definitions of likelihood used as a guide are provided in **Table 10-3**.

Table 10-3 Risk analysis likelihood definitions

Likelihood	Definition	Probability
Almost certain	The event is almost certain to occur in the course of normal or abnormal construction / operational circumstances.	>90%
Likely	The event is more likely than not to occur in the course of normal construction / operational circumstances.	51% - 90%
Possible	The event may occur in the course of normal construction / operational circumstances.	26% - 50%
Unlikely	The event is unlikely to occur in the course of normal construction / operational circumstances.	5% - 25%
Very unlikely	The event may occur in exceptional construction / operational circumstances only.	<5%

The risk rating was then determined by combining the consequence and likelihood according to the matrix in **Table 10-4**.

Table 10-4 Risk Matrix

Consequences	Likelihood				
	Very unlikely	Unlikely	Possible	Likely	Almost certain
Catastrophic	15	19	22	24	25
Major	10	14	18	21	23
Moderate	6	9	13	17	20
Minor	3	5	8	12	16
Insignificant	1	2	4	7	11

Table 10-5 Risk rating categories

Risk rating score	Risk category	Comments
23 - 25	Extreme	Assessment and planning is necessary to avoid these potential impacts to the greatest extent possible.
19 – 22	Very high	Detailed assessment and planning is necessary to develop appropriate measures to mitigate the potential impacts wherever possible.
13 – 18	High	Detailed assessment and planning is necessary to develop appropriate measures to mitigate the potential impacts.
8 – 12	Moderate	Potential impacts can be mitigated through the application of relatively standard environmental mitigation measures.
1 - 7	Low	Potential impacts either require no specific mitigation measures or are adequately mitigated through other working controls (such as detailed design requirements, normal working practice, quality and safety controls)

10.5 Environmental risk analysis

Using the risk framework in **Section 10.4**, an environmental risk analysis has been undertaken for the project including a consideration of the key issues. The analysis is structured towards risk minimisation outcomes. The residual risk rating has been arrived at after the application of mitigation measures developed and recommended by this environmental impact statement (**Chapters 7** to **9**). The results of the risk analysis are presented in **Table 10-5**.

Table 10-5 Environmental risk analysis

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Key issues								
Traffic and transport	**Construction**							
	Reduced safety for road users, cyclists and pedestrians during construction.	Major	Likely	21 Very high	Traffic Management Plans would be developed to identify measures to manage road safety. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Unlikely	5 Low
	Reduction in traffic efficiency for local and regional traffic due to construction activities.	Moderate	Almost certain	20 Very high	Traffic Management Plans would identify measures to manage road network disruptions. Works would be undertaken offline wherever feasible and reasonable. Works on live roads would be staged in minimise disruptions. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Almost certain	16 High
	Traffic impacts and delays due to temporary road and / or lane closures.	Moderate	Likely	17 High	Traffic Management Plans would identify measures to manage road network disruptions.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Works on live roads would be staged in minimise disruptions. Further details on management and mitigation measures are provided in **Section 7.1**.			
	Impacts to emergency services	Major	Likely	21 Very high	Traffic Management Plans would be developed in consultation with emergency services. Communication systems would be in place with traffic controllers to provide appropriate access and routes for emergency vehicles to bypass queued traffic. Further details on management and mitigation measures are provided in **Section 7.1**.	Moderate	Unlikely	9 Moderate
	Operation							
	Impacts on cyclists	Insignificant	Unlikely	2 Low	Existing access for cyclists would be reinstated following construction. Further details on management and mitigation measures are provided in **Section 7.1**.	Insignificant	Unlikely	2 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Reduction in intersection performance around the southern and northern interchanges	Moderate	Almost Certain	20 Very high	The project has been designed with the aim of minimising deterioration in the performance of existing intersections. However there would be some minor deterioration of intersection performance due to the introduction of the tunnel and new turning movements. Further details on management and mitigation measures are provided in **Section 7.1**.	Moderate	Possible	13 High
	Reduction in road safety.	Minor	Very Unlikely	3 Low	A road safety audit would be undertaken by qualified auditors as part of the detailed design phase of the project, and again immediately prior to project opening, to examine the project design from a road safety perspective and to identify potential safety issues. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Very Unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Noise and vibration	**Construction**							
	Noise impacts to surrounding receivers from construction activities, including out of hours works	Moderate	Almost Certain	20 Very high	Construction noise impacts would be managed through a construction noise and vibration management plan. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Likely	17 High
	Noise impacts from construction traffic	Moderate	Almost Certain	20 Very high	Heavy vehicle movements outside of standard daytime construction hours would be minimised as far as feasible and reasonable. Heavy vehicle movements outside of standard construction hours associated with tunnel support works would only occur via access and egress directly to and from Pennant Hills Road or the M1 Pacific Motorway. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Likely	17 High

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Vibration impacts during construction	Moderate	Possible	13 High	Safe working distances for plant and equipment would be complied with where feasible and reasonable. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Unlikely	9 Moderate
	Operation							
	Increase road traffic noise	Major	Almost certain	23 Extreme	Low noise road surface has been incorporated into the design of the project for at surface motorway areas. The operational road traffic noise assessment has identified the requirement for and locations of noise barriers and at property acoustic treatment. A number of these properties are already experiencing acute noise levels in the absence of the project. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Possible	13 High

