6 Environmental assessment

This section of the REF provides a detailed description of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment potentially impacted upon by the proposal are considered. This includes consideration of the factors specified in the guidelines *Is an EIS required?* (DUAP 1999) and *Roads and Related Facilities* (DUAP 1996) as required under clause 228(1)(b) of the *Environmental Planning and Assessment Regulation 2000*. The factors specified in clause 228(2) of the *Environmental Planning and Assessment Regulation 2000* are also considered in Appendix A. Site-specific safeguards are provided to ameliorate the identified potential impacts.

6.1 Biodiversity

6.1.1 Methodology

An ecological impact assessment was undertaken to determine the potential impacts on threatened flora, fauna and ecological communities within the construction impact area of the proposal.

For the purposes of assessment, the construction impact area (as defined and illustrated in Section 3.3) varies between one to six metres from the edge of design to, as far as practicable, avoid environmental constraints such as *Microtis angusii* and *Grevillea caley*i. For the purposes of the ecological impact assessment, a study area buffer of 20 metres has been applied from the edge of the construction footprint to consider the potential indirect impacts on flora. That is, areas that are not directly impact during construction or operation. For fauna, the study area included habitat up to 500 metres from the construction footprint.

An SIS (SMEC, 2016) has also been prepared for the proposal. The discussion in this section draws on the SIS findings with regard to endangered ecological communities and threatened species for which the proposal was identified as likely to have a significant impact (in accordance with section 5A of the EP&A Act). A copy of the SIS is available on the Mona Vale Road project page of the Roads and Maritime website.

Literature review and database assessment

Data searches were conducted using a 10 kilometre buffer around the existing Mona Vale Road alignment from McCarrs Creek Road, Terrey Hills to Powder Works Road, Ingleside. In order to inform surveys and reporting, a review of relevant flora and fauna databases, scientific literature, aerial photography and GIS mapping was undertaken including:

- NSW Office of Environment and Heritage (OEH) Atlas of NSW Wildlife, within a 10 kilometre radius of the site
- Commonwealth Protected Matters Report for all Matters of National Environmental Significance (MNES) documented within 10 kilometres of the site; MNES include threatened species, communities and migratory species which are listed under the EPBC Act (Department of the Environment)
- NSW Flora Online Search – Rare or Threatened Australian Plants (ROTAP) species (The Royal Botanic Gardens and Domain Trust, 2012)

- NSW Office of Environment and Heritage – Vegetation Types Database
- NSW Office of Environment and Heritage – Threatened species profiles
- Department of Primary Industry (DPI): Fishing and Aquaculture – Threatened and Protected Species, Sydney Metro CMA
- NSW Department of Primary Industries (DPI) Noxious Weeds List, Pittwater and Warringah LGAs
- Atlas of Groundwater Dependent Ecosystems (BOM)
- Two baseline and targeted flora and fauna survey datasets drawn from flora and fauna surveys of the study area carried out by Smith and Smith (2011) and Ecosure (2015). Both these datasets were applicable to previous iterations of the proposal which comprised almost identical study areas relative to the current one used for the SIS.
- A Biocertification assessment of the Ingleside Planning Precinct, prepared by EcoLogical Australia (ELA, 2015), was drawn upon in the preparation of the SIS. The GIS data subset from ELA comprised vegetation mapping and *Microtis* spp. records. The ELA study area comprised the wider Ingleside locality and included the eastern half of the SIS study area (west of Kimbriki Road). This dataset was drawn upon predominantly to obtain distribution and abundance data for the endangered orchid, *Microtis angusii* and to validate existing mapping datasets.
- A *Microtis angusii* genetic study, undertaken by the Royal Botanic Gardens, Sydney (RBG, 2015), was also drawn upon for the SIS (report only, no GIS layers). The study provided information on population distribution and abundance, population structure and genetics for this terrestrial orchid species.

Based on the results of the desktop assessment and review of previous studies and datasets, an assessment of the likelihood of occurrence of threatened flora and fauna species, populations, communities and migratory species within the study area was carried out.

Survey methods were developed following a review of the OEH guidelines *Threatened Species Survey and Assessment: Guidelines for Developments and Activities* (working draft) (DEC, 2004).

The following is a summary of the flora and fauna surveys carried out for the proposal, and the survey datasets used to inform preparation of the SIS and the broader biodiversity assessment reported in this REF.

Flora surveys

Baseline surveys by Smith and Smith (2011) and Ecosure (2015)

- Smith and Smith (2011): Plant species and vegetation communities were surveyed over 10 days between 17 June 2011 and 3 August 2011
- Ecosure (2015): Twenty Biobank plots were carried out comprising a full floristic 20 x 20 metre quadrat nested within a larger 50 x 20 metre plot. Ecosure (2015) also undertook a series of rapid data points (RDPs) to validate vegetation mapping and condition. Surveys were carried out between 26 September and 18 October 2013.

Targeted threatened flora searches

Smith and Smith (2011), Ecosure (2015) and SMEC (2016) undertook targeted searches for a suite of threatened flora species that had been previously recorded in the Ingleside/Terrey Hills locality including:

- *Acacia bynoeana* (Bynoe's Wattle)*
- *Callistemon linearifolius* (Netted Bottlebrush)*
- *Darwinia biflora**
- *Epacris purpurascens* var. *purpurascens* (Port Jackson Heath)
- *Eucalyptus camfieldii* (Camfield's Stringybark)
- *Genoplesium baueri* (Bauer's Midge Orchid)
- *Grevillea caley*i (Caley's Grevillea)*
- *Haloragodendron lucasii*
- *Leptospermum deanei*
- *Melaleuca deanei* (Deane's Paperbark)
- *Microtis angusii* (Angus' Onion Orchid)
- *Persoonia hirsute* (Hairy Geebung)
- *Pimelea curviflora* var. *curviflora*
- *Tetratheca juncea*.

* SMEC undertook additional targeted flora surveys for these four threatened species to comply with the SIS DGRs and supplement the previous flora survey datasets.

A detailed account of survey methods, dates and weather conditions, and other relevant details is provided in the SIS.

Fauna surveys

Fauna surveys (including habitat assessments) were carried out by Ecosure between 31 October 2013 and January 2015. SMEC undertook additional targeted surveys between October 2015 and January 2016 targeting the Eastern Pygmy-possum, Southern Brown Bandicoot, Threatened amphibians and Rosenberg's Goanna to comply with the DGRs and supplement gaps in information from previous surveys.

Fauna habitat assessment

The vegetation types found in the study area (Ecosure, 2015) were stratified by Ecosure into six fauna habitat stratification units: wetland, casuarina, swamp, sandstone heath, open woodland and disturbed areas. Three of these habitat units were then sampled during fauna habitat assessments in the field. The other three are not located within the subject site and occupy none or very small parts of the study area.

Within these fauna habitat stratification units, quadrats of 50 x10 metres were randomly assigned. In each quadrat, the following components were documented:

- Rocks and boulders, rocky outcrops, exfoliating rocks and rocks with crevices

- Trees and logs with hollows: presence of senescent (old) or dead trees (stags) and trees or logs with peeling bark or loose bark (abundance)
- Estimate of habitat condition including % of shrub layer, ground cover and leaf litter (estimated percentage cover)
- Habitat features/critical food resources e.g. termite mounds, mistletoe (abundance)
- Presence of standing water or ephemeral waterways including wetland, riverine and groundwater springs (presence/absence).

In addition to formal habitat assessments, any features encountered during surveys (for example, hollow-bearing trees, termite mounds, seeps, nests.) were documented and marked with a hand-held GPS. This information contributed to determination of fauna survey sites and the impact assessment for threatened species.

Hollow-bearing tree searches

Not all hollow-bearing trees within the study area were recorded by Ecosure (2015) as part of the scope of their survey; however at each fauna habitat assessment point the number of hollow-bearing trees was noted within each quadrat.

A hollow-bearing tree assessment was conducted by SMEC within the subject site between August 2015 and January 2016. The information recorded included GPS location of the tree, species name, approximate height of hollow and a georeferenced photograph of each tree. Hollows were classified into four size classes as follows:

- Small – Less than 5 centimetres diameter
- Medium – Between 5–10 centimetres diameter
- Large – Between 10–15 centimetres diameter
- Extra-large – Greater than 15 centimetres diameter.

Area searches – birds

Ecosure (2015) searched areas of potential habitat of two hectares for 20 minutes in the early morning. Sites were searched at least three times over the survey period.

Searches were also undertaken for hollow-bearing trees that provide suitable habitat for breeding and concentrations of foraging resources (e.g. mapping of areas of *Allocasuarina* as foraging habitat for Glossy Black-cockatoo) as part of general habitat searches.

Point surveys – birds

Ecosure (2015) established 16 point sites for timed bird surveys within the local area, including eight in the vicinity of the survey area.

These point sites were visited in May, June, August and October 2014 to provide additional information on occurrence of bird species within the local area, and determine if any threatened bird species that were utilising the study area. This was in addition to the timed area searches (described above). These point sites represented areas with different microhabitat features and also provided sites with less disturbance than other sites that were adjacent to the current Mona Vale Road.

