4.8.2 Potential impacts

Construction

During construction, potential impacts to land use and property issues could occur as a result of:

- Ancillary construction facilities, such as site compounds or construction sediment basins, if located outside of existing road reserves. This would potentially require full or partial land acquisition and a temporary change in land use.
- Temporary diversions for road construction, cyclists and pedestrians. Diversions of local roads, if required, would be identified in the Environmental Impact Statement, and would be managed in consultation with the relevant local Council and Roads and Maritime.
- Alteration and / or temporary disruption to property access. Alternative arrangements would be negotiated with the affected parties in order to enable continued access and to minimise disruption as much as reasonably possible.

The location and size of ancillary construction facilities would be developed during the design development process for the preferred project design and reflected in the Environmental Impact Statement. At a minimum, construction facilities would be required at the St Peters interchange and where the project would be integrated with the M5 East Motorway. Intermediate sites would also be required and would be dependent on the construction methodology for tunnelling and determining the location of ancillary operational facilities.

Existing land uses, site accessibility and potential opportunities to co-locate permanent operation facilities would be considered when determining the size and location of construction facilities. In the event that land is required that is not owned by the NSW Government, discussions would be held with the affected property owner concerning the purchase or lease of the land required during construction.

Operation

Impacts on land use and property could occur as a result of:

- Full or partial property acquisition to accommodate surface infrastructure and activities, such as at-surface roads, interchanges and ancillary infrastructure. The need for acquisition would be minimised, where possible, and the location of surface infrastructure would consider potential impacts on land uses.
- Severance and sterilisation of land. Options for incorporating sterilised or fragmented land into the future road corridor would also be investigated, or alternatively, suitability for the land to be consolidated and resold following the completion of construction would be explored.
- Changes in property access. In some cases, accesses would require permanent relocation to cater for new or widened road reserves. The extent of such changes, including the number of properties affected and whether access would be lost or relocated, would be assessed and identified in the Environmental Impact Statement.
- Changes to development potential of properties.
- Impacts on land uses along key surface roads within the project corridor due to the associated improvements to amenity and local network efficiencies. Improvements to travel times would also deliver benefits to businesses that would support the continued growth of key employment areas in the immediate vicinity of the project corridor (such as the Port Botany precinct).
- Full or partial property acquisition for the location of permanent operational ancillary facilities.

With the majority of the project being in tunnel, substantial direct land use impacts would generally be avoided for the majority of the project length in terms of acquisition, severance or sterilisation. As such, direct land use and property impacts are anticipated to be limited to areas where surface components are proposed that extend outside existing road corridors. This is anticipated to occur primarily in areas close to the southern and northern extents of the project and at other surface infrastructure locations.

The potential impacts on any relevant future strategic planning initiatives being progressed by the Department of Planning and Environment and the Urban Growth Development Corporation (as detailed earlier in this section) would be dependent on the preferred project design. These would be identified and assessed as part of the Environmental Impact Statement, supported by consultation with these agencies.

4.8.3 Proposed further assessment

A detailed assessment of the land use and property issues of the area would be undertaken. This would include:

- The identification of the local land uses, existing access arrangements and potential property acquisition for both public and private land adjacent to the project.
- Assessment of the potential impacts of the project on property, land use (including approved developments) and access arrangements during construction and operation of the project.
- Identification of appropriate management and safeguard measures to minimise these impacts.

4.9 Hydrology and flooding

4.9.1 Overview

The project corridor is located within the Cooks River catchment, which covers an area of about 10,200 hectares and flows for about 23 kilometres from Graf Park in Bankstown into Botany Bay at Kyeemagh (Cooks River Alliance 2013).

The River was stripped of its natural vegetation during early European settlement and has been subject to long term anthropogenic degradation. The landscape and natural function of the catchment has been impeded by dredging and artificial channel modifications, including re-alignment.

The eight tributaries of the Cooks River are:

- Greenacre Creek.
- Cox's Creek.
- Cup and Saucer Creek.
- Fresh Water Creek.
- Bardwell Creek.
- Wolli Creek.
- Muddy Creek.
- Sheas Creek / Alexandra Canal.

Water quality of the Cooks River catchment is discussed in **Section 4.10** (Geology, soils and water quality).

Wolli Creek and Alexandra Canal / Sheas Creek sub-catchments are located within the project corridor. The location of key waterways within the project corridor are shown on **Figure 4-6**.

Wolli Creek is the largest tributary of the Cooks River. The creek runs through the Wolli Creek Valley in a north-easterly direction from Kingsgrove in the west, joining the Cooks River near Tempe.

Wolli Creek is a concrete channel for 3.5 kilometres, from its westernmost extent in the vicinity of the King Georges Road interchange to Bexley Road in the east, where the watercourse flows through a box culvert. East of Bexley Road, Wolli Creek comprises a natural streambed, which flows through Wolli Creek Valley and Wolli Creek Regional Park. Wolli Creek is joined by the Bardwell Creek tributary within Wolli Creek Regional Park on the northern side of the passenger rail line at Bardwell Park, before reaching its confluence with the Cooks River south of Wentworth Park, Wolli Creek.

Alexandra Canal is an adapted artificial waterway (formerly known as Sheas Creek), which extends for about four kilometres from Huntley Street, Alexandria in the north-west to its confluence with the Cooks River at Tempe. Alexandra Canal was built during the 1890s to provide access for water transport for the delivery of cargo (Heritage Branch 2014).

Sections of the project corridor in proximity to Wolli Creek, Alexandra Canal / Sheas Creek and the Cooks River are located within land which could potentially be affected by a one in 100 year Average Recurrence Interval flood event.

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KEY

- Wolli Creek Regional Park
- Road
- Rail
- Waterbody
- Named watercourse
- Drainage line

Figure 4-6: Key waterways within the project corridor

0 1 2 Km

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4.9.2 Summary of issues

Construction

Construction of the project has the potential to result in the following surface water:

- Changes to flooding regimes from construction work and / or from the positioning of temporary construction infrastructure within areas of flood prone land.
- Impacts to the geomorphology of creeks that receive treated groundwater discharges.
- Reduction in water quality from erosion and sedimentation and / or discharge of water into waterways.

Operation

Operation of the project has the potential to result in impacts to surface water from the following activities:

- Impact to the geomorphology of receiving watercourses due to the discharge of treated groundwater and other waste waters (such as tunnel wash or deluge system water). The discharge would likely be into a local watercourse, such as Wolli Creek, the Cooks River or Alexandra Canal. This could depend on the discharge volumes and the point of discharge.
- Increased impervious surfaces and/or changes to the total catchment area of existing drainage infrastructure due to surface work at tunnel portals and tie-ins to existing roads. This could lead to potential localised flooding. Considerable increases to runoff at these locations could potentially require upgrades to existing drainage infrastructure, and may require additional mitigation measures (such as stormwater drainage basins and the like).
- Potential obstruction to flood flows as a result of new infrastructure or a reduction in flood plain, which could have an impact downstream flooding behaviour or on nearby existing developments.

4.9.3 Proposed further assessments

The Environmental Impact Statement for the project would include an assessment of the potential construction and operational impacts on surface water and flooding, including identification of the following:

- Likely groundwater discharge volumes into local watercourses during construction and operation, and the potential impacts on geomorphology of those waterways. Associated impacts on biodiversity values are considered in **Section 4.5**.
- Potential flooding impacts during construction and / or operation of the project.
- Operational drainage infrastructure required to convey stormwater flows.
- Required alterations to existing road drainage infrastructure in the vicinity of surface work at tunnel portals and tie-ins to existing roads.
- Required connections to third party stormwater systems for operational surface ancillary facilities.
- Appropriate mitigation and management measures to safeguard the environment during construction and operation of the project.

4.10 Geology, soils and water quality

4.10.1 Overview

Topography

Western areas of the project corridor are relatively flat, low lying, with gentle undulating hills ranging between 30 metres Australian height datum (AHD) and 40 metres AHD.

Wolli Creek and its southern tributary, Bardwell Creek have incised gullies through a subterranean (under the surface) sandstone and shale plateau, which is higher in elevation than in other parts of the Sydney basin. Wolli Creek flows to the east to join the Cooks River. The Wolli Creek and Cooks River valleys widen as they approach Botany Bay and the incised valley floors have been filled with alluvial sediment to create flat alluvial plains. The Wolli Creek and Cooks River channels have been modified over much of their length to improve drainage and control flooding.

The topography of the project corridor near the confluence of Wolli Creek and the Cooks River is relatively flat and low-lying (around five metres AHD to 10 metres AHD), and gradually declining towards Botany Bay. Land within and adjoining the central and north-eastern areas of the project corridor have been substantially modified over time due to land reclamation and industrial activities. This has resulted in large areas of low-lying flat land. Terrain in areas to the north-west of the Princes Highway is undulating following a gentle rise from the Cooks River.

Soils

Soils within the project corridor are identified from the Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman, G.A and Murphy, C.L., 1989). The Gymea soil landscape covers the majority of the project corridor in the west, with smaller areas of the Hawkesbury, Blacktown, Birrong, Warriewood and Oxford Falls soil landscapes. The eastern extent of the project corridor is largely covered by land identified as being disturbed terrains, associated with Alexandra Canal and industrial land uses. Relevant characteristics of these landscapes are provided in **Table 4-4**.

Table 4-4 Soil landscapes within the project corridor

Soil Landscape	Limitations
Gymea (Gy)	• Undulating to rolling rises and low hills on Hawkesbury Sandstone. • Localised steep slopes. • High soil erosion hazard. • Rock outcrops. • Shallow, highly permeable soil. • Very low soil fertility.
Hawkesbury (Ha)	• Rugged, rolling to very steep hills on Hawkesbury Sandstone. • Extreme soil erosion hazard. • Mass movement (rock fall) hazard. • Steep slopes. • Rock outcrops. • Shallow, stony, highly permeable soil. • Low soil fertility.
Blacktown (Bt)	• Gently undulating rises on Wianamatta Group shales and Hawkesbury shale. • Moderately reactive highly plastic subsoil. • Low soil fertility. • Poor soil drainage.
Birrong (Bg)	• Level to gently undulating alluvial floodplain draining Wianamatta Group shales. • Localised flooding. • High soil erosion hazard. • Saline subsoil. • Seasonal waterlogging. • Very low soil fertility.
Oxford Falls (Of)	• Hanging valleys on Hawkesbury Sandstone. • Very high soil erosion hazard. • Perched water tables and swamps. • Highly permeable soil. • Very low to low soil fertility. • Localised rock outcrop.
Warriewood (Wa)	• Level to gently undulating swales, depressions and infilled lagoons on Quaternary sands. • Localised flooding and run-on. • High water table. • Highly permeable soil.
Disturbed (xx)	• Level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. • Dependent on nature of fill material. • Mass movement hazard. • Unconsolidated low wet-strength materials. • Impermeable soil. • Poor drainage. • Localised very low fertility. • Toxic materials.