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Air quality	**Construction**							
	Dust impact to surrounding receivers.	Moderate	Likely	17 High	Potential dust emissions from construction would be managed through standard mitigation measures. Underground tunnels would be ventilated during construction in order to provide safe working environment for the construction workforce. Further details on management and mitigation measures are provided in **Section 7.3**.	Minor	Possible	8 Moderate
	Exhaust emissions during construction.	Minor	Likely	12 Moderate	Plant and equipment used during construction would comply with the *Protection of the Environment Operations (Clean Air) Regulation 2010*. Further details on management and mitigation measures are provided in **Section 7.3**	Minor	Possible	8 Moderate
	Odours from groundwater treatment plants.	Minor	Unlikely	5 Low	If odours arise, appropriate management measures would be developed as part of the Air Quality Management Plan.	Minor	Very unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.3**			
	Operation							
	Air quality impact in the vicinity of ventilation outlets.	Insignificant	Unlikely	2 Low	Air quality in the vicinity of the project would be monitored for a specified time period following project opening. If pollutant concentrations are above predicted levels, additional feasible and reasonable mitigation measures would be considered to meet applicable predicted limits. Further details on management and mitigation measures are provided in **Section 7.3**.	Insignificant	Unlikely	2 Low
	In-tunnel air quality.	Minor	Possible	8 Moderate	An operational air quality management plan would be developed to manage air quality within the tunnels. Further details on management and mitigation measures are provided in **Section 7.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Human health	**Construction**							
	Adverse health outcomes from construction noise	Moderate	Likely	17 High	Impacts to health from construction noise would be managed through a construction noise and vibration management plan developed prior to construction. Further details on management and mitigation measures of construction noise are provided in **Section 7.2**.	Minor	Possible	8 Moderate
	Operation							
	Adverse health outcomes from air pollutants	Insignificant	Unlikely	2 Low	Mitigation measures relevant to potential adverse health impacts from air pollutants are provided in **Section 7.3**.	Insignificant	Unlikely	2 Low
	Adverse health outcomes for in-tunnel air quality exposure	Insignificant	Unlikely	2 Low	Mitigation measures relevant to potential adverse health impacts from air pollutants are provided in **Section 7.3**	Insignificant	Unlikely	2 Low
	Adverse health outcomes from operational noise	Moderate	Likely	17 High	Mitigation measures relevant to potential adverse health impacts from noise and vibration are provided in **Section 7.3**	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Urban design, landscape character and visual amenity	**Construction**							
	Visual impacts from the introduction of construction activities and construction ancillary facilities.	Moderate	Likely	17 High	Opportunities to minimise the visual impact of construction activities and facilities would be considered, where possible, including landscaping and rehabilitation following construction. Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Likely	12 Moderate
	Visual impact of construction night lighting.	Moderate	Likely	17 High	Mitigation measures would be adopted to reduce potential construction lighting impacts including the use of directional lights and cut off fittings. Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Possible	8 Moderate
	Operation							
	Visual impacts from the introduction of operational surface infrastructure	Moderate	Likely	17 High	During detailed design, opportunities to minimise the visual impact of the project would be considered.	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.5**.			
	Visual impact of operational lighting.	Moderate	Likely	17 High	Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Possible	8 Moderate
Biodiversity	**Construction and operation**							
	Loss of or disturbance to endangered ecological communities (EECs).	Major	Almost certain	23 Extreme	Opportunities to minimise the loss of EECs would be investigated during detailed design. The permanent loss of EEC vegetation would be offset. The details of vegetation offsets would be provided in a Biodiversity Offset Strategy. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Disturbance to terrestrial habitats, including increased fragmentation, edge effects, reduced connectivity and disturbance to wildlife corridors.	Moderate	Likely	17 High	A Flora and Fauna Management Plan(s) would be prepared to detail measures to manage potential impacts on habitat for threatened flora and fauna.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.6**.			
	Impacts to or removal of threatened or migratory species (aquatic and terrestrial).	Major	Almost certain	23 Extreme	Further field surveys would be carried out prior to the commencement of construction, to confirm the actual extent of clearing of *Epacris purpurascens* var. *purpurascens*. Opportunities to avoid or minimise impacts to individual would be investigated during the detailed design phase. Direct impact to *Epacris purpurascens* var. *purpurascens* would be offset as part of the Biodiversity Offset Strategy. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Disturbance to aquatic habitats and reductions in water quality.	Moderate	Likely	17 High	During construction discharge would be treated to meet the requirements of an environment protection	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					licence issued for the project. Operational discharge water quality level would be agreed with NSW EPA. Further details on management and mitigation measures are provided in **Section 7.6**.			
	Invasion of environmental weed species.	Moderate	Possible	13 High	Weed management strategies would be implemented during the construction and operation of the project. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Increased mortality or injuring of fauna during construction and operation.	Moderate	Possible	13 High	Management of fauna during construction and operation would be in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011b). Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Alterations to surface water flow regimes and interruptions to fish passage.	Moderate	Possible	13 High	Creek crossings would be constructed in accordance with relevant guidelines. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
Social and economic	**Construction**							
	Amenity impacts from construction activities, such as noise, dust and visual impacts.	Moderate	Possible	13 High	Construction amenity impacts would be managed as per the traffic and transport; noise and vibration; air quality; and urban design, landscape character and visual amenity sections above. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low
	Construction traffic impacts, including, temporary disruptions and delays to local and regional traffic and temporary changes to access arrangements to local properties.	Moderate	Possible	13 High	Alterations to traffic flow and access would be managed through the implementation of Traffic Management Plans. Further details on management and mitigation measures are provided in **Section 7.7.**	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Operation							
	Reductions in amenity, particularly around the northern and southern interchanges, and the tunnel support facilities.	Moderate	Likely	17 High	Visual amenity impacts associated with new structures would be managed through design as described in **Section 7.5**. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Possible	8 Moderate
	Severance of communities, including property acquisition, severance of properties and reduced access to community and recreational facilities.	Minor	Unlikely	5 Low	*All property acquisition would be undertaken in accordance with the Land Acquisition (Just Terms Compensation) Act 1991.* Alterations to local roads have been designed to not change the existing movements available from properties to the arterial road network. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Impacts on local businesses, including decreased turnover for businesses along Pennant Hills Road as a result of decreases in passing trade.	Moderate	Likely	17 High	Management and mitigation measures are provided in **Section 7.7**. There is also the potential for an increase in turnover from local customers due to increased amenity and accessibility.	Minor	Likely	12 Moderate
	Impacts to community facilities.	Minor	Possible	8 Moderate	Amenity and traffic related mitigation measures would be implemented to manage impacts to community facilities. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low
Hydrogeology and soils	**Construction**							
	Exposing, disturbing or spreading acid sulfate soils.	Minor	Very unlikely	3 Low	In the event that acid sulphate soils (ASS) are encountered, they would be effectively managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998). Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Very unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Impacts on groundwater quality and quantity, including drawdown.	Moderate	Likely	17 High	During detailed design, additional geotechnical investigations would be completed to inform design opportunities to minimise impacts on groundwater quality and drawdown. If groundwater drawdown impacts are identified, consultation would occur with the groundwater users to develop appropriate mitigation. Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Possible	8 Moderate
	Exposure and release of contamination at Pioneer Avenue compound (C8)	Major	Possible	18 High	Potentially contaminated areas directly affected by the project would be investigated and managed in accordance with the requirements of the *Contaminated Land Management Act 1997* and Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites (EPA, 1997).	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.8**.			
	Operation							
	Groundwater inflow into the tunnel resulting in localised groundwater drawdown.	Moderate	Likely	17 High	During detailed design, additional geotechnical investigations would be completed to inform design opportunities to minimise impacts on groundwater quality and drawdown. If groundwater drawdown impacts are identified, consultation would occur with the groundwater users to develop appropriate mitigation. Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Possible	8 Moderate
Surface water	**Construction**							
	Downstream water quality impacts from water discharge.	Moderate	Likely	17 High	The discharge of water would occur in accordance with the provision of an environment protection licence issued for the project.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.9**.			
	Changes to surface water flow regimes	Moderate	Likely	17 High	The location of the discharge points would be investigated in order to prevent erosion and sedimentation impacts. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Possible	8 Moderate
	Erosion and sedimentation during and following construction.	Major	Likely	21 Very high	Erosion and sedimentation would be managed in accordance with the Blue Book 2 (Department of Environment and Climate Change (DECC), 2008) and follow the Roads and Maritime Erosion and Sediment Management Procedure (Roads and Further details on management and mitigation measures are provided in **Section 7.9**.	Moderate	Possible	13 High
	Spills from construction vehicles, equipment and plant.	Major	Possible	18 High	Construction equipment would be maintained to reduce the potential for spills and leaks.	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Spill response procedures would be implemented on-site to respond to spills and to limit the potential for off-site impacts. Further details on management and mitigation measures are provided in **Section 7.9**.			
	Operation							
	Modifications to existing drainage infrastructure resulting in water quality impacts.	Moderate	Possible	13 High	Works in the vicinity of existing waterways would be managed to protect bed and bank stability. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Unlikely	5 Low
	Impact to surface water quality and receiving environments from spillages due to vehicle and truck accidents.	Major	Possible	18 High	The operational drainage infrastructure includes provision for capture of hydrocarbons in the event of a spillage. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Unlikely	5 Low
	Downstream water quality impacts from water discharge.	Moderate	Likely	17 High	The discharge water quality level would be determined in consultation	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					with the NSW Environment Protection Authority during the detailed design phase taking into consideration the current water quality of the receiving watercourses. Further details on management and mitigation measures are provided in **Section 7.9**.			
	Changes to surface water flow regimes.	Moderate	Likely	17 High	Further investigation would be undertaken in relation to the specific discharge point and waterway stabilisation works if required in order to manage downstream erosion and sedimentation. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Possible	8 Moderate
	Impact to surface water quality and receiving environments due to runoff from road surfaces.	Moderate	Likely	17 High	Water captured within the tunnels would be treated at the water treatment plant prior to discharge. Where changes would occur to surface roads,	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					existing operational drainage system and detention basins would be augmented, as required, to manage the additional drainage catchment area. Further details on management and mitigation measures are provided in **Section 7.9**.			
Non-Aboriginal heritage	**Construction and operation**							
	Potentially direct impact to a heritage item.	Moderate	Possible	13 High	Where feasible and reasonable, plant and equipment would be selected to maintain safe working distances to minimise the potential for vibration related impacts. Further assessments would be undertaken during detailed design to determine the level of potential impact on structures and to identify appropriate mitigation and management measures to minimise these impacts. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Indirect impacts (visual context and surrounds) to heritage items.	Moderate	Possible	13 High	Further investigations would be undertaken during the detailed design phase to minimise these potential impacts where reasonable and feasible. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Unlikely	5 Low
	Direct impact to the heritage listed Thornleigh Maltworks (ID No A66 under the Hornsby LEP).	Moderate	Almost certain	20 Very high	An archival recording would be undertaken to record the connection of the original structures with the modern structures. An archaeological test excavation would also be undertaken. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Likely	12 Moderate
	Direct impact to a heritage listed garden at the northern interchange (ID No I762 under the Hornsby LEP), including two heritage listed trees.	Minor	Almost certain	16 High	Options to avoid direct impacts or to identify an appropriate area on the site for relocation would be investigated during the detailed design phase. Further details on management and	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					mitigation measures are provided in **Section 7.10**.			
	Partial and direct impacts to the Beecroft – Cheltenham heritage conservation area (ID No C2 under the Hornsby LEP), the Wahroonga North heritage conservation area (ID No C8 under the Hornsby LEP) and Street trees (ID No I769).	Minor	Likely	12 Moderate	Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Possible	8 Moderate
	Partial and direct impacts to Street Trees (ID No I769).	Minor	Almost certain	16 High	Measures to avoid direct impacts to the specific listed vegetation "*Blue Gum High Forest*" would be investigated during the detailed design phase. If avoidance is not feasible or reasonable the impact would be mitigated through sympathetic plantings of similar species as part of landscaping / revegetation.	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.10**.			
Aboriginal cultural heritage	**Construction and operation**							
	Impact to recorded archaeological sites and potentially archaeologically sensitive areas (ASAs).	Minor	Possible	8 Moderate	Sensitive Aboriginal archaeological and cultural heritage areas and sites would be delineated prior to the commencement of construction works in the vicinity of these items / areas. Monitoring would be carried out to ensure that indirect impacts, such as vibration, would not pose the potential for adverse impacts on these areas and sites. Further details on management and mitigation measures are provided in **Section 7.11**.	Minor	Unlikely	5 Low
Other issues								
Land use and property	**Construction**							
	Temporary acquisition.	Moderate	Almost certain	20 Very high	Discussions would be undertaken with affected property owners regarding acquisition of or leasing the required land in the	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					short term during the construction phase of the project. All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Further details on management and mitigation measures are provided in **Section 8.1**.			
	Impacts on community facilities – walking track under Darling Mills Creek viaduct.	Minor	Likely	12 Moderate	Options would be investigated for opening of the walking track at Darling Mills Creek Viaduct on the weekend or at other times when works are not actively occurring in the area. Further details on management and mitigation measures are provided in **Section 8.1**.	Minor	Possible	8 Moderate
	Changes to property access.	Minor	Almost certain	16 High	Where impacts are unavoidable consultation would be undertaken with the property owner and / or tenant to develop appropriate alternative access arrangements.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 8.1**.			
	Impacts on surrounding development.	Minor	Possible	8 Moderate	Mitigation measures relevant to impacts such as noise, traffic and air quality are provided in **Sections 7.1, 7.2** and **7.3.**	Minor	Unlikely	5 Low
	Operation							
	Permanent acquisition of private property.	Major	Almost certain	23 Extreme	All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Further details on management and mitigation measures are provided in **Section 8.1**.	Moderate	Likely	17 High
	Property access.	Minor	Almost certain	16 High	Arrangements for altered property accesses would be subject to consultation with the affected property owner. Further details on management and mitigation measures are provided in **Section 8.1**.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Hazard and risk	**Construction**							
	Impacts from handling, storage and transport of dangerous goods and hazardous substances.	Major	Possible	18 High	The transport, storage, handling and use of hazardous construction materials would be undertaken in accordance with Occupational Health and Safety (OH&S) legislation and codes. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Occupational health and safety hazards, such as dangers to construction workers and road users.	Major	Likely	21 Very high	Appropriate processes would be implemented including a permit to tunnel to ensure the ongoing structural integrity of the tunnel. Site specific hazard and risk management plans would be prepared and implemented as part of the CEMP. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Rupture of underground services	Moderate	Likely	17 High	Utility checks and consultation with the relevant service	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					infrastructure providers would occur prior to construction. Utilities would be relocated or protected as required. Further details on management and mitigation measures are provided in **Section 8.2**.			
	Bushfires	Major	Possible	18 High	Measures to mitigate and manage bushfire risks would be developed and included in site-specific hazard and risk management measures within the Construction Environmental Management Plan(s). Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Operation							
	Impact from handling, storage and transport of dangerous goods and hazardous substances for the operational water treatment plant.	Major	Possible	18 High	The transport, storage, handling and use of hazardous materials would be undertaken in accordance with Occupational Health and Safety (OH&S) legislation and codes.	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 8.2**.			
	Vehicle collisions	Major	Likely	21 Very high	The project design has incorporated feasible and reasonable design measures including in relation to geometry, pavement, lighting and signage, consistent with current Australian Standards, road design guidelines and industry best practice. To minimise the likelihood of an incident associated with over height vehicles within the tunnel, an over height detection system has been included in the design of the project. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Possible	13 High
	Accidental spills of dangerous goods as a result of vehicle collisions	Major	Likely	21 Very high	Dangerous goods vehicles would be restricted from entering the tunnels. Drainage infrastructure	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					would provide capacity to capture spillages and capacity to treat the first flush from the pavement surface as a minimum. Further details on management and mitigation measures are provided in **Section 8.2**.			
	Bushfires	Major	Possible	18 High	Infrastructure critical to the ongoing safe operation of the project, including the motorway operations complex, would be located outside of bushfire prone areas. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
Resource and waste	**Construction**							
	Inappropriate management of waste generated during construction of the project.	Moderate	Likely	17 High	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Incorrect management and disposal of spoil management	Moderate	Likely	17 High	A Spoil Management Strategy would be developed and documented for the project prior to the commencement of soil disturbing works. Options for the beneficial re-use of spoil within the project or within other developments would be considered during the detailed design phase. Spoil disposal offsite would be to a location that has an appropriate licence or approval to accept the material. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low
	Incorrect management of demolition waste containing hazardous materials.	Moderate	Likely	17 High	Management and disposal of asbestos containing materials would be undertaken in accordance with relevant legislation and guidelines. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Operation							
	Inappropriate management of waste generated during the operation and maintenance of the project.	Moderate	Likely	17 High	Standard work practices and Roads and Maritime waste policies and specifications would be implemented during routine maintenance and repair activities. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low
Greenhouse gas and climate change	**Construction and operation**							
	Release of greenhouse gas emissions during construction.	Moderate	Likely	17 High	Standard procedures would be implemented to reduce greenhouse gas emissions associated with the use of carbon based fuels and energy sources, the removal of vegetation, and emissions resulting from the use of materials to construct the project. Further details on management and mitigation measures are provided in **Section 8.4**.	Minor	Possible	8 Moderate
	Release of greenhouse gases during operation (including maintenance).	Moderate	Likely	17 High	During detailed design, measures to reduce greenhouse gas emissions over the life of the project would be	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					considered, where feasible and feasible. Further details on management and mitigation measures are provided in **Section 8.4**.			
	Climate change impacts on the project.	Moderate	Likely	17 High	Future climate change predictions would be considered in maintenance procedures, such as monitoring, review and maintenance of road surfaces and drainage structures. Further details on management and mitigation measures are provided in **Section 8.4**.	Minor	Possible	8 Moderate