Diurnal active searches

A minimum of two diurnal active searches of at least 30 minutes each along a single transect in each of the three main stratified fauna habitat units was undertaken. Areas of potentially good habitat were also targeted (i.e. gullies, waterways, sandstone escarpments). Habitats were searched for inconspicuous fauna (such as reptiles in crevices or under bark, roosting bats) as well as for signs of fauna (scats, tracks, fur, feathers, diggings, scratches, nests, owl wash and pellets).

Nocturnal spotlight searches

Nocturnal spotlight searches targeted nocturnal birds and mammals such as owls, possums and flying-foxes. Spotlight search transects were completed in fauna habitats with the same survey effort as diurnal searches. These surveys consisted of spotlight searches on foot and road surveys (on Tumburra Street, Addison Road, Wirreanda Road and other surrounding roads).

Infra-red motion-sensitive cameras

Infra-red motion-sensitive cameras were set up by Ecosure (2015) at areas with likely high fauna activity based on results of an initial one day site inspection and the diurnal active searches. Cameras were used for detecting species such as the Spotted-tailed Quoll, Brush-tailed Phascogale and Southern Brown Bandicoot. Cameras were set up for a minimum of four nights at each location throughout the survey area.

Additional cameras were set up by SMEC in 2015 to monitor the Southern Brown Bandicoot and Rosenberg's Goanna.

Echolocation call recording and analysis

Six echolocation call devices were placed in areas of potential high bat activity across the study area, sampling woodland, heath and disturbed habitats. Identification of species was carried out by comparing to regional reference calls and published descriptions.

Harp traps

Six harp traps were placed in suitable flyways to sample the length of the study area (clearings/ tracks in open woodland habitats (excluding 'disturbed' areas)). Traps were checked each morning between 5am and 7am.

Spot Assessment Technique

The Spot Assessment Technique (SAT) (Phillips & Callaghan, 2011) was used to determine the presence or absence of koalas (*Phascolarctos cinereus*), and their activity throughout the study area. DoE (2013b) recommend the use of SAT in their koala referral advice for proponents. Eleven survey site locations were selected about 350 metres apart using an alternating point transect along the survey area. This survey method was designed to provide even and unbiased sampling along adjacent sides of the road alignment. A central tree with a diameter at breast height (DBH) greater than 100 millimetres was selected; flagged and associated coordinates recorded using a handheld GPS device. The closest 29 trees with a DBH over 100 millimetres were also sampled to complete the survey within each grid, with the species and DBH recorded for each tree. The base of each tree was searched for the presence or absence of scats using the one metre protocol of Phillips &

Callaghan (2011) to determine the extent of tree use and associated activity by koalas.

Line transects are typically undertaken in areas that confirm koala presence during SAT surveys, and enable area-based koala density estimates to be derived. Three observers spaced 15 metres apart walked a fixed bearing searching for koalas along a 250–300 metre transect.

In order to support findings from the assessment, three targeted SAT surveys were undertaken in nearby Ku-ring-gai Chase National Park. These surveys assessed areas within the vicinity of the most recent known sightings for koalas recorded in the region; about 5.5 kilometres away in 2009 and 2010 (OEH, 2013). To identify any potential koala presence, targeted surveys were conducted in areas containing known primary koala food trees (PKFTs), and SAT searches were conducted under each PKFT.

SMEC (2016) targeted fauna surveys

Targeted threatened fauna surveys were undertaken by SMEC in spring and summer 2015/2016 to supplement previous fauna datasets and to address the SIS DGRs. Targeted fauna surveys were undertaken for:

- Eastern Pygmy-possum
- Southern Brown Bandicoot
- Red-crowned Toadlet
- Giant Burrowing Frog

Survey details for these species are provided in the SIS.

Assessments of significance

Potential impacts of the proposal were assessed for terrestrial and aquatic biodiversity of the survey area and included assessments of significance under the EPBC Act for relevant Matters of National Environmental Significance (MNES) and seven part tests under the EP&A Act. These are provided in Appendix K.

6.1.2 Existing environment

Vegetation

The study area along Mona Vale Road occupies a ridge-line on undulating terrain within a highly dissected sandstone plateau landscape. The locality is well vegetated with a diversity of native vegetation communities and includes areas within Ku-ring-gai Chase National Park to the north and Garigal National Park to the south.

The study area is centred on a narrow ridgeline within a sandstone environment extending a short distance into steeper slopes and gully heads. The vegetation was originally mapped and described by Smith and Smith (2011) and subsequently mapped by OEH (2013) and then ground-truthed and revised by Ecosure (2015) specifically within the study area for this proposal. The vegetation mapping references both the Ecosure (2015) and OEH (2013) mapping. The detailed ground-truthed mapping produced by Ecosure (2015) is used within the study area, with some additional areas mapped by SMEC.

The study area contains around 34 hectares of remnant vegetation and includes seven native vegetation communities. A summary of the vegetation communities occurring within the study area is provided in Table 6-1.

All vegetation types identified within the study area also occur within the construction impact area. About 17.4 hectares of native vegetation occurs within the latter area. The dominant communities are Sydney North Exposed Sandstone Woodland and Coastal Sandstone Gully Forest.

One of these vegetation communities, Duffys Forest Ecological Community (DFEC), is listed as an endangered ecological community (EEC) under the TSC Act.

Condition of vegetation

Native vegetation through much of the study area away from road/pathway/track edges is in good to moderate condition with moderate to high levels of resilience largely reflecting the infertile sandstone geology.

Native vegetation adjacent to Mona Vale Road (one to three metres), side roads and pathways is affected by edge-effects with evidence of physical disturbance, weed invasion, altered micro-climate and batter fill areas.

Edge effects also occur along power lines, service tracks and close to non-bushland land uses. Most remnants within the study area are fragmented by power lines and associated tracks. There are areas of vegetation which have been classified as highly disturbed vegetation, and are non-resilient with a permanently altered soil profile and minimal potential for natural regeneration. Typically, native vegetation has been largely replaced by weed species.

Twenty-three weed species were recorded in floristic plots (Ecosure, 2015). A total of 10 noxious weeds have been recorded in surveys within the study area. No targeted weed surveys have been undertaken and the number of exotic species present is likely to be much higher.

Table 6-1 Vegetation types impacted by the proposal

Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Area within study area (ha)	Area within construction impact area (ha)	Locality (5 km radius) (ha)
PCT ME106 - Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast (Good)	Bloodwood-Scribbly Gum Woodland	Sydney North Exposed Sandstone Woodland (S_DSF11)	Red Bloodwood - scribbly gum heathy woodland on sandstone plateau of the Sydney Basin Bioregion (ME014)	Not listed	Not listed	16.3	9.3	2776
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Good)	Duffys Forest Ecological Community (DFEC)	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateau, Sydney Basin Bioregion (ME039)	Endangered	Not listed	6.97	3.06	296
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Moderate - Good) - other	DFEC translocation sites	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateau, Sydney Basin Bioregion (ME039)	Endangered	Not listed	0.7	0.2	–

Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Area within study area (ha)	Area within construction impact area (ha)	Locality (5 km radius) (ha)
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Moderate - Good) - poor	DFEC with highly disturbed understory	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateau, Sydney Basin Bioregion (ME039)	Endangered	Not listed	0.4	0.1	–
PCT ME012 - Peppermint-Angophora Forest (Good)	Peppermint-Angophora Forest	Coastal Sandstone Gully Forest (S_DSF09)	Sydney Peppermint – Smooth-barked Apple – Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion (ME012) NSW PCT1250)	Not listed	Not listed	6.6	3.6	1832
PCT ME008 - Sandstone Rocky Heath	Sandstone Heath, Sandstone Rocky Heath	Coastal Sandstone Heath Mallee (S_HL08)	Hairpin Banksia – *Kunzea ambigua* – *Allocasuarina distyla* heath on coastal sandstone plateaux, Sydney Basin Bioregion (ME008) NSW PCT881	Not listed	Not listed	0.9	0.2	72

Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Area within study area (ha)	Area within construction impact area (ha)	Locality (5 km radius) (ha)
PCT ME100 Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	Yellow-top Ash Mallee	Coastal Sandstone Heath Mallee (S_HL08)	Hairpin Banksia-Slender Tea-tree heath on coastal sandstone plateau, Sydney Basin Bioregion (ME013)	Not listed	Not listed	2.5	1.3	1158
Highly disturbed vegetation	Highly disturbed vegetation	Weeds and exotics	n/a	–	–	1.1	0.7	–
Plantings	Plantings	–	n/a	–	–	0.1	0.04	–
Urban/Exotic Native	–	Urban exotics and natives	n/a			1.4	0.5	–
Weeds	Weeds	Weeds and exotics	n/a	–	–	0.4	0.3	–
Total						**37.37**	**19.3**	

Threatened flora

Threatened flora species

Database searches and relevant reports and studies identified 43 threatened flora species with known populations within a 10 kilometre radius of the site. An assessment of the likely occurrence of threatened flora species within the study area identified 10 flora species with a moderate or high likelihood of occurrence (Table 6-2).