Acid sulfate soils and potential acid sulfate soils are naturally occurring soils containing iron sulfides which, on exposure to air, oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron and manganese from the soils. The project corridor is located on land classified as Class 1, 2, 3, and 5 acid sulfate soils. Definitions of the acid sulfate soils classes are provided in **Table 4-5** below.

Table 4-5 Acid sulfate soils class definition

Acid sulfate soils class	Work which would potentially expose acid sulfate soils
Class 1	Any work
Class 2	Work beyond the natural ground surface and work by which the watertable is likely to be lowered.
Class 3	Work beyond one metre below the natural ground surface and work by which the watertable is likely to be lowered beyond one metre below the natural ground surface.
Class 4	Work beyond two metres below the natural ground surface and work by which the watertable is likely to be lowered beyond two metres below the natural ground surface.
Class 5	Work within 500 metres of adjacent Class 1, 2, 3, or 4 land which are likely to lower the watertable below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land.

Source: Acid sulfate soils assessment guidelines (Ahern C. R., Stone, Y. and Blunden, B., 1998)

A search of the Australian Soils Resource Information System indicated the majority of the project corridor has a low to extremely low probability of occurrence of acid sulfate soils. Land adjacent to watercourses, namely the Cooks River, Wolli Creek and Alexandra Canal were identified as having a high probability of acid sulfate soils occurring. These areas correspond to land identified as containing Class 1, 2 and 3 acid sulfate soils.

Geology

The geology along the project corridor has been interpreted using the Geology of the Sydney 1:100,000 Sheet 9130 (Herbert, C. 1983). A summary of the geological units present within the Project corridor is provided in **Table 4-6**. The geology of the project corridor relates to the Sydney Basin Stratigraphy, with Ashfield Shale (part of the Wianamatta Group) overlying Hawkesbury Sandstone. The Mittagong Formation separates the Ashfield Shale from the underlying Hawkesbury Sandstone over much of the Sydney Basin.

Ashfield Shale corresponds to ridgelines within the project corridor, and is present largely in the west and to the north of Sydney Airport. The Ashfield Shale is estimated to be around 60 metres to 70 metres in thickness, and consists of siltstone and laminate subgroup units.

The Mittagong Formation comprises fine grained sandstone and siltstone. The thickness of the formation is variable but is generally less than 10 metres.

Hawkesbury Sandstone is present towards the Cooks River within the project corridor, in areas of steeper topography. Hawkesbury Sandstone is a medium to coarse grained quartz sandstone deposited in beds one to three metres thick.

Hawkesbury Sandstone and Ashfield Shale are overlain by unconsolidated Quaternary sediments in areas adjacent to the Cooks River and Alexandra Canal.

Table 4-6 Geological units within the project corridor

Unit	Era	Period	Epoch	Environment / Palaeo-environment
Qha	Cainozoic	Quaternary	Holocene	Stream alluvial and estuarine sediment.
Qhs	Cainozoic	Quaternary	Holocene	Freshwater swamp.
Qhd	Cainozoic	Quaternary	Holocene	Transgressive dune.
Rwa	Mesozoic	Triassic	Middle Triassic	Potentially lacustrine (related to a lake).
Rh	Mesozoic	Triassic	Middle Triassic	Braided alluvial channel fill.

Source: Geology of the Sydney 1:100,000 Sheet 9130 (Herbert, C. 1983)

Sections of the project corridor in the vicinity of Tempe and St Peters are understood to be located beneath or proximal to the location of historical brick pits, quarries and disposal facilities, which are underlain by Pleistocene aged Botany Sands, comprising Aeolian sand and dune deposits with lenses of peat and clay.

Groundwater

Groundwater along the project corridor is present within the Ashfield Shale and underlying Hawkesbury Sandstone, although the Ashfield Shale is not always present along the project corridor.

Groundwater levels within the two main geological units are variable but typically the shape of the regional water table is a subdued reflection of the topography with the water table being deepest beneath hills and shallowest beneath creeks or gullies.

The quality of groundwater within the Ashfield Shale is generally saline and corrosive. Groundwater quality within the Hawkesbury Sandstone is generally of good quality and often of potable quality. Elevated concentrations of dissolved iron and manganese naturally occur within the Hawkesbury Sandstone which can cause iron staining when discharged. Groundwater quality in the upper part of the Hawkesbury Sandstone is sometimes poor due to leakage from the overlying Ashfield Shale.

Perched groundwater is also present within weathered sections of the Ashfield Shale. The perched groundwater typically forms isolated pockets of groundwater above the regional water table. Perched groundwater is not continuous and does not form an aquifer.

An alluvial and coastal sand bed aquifer, the Botany Sands Bed aquifer, is located in areas surrounding Botany Bay, and extends along the Cooks River and its tributaries, as well as north towards Centennial Park. There are two main groundwater systems operating within the Botany Sand Beds; the deeper, confined fractured / porous Triassic Hawkesbury Sandstone and upper Quaternary Botany Sand Beds (Ivkovic, K M, Marshall, S K et. al 2013). The upper Quaternary Botany Sands aquifer has a shallow water table and unconfined to semi-confined. The sediments within the sand beds are highly permeable, resulting in the semi-confined layers of the sand beds being highly vulnerable to contamination. For this reason, parts of the aquifer are under embargo for certain uses due to contamination. This is discussed later in this section.

The project corridor is also located within land under regulation by the Greater Metropolitan Region Groundwater Sources Water Sharing Plan.

Sixty-seven existing registered bores have been identified in close proximity to the project M5 Project corridor from a search of the NSW Natural Resource Atlas. These boreholes include:

- Fifty-one monitoring bores.
- Ten domestic bores.
- Five recreation bores.
- One test bore.

Water quality

The catchments located within the project are identified in **Section 4.9** (Hydrology and flooding). The Cooks River catchment is regarded as one of the most polluted urban river catchments in Australia. Water quality of the catchment has been affected historically by stormwater pollution, industrial and domestic wastewater discharge, rubbish dumping and modifications of the waterway. Present levels of pollutants, including nutrients, sediments, toxicants and faecal coliforms make the Cooks River unsafe for swimming, unsuitable for many aquatic species and a health risk for commercial fishing.

Sewage overflows, rubbish dumping and stormwater pollution continue to affect the water quality of the catchment. Detrimental impacts to the Cooks River catchment are further compounded by continued urbanisation within the catchment area, hindering opportunities to improve the management, environmental and recreational qualities of the Cooks River.

Contamination

Areas of known contamination

There are six contaminated sites within the project corridor listed on the Environment Protection Authority's Contaminated Land record (EPA, 2014). Details of these sites and the nature of their contamination are provided in **Table 4-7**.

The St Peters interchange is also located on land that includes a former quarry that has been operated as a landfill since about 1988. It would be made suitable for road infrastructure purposes prior to the commencement of construction. Some remediation of this site is expected to occur prior to the commencement of the project. Any approvals (if required) would be sought separate to this project.

The Botany Sands aquifer is highly vulnerable to contamination. Botany and its surrounding suburbs have been heavily used by industry for more than 100 years, including tanneries, metal platers, service stations and depots, landfills, dry cleaners and wool scourers. Industrial activity has been undertaken in this area largely before any environmental protection controls were in place, and as a result, heavy metals including chromium, nickel, lead and arsenic may have contaminated the aquifer.

Some of these industrial uses have led to contamination of the groundwater within the aquifer. Because of known or potential contamination, the NSW Government has taken a precautionary approach to ensure public health is not put at risk from exposure to potentially contaminated groundwater. Under the precautionary approach, the Botany Sand Beds aquifer is divided into four management zones; the known contaminated Orica exclusion area, and three other management zones. Domestic groundwater use is banned within all four management zones in order to minimise the risk to bore users and prevent the spread of contamination through pumping. Industrial bore users within all management zones are required to test their bore water annually and report the results of testing to the NSW Office of Water and the Office of Environment and Heritage. There has been an embargo in place since August 2003 on the acceptance of new licence applications to extract groundwater.

Areas of potential contamination

There are a number of current and former land uses within the project corridor which may have resulted in contamination. These include service stations and industrial facilities. As the development of the design progresses the likelihood that these areas would be affected would be known and approaches to mitigate impacts would be developed.

The bed of Alexandra Canal is declared as a remediation site under the *Contaminated Land Management Act 1997*. The bed sediments of Alexandra Canal have been identified as containing chlorinated hydrocarbons, including organochloride pesticides (chlordane, total DDT and dieldrin), polychlorinated biphenyls and metals. The contamination of the bed sediments has been found to present a significant risk of harm to human health and the environment (NSW Environment Protection Authority, 2000).

Table 4-7 Land within the project corridor declared as significantly contaminated under the Contaminated Land Management Act 1997

Contaminated Site	Contaminants present	Nature of contamination
Pioneer Plating Work 25-29 Ricketty Street, Mascot. Part Lot K in DP356471 and Lot B in DP399409.	• Total petroleum hydrocarbons (TPH). • Benzene, toluene, ethyl benzene and xylene (BTEX). • Total cyanide. • Heavy metals, including cadmium, chromium (III and VI), copper, nickel and zinc.	• The contaminants have been introduced to the site from past activities and through the importation of contaminated fill. The contaminants are or may be exposed across the surface of the site and are impacting on groundwater beneath the site.
Former drum reconditioning facility 15 Campbell Street, St Peters. Lot 1 DP 223531.	• Polycyclic aromatic hydrocarbons (PAHs). • TPHs. • BTEX. • Napthalene.	• PAHs, TPH and BTEX are present in the soil on the site at levels significantly exceeding guideline levels for sensitive land use. • Napthalene is present in groundwater on the site at levels about relevant trigger values for the protection of aquatic ecosystems. • TPH is present in the groundwater at significant concentrations. • It is likely contaminated groundwater on the site is migrating off-site towards Alexandra Canal.
Former Tempe Tip. 2-14 Fisher Street, Petersham. Lot 1 DP 62963, Lot 1 DP124394, Lot 8 Sec 20 DP57638, Lot 7 DP63236, Lot 3 DP662867, Lot 1 DP124399, Lot C DP385209, Lot F DP385210, Lot A DP382059, Lot 40 DP 746918, Lot 3 DP 261958, Lot 723 and Lot 725 DP48012, Lot 19 and lot 20 DP 825649, Lot 2 DP869306.	• Ammonia	• Leachate containing ammonia is migrating offsite towards the adjoining Alexandra Canal via groundwater flow, further contaminating the watercourse. • Applicable guidance levels for ammonia in water have been markedly exceeded. • The ammonia migrating off site is causing harm to fresh water biota in contact with the contaminated groundwater and to water quality in Alexandra Canal as a receiving body of the contaminated groundwater.
Alexandra Canal Off Swamp Road, Tempe. Lot 1 DP532493, Lot 1 DP749404 and Lot 3 DP 878489.	• Chlorinated hydrocarbons, including organochlorine pesticides (chlordane, total DDT and dieldrin). • Polychlorinated biphenyls (PCBs). • Metals.	• The contaminants within Alexandra Canal are present within the bed sediments in such a way as to present a significant risk of harm to human health and the environment. • Contamination at the site presents a significant risk of harm because harm is being caused to benthic biota in contact with contaminants in the sediments and to humans from increased risk associated with the consumption of contaminated fish. Disturbance of the sediments would mobilise the contaminants and increase the risk of harm.