10.6 Confirmation of key environmental issues

Based on the results of the environmental risk analysis, the following issues have been confirmed as the key environmental issues for the project based on the information presented in this environmental impact statement:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Human health.
- Urban design, landscape character and visual amenity.
- Biodiversity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.
- Non-Aboriginal heritage.
- Aboriginal heritage.
- Community liaison.

The majority of environmental issues have a residual risk rating of low or moderate and a few issues with a residual risk of high. No environmental issues have a residual risk rating of very high or extreme and, as such, it is considered that no environmental issues would have a significant risk to the environment. As such, no contingency plans are required.

All key issues have been addressed in **Chapter 7**, with community liaison addressed in **Chapter 6**.

11 Project justification and conclusion

This chapter presents a justification for the project and a conclusion to the environmental impact statement. The justification is based on the strategic need for the project and in particular, how it would fulfil the project objectives outlined in **Section 3.4**. **Table 11-1** sets out the Director-General's Requirements as they relate to the justification of the project and where these have been addressed in the environmental impact statement.

Table 11-1 Director-General's Requirements – project justification and conclusion

Director-General's Requirements	Where addressed
An analysis of feasible alternatives to the carrying out of the project and project justification, including: • an analysis of alternatives/options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the project is in the public interest, and • justification for the preferred project taking into consideration the objects of the *Environmental Planning and Assessment Act 1979*.	Analysis of alternatives and options considered for the project are described in **Chapter 4** with further details provided in **Section 11.1**. The project justification and consideration of relevant strategic planning policies is provided in **Chapter 3** and **Section 11.1**. The objects of the *Environmental Planning and Assessment Act 1979* are considered in **Section 11.3.2**.

11.1 Project justification

11.1.1 Summary of strategic need and justification

The project would provide the missing link in Sydney's motorway network between the M1 Pacific Motorway and the Sydney orbital road network.

The National Land Transport Network provides connections between all mainland states and territories of Australia. The primary objectives of the National Land Transport Network are to facilitate overseas and interstate trade, to support regional development and to allow safe and reliable access to major population centres. As such, the National Land Transport Network plays an important role in the economy of NSW and Australia as a whole.

The project would transform this section of the National Land Transport Network, providing efficiencies for heavy vehicles transporting freight to, from or through Sydney to major cities and regional centres such as the Central Coast, Newcastle, Brisbane and Melbourne.

By providing an alternative and more efficient route for travel for heavy vehicles and other through traffic between the M1 Pacific Motorway and the Hills M2 Motorway, The project would also reduce interaction between road freight and other road users, thereby reducing congestion and improving safety and amenity along Pennant Hills Road.

11.1.2 Achieving project objectives

As discussed in **Section 3.4**, nine key objectives have been developed for the project to respond to key issues that underlie the strategic need for the project. The project objectives are consistent with strategic objectives of State and national planning and policy documents. **Table 11-2** provides a summary of how the NorthConnex project would meet these objectives.

Table 11-2 Achieving the project objectives

Project objective	Comment
Provide a high standard access controlled motorway that integrates with the regional transport network.	The NorthConnex project would provide a motorway standard connection between the M1 Pacific Motorway and the Hills M2 Motorway. At the northern and southern ends of the project, direct motorway to motorway connections would be provided. On and off-ramps would also provide connections to Pennant Hills Road at the south and the north of the tunnels. The provision a motorway standard connection would provide an efficient connection with travel times of six minutes for the northbound journey and five minutes for the southbound journey.
Minimise adverse social and environmental impacts in the local area during construction and operation.	The design of the project has aimed to avoid or minimise potential environment and social impacts. For example, the design has: • Minimised permanent land acquisition by locating the on and off-ramps within existing road corridors and locating ancillary infrastructure on land already owned by Roads and Maritime, where feasible. • Minimised temporary land acquisition by locating temporary construction facilities within existing road reserves, or co-located within the footprint of the operational infrastructure. • Avoided direct impacts to the community facilities located at Brickpit Park. • Avoided high value ecological areas such as the Blue Gum High Forest at Brickpit Park and Kenley Park. Additionally, the project would reduce the number of heavy vehicles on Pennant Hills Road, providing improvements to safety, local traffic conditions, air quality and noise amenity. Where potential negative impacts were not able to be completely avoided through design, additional mitigation and management measures have been identified. The environmental, social and economic impacts and measures identified to minimise those impacts are described in **Chapter 7** (assessment of key issues) and **Chapter 8** (assessment of other issues) of this environmental impact statement. These measures would minimise adverse social and environmental impacts in the local area during construction and operation as far as feasible and reasonable.

Project objective	Comment
Provide opportunities for improved public transport in the area around Pennant Hills Road.	The reduction in heavy vehicle numbers on Pennant Hills Road would provide future opportunities to consider changes to improve the operation of bus services and local traffic movements. Roads and Maritime and Transport for NSW have carried out a preliminary assessment of the public transport improvements that could be delivered due a reduction in traffic congestion on Pennant Hills Road. Potential opportunities identified include: • Development of a rapid bus route along Pennant Hills Road between Hornsby and Baulkham Hills (via Castle Hill). • Bus priority treatment to address bus pinch points along Pennant Hills Road, including around Boundary Road. • Signal re-phasing, or changing the pattern of traffic signals at key intersections, to ease traffic flows across Pennant Hill Road by focusing on longer stopping time for through traffic and increased entry time for side traffic. • Bus stop relocations along the corridor to be closer to intersections, taking advantage of the additional stopping time created by signal re-phasing to reduce overall journey time. • Bus priority measures at key intersections to provide better bus reliability. • More frequent bus services on Pennant Hills Road. • Reconfiguring the bus route network to take advantage of easier crossing of the corridor at junctions, in alignment with Sydney's Bus Future strategy. • Linking the wider transport network better with railway stations in the area. • Improving walking and cycling infrastructure along and across the corridor. These options for improving public transport are at a preliminary stage and would require further consideration by Roads and Maritime and Transport for NSW. These additional improvements to public transport do not form part of this project and would be subject to separate planning processes and approvals as appropriate.
Assist in a reduction in traffic congestion, particularly along Pennant Hills Road, and provide shorter travel times for road users.	The project would reduce the number of heavy vehicles that currently travel on Pennant Hills Road, resulting in improvements to travel times for road users. For example, the project is forecast to result in a travel time saving of around 21 minutes for a northbound journey along Pennant Hills Road during the PM peak period in 2029, compared with the 'without project' scenario. Calculated travel times for motorists using NorthConnex show that, in both 2019 and 2029, the average travel time during the AM and PM peaks is anticipated to be six minutes in the northbound direction and five minutes in the southbound direction. This would offer a maximum travel time saving of around 40 minutes in 2029 (in the northbound direction in the PM peak) compared with the 'without project' scenario where vehicles would be travelling along Pennant Hills Road. Motorists would also be able to avoid 21 sets of traffic light compared to

Project objective	Comment
	the current situation on Pennant Hills Road.
Provide a motorway that is safe and reliable for road users.	NorthConnex project would be built to motorway standard including grade separated interchanges and physically separated carriageways. As a result, crash rates within the tunnels would be significantly lower than the existing situation on Pennant Hills Road. At 5.3 metres, the project would be the highest of any road tunnel in Sydney, minimising the likelihood of an incident involving overheight vehicles. Monitoring systems would be used to efficiently manage and respond to in-tunnel incidents. The anticipated transfer of traffic from Pennant Hills Road to the project would reduce the interaction of local traffic with through road freight movements along Pennant Hills Road, improving road safety along Pennant Hills Road.
Contribute towards the achievement of the national objective of connecting Melbourne to Brisbane via a duplicated highway in order to improve the efficient movement of state and national freight, and in doing so, reduce costs for freight operators and carriers.	The project would provide the missing link in the National Land Transport Network between the M1 Pacific Motorway and the Sydney orbital road network. The project is anticipated to result in significant travel time savings of up to 40 minutes (northbound in the PM peak in 2029) compared to the anticipated future conditions on Pennant Hills Road without the project. The project would also allow road freight movements to bypass 21 sets of traffic lights. These benefits would improve the efficiencies of freight movements (both intrastate and interstate) and reduce freight operating costs associated with wages, fuel use and other vehicle operating costs.
Contribute towards a reduction in the number of heavy vehicles using Pennant Hills Road and as a result improve local air quality and noise amenity along that corridor	The project would provide an efficient alternative for freight through movements between the M1 Pacific Motorway and the Sydney orbital road network, resulting in a reduction of heavy vehicle numbers on Pennant Hills Road. This would result in amenity improvements along this corridor including improvements to air quality, and a reduction in traffic noise. This improved local amenity could contribute to a reinvigoration of the Pennant Hills Road corridor through improving the desirability over the longer-term for land uses such as residential and commercial developments (in particular retail).
Demonstrate excellence in design and environmental sustainability	A competitive design and construct tender process was undertaken in order to identify an innovative, cost effective and environmentally-responsive design solution. Throughout this process tenderers were encouraged to show excellence and innovation as part of their tender submission. The design of the project has incorporated lessons learnt from previous Sydney road tunnels, and advances in technology and engineering to include energy efficient ventilation design. The anticipated travel time benefits brought about by the project would reduce overall vehicle operational costs and fuel use. Although there would be emissions during construction, the project

Project objective	Comment
	would result in long-term greenhouse gas savings. By the year 2029 the savings in greenhouse gas emissions with the project are predicted to be around 68,600 t CO_2-e when compared to the 'without project' scenario.
Be economically justified and affordable to the government	The project is an unsolicited proposal from Transurban and the Westlink M7 Shareholders to construct, operate and maintain the project. The project would be funded as part of an infrastructure delivery partnership between the State and the private sector, utilising innovative procurement and funding models. The upfront capital costs would be covered by private funding from Transurban and the Westlink M7 Shareholders with contributions of up to $405 million from both the NSW and Australian Governments. The cost of the project would be recouped through a toll on the project and changes to concession deeds on other Sydney motorways.