Table 6-2 Threatened flora species likely to occur in the study area

Name	Presence within study area	Known or predicted location in study area
Acacia bynoeana	None	Potentially in any of the drier heath and woodland mapped communities
Acacia terminalis subsp. *terminalis*	Tentative id (2011) some plants since identified as ssp. *angustifolia*	Potentially in any of the mapped heath and woodland communities
Callistemon linearifolius	None but record from Mona Vale Road (2014) just out of study area	Potentially in the mapped open-forest communities
Darwinia biflora	None	Potentially in any of the mapped communities except Upland Swamp
Genoplesium baueri	None	Woodland and sparse forest
Grevillea caleyi	77 plants – 2011 29 plants - 2014	Duffy's Forest EEC and Bloodwood-Scribbly Gum Woodland
Microtis angusii	Yes, 1240 counted in 2014 but varies from year to year (RBG 2015)	Disturbed areas
Persoonia hirsuta	1994 record from Tumbledown Dick Hill but since destroyed, one record from Baha'i Temple (Scott et al 1995, Smith and Smith 2000).	Potentially in the heath and woodland
Pimelea curviflora var. curviflora	Yes,1996 (unknown number) Also record in 2007 close to study area at Ingleside	Duffys Forest EEC, Western end on southern side (1996)
Tetratheca glandulosa	Found western end on south side (1996-1998) and just south of Wirreanda Road (2011)	Duffys Forest, Bloodwood-Scribbly Gum Woodland, Heath

Of the species listed in Table 6-2:

- Two species, *Grevillea caleyi* and *Microtis angusii,* have known extant populations within the construction impact area of the proposal (refer Figure 6-1)
- Three species (*Pimelea curviflora* var. *curviflora, Tetratheca glandulosa* and *Persoonia hirsuta*) had been previously recorded from the study area and although were not relocated in 2014-15, they may still persist as plants, rootstock or seed in the soil seedbank
- *Pimelea curviflora* var. *curviflora* was identified in the study area by SMEC in December 2016
- Three species, *Acacia bynoeana, Callistemon linearifolius* and *Darwinia biflora* have not been recorded in the study area, but there is a moderate probability of occurrence based on a consideration of local records and/or suitable habitat being present.

A comprehensive description of each of these species and their occurrence in the study area is presented in the SIS.

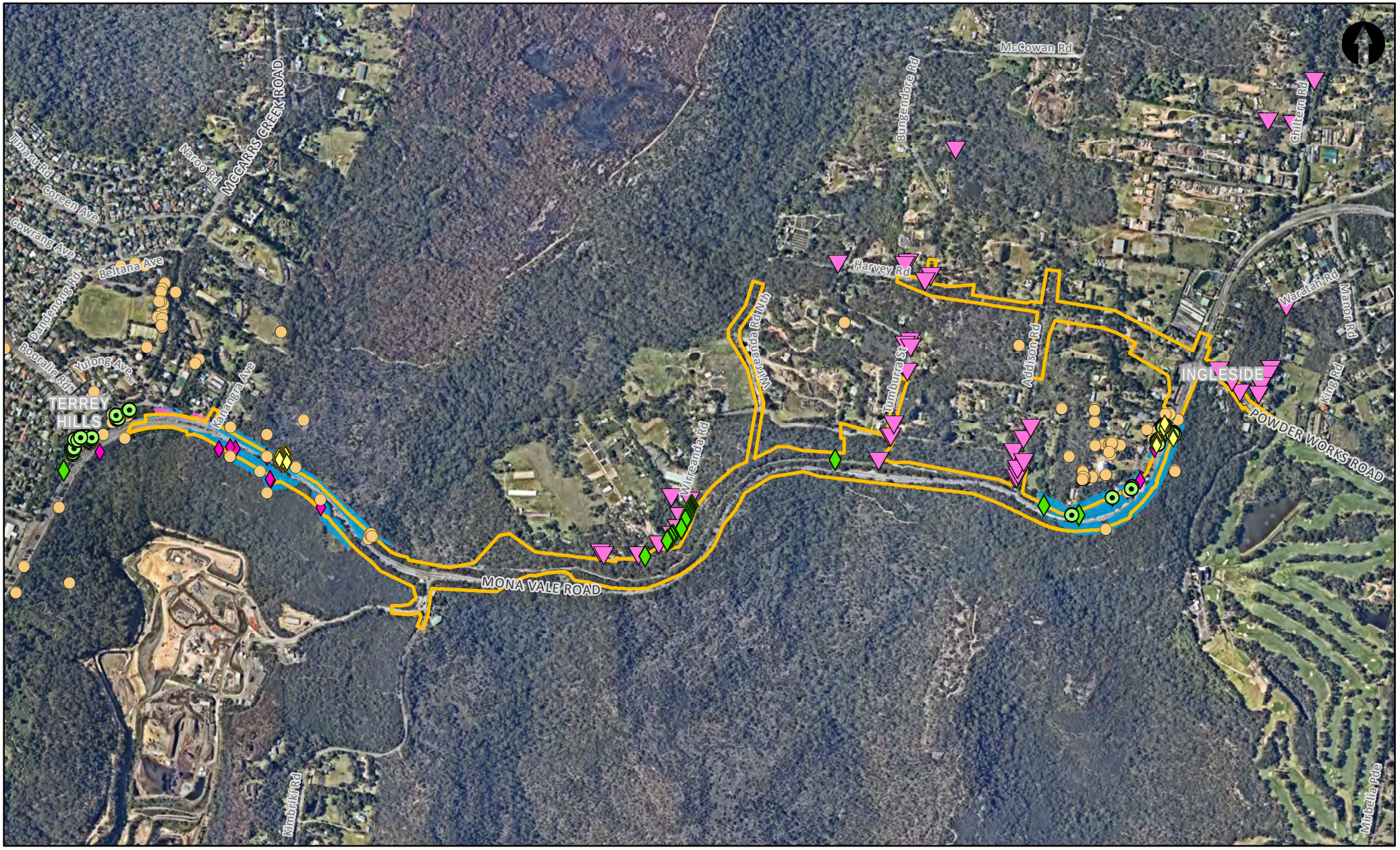
Endangered ecological communities

Ecosure (2015) and Smith and Smith (2011) recorded and mapped one EEC within the study area. DFEC (Duffys Forest Ecological Community in the Sydney Basin Bioregion) is listed as an EEC under the TSC Act.

DFEC is associated with shale lenses in Hawkesbury Sandstone, usually where these form ridgetop caps over the sandstone (Smith and Smith 2011). Soils are slightly more fertile and have a higher clay content than typical Hawkesbury Sandstone soils, and are usually lateritic, characterised by the presence of ironstone gravel.

The community is associated in the study area with the Somersby residual soil landscape Sandstone outcrops are generally absent, except on the fringes of the community. The community occurs on the higher ground at the western (Tumbledown Dick Hill) and eastern (Baha'i Temple) ends of the study area and represents intact good condition vegetation.

Two DFEC translocation sites occur within the study area, north and south of Mona Vale Road at Tumbledown Dick Hill. These are receptor sites for soil seedbank translocation projects arising from previous developments at Belrose. These sites were highly degraded areas that previously supported Duffys Forest EEC.



Grevillea caleyi (SMEC 2016)

Grevillea caleyi (Ecosure 2015)

Grevillea caleyi (BioNet)

Grevillea caleyi (Smith and Smith 2011)

Microtis angusii (Ecosure 2015)

Microtis angusii (Eco Logical 2015)

Construction Boundary

Duffys Forest (Condition: Good)

Duffys Forest (Condition: Moderate)

***Grevillea caleyi, Microtis angusii* and Duffys Forest EEC** **Figure 6-1**

Vector base dataset RoadNet © MDS 2016

0 200 400 m

Fauna

Fauna habitat

The study area includes a large number of rock outcrops, providing habitat for invertebrates, reptiles and mammals.

There is a low density of hollow-bearing trees, due primarily to the shallow sandy soils, with large hollow bearing trees only occasionally found. SMEC identified 135 hollow-bearing trees within the subject site including 219 hollows of varying sizes (78 small, 70 medium, 59 large and 12 extra-large). A number of trees also had fissures that may be suitable for reptiles and small mammals, including microbats.

A total of 22 termite mounds have been identified; five were terrestrial termite mounds suitable for use by female Rosenberg's Goannas. Three had evidence of recent excavation by lizards, suggesting breeding activity.

Table 6-3 presents a summary of fauna habitats present in the study area and construction impact area.