Contaminated Site	Contaminants present	Nature of contamination
Solvent Recycler and Distributor 61 Turella Street, Turella Lot 1 DP563180	• Tetrachloroethene (or perchloroethylene (PCE)). • Trichloroethene (TCE). • Cis-1, 2-dichloroethene (DCE). • Chloroethene (vinyl chloride (VC)). • Dichloromethane (DCM). • TPHs • BTEX	• Groundwater at the site is contaminated with high concentrations of chlorinated solvents and petroleum hydrocarbons exceeding human health and ecological guideline criteria. • Contaminated groundwater may be migrating offsite where there is the potential for exposure to occur.
Roads and Maritime Services Land Lot 3 Jackson Place, Earlwood Lot 1 DP557246	• Lead. • DDT (including breakdown products). • Asbestos.	• The Site is contaminated is contaminated with concentrations of primarily lead and organochlorine pesticides (OCP), as well as some polycyclic aromatic hydrocarbons (PAH). • Asbestos in bonded cement and fibre forms has been detected in soils on the Site.

4.10.2 Summary of issues

Construction

Construction of the project has the potential for the following soil, groundwater and contamination related impacts:

- Impacts to water and soils due to spills or leaks of fuels and / or oils from construction plant and equipment and / or from vehicle / truck incidents.
- Impacts to water and soils due to spills or leaks of other hazardous substances and dangerous goods from construction work and / or from vehicle / truck incidents
- Exposure of soils during construction resulting in direct erosion impacts. This may lead to dirty water runoff and sedimentation in local watercourses including Wolli Creek, the Cooks River, Alexandra Canal and / or Botany Bay or on adjacent land.
- Interception of groundwater, which may require treatment before re-use or disposal. The volumes of groundwater and treatment requirements would differ depending on the depth of the tunnel to be constructed, and the geological units through which it passes. It is expected as a minimum, treatment for suspended solids would be required, and further consideration would need to be given to the management of potentially contaminated groundwater, as well as elevated levels of salinity, iron and manganese.
- Discharge of treated groundwater from tunnel construction work. It is likely that groundwater encountered by tunnelling activities would be discharged to a local watercourse as surface water. Alternatively, groundwater may be discharged to sewer under a trade waste agreement.
- Generation of a net surplus of spoil as tunnelling would comprise of a large component of the project. Construction of a tunnel within the project corridor would likely occur within the Ashfield Shale and Hawkesbury Sandstone geological units.
- Interaction with quaternary aged sediments present within the project corridor may include soft clays and organic soils, loose silts and sands. These can pose a constraint to construction for reasons such as instability, low bearing capacity and settlement. These constraints are commonly encountered and established treatment options are available for structures, earthworks and pavements.
- Disturbance of contaminated soils, especially if surface work is undertaken within land known to be contaminated, or on land which has been identified as potentially contaminated based on current and historic activities. Disturbance of contaminated soils has the potential to result in offsite pollution.
- Potential disruption of contaminated bed sediments within Alexandra Canal from bridge construction.
- Exposure of soil containing acid sulfides to oxygen, resulting in the production of sulfuric acid, which may become bioavailable in the environment and affect local aquatic ecosystems, water quality and visual amenity.

Operation

Depending on the final design, the tunnel component of the project may either be drained or undrained. An un-drained tunnel precludes the inflow of groundwater into the tunnel. A drained tunnel allows ongoing groundwater inflow requiring groundwater collection, treatment and discharge during the operational phase.

If the final design of the tunnel component of the project is a drained tunnel (ie a tunnel allowing ongoing groundwater inflow), local groundwater in the vicinity of the tunnel may be drawn down to the tunnel invert level. This may impact the functionality of existing groundwater bores listed above and could have an impact on groundwater dependent ecosystems. Should the final design include a drained tunnel, there is the potential for contaminated groundwater to be intercepted as part of ongoing groundwater inflow. The extent of potential impact, if any, on existing bores, would be considered in the Environmental Impact Statement for the project.

Other potential impacts during operation would also include:

- Impact to water quality of receiving watercourses due to the discharge of treated groundwater and other waste waters (such as tunnel wash or deluge system water). The discharge would likely be into a local watercourse, such as Wolli Creek, the Cooks River or Alexandra Canal. This could have an impact on the water quality of the receiving waterway, depending on the discharge volumes, treatment and the point of discharge.
- Impact to water quality of receiving watercourses due to increased runoff from roads. This would typically contain oils and greases, petrochemicals and heavy metals as a result of vehicle leaks, operational wear, road wear and atmospheric deposition. Increased flows could also lead to increased potential for scouring of soils and watercourses.
- Spills or leaks of fuels and / or oils from vehicle accidents, or from operational plant and equipment.

4.10.3 Proposed further assessments

Geotechnical, groundwater preliminary contamination and environmental investigations are currently underway to inform the design and construct tender process and the Environmental Impact Statement. These investigations will identify the ground conditions for tunnelling and hydrogeological conditions across the project corridor, as well as provide preliminary contamination information. These investigations would include an assessment of the groundwater quality at monitoring well locations, anticipated groundwater flow rates.

Geotechnical investigations would inform the design of the tunnel and therefore the expected quantities of spoil from tunnelling activities (refer to **Section 5.5** for additional information related to resource management and waste). The quantity of spoil would also depend on the tunnelling technique adopted for the project. Spoil management is discussed further in **Section 4.11**.

The Environmental Impact Statement for the project would also include:

- Identification of waterways and groundwater systems that may be impacted by the construction and operation of the project.
- Assessment of the potential impacts to soil and water, including field investigations.
- Assessment of the risk of erosion and sedimentation in accordance with RMS Erosion and Sedimentation Management Procedure (RMS, 2008).
- Likely groundwater discharge volumes into local watercourses during construction and operation, and the associated impacts on water quality. Associated impacts on biodiversity values are considered in **section 4.5**.
- Assessment of potential settlement along the tunnel alignment and the potential impacts to structures and infrastructure.
- Identification of areas of known contamination or with potential contamination (soil and groundwater) that could be impacted by the project, and the potential impacts associated with the disturbance of these areas. This would be supported by investigations to identify, quantify and assess the contamination.

4.11 Non-Aboriginal heritage

4.11.1 Overview

The project corridor spans an area which was initially colonised soon after European settlement in 1788. Now known as Wolli Creek, the Cooks River swampland made early access from Sydney Cove difficult and was an inhibiting factor for early and intensive settlement. Land grants began in 1799 and were generally divided into areas of small farms and large estates which saw mansions such as Tempe House erected as retreats for their owners. By the later 19th century, particularly near the waterfront, older houses and mansions were being replaced by working class housing and industries. This saw the establishment of industrialisation in suburbs such as Arncliffe and Mascot (Thorp, 1994).

A preliminary non-Aboriginal heritage desktop assessment was performed in August 2014, which included a search of relevant statutory and non-statutory heritage databases and a review of the heritage listings within local environmental plans. These included:

- NSW State Heritage Register and Inventory.
- Section 170 Heritage and Conservation Registers administrated by Sydney Water, Department of Commerce, RailCorp, Roads and Maritime, Ausgrid and NSW Ports.
- Hurstville Local Environmental Plan 2012.
- Canterbury Local Environmental Plan 2012.
- Rockdale Local Environmental Plan 2011.
- Botany Bay Local Environmental Plan 2013.
- Marrickville Local Environmental Plan 2011.
- Sydney Local Environmental Plan 2012.
- Register of National Estate.
- National Trust of Australia.
- Australian Heritage Places Inventory.
- Commonwealth and National Heritage Lists.

A number of heritage items were identified within the project corridor (refer to **Figure 4-7**). Of these, nine items were identified as being of State significance, being:

- Sydenham Railway Station group.
- Alexandra Canal.
- Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS)—Western Main Carrier.
- St Peter's Anglican Church.
- Cairnsfoot Special School.
- A Timber slab cottage, Tempe.
- Milford Haven.
- Tempe House and St Magdalene's Chapel.

The remaining items are of local significance and/or listed on Section 170 Heritage and Conservation registers.

The majority of items identified within the project corridor are:

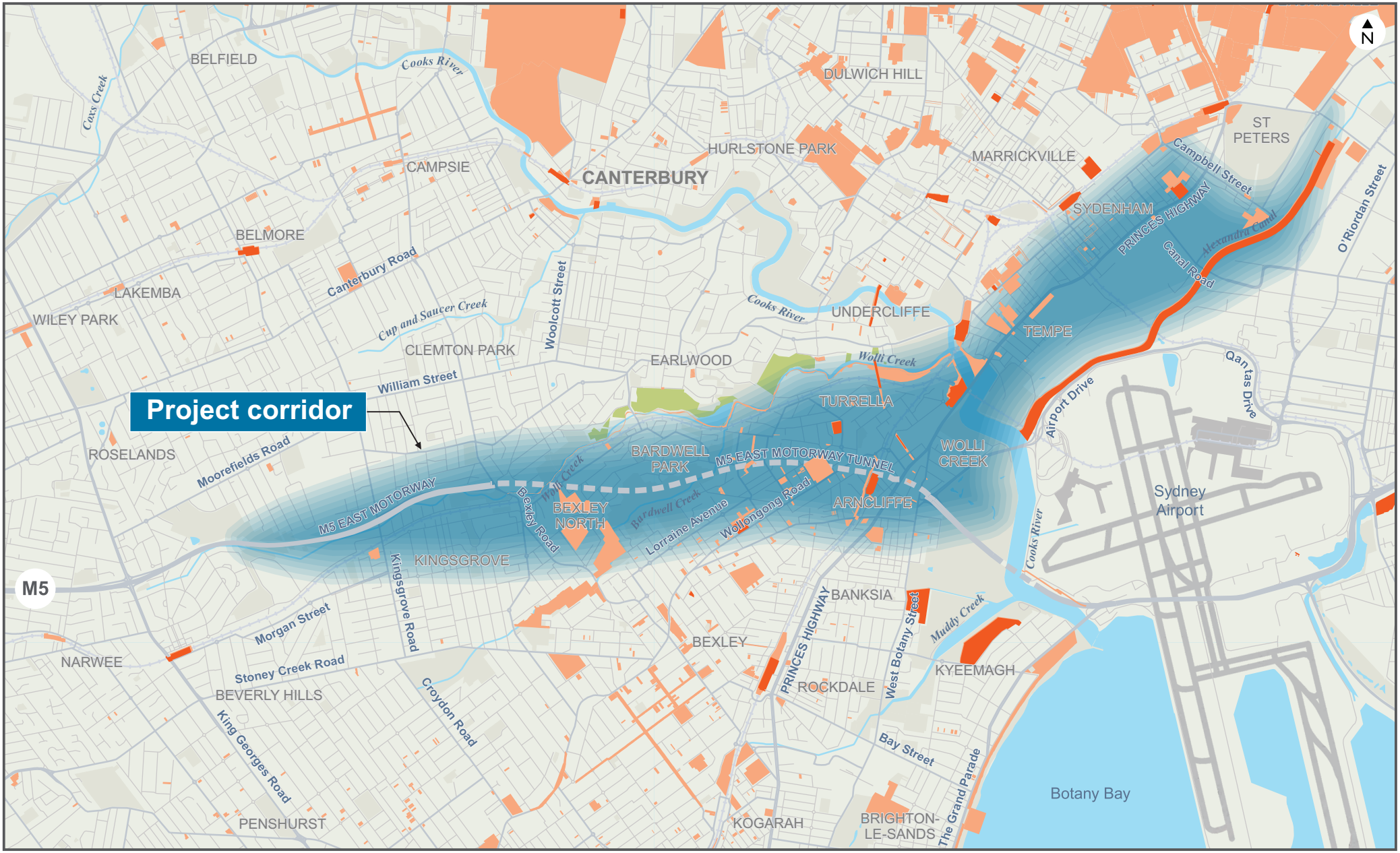
- Houses and structures (school, churches, cottages, brickwork). This includes the State Heritage listed Tempe House and St Magdalene's Chapel on the banks of the Cooks River, and the locally listed Rudders Bond Store at St Peters.
- Recreational areas, waterways and wetlands (for example, Wolli Creek and Alexandria Canal).
- Utility infrastructure, including the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) aqueduct.
- Railway station groups.