11.1.3 Objects of the Environmental Planning & Assessment Act

The objects of the *Environmental Planning and Assessment Act 1979* provide a framework within which the justification of the project has been considered. A summary of this assessment is provided in **Table 11-3**.

Table 11-3 Objects of the *Environmental Planning and Assessment Act 1979*

***Environmental Planning and Assessment Act 1979* objective**	**Comment**
To encourage the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, waters, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment.	Where possible the project has been designed to conserve natural and artificial resources. Where reasonable and feasible, the project has been designed to avoid impacts on the surrounding natural environment and to minimise the need for land acquisition, impacts on existing development and local communities. The improved efficiency of the road network and the predicted travel time savings would result in a reduction in fuel use in the future. Additionally, the project would result in a long term reduction in greenhouse gas emissions. The project would provide improved traffic conditions, safety and efficiency on Pennant Hills Road and would result in improvements to local amenity in terms of noise and vibration, air quality and traffic. Measures would be implemented to ensure that impacts of the project on the natural and built environment are minimised.

Environmental Planning and Assessment Act 1979 objective	Comment
To encourage the promotion and co-ordination of the orderly and economic use and development of land.	The project would provide efficiencies to the National Land Transport Network, providing travel time savings for intrastate and interstate freight movements. This would provide cost savings for freight movements associated with wages, fuels use and other operating costs. The expected amenity improvements along Pennant Hills Road could contribute to a reinvigoration of the project corridor, improving the desirability over the longer-term for residential and commercial land uses. The project has been designed to minimise impacts to the surrounding natural and built environments, and to minimise disruption to existing development patterns. Provision of a mostly underground motorway is an orderly and economic approach to delivery of the project in the context of existing development along the Pennant Hills Road corridor.
To encourage the protection, provision and co-ordination of communication and utility services.	The project has been designed to minimise impacts on communications and utility services, where possible. Utility services would be relocated, adjusted or protected where affected by the construction of the project. Communication and utility service providers would be consulted during design and implementation of relevant works to ensure coordination and delivery of new and / or modified communications and utility infrastructure.
To encourage the provision and co-ordination of community services and facilities.	The main alignment tunnels and the location of temporary construction compounds have been designed and located to avoid direct impacts to community facilities. The reduction in heavy vehicle use of Pennant Hills Road would provide for future opportunities for improvements to or establishment of new community facilities along the corridor. For example, the improvements to amenity created by the project may increase the desirability of the community to utilise existing recreational areas such as local parks. Improvements in amenity, traffic efficiency and safety may also encourage the establishment of new community services and facilities, such as schools, libraries and community halls in the longer term. The predicted improvements in travel times along Pennant Hills Road would improve the local access to community services and community facilities

***Environmental Planning and Assessment Act 1979* objective**	**Comment**
To encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats.	The design of the project has avoided known high value ecological areas such the Blue Gum High Forest at Brickpit Park and Kenley Park. Potential impacts of the project on terrestrial and aquatic ecology have been assessed in **Section 7.6** of this environmental impact statement and measures to avoid, mitigate and offset potential impacts on native plants and animals, and their habitats, have been identified. Potential impacts on ecology of conservation significance have been minimised through the project design.
To encourage ecologically sustainable development.	The project is consistent with the four principles of ecologically sustainable development. Ecologically sustainable development is further considered in **Section 11.2**.
To encourage the provision and maintenance of affordable housing.	Not applicable.
To promote the sharing of the responsibility for environmental planning between different levels of government in the State.	Consultation has been undertaken with the relevant local councils and government agencies throughout the development of the project and the preparation of this environmental impact statement. All levels of government have been encouraged to be actively involved in and to contribute to the evolution of the project and this environmental impact statement through historical and continuing consultation activities.
To provide increased opportunity for public involvement and participation in environmental planning and assessment.	Community consultation has been carried out through all stages of the project development, commencing in 2002 with the alternatives and options development, through to the exhibition of the preferred tender design. Community feedback has been considered at each stage of the project development to inform the selection of the purple corridor alignment and subsequent design development and refinements. Community consultation would continue through the detailed design, construction and operational stages should the project be approved. Details of community involvement are provided in **Chapter 6**.

11.1.4 Ecologically sustainable development

Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends is referred to as ecologically sustainable development. The principles of ecologically sustainable development have been considered throughout the development of the project.

The *Environmental Planning and Assessment Act 1979* recognises that ecologically sustainable development requires the effective integration of social, economic and environmental considerations in decision-making processes. The *Environmental Planning and Assessment Act 1979* identifies four principles to support the achievement of ecologically sustainable development:

- The precautionary principle.
- Inter-generational equity.
- Conservation of biological diversity and ecological integrity.
- Improved valuation and pricing and incentive mechanisms.

The four main principles of ecologically sustainable development are discussed below in the context of the project.

Precautionary principle

If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The precautionary principle has been applied throughout the design and development of the project.

The alternatives and options analysis as part of the 2004 report considered environmental impacts, evident through the selection of the purple corridor option which minimised surface disturbance and potential impacts to National Parks and other ecologically sensitive areas.

The design has first aimed to avoid, to the greatest extent practicable, known areas or items of environmental value such as the Blue Gum High Forest at Brickpit Park and Kenley Park. Where avoidance was not possible, mitigation measures have been identified to avoid or manage the these risks

This environmental impact statement details the evaluation of environmental impacts associated with the project and has been undertaken using the best available technical information and adoption of best practice environmental standards, goals and measures to minimise environmental risks. The environmental assessment has been undertaken in collaboration with key stakeholders and relevant statutory and agency requirements.

The environmental impact statement adopts a conservative approach by assessing the worst case impacts and scenarios, such as assessing the theoretical maximum peak hour capacity of the project in relation to air quality and human health impacts.

Inter-generational equity

The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

One of the key objectives of the project is to assist in a reduction in traffic congestion along Pennant Hills Road and provide shorter travel times for road users. The project would provide an alternative travel route between the M1 Pacific Motorway and the Sydney orbital road network increasing the capacity of the road network. The project is also being future proofed with the ability to be retro-fitted to three lanes in each direction if required in the future.

The project would also provide the following benefits for today's generations and future generations:

- Provide a reduction in air quality emissions along the Pennant Hills Road corridor. Further information on local air quality improvements are provided in **Section 7.3** (Air quality).
- Improve noise amenity along the Pennant Hills Road corridor through the reduction in heavy vehicle use.
- Improve road safety through the provision of a motorway standard connection. Road safety improvements along Pennant Hills Road are also anticipated due to the reduction in heavy vehicles and the interaction of local traffic with through freight movements. Further information on road safety improvements are provided in **Section 7.1** (Traffic and transport).
- Result in improvements to local amenity, which would contribute to a reinvigoration of the Pennant Hills Road corridor, improving the desirability over the longer-term for residential and commercial land uses.
- Result in reduced operational greenhouse gas emissions when compared to the project not being built. For the year 2029 the savings in greenhouse gas emissions with the project are predicted to be around 68,600 t CO_2-e when compared to the 'without project' scenario. Further information on greenhouse gas emissions and savings are provided in **Section 8.4** (Greenhouse gas and climate change).

As a result the project would provide benefits for current and future generations and is considered to be in the public interest.

Conservation of biological diversity and ecological integrity

Conservation of biological diversity and ecological integrity is a fundamental consideration of the project.

The alternatives and options analysis as part of the 2004 report considered ecological integrity, evident through the selection of an option which minimised potential impacts to National Parks and other ecologically sensitive areas.

The current project design avoids impacts to areas of high ecological value as far as practical. For example, the design has avoided impacts to the Blue Gum High Forest at Kenley Park and Brickpit Park. This environmental impact assessment provides a detailed ecological assessment which identifies flora and fauna impacts and provides a range of mitigation measures which would be implemented in order to further avoid and minimise these potential impacts. Additionally, preliminary offset calculations have been provided in order to offset the identified impacts to endangered ecologically communities and threatened species.

Improved valuation and pricing of environmental resources

Environmental factors should be included in the valuation of assets and services. Such as:

- Polluter pays (ie those who generate pollution and waste should bear the cost of containment, avoidance, or abatement).
- The users of goods and services should pay prices based on the full life cycle of costs of providing the goods.
- Environmental goals, having been established, should be pursued in the most cost effective ways.

The value placed on the environment is evident in the development of design features and also in the extent of environmental investigations for the project. In addition the costs associated with the planning and design of measures to avoid / minimise adverse environmental impacts and the costs to implement them have been built into the overall project costs. For example, the increased capital cost of the longer tunnel has been preferred over the environmental and community impacts associated with land acquisition of a shorter tunnel option (refer to **Section 4.4.1**).

The provision of a toll on the project supports the concept of users of goods and services paying prices based on the full life cycle of costs of providing the goods. Whilst the upfront capital costs would be provided by a combination of private funding and a contribution from the NSW and Australian Governments, this funding would be recouped through a toll to cover the upfront construction, and ongoing operation and maintenance costs.

11.2 Conclusion

The project has been identified as a key transport infrastructure project and a priority action for addressing a missing link in the National Land Transport Network, in line with State and national planning strategies.

The project would provide the following benefits and is therefore in the public interest:

- Providing the missing link in Sydney's motorway network sand the National Land Transport Network between the M1 Pacific Motorway and the Sydney orbital road network.
- Future travel time savings of up to 40 minutes compared to without the project.
- Bypassing of 21 sets of traffic lights.
- Improving the efficiencies of intrastate and interstate freight movements through travel time saving and reduced operating costs.
- Improving safety of motorists, cyclists and pedestrians on Pennant Hills Road through the reduction in heavy vehicles.
- Improving local amenity and connectivity for people living, working and traveling along Pennant Hills Road.
- Providing opportunities for future public transport improvements and the reinvigoration of the Pennant Hills Road corridor.