Table 6-3 Summary of fauna habitats impacted by the proposal

Fauna habitat type	Description (Pittwater Council 2011a, 2011b, 2011c)	Main areas within study area	Area within construction impact area	Significant fauna species detected during current surveys (Ecosure)
Wetland	Dam on private property	On private land unlikely to be impacted	–	Not investigated further
Casuarina	Grove of casuarina trees within open woodland areas		–	May be occasionally utilised by glossy black cockatoos (located within the local area, but not within the current study area)
Swamp	Small area of coastal upland swamp	One small area towards the western extent of the study area.	–	None
Open Woodland	Mixed species of eucalypt, including silvertop ash, red bloodwood and broad-leaved scribbly gum and small sections of smooth-barked apple. Mid storey and ground cover often containing heath species, especially heath-leaved banksia and tea tree. Trees with hollows are not common, due to the lack of soil nutrition and subsequent slow growth of the trees within this area. Mistletoe rarely encountered. Sections of *Allocasuarina distyla.*	Throughout.	17.6 ha	Giant Burrowing Frog, Rosenberg's Goanna and Red-crowned Toadlet, Powerful Owl, Glossy Black-cockatoo, Eastern Pygmy-possum.

Fauna habitat type	Description (Pittwater Council 2011a, 2011b, 2011c)	Main areas within study area	Area within construction impact area	Significant fauna species detected during current surveys (Ecosure)
Sandstone Heath	Occasional eucalypt species as emergents, especially red bloodwood, broad-leaved scribbly gum and stringybark. Sub-canopy and mid-storey dominated by heath-leaved banksia, slender tea-tree, hakeas and conesticks. Dense shrub in some areas. Subject to burning, surrounding rock plateaux in a small number of areas. Rock outcrops common. Hollow-bearing trees absent or uncommon.	Limited in this section of the road. Patches throughout extent of study area.	0.2 ha	None, but likely to be foraging habitat for Eastern Pygmy-possum and Rosenberg's Goanna.
Disturbed	Cleared areas with little or no remnant vegetation. Occasional paddock trees may have been kept after clearing. Planted native, but not indigenous trees also present. Non-native pasture, weeds and/or cement constitutes the ground layer of this community.	Patches throughout, especially either end of concept design footprint	1.54 ha	None

Overview of fauna survey results

Database searches and relevant reports and studies identified 102 threatened or migratory fauna species have been recorded within 10 kilometres of the proposal. In addition, a total of 104 vertebrate fauna species were confirmed during surveys (refer Table 6-4). These species were recorded within three main fauna habitats (open woodland, sandstone heath and disturbed) found to be present within or immediately surrounding the study area. Four additional microbat species could potentially occur, based on echolocation call analysis, but were not confirmed.

Table 6-4 Summary of fauna species recorded during surveys

Taxa	Number of species detected during surveys
Amphibians	8**
Birds	73
Bats	8*
Non-flying mammals	5
Reptiles	7+
Total	108 (104 confirmed)

1 definite threatened species, 3 definite common species, 4 possible species and one species group
**two threatened species, +one threatened species.

Reptiles

Two locally significant reptile species were recorded (Lace Monitor *Varanua varius* and Yellow-faced Whipsnake *Demansia psammophis*) and another four species (Snake-eyed Skink *Cryptoblepharus virgatus*, Broad-tailed Gecko *Phyllurus platurus*, Garden Skink *Lampropholis delicata* and Grass Skink *Lampropholis guichenoti* were also found during active searches and opportunistically.

One threatened reptile, the Rosenberg's Goanna *Varanus rosenbergi* was found during current surveys and numerous termite mounds exhibiting nesting by a varanid lizard were also found.

Amphibians

Five species of commonly occurring frogs were recorded: Eastern Dwarf Tree Frog *Litoria fallax*, Striped Marsh Frog *Limnodynastes peronei*, Common Eastern Froglet *Crinia signifera*, Emerald Spotted Tree Frog *Litoria peronei* and Wallum Rocket Frog *Litoria freycineti*. These species were recorded in or adjacent to nearby farm dams associated with semi-rural properties, outside of the study area.

Two individuals of the Giant Burrowing Frog were located and the Red-crowned Toadlet was heard calling during the most recent surveys.

Birds

Four species of birds are listed as threatened under NSW or Commonwealth legislation: Glossy Black-cockatoo *Calyptorhynchus lathami*, Powerful Owl *Ninox strenua*, Regent Honeyeater *Anthochaera Phrygia,* and Little Lorikeet *Glossopsitta pusilla*.

One migratory species listed under the EPBC Act (White-throated Needletail *Hirundapus caudacutus)* and six marine species listed under the EPBC Act including Fan-tailed Cuckoo *Cacomantis flabelliformis*, Black-faced Cuckoo Shrike *Coracina novaehollandiae*, Dollarbird *Eurystomus orientalis*, Pacific Koel *Eudynamys orientalis*, Channel-billed Cuckoo *Scythrops novaehollandiae* and the Sacred Kingfisher *Todiramphus sanctus* were recorded during surveys.

Small insectivorous species (Eastern Yellow Robin *Eopsaltria australis*, Grey Fantail *Rhipidura albiscapa*, Striated and Brown Thornbill *Acanthiza lineata* and White-browed Scrubwren *Sericornis frontalis* were commonly recorded, as were the Channel-billed Cuckoo and Eastern Spine-bill *Acanthorhynchus tenuirostris*.

Ground-nesting birds such as Superb Lyrebirds *Menura novaehollandiae* and Brush-turkeys *Alectura lathami* were also observed several times as part of opportunistic surveys. This suggests a low level of predation by pests such as foxes; fox baiting was being carried out concurrently with surveys in Garigal and Ku-ring-gai Chase National Parks surrounding the study area.

Mammals

Five non-threatened species of mammal were recorded during surveys: Feathertail Glider *Acrobates pygmaeus*, Swamp Wallaby *Wallabia bicolor*, Bush Rat *Rattus fuscipes*, Long-nosed Bandicoot *Perameles nasuta* and Sugar Glider *Petaurus breviceps*. These species are locally significant within the former Pittwater LGA but none are listed as threatened under the TSC Act or the EPBC Act.

As well as these locally significant species, the Ringtail Possum *Pseudocheirus peregrinus* and Brushtail Possum *Trichosurus vulpecula*, were found in abundance within and surrounding the study area and evidence of the introduced European Rabbit *Oryctolagus cuniculus* was noted.

A total of 1096 bat calls were recorded by ultrasonic call detection within the study area. Eighty per cent of calls were attributed to just one call type, the forest bats (*Vespadelus* sp. group) (potentially consisting of up to three species; Eastern Forest Bat (*Vespadelus pumilius*), Eastern Cave Bat (*V. troughtoni*) and Little Forest Bat (*V. vulturnus*)). Four species could be definitively identified from echolocation call analysis with an additional species, Large Forest Bat (*V. darlingtoni*), captured during harp trapping.

Aquatic fauna

There are no records of aquatic species listed as threatened under the FM Act for the region. However, four fish species and one invertebrate listed under the FM Act or EPBC Act were identified as potentially occurring.

Threatened fauna

One hundred and two threatened or migratory fauna species have been recorded within 10 kilometres of the study area. An assessment of likely occurrence was made

based on database and other records, habitat availability, targeted survey (Ecosure, 2015; SMEC, 2015), preliminary field inspection and professional knowledge.

The following fauna species have a medium to high chance of occurring within the study area:

- Giant Burrowing Frog *Heleioporus australiacus*
- Red-crowned Toadlet *Pseudophryne australis*
- Powerful Owl *Ninox strenua*
- Eastern Pygmy-possum *Cercatetus nanus*
- Southern Brown Bandicoot (eastern) *Isoodon obesulus obesulus*
- Large-eared Pied Bat *Chalinolobus dwyeri*
- Little Bentwing-Bat *Miniopterus australis*
- Eastern Bent-wing Bat *Minopterus orianae oceanensis*
- Eastern Freetail-Bat *Mormopterus norfolkensis*
- Greater Broad-Nosed Bat *Scoteanax rueppellii*
- Grey-headed Flying-fox *Pteropus poliocephalus*
- Rosenberg's Goanna *Varanus rosenbergi*

Of these, Rosenberg's Goanna, Giant Burrowing Frog, Red-crowned Toadlet, three microchiropteran bats (Large-eared Pied Bat, Eastern Cave Bat and Eastern Bent-wing Bat) and Eastern Pygmy-possum were recorded during the surveys and are discussed below (refer also

Figure 6-2):

- The Rosenberg's Goanna was found during current surveys and numerous termite mounds exhibiting signs of nesting of by a varanid lizard were also found
- Two individuals of the Giant Burrowing Frog were located along the Caleyi Track in Garigal National Park
- The Red-crowned Toadlet was heard along the Caleyi Track in Garigal National Park. It was also heard calling near Wirreanda Road
- A number of possible calls from the EPBC Act listed Large-eared Pied Bat were recorded within the road corridor, but the duration and quality were not sufficient to confirm its presence. The Eastern Bentwing Bat, listed as vulnerable under the TSC Act, was one of the four species positively identified from call analysis. The sandstone heath and open woodland provides foraging and roosting opportunities for microbats
- 22 Eastern Pygmy-possums were recorded from May 2014 to January 2016 within the study area
- No individuals of the Southern Brown Bandicoot were recorded during the Ecosure or SMEC supplementary surveys, suitable habitat for this species has been identified.