Four heritage conservation areas are also located within the project corridor and within the Marrickville local government area. This includes:

- Collins Street Heritage Conservation Area.
- Wells Avenue Heritage Conservation Area.
- Stanley Street Heritage Conservation Area.
- Goodsell Estate Heritage Conservation Area.

There are no World Heritage, National Heritage or Commonwealth Heritage Places recorded within the project corridor.

In addition to being listed as a local heritage item under the Botany Bay Local Environmental Plan 2012, the Sydney (Kingsford-Smith) Airport Group (located immediately to the south east of the project corridor) is also identified as an indicative place on the Commonwealth Heritage List and is on the interim list of the Register of the National Estate (a non-statutory register).



KEY

- Wolli Creek Regional Park
- Road
- Rail
- Watercourse
- State heritage
- Local heritage

0 1 2 Km

Figure 4-7: Listed heritage items within the project corridor

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4.11.2 Potential impacts

There is the potential for direct and indirect impacts to non-Aboriginal heritage items and conservation areas to occur during the construction and operation of the project. Potential impacts would include:

- Physical impact on the item or within the curtilage of the item. This could include the demolition of the item or architectural treatment to buildings for operational noise attenuation.
- Structural damage due to vibration and settlement associated with tunnelling or surface works.
- Temporary and permanent changes to views to or from heritage items
- Permanent alteration to curtilage of a heritage listed item.

The majority of the potential impacts to non-Aboriginal heritage items would be associated with the construction of the project. Depending on the final location and design of surface infrastructure, there would be minimal potential for permanent operational impacts.

There is also the potential for non-Aboriginal heritage items in addition to those already identified to be discovered during the construction process. These are likely to be primarily archaeological remains of earlier habitation and industrial activities within sections of the project corridor.

4.11.3 Proposed further assessment

The project would be designed and constructed to avoid and/or minimise any impacts to areas of heritage value wherever feasible, and to avoid direct impacts to items listed on the State Heritage Register. Further investigation of the potential impacts on non-Aboriginal heritage items would be undertaken and presented in the Environmental Impact Statement. This would include:

- Updated searches of non-Aboriginal heritage databases and a review of literature relating to heritage within the project corridor.
- An assessment of significance for known State and local heritage items within the project corridor in accordance with the Burra Charter (ICOMOS, 1999) and the *Assessing Heritage Significance, NSW Heritage Manual 2, 2001* (NSW Heritage Office, 2001) and *Statements of Heritage Impact, 1996* (NSW Heritage Office, 1996).
- Pedestrian survey of areas around the surface elements, to identify additional building stock that may not have been included in LEP listings.
- Assessment of potential impacts to items of local and state heritage significance.
- An archaeological assessment, where required, to determine the presence of potential non-Aboriginal archaeological items and the potential impacts as a result of the project. The need for an archaeological assessment would be determined based on the outcomes of the literature review, the investigations detailed above and the nature of the potential impact. It may include archaeological test excavations.
- Consultation with the relevant stakeholders such as the Office of Environment and Heritage and local councils.
- Mitigation and management measures to minimise impacts to identified non-Aboriginal heritage values.

4.12 Resource management and waste minimisation

4.12.1 Overview

Resource management and waste minimisation would be considered throughout various stages of the project from design and construction through to operation. Large quantities of materials would be required for the construction of the project such as concrete, asphalt, steel, gravel, sand, aggregate and road base. This would need to be sourced from quarries, manufactures and suppliers, which would be largely sourced from areas outside the project corridor.

Waste associated with the project would be generated from a number of streams including:

- Excavation waste.
- Demolition waste.
- Wastewater.
- Hazardous waste.
- Vegetation waste.
- Liquid waste.
- Construction waste.
- General waste.

All wastes would be managed using the waste hierarchy approach of waste avoidance, waste re-use before consideration of waste disposal. 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 NSW Environment Protection Authority resource recovery exemptions.

The most significant waste stream associated with the project is likely to be spoil generated from the excavation of the road tunnels that is in excess of project requirements. Spoil that is in excess of project requirements would be preferentially beneficially re-used in other road projects and any non-road development sites that may require engineered fill, or other land rehabilitation projects. This would be managed in accordance with the broader WestConnex spoil management strategy that is currently under development.

Water resources would be required during construction. Water resources would be required during tunnelling, as well as other construction activities such as compaction of pavement materials, dust suppression and concrete batching.

Water resources could be sourced from within or outside the project corridor. Higher quality water for some construction activities may be sourced from potable water supplies. Water from groundwater sources may also be used. The final volume, source and quality requirements for water supplied to the project would be determined through the design development process for the preferred project design and reflected in the Environmental Impact Statement.

4.12.2 Potential impacts

Construction

Impacts associated with resource use and waste generation are likely to be predominantly associated with the construction of the project. These include:

- Potential impact on resource availability as a result of resource use requirements for the project.
- Generation of waste during construction of the project, including:
  - Demolition wastes from existing structures that require removal.
  - Excavated wastes, such as soil and rock, primarily from tunnelling and cutting. Depending on the final locations of excavation activities, these wastes are expected to be largely characterised as Virgin Excavated Natural Material although contaminated spoil may be generated.
  - Vegetation waste from the removal of trees, shrubs and ground covers that are unable to be mulched and reused within the project.
  - Packaging materials such as crates, pallets, cartons, plastics and wrapping materials.
  - Site compound waste such as liquid wastes from cleaning, repairing and maintenance, waste from spillages, fuel or oil waste, effluent from site amenities and general office wastes.

Operation

The operation of the project has the following resource use and waste management related impacts:

- Generation of wastes from operational maintenance and repair activities required over the lift of the project. The type and volume of wastes generated would be dependent on the nature of the activity, but would predominantly consist of green waste, oil, road materials, as well as contaminated waste resulting from potential fuel spills and leaks.
- Supply of water for the deluge system, which would form part of the fire and lift safety system.
- Water used as part of the deluge system or for tunnel washing would be captured, and treated using the groundwater inflow water treatment plant, prior to being discharged into the environment. This is discussed in **Section 5.8** (Hydrology and flooding).
- Litter generated by road users.

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

4.12.3 Proposed further assessment

The Environmental Impact Statement would provide further details on waste and resource management for the project, including:

- Estimates of the quantity of spoil that would be generated.
- Identification of a management hierarchy to reduce the volume of excess spoil generated by the project, such as through design, through use within the project, or use in other projects.
- Identification of the approximate resource requirements for the project, including estimation of the material and water requirements.
- Identification of available materials in the region including from quarries, potential material suppliers, and reuse of materials.

- Identification of available water supplies in the region and the locality (including recycled water).
- Identification of specific waste impacts of the project and the waste management approach.
- Identification of management and mitigation measures for resource use and waste across the project including potential spoil re-use and disposal sites and transport impacts. This includes strategies to minimising the export of excavated materials off-site, maximising re-use opportunities and minimising the volume of excavated material disposal to landfill.
- Identification of opportunities to use recycled materials provided they are fit for purpose and meet engineering requirements.

The impacts associated with the handling, storage and transport for spoil has been discussed in **Section 4.2** (Traffic and transport), **Section 4.3** (Air quality and human health), **Section 4.4** (Noise and vibration) and **Section 4.10** (Geology, soils and groundwater).

5 Other environmental issues

5.1 Aboriginal heritage

5.1.1 Overview

The traditional owners of the land within the project corridor are the Gameygal (Eora) people. The Gameygal (or Camerigal) people are believed to have occupied the western edge of Botany Bay from the Cooks River to Georges River. Previous investigations in the area suggest Aboriginal people relied on the banks of the Cooks River for food and medicinal plants (Attenbrow 1992). The Cooks River Valley was originally covered in a network of tracks providing trade and social and ceremonial linkages which played a key role in the social and economic structure of Aboriginal society.

Since early European settlement, the project corridor has been subject to significant disturbance from agricultural uses, residential, industrial and infrastructure uses. Items and sites of Aboriginal heritage significance are most likely to occur in areas associated with water sources, especially swamps (Smith 1988). Therefore, it is likely there may be areas of Aboriginal heritage significance located along and areas adjoining the shorelines of the Cooks River and Wolli Creek. There is potential that areas of archaeological sensitivity are considerably inland and / or buried beneath fill material as a result of extensive historic disturbance and development in the area, including land reclamation and the realignment of the Cooks River, as well as sea level rise.

A search of the Aboriginal Heritage Information Management System (AHIMS) was undertaken in August 2014 which identified a number of previously recorded sites within or close to the project corridor (refer to **Figure 5-1**). Of the sites, seven AHIMS registered sites are located within the project corridor and located near to the Cooks River and Wolli Creek (refer to **Table 5-1**).