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List of tables

List of figures

Appendix A

Director-General's Requirements

Appendix A Director General's Requirements

Table A-1 Director-General's Requirements

General Requirements	Section in EIS
The Environmental Impact Statement (EIS) must be prepared in accordance with, and meet the minimum requirements of, Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation), including: • 1. The information required under clause 6 of Schedule 2 of the Regulation. • 2. The content listed in clause 7 of Schedule 2 of the Regulation, including but not limited to:	
• a statement of the objectives of the project, including a description of the strategic need, justification, objectives and outcomes for the project, taking into account existing and proposed transport infrastructure and services within the adjoining subregions, and as relevant the outcomes and objectives of relevant strategic planning and transport policies, including, but not limited to, *NSW 2021, NSW Government State Infrastructure Strategy, NSW Long Term Transport Master Plan* (December 2012), *draft Metropolitan Plan for Sydney* (March 2013) and any other relevant plans;	**Chapter 3** – Justification and need
• an analysis of feasible alternatives to the carrying out of the project and project justification, including: - an analysis of alternatives/options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the project is in the public interest, and - justification for the preferred project taking into consideration the objects of the *Environmental Planning and Assessment Act 1979*.	**Chapter 4** – Project development and alternatives
• an analysis of the project including an assessment, with a particular focus on the requirements of the listed key issues, in accordance with clause 7(1)(d) of Schedule 2 of the Regulation (where relevant), including an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management/mitigation measures;	**Chapter 2** – Assessment process
• a detailed description of the project and its relationship and/or interaction with the existing public transport service (rail and bus), bus stops, passenger facilities, location of routes, operator amenities, cyclist facilities, the proposed removal of trees and the location and operational requirements of construction compounds; and	**Chapter 5** – Project description
• detail how the principles of ecologically sustainable development will be incorporated in the design, construction and ongoing operation phases of the project.	**Chapter 4** – Project development and alternatives

General Requirements	Section in EIS
Notwithstanding the key issues identified for consideration, the EIS must include an environmental risk analysis to identify the potential environmental impacts associated with the infrastructure. Where relevant, the assessment of key issues identified for consideration, and any additional significant issues identified in the risk assessment, must include: • adequate baseline data; • consideration of the potential cumulative impacts due to other development in the vicinity; and • measures to avoid, minimise and if necessary, offset the predicted impacts, including detailed contingency plans for managing any significant risks to the environment.	**Chapter 10** – Environmental risk analysis **Chapter 7** – Assessment of key issues
Traffic and transport	
An assessment (including modelling) of the operational traffic impacts of the project, impacts (volumes, speeds, intersection performance, freight volumes, tolling etc) on the M1 (F3 Freeway), M2 and M7 Motorways, Pennant Hills Road, Windsor Road and the surrounding local, regional and state road network.	Detailed description of the existing environment is provided in **Section 7.1.2** and **Appendix E**.
An assessment of wider transport interactions (local and regional roads and public and freight transport).	Operational traffic impacts are addressed in **Section 7.1.4** and **Appendix E**.
An assessment of the induced traffic and operational implications for public transport (particularly with respect to strategic bus corridors and bus routes) and consideration of opportunities to improve public transport. The assessment must address impacts on cyclists and pedestrian access and safety (for those ancillary works around the Motorway corridor, as relevant) and consider opportunities to integrate cycleway and pedestrian elements with surrounding networks.	Wider transport interactions are discussed in **Section 7.1.4** and **Appendix E**.
An assessment of construction traffic impacts, including a considered approach to route identification and scheduling of transport movements, the number, frequency and size of construction related vehicles (passenger, commercial and heavy vehicles, including spoil management movements), construction worker parking, the nature of existing traffic on construction access routes (including consideration of peak traffic times and sensitive road users, including emergency vehicles and buses), and the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the project.	Operational implications for public transport are assessed in **Section 7.1.4** and **Appendix E**.
A strategy for managing construction traffic impacts, with a particular focus placed on those activities identified as having the greatest potential for adverse traffic flow, capacity or safety implications, and a broader, more generic approach developed for day-to-day traffic management.	Construction traffic impacts including the identification of haulage routes and construction vehicle numbers are assessed in **Section 7.1.4** and **Appendix E**.
Consideration of the cumulative construction impacts on residents/businesses taking into account other infrastructure projects that have either commenced construction, are preparing for construction or have recently been completed.	Measures to manage and mitigate construction traffic impacts are provided in **Section 7.1.5** and **Appendix E**.
Noise and vibration	
An assessment of the noise impacts of the project during operation, consistent with the *Road Noise Policy (EPA, 2011)* and *NSW Industrial Noise Policy (EPA, 2000).* The assessment must include specific consideration of impacts to	Operational traffic noise assessment consistent with the Road Noise Policy is provided in **Section 7.2.4**.

General Requirements	Section in EIS
receivers (dwellings, child care centres, educational establishments, hospitals, motels, nursing homes, or places of worship), including specific consideration of sleep disturbance and, as relevant, the characteristics of noise (eg. low frequency noise), and identify reasonable and feasible mitigation measures.	Operational noise assessment from surface ancillary facilities consistent with the NSW Industrial Noise Policy is provided in **Section 7.2.4**. Feasible and reasonable mitigation measures are identified in **Section 7.2.5**.
An assessment of construction noise and vibration impacts, consistent with the *Interim Construction Noise Guideline* (DECCW, 2009) and *Assessing Vibration: a technical guideline* (DEC, 2006). The assessment must have regard to the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially affected receivers, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management), and mitigation and management measures. The assessment should present, as relevant, an indication of potential for works outside standard working hours, including predicted levels and exceedences, justification for the activity and discussion of available mitigation and management measures.	Construction noise and vibration impact assessment consistent with the Interim Construction Noise Guideline and Assessing Vibration: a technical guideline is provided in **Section 7.2.4**. The assessment considers the potential for works outside of standard construction hours, including tunnelling and associated support work, and spoil haulage. Feasible and reasonable mitigation measures are identified in **Section 7.2.5**.
Consideration of the nature and duration of construction noise and vibration impacts of the project, in terms of a continuance of these impacts from the recently completed M2 Upgrade project, on residents located adjacent to the Hills M2 Motorway between Windsor Road and Pennant Hills Road.	Consideration of the continuance of noise and vibration impacts of the project and the recently completed Hills M2 Motorway Upgrade project is provided in **Section 7.2.4**.
Air quality	
An assessment of construction and operation activities that have the potential to impact on local and regional air quality. The assessment should provide an assessment of the risk associated with potential discharges of fugitive and point source emissions, and include:	Operational and construction air quality impacts, including construction activities with the potential to impact on air quality, are identified and addressed in **Section 7.3.4** and **Appendix G**.
• details of the proposed methods to minimise adverse impacts on air quality during construction, particularly in relation to mobile plant,	Measures to manage and mitigate construction air quality impacts are provided in **Section 7.3.5** and **Appendix G**.
• air quality impact assessment and air dispersion modelling conducted in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2005) where there is a risk of adverse air quality impacts, or where there is sufficient uncertainty as to the potential level of risk, including a particle assessment addressing PM10 and PM2.5 values, consideration of impacts from dispersal of TSP, CO, NO_2 and other nitrogen oxides, volatile organic compounds (eg BTEX), details of the proposed mitigation measures to address air quality in tunnels and in the vicinity of portals and any mechanical ventilation systems (ie ventilation stacks), including details of proposed monitoring,	Detailed description of the methodology of the air quality assessment, including description of modelling is provided in **Section 7.3.2** and **Appendix G**. Measures to manage and mitigate air quality during operation are provided in **Section 7.3.5** and **Appendix G**.

General Requirements	Section in EIS
• consideration of the requirements of *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards* (enHealth, 2012), and	Requirements of these guidelines are discussed in **Section 7.4** (Human health) and **Appendix H**.
• take into account any applicable advice provided by the Independent Advisory Committee on Tunnel Air Quality.	Engagement with the Independent Advisory Committee on Tunnel Air Quality is discussed in **Section 7.3.2** and **Appendix G**.
Soil and water	
An assessment of construction and operational erosion and sediment and water quality impacts, taking into account impacts from both accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, and urban and regional salinity. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000), and any applicable regional, local or site-specific guidelines.	Construction and operational ground water quality impacts are addressed in **Section 7.8.3**. Surface water impacts, including erosion and sedimentation, are addressed in **Section 7.9** (Surface water).
Groundwater impacts as a result of the project (including ancillary facilities such as the tunnel control centre and any deluge systems), considering local impacts along the length of the tunnels and impacts on local and regional hydrology. The assessment must consider: extent of drawdown; impacts to groundwater quality; discharge requirements; location and details of groundwater management and implications for groundwater-dependent surface flows, groundwater-dependent ecological communities, and groundwater users. The assessment should be prepared having consideration to the requirements of the NSW Aquifer Interference Policy.	Groundwater impacts are assessed in **Section 7.8.3**. Details regarding the treatment and discharge of tunnel groundwater, a depiction of the overall water management strategy for the project, and an assessment of the hydrological changes from the loss of surface water flows are provided in **Section 7.9** (Surface water). The implications for groundwater dependent ecological communities are assessed in **Section 7.6** (Biodiversity).
A Spoil Management Strategy detailing how spoil will be managed during construction, including likely volumes, likely nature and classification of excavated material, opportunities for recycling, potential disposal sites, stockpile management, and method of transportation.	A Spoil Management Strategy is provided in **Section 8.3** (Resource management and waste minimisation).
Community liaison	
A Community Communication Framework for construction, identifying relevant stakeholders, procedures for distributing information and receiving/responding to feedback and procedures for resolving community complaints during construction. Key issues that should be addressed in the draft framework should include (but not necessarily be limited to): • air quality monitoring and management, • traffic management (including property access, pedestrian access), • landscaping/urban design matters, • construction activities including out of hours work, and • noise and vibration mitigation and management.	A Community Communication Framework is provided in **Appendix D**.
Urban design and visual amenity	
A consideration of the urban design and visual amenity implications of the project, including supporting infrastructure,	Potential impacts to visual amenity during the construction and