The Koala in the Pittwater Local Government Area is listed as an Endangered Population under Part 2 of Schedule 1 of the TSC Act. Targeted surveys (Spot

Assessment Technique), and frequency of records revealed that although habitat is present for koalas in parts of the survey area, the likelihood of a resident population occurring is low. No other endangered fauna populations are known to occur within the study area and are not considered further.

Migratory species

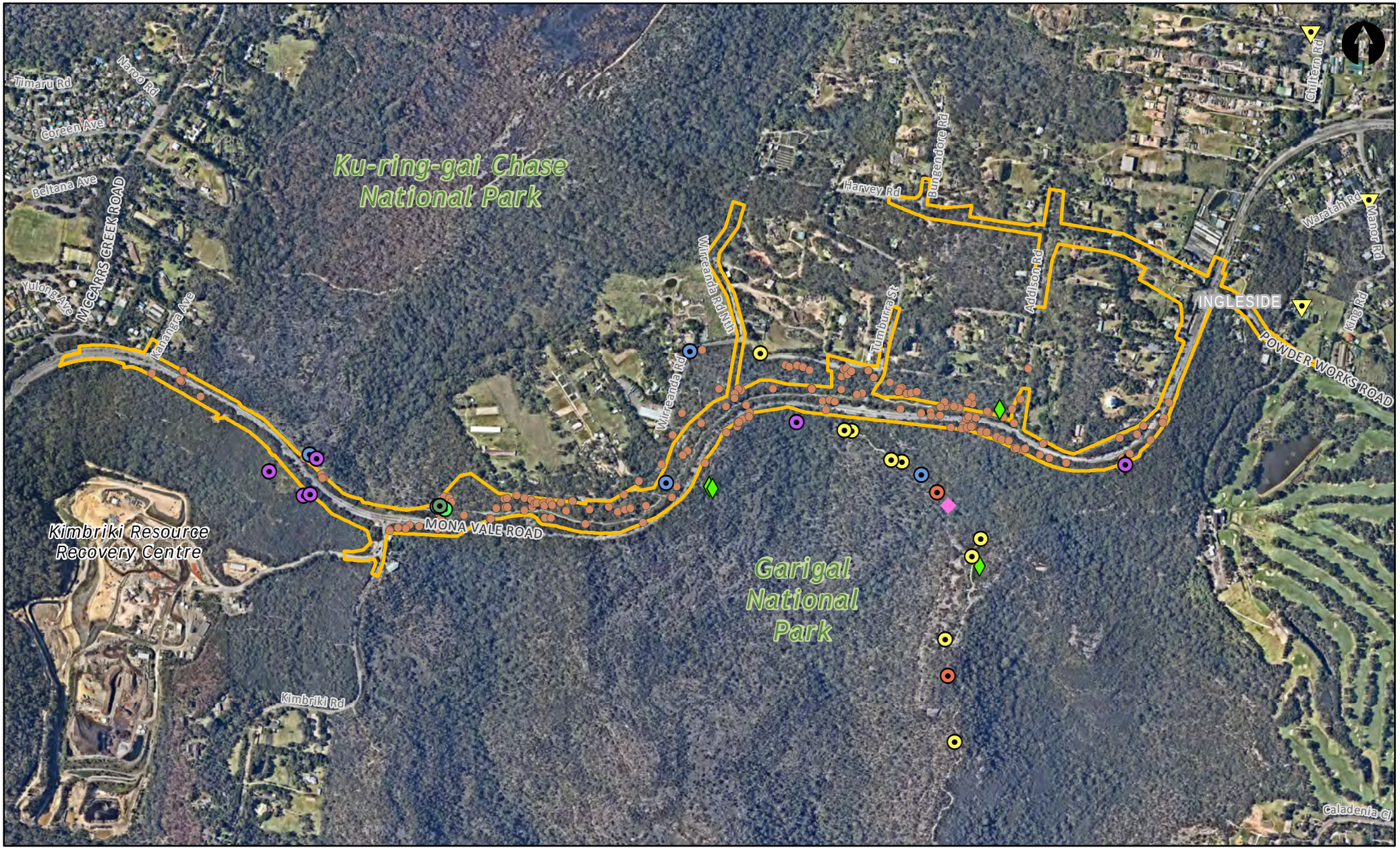
A total of 82 migratory and marine species listed under the EPBC Act were found during the desktop assessment to potentially occur within the study area. These species were then evaluated for their likelihood of occurrence within the survey area and a sub-set of 16 species developed by excluding those with no habitat within the survey area (Ecosure, 2015).

Of these 16 species:

- One species (White-throated Needletail *Hirundapus caudacutus*) was detected at the eastern extent of the survey area during field investigations
- One species (Fork-tailed Swift *Apus pacificus*) has a high likelihood of occurrence
- Four species have a moderate likelihood of occurrence, mostly assessed as potentially using the survey area for a short period of time during migration, but are unlikely to be reliant on the area
- The remaining seven species have a low likelihood of occurrence.

Critical habitat

No critical habitat for any threatened species was recorded within the study area.



Bats (Pittwater Council)
Rosenberg's goanna (SMEC 2015)
EPP captures (SMEC 2016)
Hollow bearing trees
Construction Boundary

Threatened fauna (Ecosure 2015)
Eastern bentwing-bat
Eastern pygmy possum
Giant burrowing frog
Grey-headed flying-fox
Heath monitor
Red-crowned toadlet

Threatened Fauna Locations **Figure 6-2**

Vector base dataset RoadNet © MDS 2016

0 250 500 m

6.1.3 Potential impacts

Construction

Removal of vegetation

The proposal would result in the removal of about 17 hectares of remnant native vegetation. This includes the removal of about 3.4 hectares of Duffys Forest EEC. The approximate extent of each vegetation community proposed for removal is listed in Table 6-1.

Clearing of vegetation associated with the proposal would result in the removal of habitat for native fauna species. Other impacts on fauna habitat include habitat fragmentation, increased fauna injury and mortality and disturbance to fauna as a result of noise, vibration and light.

Potential impacts on EECs and threatened flora species (and assessments of significance)

Assessments of significance were undertaken for threatened species listed under the TSC Act and EPBC Act which were likely to be impacted by the proposal. The complete Assessments of Significance prepared for the proposal are provided in Appendix K. The following is a summary of the potential impacts drawn from the SIS.

Duffys Forest EEC

The proposal would result in the removal or modification of about 3.4 hectares of DFEC with some indirect impacts also possible. DFEC to be impacted is considered important to the long-term viability of the community which is largely restricted to the locality as all remnants are considered significant due to the high level of historical clearing, highly restricted distribution and small size of remaining remnants. DFEC within the construction impact area also provides habitat for a population of the critically endangered *Grevillea caleyi*.

Grevillea caleyi

The proposal would result in the removal or modification of up to three hectares of habitat for this species, 75 above-ground individuals and potentially around 10,000 seeds in the soil seed bank. Due to the highly restricted distribution of *Grevillea caleyi* and its close association with DFEC, the size and condition of habitat remnants and the relatively high plant densities, the habitat to be removed is considered important to the long-term survival of the species.

Microtis angusii

A total of 1469 *M. angusii* individuals have the potential to be disturbed as a result of the proposal with the entire Kimbriki Road (type population) within the construction footprint. This loss represents about 49 per cent of the total known local Ingleside/Terrey Hills population, estimated to be around 3000 individuals (Greg Steenbeeke, ELA 2016, pers. comm.). Other impacts on this species include loss of genetic diversity and loss of habitat for pollinators.

There is likely to be an adverse effect on the life cycle of the species through loss of individuals across its distribution, loss of genetic diversity and potentially habitat for pollinators increasing the risk of local extinction. In the absence of any published minimum viable population sizes for the species (or for the *Microtis* genus) or any

impact assessment threshold guidelines for the species, a precautionary approach has assumed that the proposal has the potential to result in a localised extinction of *M. angusii*, particularly when coupled with the potential impact from the future Ingleside planning development.

M. angusii has a highly restricted distribution and was originally reported as occurring in one population at one location along Mona Vale Road, at Ingleside. Individual plants or populations have since been reported at other locations around Ingleside, in other suburbs of Sydney, and in one location west of the Blue Mountains (Flanagan et al. 2006; DECCW 2010). The presence of *M. angusii* in these additional locations has been difficult to confirm due to strong morphological similarities with other Microtis species (*M. parviflora*, *M. unifolia*) and awaits the findings of further phylogenetic analysis.

As part of the Ingleside Precinct Biocertification, EcoLogical Australia were commissioned to undertake a targeted survey and habitat mapping of *M. angusii* in September and October 2015, during which 8500 Microtis individuals were counted and classified into species based on morphology. As part of the targeted survey, leaf samples of *Microtis* individuals were obtained and submitted to the plant pathology unit of the Royal Botanic Gardens, Sydney, for genetic analysis. The study area for the *Microtis* survey overlaps that of the Mona Vale Road West project and is thus relevant to the SIS. Key results from the ELA study are as follows:

- Four *Microtis* species were genetically confirmed from a subset of the 8500 individuals, these being *M. angusii*, *M. rara*, *M. parviflora* and *M. angusii*
- None of the samples submitted were genetically confirmed as *M. unifolia*, even though the samples submitted were initially classified as *M. unifolia* based on morphological characteristics. All these samples that were initially classified as *M. unifolia* were genetically confirmed to be *M. angusii.*

It is also understood that additional samples of *M.* '*unifolia*' from other areas of NSW and Australia (including two samples from the study area collected by Ecosure) were sent to the RBG in 2015 and subject to similar genetic analysis. Most of these additional samples were also understood to be genetically confirmed as *M. angusii* (Greg Steenbeeke, ELA 2016, pers.comm.).