Table 5-1 AHIMS sites located within the Project corridor

AHIMS ID	Description
45-6-2414	Rockshelter with deposit
45-6-2415	Rockshelter with deposit
45-6-2416	Rockshelter with midden
45-6-2417	Rockshelter with midden
45-6-2418	Rockshelter with deposit
45-6-2198	Midden
45-6-2737	Potential Archaeological Deposit (PAD)

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Figure 5-1: Listed AHIMS sites within and in proximity to the project corridor

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5.1.2 Potential impacts

Potential direct or indirect impacts on previously recorded AHIMS sites would be dependent on the preferred project design, the location of surface infrastructure and construction activities. The potential impact on these sites would be determined during the preparation of the Environmental Impact Statement. The project would be designed and constructed to minimise the potential for direct and indirect impacts on the known Aboriginal heritage sites. Given the nature of the surface infrastructure required, it may be possible to avoid direct impacts to the sites.

There is also potential for unknown Aboriginal sites and / or artefacts to be impacted by the project and this would be taken into consideration during the preparation of the Environmental Impact Statement. The risk of significant impacts to Aboriginal sites and / or artefacts is likely to be low given that most of the project would be located below ground. This risk is further mitigated by the disturbed and highly urbanised environment along most of the project corridor.

5.1.3 Proposed further assessment

An Aboriginal cultural heritage assessment report would be prepared for the project, including completion of at least stage 2 of the Roads and Maritime Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI). The Aboriginal cultural heritage assessment report would include but not be limited to:

- An archaeological survey of the project area to identify known and potential Aboriginal objects, places and cultural values.
- A review of relevant plans or diagrams showing the location of the project in relation to known and potential Aboriginal objects, places or cultural values.
- An assessment of significance of known and potential Aboriginal objects, places and cultural values.
- An assessment of known and potential impacts to Aboriginal objects, places and cultural values resulting from the construction and implementation of the project.
- If advancing to Stage 3 of the PACHCI, consultation with the Aboriginal community in accordance with that guideline. If advancing to Stage 3, consultation with the Aboriginal community would occur in accordance with the Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW, 2010).
- Identification of mitigation measures required to minimise impacts of the project on Aboriginal cultural heritage.

The Aboriginal cultural heritage assessment report would be prepared in accordance with the following policy documents and heritage guidelines:

- Procedure for Aboriginal Cultural Heritage Consultation and Investigation, (PACHCI) (Roads and Maritime Services, 2011).
- Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW, 2010).
- Code of practice for archaeological investigation of Aboriginal Objects in NSW (DECCW, 2010).

5.1.4 Management and safeguard measures

Standard management and safeguard measures would be considered through the design development process for the preferred project design and preparation of the Environmental Impact Statement including the implementation of stop works and referral procedures in the event of unexpected finds of Aboriginal heritage items.

5.2 Energy efficiency

5.2.1 Overview

The transport sector is a key contributor to greenhouse gas emissions in Sydney, contributing 13 per cent of total greenhouse gas emissions in NSW in 2007 (DCCEE, 2009). Transport emissions produced from the use of fuels are currently the third fastest growing component of NSW-generated greenhouse gases after electricity generation and industrial processes (EPA, 2012). Investment in roads to improve the efficiency of the transport network in NSW is likely to have a positive impact on greenhouse gas emissions by easing congestion and reducing vehicle emissions.

Greenhouse gas emission sources listed in the Australian Government's reporting legislation include:

- Carbon dioxide (CO_2).
- Sulfur hexafluoride (SF_6).
- Methane (CH_4).
- Nitrous oxide (N_2O).
- Hydrofluorocarbons (HFCs).
- Perflurocarbons (PFCs).

Emissions of these greenhouse gas emissions sources can be categorised into three different scopes (1, 2 or 3) in accordance with the World Business Council for Sustainable Development and World Resources Institute Greenhouse Gas Protocol (2004), and the Australian Government greenhouse has accounting and reporting systems. Specifically:

- Scope 1 emissions, also referred to as direct emissions are emissions generated directly by the project, such as those from the combustion of fuels used to power plant, equipment and vehicles used on site and the clearing of vegetation.
- Scope 2 emissions, also referred to as indirect emissions are emissions generated from the consumption of electricity that is generated off-site and used by the project, such as the electricity used to power tunnel ventilation systems and lights.
- Scope 3 emissions, also referred to as indirect upstream emissions, includes emissions in the supply chain, or those from the use of a product. These include embodied energy in construction materials and vehicles travelling on the completed project. Examples of road project Scope 3 emissions include:
  - Emission associated with offsite mining and production of materials such as concrete, asphalt and aggregates used in the construction and maintenance of a road.
  - Emissions from the combustion of fuel when transporting materials.
  - Emission from the vehicles using the road.

5.2.2 Potential impacts

Construction

The construction of the project would contribute to greenhouse gas emissions, either directly or indirectly, as a result of:

- Fuel consumption for transporting materials to site and the operation of construction plant
- Vegetation clearing.
- Indirect GHG emissions such as through embodied energy of products used for construction works, and their supply chains (such as concrete, and steel), or through the generation of electricity for consumption by the project.

Operation

The key source of greenhouse gas emissions during the operation of the project would be associated with the use of fuel by vehicles travelling along the project route and in road maintenance activities, and the electricity used for tunnel systems (such as tunnel ventilation and lighting).

There is likely to be some offset due to a reduction in fuel used by vehicles that have been diverted to the project given the operational traffic efficiencies gained by the project as well as improved traffic conditions and road maintenance regimes along main surface roads.

Mechanical tunnel ventilation systems are anticipated to be a major contributor to GHG, given the energy associated with the pumping of in-tunnel air. Energy consumption by tunnel ventilation systems can be reduced by good road design and efficient ventilation design. The air quality approach for the project, and the selected ventilation infrastructure, would be a key component of determining the energy consumption for the project.

5.2.3 Proposed further assessments

A greenhouse gas assessment would be conducted for the construction and operation of the project in accordance with the following:

- 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 organisation 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), 2013).
- Greenhouse Gas Assessment Workbook for Road Projects (the TAGG Workbook) (Transport Authorities Greenhouse Gas Group (TAGG), 2013).

It is anticipated that the greenhouse gas assessment would:

- Identify the assessment boundary and sources of greenhouse gas emissions associated with the construction, operation and maintenance of the project.
- Determine the quantity of each emissions source (such as fuel consumed, electricity, and construction materials) in line with the TAGG workbook.

- Quantify the greenhouse gas emissions associated with each greenhouse gas source using equations specified in the NGA factors (DIICCSRTE, 2013).
- Present the greenhouse gas emissions associated with the construction, operation and maintenance of the project.
- Identify opportunities (mitigation measures) which may be implemented to reduce greenhouse gas emissions associated with the project.

The design of the project would be prepared with consideration of the WestConnex sustainability strategy that is under development for the overall program of works. This strategy will reflect the ISCA's Infrastructure Sustainability Rating Tool Scorecard, which sets out specific requirements relating to energy and carbon for large infrastructure projects.

Project specific energy targets would be established, consistent with the NSW Government's 20 per cent renewable energy target by 2020 (identified as goal 22 in NSW 2021), and the Infrastructure Sustainability Council of Australia's (ISCA) Infrastructure Sustainability Rating Tool Scorecard. This would include:

- Implementation of identified energy reduction activities across all emission scopes including:
  - Energy and carbon reduction activities with a payback of less than four years.
  - At least one energy and carbon reduction activity with a payback of more than four years.
  - An assessment of feasibility of reductions in energy consumption during 'peak demand' periods.
- Investigating further opportunities for renewable energy use, such as providing 20-40 per cent of energy from renewable sources for the infrastructure lifecycle.

Further, it is anticipated that the design of the project would consider opportunities to utilise renewable energy technologies where possible.

5.2.4 Safeguards and management measures

Greenhouse gas and climate change issues are commonly encountered on road projects and can be managed and mitigated through the implementation of standard approaches. Standard management and safeguard measures have been identified below, which would be considered through the design development process for the preferred project design and identified as appropriate in the Environmental Impact Statement for the project. These may include:

- Consideration of the preferential selection of materials, vehicles and construction equipment with characteristics such as lower embodied energy and greater fuel efficiency, where feasible.
- Construction plant and equipment would be maintained to reduce energy efficiency losses associated with damaged or unmaintained equipment.
- Construction transport requirements would be reduced wherever reasonably possible, for example through use of local staff, resources, suppliers, and landfills.
- Vegetation clearance would be minimised wherever reasonably possible.
- Reductions in operational emissions would be achieved by developing an optimal design, including the vertical and horizontal alignments and reduction of stop start driving. These reductions would be cumulative over the design life of the project. Energy efficient ventilation and lighting system designs would also be key areas of consideration for achieving optimal energy efficiency outcomes during the operational phase.

5.3 Climate change risk and adaptation

5.3.1 Overview

An increase in the global concentration of greenhouse gases has led to an increase in the Earth's average surface temperature, contributing to the phenomenon of climate change. The State of the Climate 2012 (CSIRO and the Australian Bureau of Meteorology, 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 greenhouse gas concentrations. Due to long lag times associated with climate processes, even if greenhouse gas emissions are mitigates and significantly reduced, the warming trend is expected to continue for centuries (Intergovernmental Panel on Climate Change, 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 trend 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 physical implications of climate change on major road infrastructure projects, such as roads and highways, are typically considered during the design and environmental assessment process for such projects.

An understanding of greenhouse gas emissions and their effect on climate change is essential in minimising potential impacts associated with the project.

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, 2012) promotes the need to ensure that transport infrastructure is 'able to withstand the predicted impacts of changing climate'.

Using climate change projections produced by the Intergovernmental Panel on Climate Change, both the Commonwealth Scientific and Industrial Research Organisation and the Bureau of Meteorology have produced regional downscaled projections for Australia. In 2010 the then Department of Environment Climate Change and Water released the NSW Climate Impact Profile, which included projected climate change impacts in 2050 for each region in NSW. In summary, climate change projections for the Sydney/Central Coast region include:

- Higher average temperatures. The magnitude of projected increases ranges from 1.5–3 degrees Celsius.
- Higher rainfall in all seasons except winter.
- Greater evaporation in spring and summer.
- More extreme impacts associated with the El Niño-Southern Oscillation.

5.3.2 Potential 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.

Road infrastructure is particularly vulnerable to very high temperatures, changes in soil moisture and the ground stability of sloping land forms (Thorn 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 (Thorn 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 Thorn et al, 2010).

The key climate change risks to road projects are associated with changes in rainfall intensity which may typically result in the following:

- Increased potential for localised flooding impacting on road infrastructure and potential increases in road maintenance activities and costs.
- Increased risk of road closures
- Drainage and stormwater impacts.
- Erosion impacts, resulting in sediment loss from the site.
- Watercourse impacts, including changes to channel structure and other characteristics resulting from changes in hydrological conditions.

Risks to infrastructure associated with climate change 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.
- Increased maintenance and replacement costs.
- Increased liability resulting from damage to road infrastructure.
- Higher insurance costs for road authorities.

5.3.3 Proposed further assessment

A climate change-related risk assessment of the project would be undertaken which would include:

- Identification of key climate variables such as temperature, rainfall and extreme events.
- 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.
- An 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.