General Requirements	Section in EIS
during construction and operation. The assessment must identify urban design and landscaping objectives and must demonstrate how the proposed urban design elements of the project would be consistent with the existing and desired future character of the area.	operation phase are provided in **Section 7.5.5**. Urban design and landscaping objectives are provided in **Section 7.5.4** and **Appendix I**. Consideration of the existing and desired future character of the area is provided in **Section 7.5.2** and **Section 7.5.5.** .
Identification and evaluation of the visual impacts and urban design aspects of the project (and its components) on surrounding areas.	Consideration and assessment of potential visual impacts is provided in **Section 7.5.5**.
A consideration of impacts on views and vistas, streetscapes, key sites and buildings.	Consideration and assessment of potential visual impacts is provided in **Section 7.5.5**.
Measures to manage lighting impacts both during construction and operation.	Management and mitigation measures for lighting during construction and operation are provided in **Section 7.5.6**.
Artist's impressions and perspective drawings of the proposal from a variety of locations along the route.	Artist's impressions of the project are provided in **Section 7.5.5** and **Appendix I**.
Biodiversity	
An assessment of the potential ecological impacts of the project, with specific reference to vegetation and habitat clearing, connectivity, edge effects, weed dispersal, bushfire risk, riparian and aquatic habitat impacts and soil and water quality impacts. The assessment must: • Make specific reference to impacts on threatened species and endangered ecological communities. • Have reference to the *Draft Guidelines for Threatened Species Assessment* (DEC/DPI, 2005), *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC), the *Guidelines for Aquatic Habitat Management and Fish Conservation* (DPI, 1999) and any relevant draft or final recovery plans. • Include details of any off-set measures that may be required, including demonstration that the measures are consistent with the *NSW offset principles for major projects (state significant development and state significant infrastructure*) (OEH, 2013).	Identification and assessment of potential ecological impacts including impacts on threatened species and endangered ecological communities is provided in **Section 7.6.3**. Offset measures are provided in **Section 7.6.4**. Additional detail regarding ecological impacts is provided in **Appendix J** – Technical working paper: biodiversity.
Land use, property and socio-economic	
Impacts on directly affected properties and land uses, including impacts related to access, land use, property acquisition and amenity related changes.	Impacts to properties, land use, property acquisition and amenity impacts provided in **Section 8.1.2**. Further details regarding amenity related changes are provided in **Section 7.1** (Traffic and transport), **Section 7.2** (Noise and vibration) and **Section 7.3** (Air quality).

General Requirements	Section in EIS
Social and economic impacts to businesses along Pennant Hills Road and the Pacific Highway, and the community associated with traffic, access, property, public domain and amenity related changes.	Social and economic impact assessment in **Section 7.7.3** including consideration of traffic, access, property, public domain and amenity related changes. Additional assessments are also provided as follows: • Traffic and access impacts in **Section 7.1**. • Property impacts in **Section 8.1**. • Amenity impacts in **Section 7.2** (Noise and vibration), **Section 7.3** (Air quality) and **Section 7.5** (Urban design, landscape character and visual amenity).
Aboriginal cultural heritage	
An assessment of the potential Aboriginal cultural heritage impacts of the project, including an assessment of objects, places of significance, natural and landscape values of the corridor and surrounding area, taking into account the *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, July 2005).	Assessment of Aboriginal cultural heritage impacts is provided in **Section 7.11.3**. Consultation with Aboriginal heritage stakeholders is provided in **Section 7.11.1**. Further details are provided in **Appendix M** – technical working paper: Aboriginal heritage.
Demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and mitigation measures (including the final proposed measures).	
Historic heritage	
An assessment of direct and/or indirect impacts to state and local heritage. Where impacts to State or locally significant historic heritage is identified, the assessment shall: • Outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the guidelines in the *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning 1996). • A statement of heritage impact for all heritage items/areas to be impacted (including significance assessment). • Consider the impacts from vibration, demolition, altered historical arrangements and access, and architectural noise treatment.	Potential direct and indirect impacts to non-Aboriginal heritage items are identified in **Section 7.10.3**. Proposed mitigation and management measures are identified in **Section 7.10.4**. **Appendix L** – Technical working paper: non-Aboriginal heritage.
Consultation	
During the preparation of the EIS, you must consult with the relevant local, State or Commonwealth Government authorities, service providers, community groups and affected landowners. In particular you must consult with:	Information regarding consultation carried out during the environmental impact statement is provided in this chapter.
• Local, State and Commonwealth government authorities, including the: - Environment Protection Authority; - NSW Health; - Office of Environment and Heritage (including Heritage Division);	Consultation with government authorities is described in **Section 6.3** and **Section 6.4**. Issues raised by government agencies are identified in

General Requirements	Section in EIS
- NSW Office of Water; - Department of Primary Industries; - The Hills Shire Council; - Hornsby Shire Council; and - Ku-ring-gai Municipal Council.	**Table 6-6** and issues raised by local councils are identified in **Table 6-7**.
• specialist interest groups, including Local Aboriginal Land Councils, Aboriginal stakeholders;	Consultation with Aboriginal stakeholders is described in **Section 6.3.2** and **Section 6.4.4**. Further details are provided in **Section 7.11** and the technical working paper: Aboriginal heritage (**Appendix M**).
• emergency services;	Consultation with emergency services is described in **Section 6.3**.
• utilities and service providers; and	Consultation with utility and service providers is described in **Section 6.3**.
• the public, including community groups and adjoining and affected landowners.	Consultation with the public, including community groups and adjoining and affected landowners is described in **Section 6.3**.
The EIS must describe the consultation process and the issues raised, and identify where the design of the infrastructure has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.	The consultation process, the issues raised, and where in the environmental impact statement these issues have been addressed is provided in **Section 6.3** and **Section 6.4**.

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Appendix B

Environmental Planning and Assessment Regulation 2000 Checklist

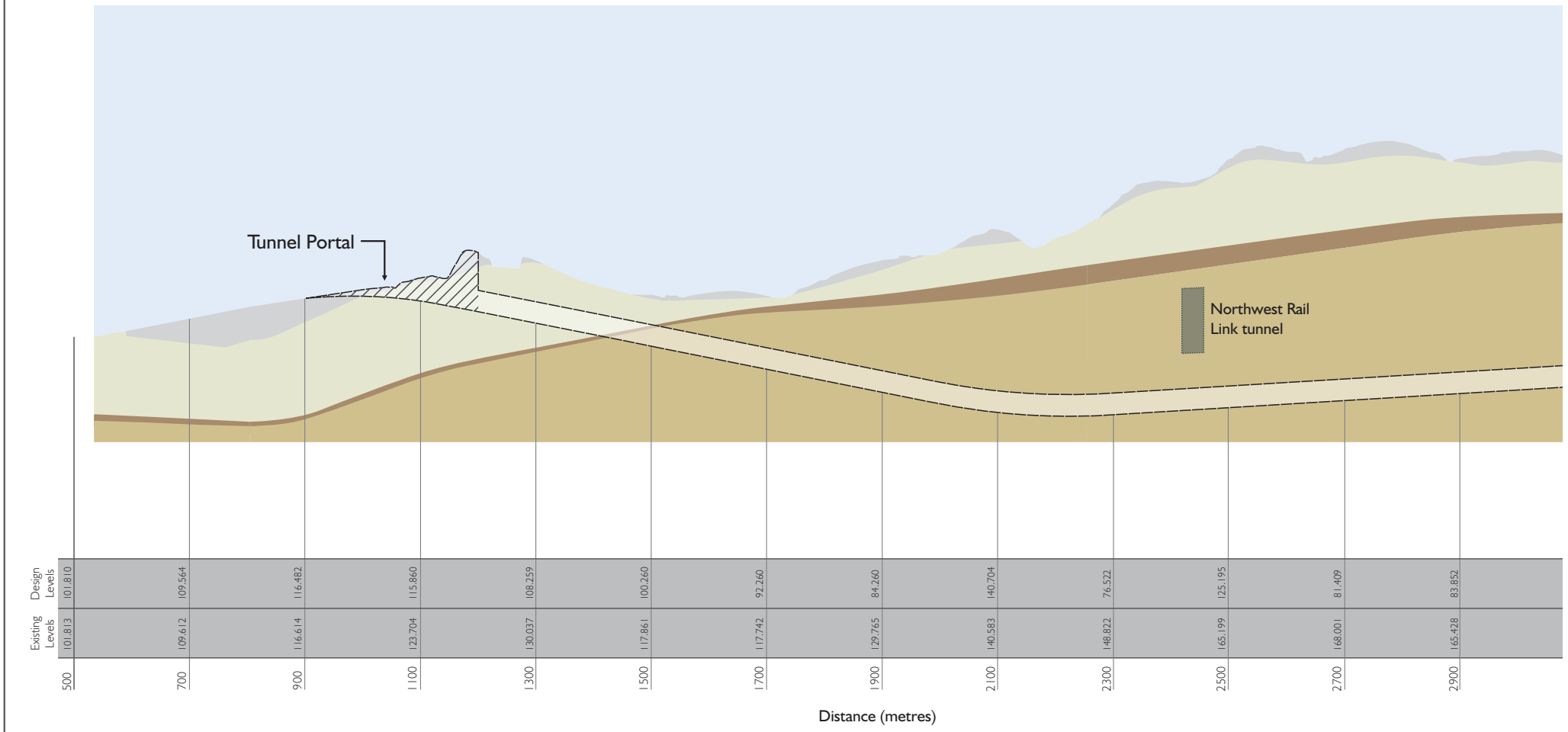
Appendix B – Environmental Planning and Assessment Regulation 2000 checklist

Requirement	Where addressed
6 Form of the environmental impact statement	
An environmental impact statement must contain the following information:	
a) the name, address and professional qualifications of the person by whom the statement is prepared,	Certification page
b) the name and address of the responsible person,	Certification page
c) the address of the land: i) in respect of which the development application is made, or ii) on which the activity or infrastructure to which the statement relates is to be carried out,	Certification page
d) a description of the development, activity or infrastructure to which the statement relates,	Certification page
e) an assessment by the person by whom the statement is prepared of the environmental impact of the development, activity or infrastructure to which the statement relates, dealing with the matters referred to in this Schedule, and	Certification page
f) a declaration by the person by whom the statement is prepared to the effect that: i) the statement has been prepared in accordance with this Schedule, and ii) the statement contains all available information that is relevant to the environmental assessment of the development, activity or infrastructure to which the statement relates, and iii) that the information contained in the statement is neither false nor misleading.	Certification page
7 Content of the environmental impact statement	
1) An environmental impact statement must also include each of the following:	
a) a summary of the environmental impact statement,	Executive summary
b) a statement of the objectives of the development, activity or infrastructure,	**Chapter 3**
c) an analysis of any feasible alternatives to the carrying out of the development activity or infrastructure, having regard to its objectives, including the consequences of not carrying out the development, activity or infrastructure,	**Section 4** – Project development and alternatives
d) an analysis of the development, activity or infrastructure, and	
i) a full description of the development, activity or infrastructure,	**Chapter 5** – Project description
ii) a general description of the environment likely to be affected by the development activity or infrastructure, together with a detailed description of those aspects of the environment that are likely to be significantly affected, and	Executive summary **Chapter 7** – Assessment of key issues
iii) the likely impact on the environment of the development, activity or infrastructure, and	**Chapter 7** – Assessment of key issues
iv) a full description of the measures proposed to mitigate any adverse effects of the development, activity or infrastructure on the environment, and	**Chapter 7** – Assessment of key issues
v) a list of any approvals that must be obtained under any other Act or law before the development, activity or infrastructure may lawfully be carried out,	**Chapter 2** – Assessment process