The results associated with the Ingleside and state-wide genetic investigations would suggest that:

- *M. angusii* is much more widespread than previously thought; and
- There may not be a presence of *M. unifolia* in NSW or Australia (the type 'unifolia' specimen was collected from the Bay or Plenty in New Zealand).

RBG (2015) note that further genetic investigations would be required to resolve the taxonomic uncertainty in relation to *M. angusii/unifolia* group.

In the absence of any published minimum viable population sizes for the species (or for the *Microtis* genus) or any impact assessment threshold guidelines for the species, a precautionary approach has been adopted and it is assumed that the proposal has the potential to result in a localised extinction of *M. angusii*, particularly when coupled with the potential impact from the future Ingleside planning development.

Notwithstanding the above discussion, the assessment must be considered heavily in the context of the current knowledge of the species which may result in a marked change in its taxonomic and conservation status, although not in the timeframe of this proposal.

Persoonia hirsuta

The proposal would result in the removal of an unknown (likely small) area of habitat associated with a single record from 1994. A further 10 hectares of potential habitat would be affected. There is a reasonable likelihood of *Persoonia hirsuta* still being present as habitat at the site is now overgrown in the absence of fire for >20 years reducing the likelihood of sightings (blends easily into its environment), and limiting pollination and seed set, seed dispersal and germination. There is likely to be an adverse effect on the life cycle of this occurrence (local population). The importance of this habitat to the long-term survival of the species is likely to be low to moderate. Although it has a wide distribution populations are not well represented in the local area (few sites on private and council land at Cromer, Collaroy and Oxford Falls), they are very small and vulnerable to extinction.

Tetratheca glandulosa

The proposal would result in the removal of an unknown area of habitat associated with previous records in 1996, 1998 and 2011. About a further nine hectares of potential habitat would be affected. There is a reasonable likelihood of *Tetratheca glandulosa* still being present as some of its known habitat is now overgrown in the absence of fire for over 20 years reducing the likelihood of sightings and limiting growth, flowering and pollination. There is likely to be an adverse effect on the life cycle. The importance of this habitat to the long-term survival of the species is relatively low with good representation within conservation reserves in most parts of its range (except the Hills). Based on current information the proposal is unlikely to result in a significant impact on the species.

Acacia bynoeana

Approximately 9.5 hectares of potential habitat is likely to be cleared or modified. The importance of this habitat to the long-term survival of this species is considered to be low.

Acacia terminalis subsp. terminalis

Approximately 9.5 hectares of potential habitat is likely to be cleared or modified. The importance of this habitat to the long-term survival of the species is considered to be low to moderate.

Callistemon linearifolius

Approximately 6.7 hectares of potential habitat is likely to be cleared or modified. The importance of this habitat to the long-term survival of the species is considered to be moderate. It is unlikely that a significant population is present within the study area and remains undetected.

Darwinia biflora

Approximately eight hectares of potential habitat is likely to be cleared or modified. The importance of this habitat to the long-term survival of the species is considered to be moderate.

Genoplesium baueri

Approximately 16.2 hectares of potential habitat is likely to be cleared or modified. The importance of this habitat to the long-term survival of the species is considered to be moderate.

Pimelea curviflora var. curviflora

The proposal would result in the removal of an unknown area of habitat associated with a single record from 1996. A further nine hectares of potential habitat would be affected. There is a reasonable likelihood of *Pimelea curviflora* var. *curviflora* still being present as habitat in the study area is overgrown (requires open conditions), it is difficult to see and often persists below the ground. If present, there is likely to be an adverse effect on the life cycle of this local population which is assumed to be relatively small.

The importance of this habitat to the long-term survival of *Pimelea curviflora* var. *curviflora* is likely to be low to moderate. It has a relatively wide distribution across coastal areas of the Greater Sydney region (north to Berowra, west to Maroota and south to the Illawarra) and populations are often in the hundreds although populations fluctuate considerably..

Wildlife connectivity and habitat fragmentation

The subject site lies within the Sydney suburbs of Terrey Hills and Ingleside. Mona Vale Road is a major road through the locality that separates Ku-ring-gai Chase and Garigal National Parks.

There is existing evidence to indicate mortality of numerous native species on Mona Vale Road as a result of collision with vehicles (SMEC, 2011; Ecosure, 2015). SMEC (2011) identified ‘hotspots’ for roadkill within the study area.

Roads are known to have deleterious effects on many flora and fauna species with creation of movement barriers being a major impact. The existing formation of Mona Vale Road has resulted in a cleared width generally of 10–25 metres which has resulted in habitat fragmentation. This represents a barrier to individual movement and, therefore, a loss or reduction of habitat connectivity for many flora and fauna species and plant communities. In additional to the direct barrier effect, if sufficiently high levels of road mortality occur, the effective barrier to gene flow is enhanced in addition to the direct impact of the mortality on population processes.

Road widening and loss of habitat associated with realignment on the northern side of Mona Vale Road would further increase the barrier effect of the road. Upgrading the existing road and formation sections of road, with associated road shoulders, the shared path and bus stops would create a cleared width of generally 35 metres, but up to 60 metres in places. This would increase the severity of habitat fragmentation, reduce rates of fauna movement, increase road mortality (compounded by increased traffic and vehicle speeds) and reduce rates of gene flow in some threatened flora and fauna species and within EECs (e.g. reduced movement of pollen and seed).

The western third of the study area directly adjoins Ku-ring-gai Chase National Park to the north and Garigal National Park to the south. The remainder of the alignment also adjoins Garigal National Park, but it is bordered by private land subject to rural residential scale development on its north side. However, this area of private land in turn adjoins Ku-ring-gai Chase National Park to the north and several potential movement corridors occur within this land, for example along Tumburra Street, Addison Road and through the grounds of the Baha'i Temple complex.

Among the threatened fauna species, Rosenberg's Goanna and the Eastern Pygmy-possum are considered to be the species most at risk of impact from the proposal. The degree of impact upon these species is not currently well defined due to several unknown factors of the species' ecology. This includes the lack of available research regarding rates of movement and response to increased gap widths and traffic volume and speed.

Relevant research that is available indicates that small mammal species may show an aversion to crossing even relatively small road gaps at low traffic volumes (Goosem 2001, 2002). It is currently unknown to what extent the Eastern Pygmy-possum crosses the existing road, if at all, though it is likely that there is very little or no movement currently occurring. On the basis that the road would be widened by the proposal it is therefore likely that this barrier effect would remain or increase. This would continue to prevent genetic exchange across the road with potential implications for long term viability of the local population.

Should individuals attempt crossing the upgraded road, the potential for vehicle strike would be increased. This would further increase the overall barrier effect and subsequent impact upon the genetic viability of the separated (north and south) populations.

Injury and mortality

Habitat clearing for the proposal may lead to incidences of fauna injury or mortality through interactions with vehicles. Although the existing road already poses a threat to native fauna for injury and mortality, it is likely that the risk would be higher during construction, particularly during habitat removal when fauna would be forced to relocate. Given the proposal would involve habitat clearing directly adjacent to the existing road, this may result in an increase in ground-dwelling mammals being injured or killed by cars in the short-term.

A total of 131 hollow-bearing trees would require removal from within the construction footprint. It is expected that resident fauna would be able to move away through connected habitat. However once constructed, it is anticipated the proposal would result in increased traffic volumes through the study area which would increase the potential of vehicle strike.

Noise, vibration and light

It is unlikely the proposal would result in significant changes to existing levels of noise, vibration and light from the existing roadway such that there would be a significant impact to native fauna. There is potential for some resident native fauna to temporarily avoid habitats directly adjacent to the proposal during construction, with bat species being particularly sensitive to any change in lighting that may be associated with the proposal.

Operation

Impacts on biodiversity following completion of construction (such as additional vegetation clearing or increased runoff) are not expected.

Conclusion on significance of impacts

The proposal is likely to significantly impact threatened species, populations or ecological communities or their habitats listed under the *Threatened Species Conservation Act 1995* or *Fisheries Management Act 1994* and therefore a Species Impact Statement is required. This has been prepared and is being displayed concurrently with this REF.

The proposal is likely to significantly impact threatened species, populations, ecological communities or migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

The following discussion summarises the assessments of significance under the TSC Act and EPBC Act that were carried out for threatened species which are likely to be impacted by the proposal.

Giant Burrowing Frog

The Giant Burrowing Frog was recorded outside the subject site along the Caleyi Trail in Garigal National Park during recent spotlighting surveys by Ecosure. Suitable foraging habitat occurs in the study area (Ecosure 2015), and larger areas of good quality habitat occur in Ku-ring-gai Chase National Park and the adjacent Garigal National Park in which the species was identified.