Given the expected design life of road infrastructure, the proposed construction timeframe for the project and available climate data, it is assumed that the climate risk assessment would be undertaken for the years 2030 and 2070. Climate change projections for 2030 would be appropriate for short term impacts of climate change on the operation of the project (about 10 years after opening to traffic), and projections for 2070 would be relevant to the longer term operation and maintenance stages of the project. The climate change risk assessment would be undertaken using the most up-to-date emission scenarios available during the preparation of the Environmental Impact Statement for the project which are the most relevant to the years of assessment (2030 and 2070).

5.3.4 Safeguards and management measures

Construction of the project would aim to minimise greenhouse gas emissions, largely through:

- Regularly maintaining construction plant and equipment to reduce energy efficiency losses associated with damaged or unmaintained equipment.
- Reduce construction transport requirements wherever reasonably possible, for example through use of local staff, resources, suppliers, and landfills.

The management of risks associated with the impacts of climate change on the operation and maintenance of the project would be through undertaking a climate change risk assessment as described in Section 5.4.3 above, and discussion with project design engineers to adequately design and plan for predicted changes in climatic conditions.

Safeguards and management measures to minimise the emission of greenhouse gases associated with the operation and maintenance of the project would include:

- Consideration of the preferential selection of materials, vehicles and construction equipment with characteristics such as lower embodied energy and greater fuel efficiency, where feasible.
- The minimisation of vegetation clearance where reasonably possible.
- Development of an optimal design, including the vertical and horizontal alignments and reduction of stop start driving. These reductions would be cumulative over the design life of the project.

5.4 Hazard and risk

5.4.1 Overview

Hazard and risk impacts associated with the project have the potential to affect the surrounding environment and human health.

Potential impacts are likely to arise during the construction and operation of the project. Impacts are likely to evolve predominantly from the use of the tunnelling system. These potential impacts may involve leakage, spillage and accidental release from the incorrect handing or storage or hazardous materials.

Potential impacts arising from the operation phase would involve tunnel air quality and vehicle and personal safety.

5.4.2 Potential impacts

Construction

Potential impacts associated with the construction of the project may include:

- Environment and human health risks associated with the accidental release of hazardous materials due to improper handling or storage, or in the event of a traffic accident resulting in the release of hazardous material. All hazardous substances that may be required for construction would be stored and managed in accordance with the *Work Health and Safety Act 2011* and the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005).
- There would also be the potential for the rupture or interference with underground services during construction.
- Occupational health and safety hazards, such as dangers to construction workers, road users and the general public may also occur during construction. This could include tunnel collapse or flooding and inundation during construction. Such risks would be managed through the implementation of an occupational health and safety plan and other management plans (such as construction traffic and an incident response plan).

Operation

Potential impacts associated with the operation of the project may include:

- Environment and human health risks associated with the accidental release of hazardous materials in the event of a traffic accident resulting in the release of hazardous material.
- Spills or leaks from minor vehicle accidents.
- Large fires or explosions from major vehicle accidents.
- Tunnel collapse or subsidence.
- Flooding and inundation during operation.

Contaminants associated with either a spill, fire suppression (including deluge system) or clean up would be contained and treated by the tunnel drainage system. At interchanges, contaminants have the potential to enter the environment from paved or unpaved surfaces. Water quality treatment measures would reduce the risk of contaminants discharging to the receiving environment.

5.4.3 Proposed further assessment

Hazards and risks would be considered in the Environmental Impact Statement. As part of this, a screening of dangerous goods and hazardous materials against the *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines* (Department of Planning, 2011) thresholds would be undertaken. Design features of the project to manage risk and hazards during the operational stage of the project would also be outlined within the Environmental Impact Statement, which would include an assessment of the potential hazards associated with chemicals associated with clean-up activities or deluge systems.

5.4.4 Management and safeguard measures

To ensure the continued management of hazards and risks during the operation of the project, standard mitigation strategies would be implemented such as:

- Prohibition of dangerous goods within the project.
- Tunnel monitoring equipment to observe traffic conditions within the tunnel.
- Fire protection systems, which would include a fire suppression and firefighting system and would allow egress for pedestrians and access for emergency services.
- The ventilation system would be designed to ensure conditions are provided for the safe egress of passengers and to vent smoke in the event of a fire.
- Visual and audible communications systems would be used to also communicate incidents to motorists within and outside the tunnel.
- An Incident Response Plan to respond to accidents or spills.
- Appropriate design criteria for portal flood immunity and drainage infrastructure capacities.

In addition to the standard management and mitigation measures identified in the hazard and risk assessment in the Environmental Impact Statement, the following measures would be implemented:

- Occupational health and safety risks associated with construction would be managed through the implementation of an occupational health and safety plan.
- The risks associated with the use and storage of hazardous substances during construction would be managed through appropriate design, preparation of a construction environmental management plan and establishment of bunded areas.
- The final locations of construction site compounds where hazardous substances would be stored would be determined during detailed design based on specific environmental criteria.
- Construction stormwater control basins and operational water quality control measures would be designed to reduce the environmental effects of pollutant runoff from the road surface and to contain spills of chemicals and hazardous substances.

5.5 Cumulative impacts

5.5.1 Overview

A cumulative impact refers to the result of the impact of an action coinciding or interacting with other impacts during the same time period and in the same area. Cumulative impacts are likely to have an effect on the following areas:

- Traffic and transport.
- Air quality and human health.
- Noise and vibration.
- Biodiversity.
- Visual impacts and urban design.
- Social and economic.
- Land use and property.
- Surface water and flooding.
- Soils and geology.
- Non-Aboriginal heritage.
- Resource management and waste minimisation.

A desktop assessment has identified developments which have the potential to interact with the project. It is likely the majority of cumulative impacts would take place during the construction of the project which is expected to take place between mid-2016 to early 2020.

5.5.2 Potential impacts

Key developments that are expected to interact with the project include:

- The M5 West Widening Project. This project would expand the existing Southern West Motorway from two to three lanes from Camden Valley Road to King Georges Road. The construction of the M5 West Widening is expected to be completed in around December 2014.
- WestConnex Stage 1 (M4 East Motorway) and Stage 3 (M4 South Motorway). If they proceed, both projects are intended to feed into this project and would improve traffic flow to/from the project. Stage 3 would also connect the project with the M4 south and the Sydney Gateway via the St Peters interchange, requiring additional construction works to tie-in connections.
- WestConnex Stage 2 (Sydney Gateway) and other associated ground transport improvements identified by Sydney Airport Corporation within its Sydney Airport Master Plan 2033. Depending on the approval and scheduling of these works, this could result in cumulative construction traffic and construction noise impacts on the surrounding community. In the long term, these projects are expected to assist in improving traffic flows to/from WestConnex and the connections to employment areas in the Sydney Airport and Port Botany area.
- Southern Access Motorway. This Project would involve extending the existing F6 corridor from Waterfall north to the M5 Corridor. Budget for the preparation of a business case for the Southern Access Motorway was announced by the NSW Roads Minister in June 2014 for the potential Project. Although the planning and assessment process is in its early stages, there is the potential that there may be some concurrent construction of the project and Southern Access Motorway, should this project proceed.

Other Sydney Airport projects. The Sydney Airport Master Plan 2033 identifies a number of construction activities associated with its aprons, airfield and terminals over the next 19 years, including works within the first five years and 10 year periods. Depending on the scheduling of these works, this could result in cumulative construction traffic and construction noise impacts on the surrounding community. In the long term, WestConnex would deliver capacity to cater for increased traffic demand associated with growth at Sydney Airport.

Concurrent or consecutive construction of the project with one or a number of the abovementioned projects has the potential to result in some adverse cumulative construction impacts for sensitive receivers. Cumulative impacts would be largely related to air quality, noise and vibration and traffic and transport. The majority of cumulative construction impacts, should they occur, would be concentrated to areas where the projects have an overlapping impact on sensitive receivers, for example at the future tie in point of the project with WestConnex Stage 3.

There are also a number of approved or potential urban developments within or outside the project corridor, particularly around Mascot, Wolli Creek and Alexandria. Depending on the location of these developments relative to the project, there is potential for cumulative traffic and noise impacts on the surrounding community. However, comparative to the abovementioned major projects in the area, the cumulative effect of these potential developments with the project would unlikely be significant. Increased traffic demand generated by these urban developments would be considered within the traffic and transport assessment as part of forecast growth.

Operation of the project simultaneously with other large road infrastructure projects and residential developments has the potential to generate cumulative impacts. Such cumulative impacts would be localised and would be largely related to amenity impacts on local residents, the local community and users of recreational areas within and in the vicinity of the project corridor. This may potentially include impacts to local traffic conditions, noise and vibration, air quality and human health, social and economic impacts as well as impacts to visual amenity.

Operation of the WestConnex program of works in conjunction with other transport infrastructure projects such as the wider WestConnex program of works and the potential future Southern Access Motorway would produce a number of operational benefits, namely:

- Improved travel efficiency and reliability.
- Enhanced economic productivity.
- Improved road safety and road surface conditions, leading to improved liveability though public and active transport.
- Improvements to air quality by removing traffic from surface roads into a suitably designed ventilated tunnel.
- Improvements to local amenity, particularly through improved traffic conditions, air quality and noise and vibration.

5.5.3 Proposed further assessment

Project-specific assessments that would be completed for the project would consider the potential for cumulative impacts, including the potential cumulative impacts associated with the completed WestConnex program of works. The Environmental Impact Statement would consider the interrelationships between the project, the remainder of the WestConnex program of works and other major developments, understand the potential cumulative impacts associated with these interaction and establish mitigation strategies.

5.5.4 Management and safeguard measures

The mitigation and management of cumulative impacts associated with the WestConnex program of works would be overseen and managed by the WestConnex Delivery Authority. The cumulative impact resulting from other major developments would be dependent on the scheduling of those developments in the context of this project. Mitigation and management measures would be detailed in the Construction Environmental Management Plan, and through coordination between the relevant construction contractors (if required).

6 Conclusion

The NSW Government is proposing the construction and operation of the New M5 (the project); which would comprise a new, tolled multi-lane road link between the M5 East Motorway east of King Georges Road and St Peters. The project would also include an interchange at St Peters and connection to the existing road network.

The project would span six local government areas including: Canterbury, Hurstville, Rockdale, Marrickville, Botany Bay and Sydney. It would include widening of the existing M5 Motorway between east of King Georges Road, Beverly Hills and Bexley Road, twin motorway tunnels, both around nine kilometres in length and local road connections in St Peters.

The WestConnex Delivery Authority (WDA) was established by the NSW Government to deliver the WestConnex program of works for Roads and Maritime on behalf of the NSW Government. The WDA is a public subsidiary corporation of the Roads and Maritime. Its role and functions are set out in Part 4A of the (NSW) *Transport Administration (General) Regulation 2013*. WDA is the proponent for this project.