Requirement	Where addressed
e) compilation (in a single section of the environmental impact statement) of the measures referred to in item (d)(iv),	**Chapter 9** – Environmental management measures
f) the reasons justifying the carrying out of the development, activity or infrastructure in the manner proposed, having regard to biophysical, economic and social considerations, including the principles of ecologically sustainable development set out in subclause (4) of Schedule 2 Part 3 Section 7.	**Chapter 11** – Project justification and conclusions **Chapter 11** – Project justification and conclusions
2) Subclause (1) is subject to the environmental assessment requirements that relate to the environmental impact statement.	DGRs are addressed throughout the document.
3) Not applicable	
4) Principles of ecologically sustainable development	**Chapter 11** – Project justification and conclusions

Appendix C

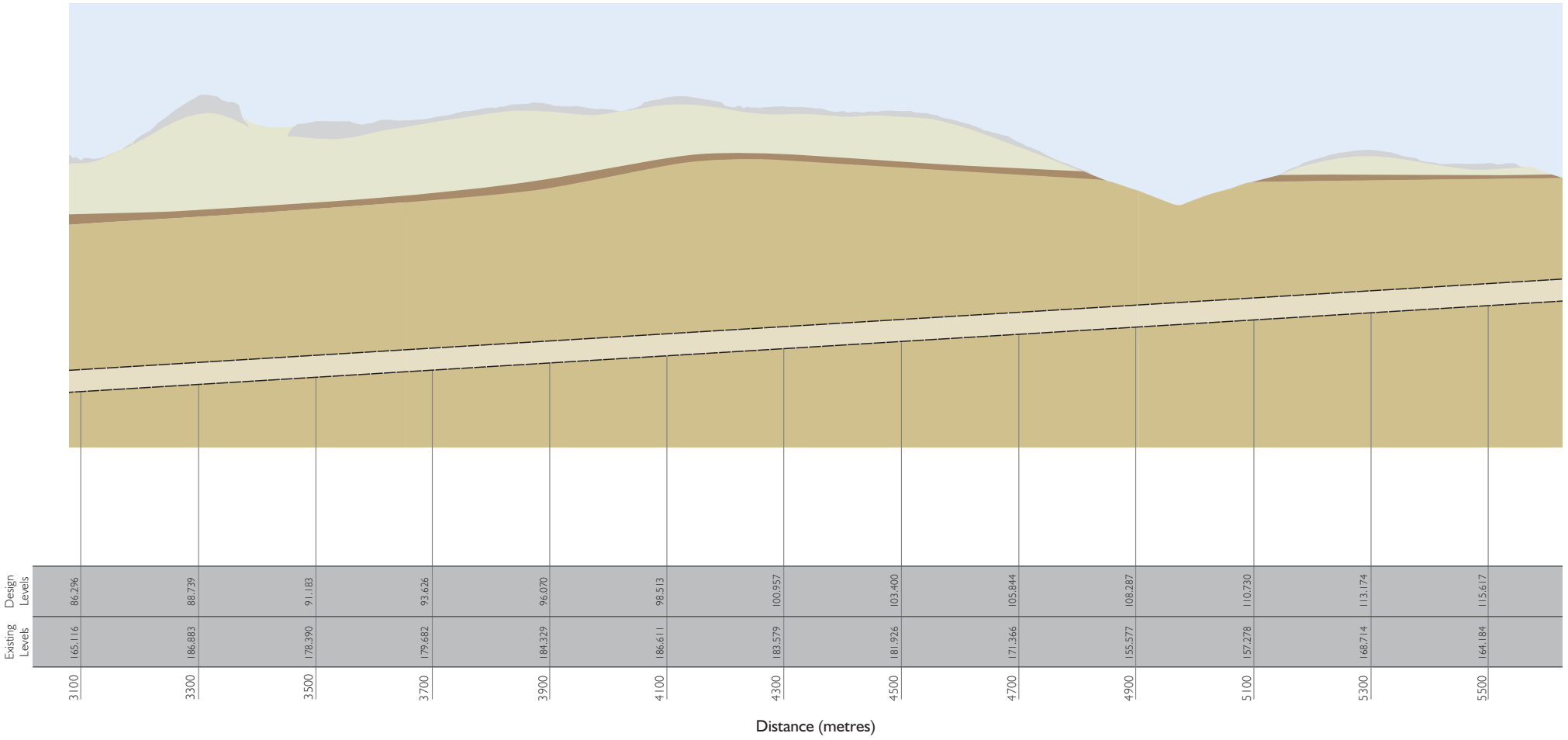
Geological long section



Note

Rock mass classes are estimations of the quality of the general rock mass based on widely spaced boreholes, local variations are expected

Figure C-1 Geological long section - Map 1



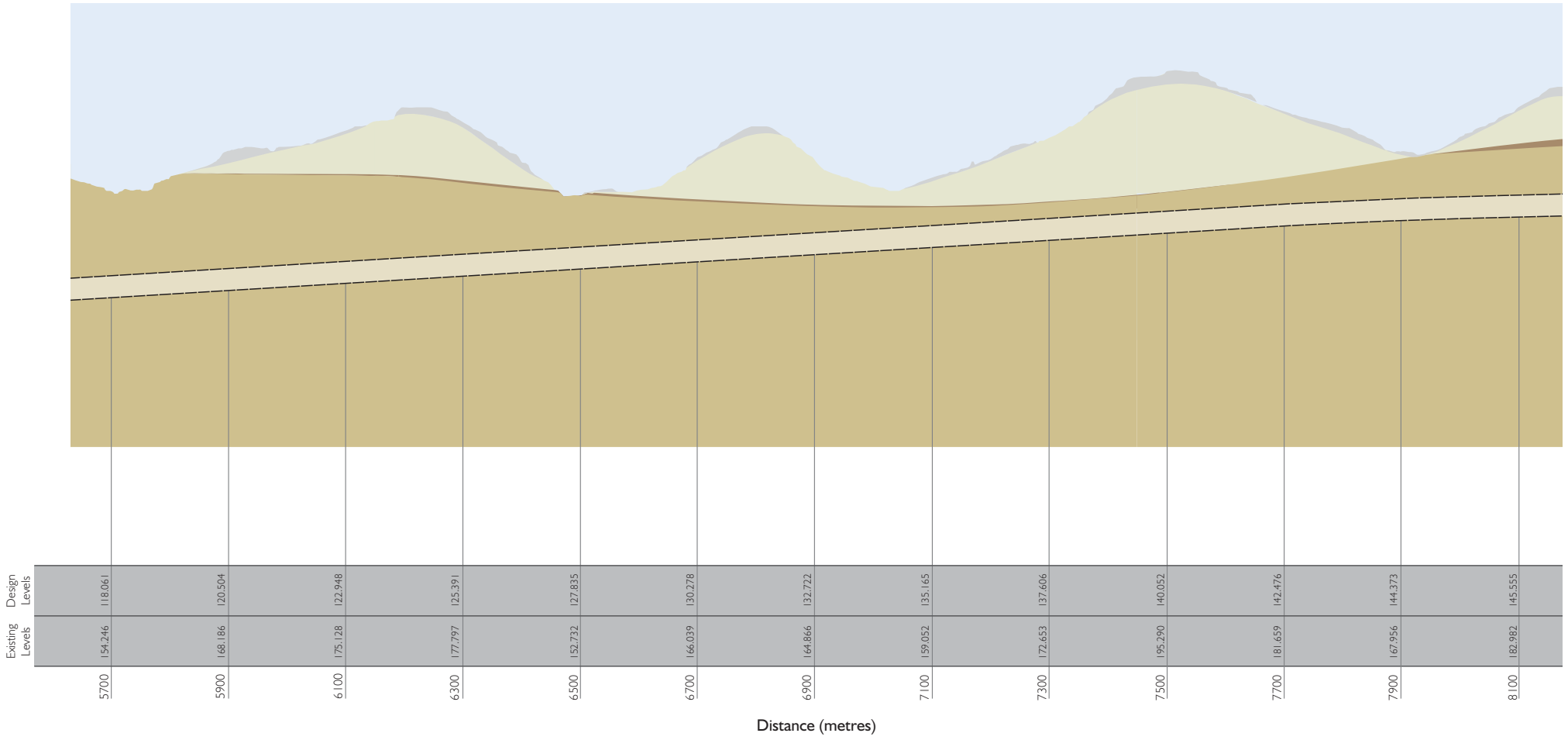
LEGEND

- Tunnel alignment
- Soil and extremely weathered rock
- Ashfield shale
- Mittagong formation
- Hawkesbury sandstone

Note

Rock mass classes are estimations of the quality of the general rock mass based on widely spaced boreholes, local variations are expected