The proposal would remove 0.22 ha of suitable breeding habitat and 12.5 ha of potential non-breeding habitat for the Giant Burrowing Frog. Although the species was only recorded to the south of Mona Vale Road, suitable habitat occurs to the north in Ku-ring-gai Chase National Park. Non-breeding habitat is also present near Wirreanda Road although the species is unlikely to occur here due to the disturbed nature of the area.

There is unlikely to be any material changes to drainage, nutrient levels or sedimentation that would affect potential Giant Burrowing Frog breeding habitat in ephemeral drainage lines outside of the construction area.

Red-crowned Toadlet

The Red-crowned Toadlet was detected at two separate locations: along the Caleyi Trail in Garigal National Park to the south of Mona Vale Road and near Wirreanda Road to the north. In Garigal National Park they were observed in four locations close to each other and less than 50 metres from the construction area. The individual heard calling along Wirreanda Road was located within the construction area.

The proposal would require the removal of about 1.43 hectares of suitable breeding and non-breeding habitat for the Red-crowned Toadlet. Additional suitable habitat for the Red-crowned Toadlet is located in Ku-ring-gai Chase and Garigal National Parks adjacent to the study area.

There are unlikely to be any material changes to drainage or groundwater that would affect breeding habitat in ephemeral drainage lines outside the construction impact area.

The proposal would further isolate and reduce habitat available to individuals identified near Wirreanda Road. Potential breeding habitat would be removed in this area.

Powerful Owl

The proposal would require the removal of 17.3 hectares of vegetation that could be utilised by the Powerful Owl for hunting. This vegetation also provides suitable habitat for prey species of the owl including hollow-bearing trees.

Powerful Owls have very large home ranges and are only likely to utilise the study area for hunting. Additional hunting habitat with suitable prey species is available in the neighbouring Ku-ring-gai Chase and Garigal National Parks.

It is unlikely that the Powerful Owl would be significantly impacted by the proposal.

Eastern Pygmy-possum

The proposal would require the removal of 18.9 hectares of habitat suitable for use by the Eastern Pygmy-possum, which is likely to result in the displacement of numerous individuals The potential impacts associated with the proposal would be mitigated to an acceptable level, particularly through the installation of the proposed 40 metre wide fauna crossing connecting the Ku-ring-gai Chase and Garigal National Parks.

Southern Brown Bandicoot

The study area contains limited breeding and foraging habitat for the Southern Brown Bandicoot. The species has a sparse distribution and has not been recorded in Garigal National Park since 2000 despite trapping efforts. It is only likely to utilise the study area on rare occasions.

The proposal would require the removal of 17.3 hectares of potential habitat that may be used by the Southern Brown Bandicoot for foraging and breeding. Given the species' absence in the locality, it is not considered that this would have a significant impact on the species. Construction of crossing structures for fauna as part of this project would improve dispersal for this species by reducing the risk of road mortality.

Large-eared Pied Bat

The proposal would require the removal of up to 17.3 hectares of vegetation containing suitable foraging and roosting habitat for the Eastern Bentwing-Bat and Large-eared Pied Bat. The Eastern Bentwing-Bat was recorded in the study area and a possible identification was made for the Large-eared Pied Bat.

This species is likely to utilise extensive areas of foraging habitat in the locality and is therefore unlikely to be affected by the removal of foraging habitat along a major road. Extensive areas of suitable foraging and roosting habitat would remain in the locality. It is unlikely the proposal would have a significant impact on this species of microbat.

Little Bentwing Bat

The proposal would require the removal of up to 17.3 hectares of open woodland containing suitable foraging and roosting habitat for the Little Bentwing Bat, Eastern Freetail Bat and Greater Broad-nosed Bat. None of these species were identified during recent surveys.

This species is likely to utilise extensive areas of foraging habitat in the locality and is therefore unlikely to be affected by the removal of foraging habitat along a major road. Extensive areas of suitable foraging and roosting habitat would remain in the locality. It is unlikely the proposal would have a significant impact on the Little Bentwing Bat.

Grey-headed Flying-fox

The Grey-headed Flying-fox was identified in the study area during recent surveys. Numerous individuals were observed foraging within the study area or flying overhead. It is expected the species forages on occasion within the study area when suitable trees are in flower. There are additional food resources available in neighbouring national parks as well as streetscapes, parks and gardens in the locality.

The proposal would not disturb any Grey-headed Flying-fox camps.

Rosenberg's Goanna

The Rosenberg's Goanna has been recorded within the study area on more than one occasion and is known to utilise key habitat resources that may be removed by the proposal.

The proposal would require the removal of termite mounds that are used for breeding. Twenty-two termite mounds occur in the construction impact area of which five are suitable for use by female Rosenberg's Goannas, with three showing signs of recent activity by lizards. The Rosenberg's Goanna is likely to compete with the Lace Monitor for these breeding sites and at least one mound was observed to be regularly used by Lace Monitors.

The provision of fauna crossing structures would improve foraging and dispersal opportunities for the Rosenberg's Goanna by reducing the likelihood of road mortality for individuals moving between Ku-ring-gai Chase National Park and Garigal National Park.

Key Threatening Processes

The following key threatening processes (KTPs) listed under the EPBC, TSC or FM Acts are considered relevant to the proposal:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (TSC Act)
- Bushrock removal
- Land clearance (EPBC Act); clearing of native vegetation (TSC Act)
- Competition and land degradation by rabbits (EPBC Act)/ Competition and grazing by the feral European rabbit *Oryctolagus cuniculus* (TSC Act)
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC Act)/ Infection of frogs by amphibian chytrid causing the disease chytridiomycosis (TSC Act)
- Invasion and establishment of exotic vines and scramblers (TSC Act)
- Invasion, establishment and spread of Lantana (*Lantana camara*) (TSC Act)

- Invasion by native plant communities by exotic perennial grasses (TSC Act)
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (TSC Act)
- Infection of native plants by *Phytophthora cinnamomi*
- Introduction and establishment of Exotic Rust Fungi of the Pucciniales pathogenic on plants of the family Myrtaceae
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
- Loss of hollow-bearing trees
- Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)
- Predation by the Feral Cat *Felis catus* (Linneaus, 1758)
- Removal of dead wood and dead trees.

These are discussed in further detail in the SIS.

EP&A Act

Assessments of significance under Section 5A of the EP&A Act were undertaken for the subject species and EECs identified by the DGRs for the SIS. A summary of the findings for the assessments is provided in Table 6-5.

The assessments of significance undertaken under the EP&A Act concluded that the proposal would have a significant impact on:

- Duffys Forest EEC
- *Grevillea caleyi*
- *Microtis angusii*
- Red-crowned Toadlet (*Pseudophryne australis*).

Table 6-5 Summary of assessments of significance under the EP&A Act

Threatened species, population or communities	Significance assessment question							Likely significant impact?
	a	b	c	d	e	f	g	
Duffys Forest EEC	X	X	Y	Y	X	Y	Y	Yes
Coastal Upland Swamp EEC	X	X	Y	N	X	Y	Y	No
Grevillea caleyi	Y	X	X	Y	X	Y	Y	Yes
Microtis angusii	Y	X	X	Y	X	Y	Y	Yes
Pimelea curviflora var. *curviflora*	Y	X	X	N	X	Y	Y	No
Persoonia hirsuta	Y	X	X	N	X	Y	Y	No
Tetratheca glandulosa	Y	X	X	N	X	Y	Y	No

Threatened species, population or communities	Significance assessment question							Likely significant impact?
	a	b	c	d	e	f	g	
Acacia bynoeana	Y	X	X	N	X	Y	Y	No
Acacia terminalis subsp. *terminalis*	Y	X	X	N	X	Y	Y	No
Callistemon linearifolius	Y	X	X	N	X	Y	Y	No
Darwinia biflora	Y	X	X	N	X	Y	Y	No
Genoplesium baueri	Y	X	X	N	X	Y	Y	No
Heleioporus australiacus (Giant Burrowing Frog)	N	X	X	N	X	N	Y	No
Pseudophryne australis (Red-crowned Toadlet)	N	X	X	Y	X	N	Y	Yes
Ninox strenua (Powerful Owl)	N	X	X	N	X	N	Y	No
Cercartetus nanus (Eastern Pygmy-possum)	N	X	X	Y	X	N	Y	No
Isoodon obesulus obesulus (Southern Brown Bandicoot)	N	X	X	N	X	N	Y	No
Chalinolobus dwyeri (Large-eared Pied Bat)	N	X	X	N	X	N	Y	No
Miniopterus schreibersii oceanensis (Eastern Bentwing Bat)	N	X	X	N	X	N	Y	No
Miniopterus australis (Little Bentwing Bat)	N	X	X	N	X	N	Y	No
Mormopterus norfolkensis (Eastern Freetail-bat)	N	X	X	N	X	N	Y	No
Scoteanax rueppellii (Greater Broad-nosed Bat)	N	X	X	N	X	N	Y	No
Pteropus poliocephalus (Grey-headed Flying-fox)	N	X	X	N	X	N	Y	No
Varanus rosenbergi (Rosenberg's Goanna)	N	X	X	N	X	N	Y	No

Y= Yes (negative impact), N= No (nil or positive impact), X= not applicable, ?= unknown impact.