WDA, as the proponent, has formed the view that the project is likely to significantly affect the environment. On this basis, the project is declared to be State significant infrastructure (SSI) under section 115U(2) of the EP&A Act by reason of the operation clause 14 and clause 1 of Schedule 3 of *State Environmental Planning Policy (State and Regional Development) 2011*. Accordingly, approval from the Minister for Planning and Infrastructure is required for the project.

The key environmental issues with the project are:

- Traffic and transport.
- Air quality and human health.
- Noise and vibration.
- Biodiversity.
- Visual impacts and urban design.
- Social and economic.
- Land use and property.
- Hydrology and flooding.
- Geology, soils and water quality.
- Non-Aboriginal heritage.
- Resource management and waste minimisation.

The Environmental Impact Statement would include the following:

- A description of the project, including its components and construction activities.
- An assessment of potential impacts on the key environmental issues, including a description of the existing environment and an assessment of potential direct and indirect impacts during construction and operation of the project.
- Consideration of the other potential environmental issues for the project.
- The identification of measures to be implemented to avoid, minimise, manage, mitigate, offset and/or monitor potential impacts of the project.
- The identification and consideration of issues raised by stakeholders.

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Appendix A

Requirements of the Environmental Planning and Assessment Regulation 2000

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Appendix A Requirements of the Environmental Planning and Assessment Regulation 2000

Clause 192 of the *Environmental Planning and Assessment Regulation 2000* requires that an application for approval of the Minister to carry out State Significant Infrastructure must include:

a) Details of any approvals that would, but for section 115ZG of the Act, be required for carrying out of the State Significant Infrastructure, and

b) Details of any authorisations that must be given under section 115ZH of the Act is the application is approved, and

c) A statement as to the basis on which the proposed infrastructure is State Significant Infrastructure including, if relevant, the capital investment value of the proposed infrastructure.

Approvals that would otherwise apply

Approvals that may be required to carry out the Project, if not for section 115ZG of the *Environmental Planning and Assessment Act 1979 (EP&A Act)* include:

- A permit under section 201, 205 or 219 of the *Fisheries Management Act 1994*.
- An approval under Part 4, or an excavation permit under section 139, of the Heritage Act 1977.
- An Aboriginal heritage impact permit under section 90 of the *National Parks and Wildlife Act 1974*.
- A water use approval under section 89, a water management work approval under section 90 or an activity approval under section 91 of the *Water Management Act 2000.* Section 115ZG does not remove the need to obtain an aquifer interference approval under the *Water Management Act* 2000, if that were to be otherwise required.

Authorisations if the application is approved

Authorisations that may be required for the Project under section 115ZH of the EP&A Act include:

- An environment protection licence under Chapter 3 of the *Protection of the Environment Operations Act 1997*.
- Consent under section 138 of the *Roads Act 1993*.

State significant infrastructure application

Clause 14(1) of the *State Environmental Planning Policy (State and Regional Development) 2011* provides that development is declared, pursuant to 115U (2) of the EP&A Act, to be State significant infrastructure for the purposes of the Act if:

(a) The development on the land concerned is, by the operation of a State Environmental Planning Policy, permissible without consent under Part 4 of the Act, and

(b) The development is specified in Schedule 3.

Clause 94 of the *State Environment Planning Policy (Infrastructure) 2007* (ISEPP) permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent. As the Project is for a road and road infrastructure facilities, and is to be carried out on behalf of WDA, the project is permissible without development consent under Part 4 of the EP&A Act.

Clause 1(1) of Schedule 3 of the *State Environmental Planning Policy (State and Regional Development) 2011* identifies as SSI, general public authority activities for infrastructure or other development (but for Part 5.1 of the Act and within meaning of Part 5 of the Act) would be an activity for which the proponent is also the determining authority and would, in the opinion of the proponent require an environmental impact statement to be obtained under Part 5 of the Act.

WDA, as the proponent, has formed the view that the impact of the Project is likely to significantly affect the environment. On this basis, the project is declared to be State significant infrastructure (SSI) under section 115U (2) of the EP&A Act by reason of the operation of clause 14 and clause 1 of Schedule 3 of the *State Environmental Planning Policy (State and Regional Development) 2011*. Accordingly, the project is subject to Part 5.1 of the EP&A Act and required the approval of the Minister for Planning and Infrastructure.

Appendix B

Threatened flora and fauna species lists

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Table B-1 Listed threatened flora species with the potential to occur or previously recorded within the Project corridor

Scientific name	Common name	Commonwealth listing (EPBC Act)		NSW listing (TSC Act)	
		Yes/No	Status	Yes/No	Status
Flora (species)					
Acacia bynoeana	Bynoe's Wattle	No	-	Yes	Endangered
Acacia pubescens	Downy Wattle	Yes	Vulnerable	Yes	Vulnerable
Acacia terminalis subsp. terminalis	Sunshine Wattle	No	-	Yes	Endangered
Allocasuarina glareicola	Sunshine Wattle	Yes	Endangered	No	-
Caladenia tessellata	Thick Lip Spider Orchid	Yes	Vulnerable	Yes	Endangered
Cryptostylis hunteriana	Leafless Tongue-orchid	Yes	Vulnerable	No	-
Deyeuxia appressa	-	Yes	Endangered	No	-
Eucalyptus nicholii	Narrow-leaved Black Peppermint	No	-	Yes	Vulnerable
Genoplesium baueri	Yellow Gnat-orchid	Yes	Endangered	No	-
Maundia triglochinoides	-	No	-	Yes	Vulnerable
Melaleuca biconvexa	Biconvex Paperbark	Yes	Vulnerable	No	-
Melaleuca deanei	Deane's Paperbark	No	-	Yes	Vulnerable
Pelargonium sp. Striatellum	Omeo Stork's-bill	No	-	Yes	Endangered
Persoonia hirsuta	Hairy Geebung	No	-	Yes	Endangered
Pimelea curviflora var. curviflora	-	No	-	Yes	Vulnerable
Pimelea spicata	Spiked Rice-flower	Yes	Endangered	No	-
Pterostylis saxicola	Sydney Plains Greenhood	Yes	Endangered	No	-
Streblus pendulinus	Siah's Backbone, Sia's Backbone, Isaac Wood	Yes	Endangered	No	-
Syzygium paniculatum	Magenta Lilly Pilly	Yes	Vulnerable	Yes	Endangered
Tetratheca juncea	Black-eyed Susan	No	-	Yes	Vulnerable
Thesium australe	Austral toadflax	Yes	Vulnerable	No	-
Wilsonia backhousei	Narrow-leafed Wilsonia	No	-	Yes	Vulnerable
Flora (populations)					
Acacia prominens	Gosford Wattle, Hurstville and Kogarah Local Government Areas	No	-	Yes	Endangered population

Table B-2 Listed threatened fauna species and populations with the potential to occur or previously recorded within the project corridor

Scientific name	Common name	Commonwealth listing (EPBC Act)		NSW listing (TSC Act)	
		Yes/No	Status	Yes/No	Status
Fauna (species)					
Aves (Birds)					
Anthochaera Phrygia	Regent Honeyeater	Yes	Endangered	Yes	Endangered
Botaurus poiciloptilus	Australasian Bittern	Yes	Endangered	Yes	Endangered
Burhinus grallarius	Bush Stone-curlew	No	-	Yes	Endangered
Calidris alba	Sanderling	No	-	Yes	Vulnerable
Calidris ferruginea	Curlew Sandpiper	No	-	Yes	Endangered
Calidris tenuirostris	Great Knot	No	-	Yes	Vulnerable
Calyptorhynchus lathami	Glossy Black-Cockatoo	No	-	Yes	Vulnerable
Charadrius leschenaultii	Greater Sand-Plover	No	-	Yes	Vulnerable
Charadrius mongolus	Lesser Sand-Plover	No	-	Yes	Vulnerable
Dasyornis brachypterus	Eastern Bristlebird	Yes	Endangered	No	-
Diomedea epomophora epomophora	Southern Royal Albatross	Yes	Vulnerable*	No	-
Diomedea epomophora sanfordi	Northern Royal Albatross	Yes	Endangered*	No	-
Diomedea exulans antipodensis	Antipodean Albatross	Yes	Vulnerable*	No	-
Diomedea exulans	Wandering Albatross	Yes	Vulnerable*	Yes	Endangered
Diomedea exulans exulans	Tristan Albatross	Yes	Endangered*	No	-
Diomedea exulans gibsoni	Gibson's Albatross	Yes	Vulnerable*	No	-
Haematopus fuliginosus	Sooty Oystercatcher	No	-	Yes	Vulnerable
Haematopus longirostris	Pied Oystercatcher	No	-	Yes	Endangered
Hieraaetus morphnoides	Little Eagle	No	-	Yes	Vulnerable
Lathamus discolor	Swift Parrot	Yes	Endangered*	Yes	Endangered
Limicola falcinellus	Black-billed Sandpiper	No	-	Yes	Vulnerable
Limosa limosa	Black-tailed Godwit	No	-	Yes	Vulnerable
Macronectes giganteus	Southern Giant-Petrel	Yes	Endangered*	No	-
Macronectes halli	Northern Giant-Petrel	Yes	Vulnerable*	No	-
Neophema chrysogaster	Orange-bellied Parrot	Yes	Critically Endangered	No	-
Neophema pulchella	Turquoise Parrot	No	-	Yes	Vulnerable
Ninox strenua	Powerful Owl	No	-	Yes	Vulnerable

Scientific name	Common name	Commonwealth listing (EPBC Act)		NSW listing (TSC Act)	
		Yes/No	Status	Yes/No	Status
Ptilinopus superbus	Superb Fruit-Dove	No	-	Yes	Vulnerable
Rostratula australis	Australian Painted Snipe	Yes	Endangered	No	-
Sternula albifrons	Little Tern	Yes	Endangered*	No	-
Sternula nereis nereis	Australian Fairy Tern	Yes	Vulnerable	No	-
Thalassarche bulleri	Buller's Albatross, Pacific Albatross	Yes	Vulnerable*	No	-
Thalassarche cauta cauta	Shy Albatross	Yes	Vulnerable*	No	-
Thalassarche cauta salvini	Salvin's Albatross	Yes	Vulnerable*	No	-
Thalassarche cauta steadi	White-capped Albatross	Yes	Vulnerable*	No	-
Thalassarche eremita	Chatham Albatross	Yes	Endangered*	No	-
Thalassarche melanophris	Black-browed Albatross	Yes	Vulnerable*	No	-
Thalassarche melanophris impavida	Campbell Albatross	Yes	Vulnerable*	No	-
Tyto novaehollandiae	Masked Owl	No	-	Yes	Vulnerable
Xenus cinereus	Terek Sandpiper	No	-	Yes	Vulnerable
Fish					
Epinephelus daemelii	Black Rockcod, Black Cod, Saddled Rockcod	Yes	Vulnerable	No	-
Amphibia (Frogs)					
Crinia tinnula	Wallum Froglet	No	-	Yes	Vulnerable
Litoria aurea	Green and Golden Bell Frog	Yes	Vulnerable	Yes	Endangered
Heleioporus australiacus	Giant Burrowing Frog	Yes	Vulnerable	No	-
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog	Yes	Vulnerable	No	-
Mammals					
Arctocephalus pusillus doriferus	Australian Fur-seal	No	-	Yes	Vulnerable
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	Yes	Vulnerable	No	-
Dasyurus viverrinus	Eastern Quoll	No	-	Yes	Endangered
Dugong dugon	Dugong	No	-	Yes	Endangered
Isoodon obesulus obesulus	Southern Brown Bandicoot (Eastern)	Yes	Endangered	No	-
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	No	-	Yes	Vulnerable
Myotis macropus	Southern Myotis	No	-	Yes	Vulnerable
Pseudomys novaehollandiae	New Holland Mouse	Yes	Vulnerable	No	-
Pterogale penicillata	Brush-tailed Rock-wallaby	Yes	Vulnerable	No	-