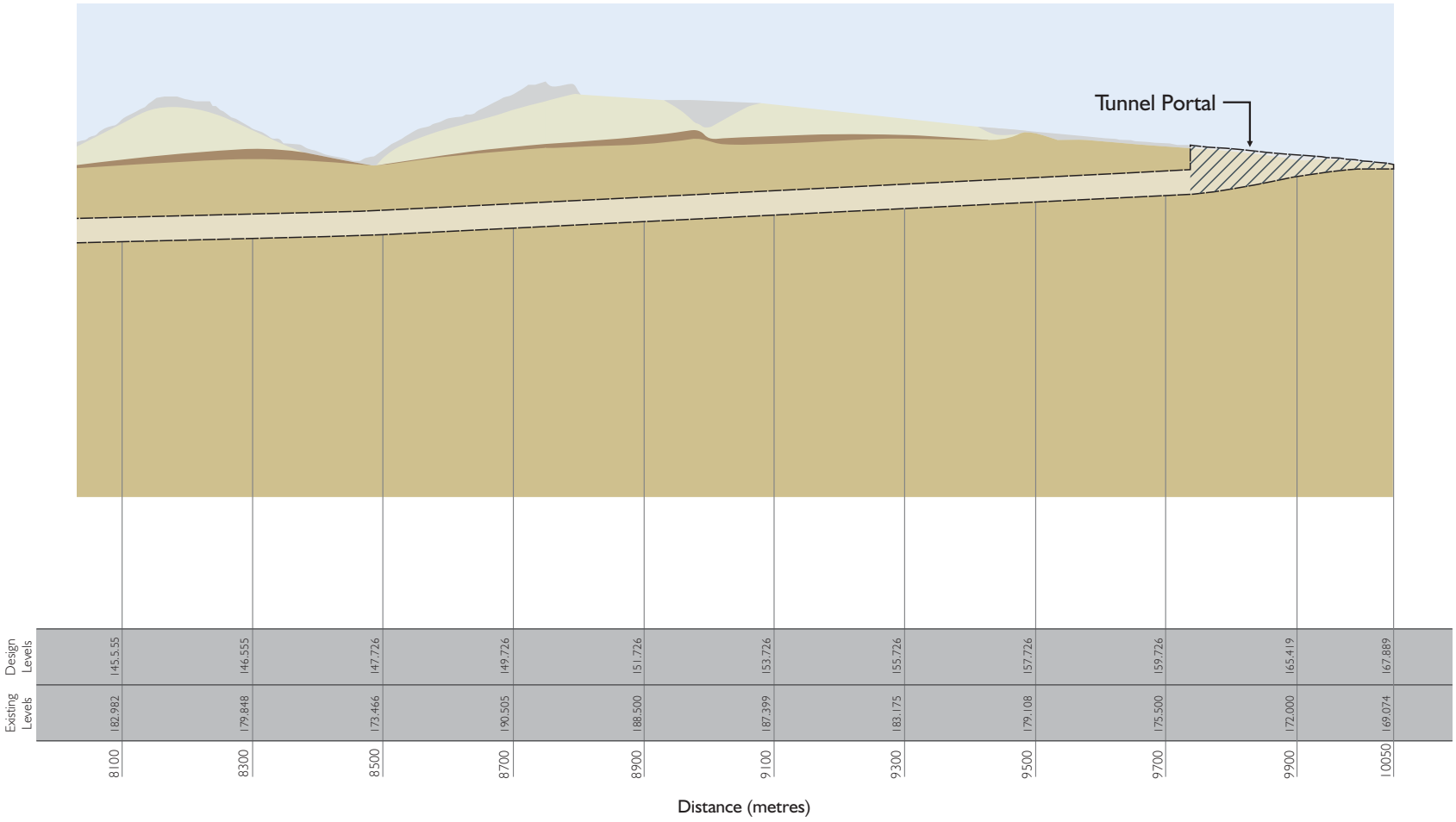
Figure C-2 Geological long section - Map 2



Note

Rock mass classes are estimations of the quality of the general rock mass based on widely spaced boreholes, local variations are expected

Figure C-3 Geological long section - Map 3



LEGEND

- Tunnel alignment
- Soil and extremely weathered rock
- Ashfield shale
- Mittagong formation
- Hawkesbury sandstone

Note

Rock mass classes are estimations of the quality of the general rock mass based on widely spaced boreholes, local variations are expected

Figure C-4 Geological long section - Map 4

Appendix D

Community communications framework

Roads and Maritime Services

NorthConnex

Community Communications Framework

July 2014

Prepared by
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Contents

1 Introduction

The purpose of the Community Communications Framework (CCF) is to provide an outline of how community communication and engagement activities would be undertaken with key stakeholders during the construction of NorthConnex.

This Community Communications Framework would be used as the basis for the development of a Community Liaison Implementation Plan. The Community Liaison Implementation Plan would be developed prior to the commencement of construction and would be a dynamic document that would be reviewed regularly and, if required, amended to ensure that it continues to meet its objectives and goals.

The aim of this Community Communications Framework is to:

- Identify relevant stakeholders.
- Identify procedures for distributing information and receiving / responding to feedback.
- Identify procedures for resolving community complaints during construction.

2 Roles and responsibilities

2.1 Community relations manager and representatives

A community relations manager and community relations representatives would be engaged on a full time basis throughout construction of the project. The community relations manager would be available for contact by local residents and community representatives to answer questions and address any concerns or complaints.

3 Communications strategy and tools

3.1 Community liaison implementation plans

This framework document would be developed into a community liaison implementation plan. The community liaison implementation plan would provide specific information in relation to community involvement during design, construction and the project opening phase. As a minimum, the plan would include:

- A list of stakeholders.
- Stakeholder level of involvement and engagement.
- Map of impacted properties.
- A register of potential impacts and timings.
- A risk assessment and proposed actions to mitigate or minimise the impact to stakeholders.
- External and internal communication protocols as relevant to the implementation of the community liaison implementation plan..
- Procedure for dealing with complaints and enquiries.
- Procedures for early notification to the community.
- Procedures for publicising the details of design and construction work.
- Procedures for training employees and subcontractors as relevant to the implementation of the community liaison implementation plan.
- A crisis communications plan.

3.2 Identification of stakeholders

Relevant stakeholders in the project include the local community, the broader Sydney community, community groups and organisations, government agencies, local councils, peak transport and freight bodies, and directly and indirectly impacted businesses. Relevant stakeholders would continue to be identified through the planning and detailed design phase of the project. The community liaison implementation plan would provide a comprehensive list of relevant project stakeholders.

3.3 Community contact database

A community contact database would be established and maintained that would include all landowners adjacent to the project works and key stakeholders. Registers would be provided at the display centre, any staffed or public display location and on the project website to enable the community to be included in the community contacts database.

3.4 Community involvement groups

A number of local community involvement groups comprising representatives of local communities, relevant local councils and others would be established as appropriate to inform and consult with the community on specific issues. The issues to be addressed as part of the community involvement groups would be determined based on the results of ongoing community consultation and in consultation with Roads and Maritime.

3.5 Liaison groups

Liaison groups would be established to address communication and coordination with affected authorities, road user groups and other groups with specific interests in the project. The liaison groups would include:

- A government agency liaison group.
- A local council liaison group.
- A traffic and transport liaison group.

3.6 Public displays

A public display centre would be established and maintained on or near to the project site prior to the commencement of construction. The centre would be maintained throughout the construction period. The display centre would:

- Contain up to date plans, diagrams and / or photographs of the project works.
- Be open to the public between 9 am to 5 pm Monday to Friday, excluding public holidays.

3.7 Community information

Relevant authorities and the local community would be kept informed throughout the construction process through a variety of methods. The method of communication would be based on the level of information to be provided and the timeframe for delivery of information. Methods of communication would include:

- Flyer for distribution to mailboxes / premises.
- Letters, emails and telephone calls to relevant authorities.
- Community updates at key milestones (newsletters).
- Website (updated monthly).
- Print and radio advertising.
- SMS.

The community would be informed of progress of the design and construction works, significant milestones, design changes, changed traffic conditions, opportunities for input, construction operations and others matters which are of interest, affect or concern to the community

The project would also maintain a 24 hour toll free telephone service throughout construction for the community to report incidents and register complaints.

3.8 Complaints management

The project would develop and implement a procedure for community contact and complaints handling and investigation during the construction period. A complaints register would be established and maintained which would record the details, response and outcome of the complaint. All complaints received would be investigated and an appropriate response provided to the complainant.

4 Specific issues communication strategies

Strategies and tools for community and stakeholder consultation during the construction phase are described in **Section 3** above. Some aspects of the construction activities would require specific consultation strategies due to the nature of the potential impact and / or the stakeholder groups. These are described below.

4.1 Air quality

The project has the potential to impact local air quality during the construction phase, mainly through the generation of dust from spoil management activities. Receivers that may experience air quality impacts as a result of construction include residents, schools and user of other facilities surrounding surface works (such as the compound which support tunnelling works, integration works and tie-in works).

Consultation with affected receivers would be carried out prior to works commencing and throughout the construction phase at each site. Consultation regarding construction air quality would be integrated with broader construction communications strategies around each site.

4.2 Traffic management

It is acknowledged that changes to traffic arrangements would impacts a range of stakeholders and a wide section of the community who may not otherwise be part of project distribution areas. These stakeholders would include, but not necessarily be limited to:

- Local councils.
- Local community – those to live and work in the vicinity of the project.
- Wider community – those who utilise the road network around the project.
- Local school communities.
- Freight companies.
- Peak freight organisations.
- Emergency service operators.
- Relevant bus operators.
- NSW Taxi Council.

4.2.1 Traffic and Transport Liaison Group

A Traffic and Transport Liaison Group would be established, including representatives from Roads and Maritime, the NSW Police, relevant bus operators and the relevant local council/s. The TTLG would provide a forum to discuss all traffic management and road safety matters associated with construction of the project.

4.2.2 Community information

Information relating to traffic management and altered traffic conditions would be disseminated to the community through:

- Regular updates to the project website with detail of current traffic arrangements.
- Signage in advance of changes of arrangement at bus stops.
- Signage in advance of changes to pedestrians and cyclist facilities.
- Major traffic detours, disruptions and switches would be advertised in advance of the change in local and State print media and the radio. Existing variable message sings on the Sydney road network would also be used to inform the community of these major changes.

4.3 Urban design and landscaping

An Urban Design and Landscape Plan would be developed based on the detailed design of the project. The Urban Design and Landscape Plan would be developed in consultation with the community and the relevant local council/s. The Plan would include, as a minimum:

- Identification of design principles and standards.
- The location of existing vegetation and proposed landscaping (including use of indigenous and endemic species where possible).
- A description of disturbed areas and details of the strategies to progressively rehabilitate regenerate and/ or revegetate these areas.
- Design features, built elements, lighting and building materials.
- Graphics such as sections, perspective views and sketches for key elements of the project, including built elements of the project.

Additionally, a signage strategy would be developed during the detailed design phase of the project. Targeted community and stakeholder consultation would be carried out during the development of the signage strategy in relation to signage location and associated impacts.

4.4 Noise and vibration

Consultation regarding construction noise and vibration would generally be undertaken as part of wider project communications outlined in **Section 3**. However, specific consultation would be carried out in relation to out of hours works. This consultation would be targeted at stakeholders and the community who are likely to be impacted by noise or vibration from these works.

Consultation for out of hours works would include community notification in accordance with the requirements of any conditions of approval and an Environmental Protection Licence issued for the project. Additional targeted consultation would be undertaken with the affected community based on the predicted level of noise exceedance of the works. This may include letter box drops, specific notifications, phone calls or individual briefings. The level of exceedance when each particular consultation tool would be utilised would be determined as part of the Construction Noise and Vibration Management Plan and the Out of Hours Works Protocol.

5 Next steps

Subject to obtaining planning approval, this framework document would be developed into a community liaison implementation plan by the construction contractor. The community liaison implementation plan would provide further details regarding community involvement during design, construction and the project opening phase. This would include the consultation tools, activities and timing for each project elements and specific issue.

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