Scientific name	Common name	Commonwealth listing (EPBC Act)		NSW listing (TSC Act)	
		Yes/No	Status	Yes/No	Status
Pteropus poliocephalus	Grey-headed Flying-fox	Yes	Vulnerable	Yes	Vulnerable
Reptiles					
Caretta caretta	Loggerhead Turtle	Yes	Endangered*	No	-
Chelonia mydas	Green Turtle	Yes	Vulnerable*	No	-
Dermochelys coriacea	Leatherback Turtle	Yes	Endangered*	No	-
Eretmochelys imbricata	Hawksbill Turtle	Yes	Vulnerable*	No	-
Hoplocephalus bungaroides	Broad-headed Snake	Yes	Vulnerable*	No	-
Natator depressus	Flatback Turtle	Yes	Vulnerable*	No	-
Fauna (populations)					
Dasyurus maculatus maculatus	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (SE mainland population)	Yes	Endangered	No	-
Perameles nasuta	Long-nosed Bandicoot population in inner western Sydney	No	-	Yes	Endangered population
Phascolarctos cinereus	Koala – combined populations of QLD, NSW and ACT	Yes	Vulnerable	No	-

*notes that the species is also recorded as being migratory and marine under the EPBC Act

Appendix C

Sensitive land uses in the project corridor

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Table C-1 Sensitive land uses in the project corridor

Sensitive land use name
Private recreation
Canterbury Golf Course, Moorefields Road, Beverly Hills.
Bardwell Valley Golf Course, Hillcrest Avenue, Bardwell Valley.
Barton Park Driving Range, West Botany Street, Arncliffe.
Kogarah Golf Club, Marsh Street, Arncliffe.
Tempe Golf Driving Range, South Street Tempe.
Public recreation / open space
Beverly Grove Park, Kingsgrove
Smith Reserve, Morgan Street, Kingsgrove.
Kingsbury Reserve, Warejee Street, Kingsgrove.
Forrester Reserve, Forrester Street, Kingsgrove.
Kookaburra Reserve, Shaw Street, Kingsgrove.
Kingsgrove Avenue Reserve, Kingsgrove Avenue, Kingsgrove.
Beaumont Park, Poole Street, Kingsgrove.
Shaw Street Reserve, Shaw Street, Kingsgrove.
Carrisbrook Avenue Reserve, Carrisbrook Avenue, Bexley North.
Whitbread Park, Barnsbury Grove, Bexley North.
Gilchrist Park, Shaw Street, Bexley North.
Scotts Reserve, Slade Road, Bexley North,
Stotts Reserve, Churchill Street, Bexley North.
Slade Road Reserve, Slade Road, Bardwell Park.
Ron Gosling Reserve, May Street, Bardwell Park.
Coolibah Reserve, Darley Road, Bardwell Park.
Broadford Street Reserve, Bardwell Valley.
Charles Daly Reserve, Bardwell Valley
Silver Jubilee Park, Lorraine Avenue, Bardwell Valley.
Braeside Crescent Reserve, Braeside Crescent, Earlwood.
Girrahween Park, Hartill-Law Avenue, Earlwood.
Albert Park, Finlays Lane, Earlwood.
Turrella Reserve, Arncliffe Road, Earlwood.
Waterworth Park, Bayview Avenue, Earlwood.
Gough Whitlam Park, Bayview Avenue, Earlwood
Canterbury Velodrome, Bayview Avenue, Earlwood.
Illoura Park, Forrest Avenue, Earlwood.
Harrison Reserve, Bray Avenue, Earlwood.
Riverine Park, Eve Street, Banksia.
Arncliffe Park, Hirst Street, Arncliffe.
Ajax Reserve, Arncliffe.
Barton Park, West Botany Street, Arncliffe.
Banksia Playing Fields, West Botany Street, Arncliffe.
Beehag Reserve, Spring Street, Arncliffe.
Empress Reserve, Arncliffe.
Memory Reserve, Arncliffe.
Marinea Street Reserve, Marinea Street, Arncliffe.
Cahill Park, Levey Street, Wolli Creek.
Kendrick Park, Princes Highway, Wolli Creek.
Tillman Park, Unwins Bridge Road, Tempe.
Tempe Recreation Reserve, Holbeach Avenue, Tempe.
Simpson Park, Hutchinson Street, Tempe.
Tempe Park, South Street, Tempe
Sydenham Green, Railway Road, Sydenham.
Sydney Park, Sydney Park Road, St Peters.
Camdenville Park, May Street, St Peters.

Sensitive land use name
Places of worship
Our Lady of Fatima Church, Shaw Street, Kingsgrove.
Anglican Church of Australia, Paterson Avenue, Kingsgrove.
Uniting Church in Australia, Way Street, Kingsgrove
South-west Chinese Christian Church, Morgan Street, Kingsgrove.
St. Andrew's Presbyterian Church. Forest Road, Bexley.
Bexley North Anglican Church, Carrisbrook Avenue, Bexley North.
Uniting Church in Australia, Earlwood Crescent, Bardwell Park.
Arncliffe Uniting Church in Bardwell Valley, Hannam Street, Bardwell Valley.
Our Lady of Lourdes Catholic Church, Homer Street, Earlwood.
Earlwood Presbyterian Church, Collingwood Avenue, Earlwood.
St George Church, Minnamorra Avenue, Earlwood.
Uniting Church in Australia, Villiers Street, Rockdale.
St Mark Coptic Orthodox Church, Wollongong Road, Arncliffe.
Bay City Church, Hattersley Street, Arncliffe.
St David's Anglican Church, Forest Road, Arncliffe.
Uniting Church in Australia, Lymerston Street, Tempe.
St Peters Anglican Church, Princes Highway, St Peters.
Community facilities
Kingsrove Community Aid Centre, Morgan Street, Kingsgrove.
Kingsgrove Scout Hall, Shaw Street, Kingsgrove.
Kingsgrove RSL Club, Brocklehurst Lane, Kingsgrove.
Kingsgrove and Bexley North Community Centre, Shaw Street, Bexley North.
Bexley North Library, Shaw Street, Bexley North.
Bexley North Scout Hall, Shaw Street, Bexley North.
Earlwood-Bardwell Park RSL Club, Hartill-Law Avenue, Bardwell Park.
Earlwood Library, William Street, Earlwood.
Lydham Hall House Museum, Lydham Avenue, Rockdale.
Arncliffe RSL Club, Wollongong Road, Arncliffe.
Arncliffe Community Centre and Coronation Hall, Barden Street, Arncliffe.
Al Zahra Muslim Womens Association, Wollongong Road, Arncliffe.
Marrickville Council Libraries, Unwins Bridge Road, Sydenham.
Child Care
Cheeky Monkeys Day Care Centre, Homer Street, Kingsgrove.
Kingsrgrove World of Learning, Richland Street, Kingsgrove.
Kids Oasis, Wolli Street, Kingsgrove.
Hilltop Kids Lond Day Care Centre, Barnsbury Grove, Bardwell Park.
Lady Bugs Child Care, Alexandria Street, Turella.
Turella Childrens Centre, Walker Street, Turella.
Macedonian Community Child Care Centre, Firth Street, Arncliffe.
Busy Bee Long Day Child Care Centre, Marinea Street, Arncliffe.
Kinderoos, Dowling Street, Arncliffe.
Betty Spears Childcare Centre, Gannon Street, Tempe.
Tillman Park Child Care Centre, 79 Unwins Bridge Road, Tempe.
Education
Regina Coeli School, Tarrilli Street, Beverly Hills.
Kingsgrove Public School, Kingsgrove Road, Kingsgrove.
St Ursula's College, Caroline Street, Kingsgrove.
Bardwell Park Infants School, Crewe Street, Bardwell Park.
Earlwood Public School, Homer Street, Earlwood.
Earlwood Pre School, Joy Avenue, Earlwood.
Cairnsfoot Special School, Loftus Street, Turella.
Kingdom Culture Christian School, Dowling Street, Arncliffe.
Athelstane Public School, East Street, Arncliffe.

Sensitive land use name
Arncliffe Public School, Princes Highway, Arncliffe.
St Francis Xavier's Catholic Primary School, Forest Road, Arncliffe.
Al Zahra College, Wollongong Road, Arncliffe.
Arncliffe West Infants Public School, Loftus Street, Arncliffe.
Tempe Public School, Unwins Bridge Road, Tempe.
Tempe High School, Unwins Bridge Road, Tempe.
St Peters Public School, Church Street, St Peters.
Health care centre
Blue Cross Medical Centre, Kingsgrove Road, Kingsgrove.
Early Childhood Health Centre, Morgan Street, Kingsgrove.
Bexley North Medical Clinic, Shaw Street, Bexley North.
Life Medical Clinic, Bexley Road, Bexley North.
Bardwell Park Family Medical Practice, Hartill-Law Drive, Bardwell Park,
Arncliffe Early Childhood Health Centre, Firth Street, Arncliffe.
Arncliffe Dental Care, Wollongong Road, Arncliffe.
Arncliffe Family Health Clinic, Queen Street, Arncliffe.
Wolli Creek Dental Care, Brodie Spark Drive, Wolli Creek.
Tempe Family Medical, Princes Highway, Tempe.
Aged care facility
Bexley Gardens Retirement Village, Ellerslie Road, Bexley North.
Glen Village, The Glen Road, Bardwell Valley.
Earlwood Senior Citizens Centre, Earlwood
Macquarie Lodge Aged Care Plus Centre, Wollongong Road, Arncliffe.
The Salvation Army Aged Care Plus, Wollongong Road, Arncliffe.
Carinya Lodge, Fairview Street, Arncliffe.
Hospital
Kingsgrove Day Hospital, Kingsgrove Road, Kingsgrove.
Regional Park
Wolli Creek Regional Park

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