Assessments of significance for those subject species and EECs listed under the EPBC Act have been undertaken using the Commonwealth MNES Significant Impact Assessment Guidelines (DoE, 2013). A summary of the assessment results is provided in Table 6-6.

The assessments of significance under the EPBC Act concluded that the proposal would have a significant impact on *Grevillea caleyi* and *Microtis angusii*.

Table 6-6 Summary of assessments of significance under the EPBC Act

Threatened species, or communities	Significance assessment criteria									Likely significant impact?
	i	ii	Iii	iv	v	vi	vii	viii	ix	
Coastal Upland Swamp in the Sydney Basin Bioregion	Y	N	Y	N	Y	N	N	–	–	No
Grevillea caleyi (Caley's Grevillea)	Y	Y	N	N	Y	N	N	N	Y	Yes
Genoplesium baueri (Bauer's Midge Orchid)	N	N	N	N	N	N	N	N	N	No
Microtis angusii (Angus' Onion Orchid)	Y	Y	Y	Y	Y	Y	N	N	Y	Yes
Pimelea curviflora var. *curvifora*	N	N	N	N	N	N	N	N	N	No
Acacia bynoeana (Bynoe's wattle)	N	N	N	N	N	N	N	N	N	No
Acacia terminalis subsp. *terminalis* (Sunshine Wattle)	N	N	N	N	N	N	N	N	N	No
Darwinia biflora	N	N	N	N	N	N	N	N	N	No
Heleioporus australiacus (Giant Burrowing Frog)	N	N	N	N	N	N	N	N	N	No
Isoodon obesulus obesulus (Southern Brown Bandicoot)	N	N	N	N	N	N	N	N	N	No
Chalinolobus dwyeri (Large-eared Pied Bat)	N	N	N	N	N	N	N	N	N	No
Pteropus poliocephalus (Grey-headed Flying-fox)	N	N	N	N	N	N	N	N	N	No

Y= Yes (negative impact), N= No (nil or positive impact), X= not applicable

6.1.4 Safeguards and mitigation measures

Table 6-7 lists the safeguards and mitigation measures that have been proposed to address potential impacts on biodiversity. These measures have been developed to mitigate the potential impacts of the proposal on threatened flora and fauna species and any residual impacts that cannot be mitigated would be offset in accordance with Roads and Maritime Guideline for Biodiversity Offsets (2016). The mitigation measures are designed to minimise impacts on threatened species as well as common flora and fauna species that occur in the study area.

Table 7-1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-7 Safeguards and mitigation measures – biodiversity

ID	Impact	Environmental safeguards	Responsibility	Timing
B-1	General	A Flora and Fauna Management Plan will be prepared in accordance with Roads and Maritime's *Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA Projects* (RTA, 2011) and implemented as part of the CEMP. It will include, but not be limited to: • plans showing areas to be cleared and areas to be protected, including exclusion zones, protected habitat features and revegetation areas • requirements set out in the Landscape Guideline (RTA, 2008) • pre-clearing survey requirements • procedures for unexpected threatened species finds and fauna handling • procedures addressing relevant matters specified in the Policy and guidelines for fish habitat conservation and management (DPI Fisheries, 2013).	Construction Contractor	Pre-construction
B-2		Measures to further avoid and minimise the construction footprint and native vegetation or habitat removal will be investigated during detailed design and implemented where practicable and feasible.	Construction Contractor	Pre-construction
B-3	Threatened flora/EEC management (*Grevillea caleyi*)	Seedbank salvage. Refer SIS Section 7.1.2	Roads and Maritime	Pre-construction Construction Post-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
B-4		Monitor the Tumbledown Dick Hill and Baha'i Temple *Grevillea caleyi* populations pre, during and post construction to establish baseline habitat conditions, ensure habitats are being maintained and exclusion zones are being adhered to during construction as well as to determine any changes to population size and extent. Following approval, an annual monitoring program of the two *G. caley*i populations shall be prepared (in consultation with an appropriately qualified specialist) and implemented for a duration of at least three years post construction. Monitoring would be undertaken by a suitably qualified botanist. Data collected would include: • number of plants (seedlings, saplings, adults); • number of flowers on each plant; • associate plant species (native and exotic), including plant heights and densities; • overall plant health and vigour; • disturbance. The monitoring program shall include a reporting requirement and shall trigger management actions where appropriate (based on threshold criteria to be developed).	Roads and Maritime	Pre-construction Construction Post-construction
B-5		Regular inspections of *G. caleyi* Tumbledown Dick Hill and Baha'i Temple populations during construction. Contractor's environment site officer shall undertake regular	Construction contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		inspections of the retained *G. caleyi* populations (including Duffys Forest EEC) during construction to ensure its protection from plant and equipment, to ensure hydrology is being maintained and to confirm the integrity of the exclusion fencing.		
B-6	Threatened flora management – *Microtis angusii* (subject to taxonomic revision and conservation status of the species)	Undertake a differential GPS survey (<1m accuracy) of the remaining *M. angusii* sub-populations within the study area during flowering season to confirm the approximate number of individuals located within the subject site. Results can then be used to inform the appropriate location for the installation of exclusion fencing in the vicinity of the four *M. angusii* subpopulations.	Roads and Maritime	Pre-construction
B-7		Maintain pre development hydrology to ensure pre development soil moisture levels are maintained within the remaining *Microtis angusii* sub-populations within the study area through design and implementation of adequate drainage structures during and post construction.	Design Contractor Construction Contractor Roads and Maritime	Pre-construction Construction Post-construction
B-8		Adopt a suitable roadside maintenance (ie. mowing) regime with the Northern Beaches Council to maintain pre development optimal *M. angusii* grassland habitat at all the remaining sub-population sites. The mowing regime should include a prohibition on mowing during autumn through to late spring during the *M. angusii* above ground life cycle (leaf, flower, fruit).	Roads and Maritime	Post-construction
B-9		Monitor remaining *M. angusii* sub-populations within the study area pre, during and	Roads and Maritime	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		post construction to establish baseline habitat conditions, ensure habitats are being maintained and exclusion zones are being adhered to during construction as well as to determine any changes to population size and extent. Following project approval, an annual monitoring program shall be adopted and for a duration of at least 3 years post construction. Monitoring would be undertaken by a suitably qualified botanist and would adopt the grid cell structure established by the RBG Sydney (2015). The monitoring program shall include a reporting requirement and shall trigger management actions where appropriate (based on threshold criteria to be developed)		Construction Post-construction
B-10		A salvage and reintroduction program shall be implemented for those *M. angusii* plants proposed for direct disturbance prior to construction with the objective of achieving a no net loss in biodiversity of the Microtis sub-populations. Following approval, a *M. angusii* salvage and reintroduction program shall be prepared by a suitably qualified ecological consultant in consultation with the Royal Botanic Gardens, Sydney. The program shall detail methods, monitoring and reporting requirements for: • excavating plants proposed for disturbance and reintroducing them into the main (type) sub-population (to be retained); or	Roads and Maritime	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		• outplanting existing RBG ex situ tubestock (propagated from seed from the main population) at a 1:1 removal/replacement ratio into the main sub-population; or • collecting seed from the main sub-population and propagating additional tubestock for outplanting into the main population. Translocation trials for *M. angusii* have been undertaken by the RBG in 2015 and have shown (at least from initial monitoring results) to be successful. RBG have also been successful in isolating the fungal symbiont necessary for successful *M. angusii* germination and growth.		
B-11		If unexpected threatened flora species are discovered, stop works immediately and follow the Roads and Maritime Unexpected Threatened Species Finds Procedure in the Roads and Maritime Biodiversity Guidelines – Guide 1 (Pre-clearing process) (RTA, 2011).	Construction Contractor	Construction
B-12	Impacts on retained native vegetation adjoining the construction footprint	Ensure exclusion zones (at the subject site boundary) are established prior to vegetation clearing in accordance with Guide 2 of the Roads and Maritime Biodiversity Guidelines (RTA 2011). Fencing and signage and should be delineated by a registered surveyor.	Construction Contractor	Pre-construction
B-13	Rehabilitation	Batters, embankments, verges and redundant areas should be planted out, where practicable and appropriate, with indigenous species in accordance with a Revegetation Plan, to be prepared following approval	Construction Contractor	Construction Post-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		(excluding the type Microtis sub-population area).		
B-14	Establishment and spread of invasive species and pathogens	Implement a Site Erosion and Sediment Control Plan or Soil Water Management Plan in accordance with the Blue Book (Landcom 2004) during construction.	Construction Contractor	Construction
B-15		Undertake weed management and control in accordance with the Roads and Maritime Biodiversity Guidelines (RTA 2011) during and post-construction in accordance with a weed management sub-plan.	Construction Contractor	Construction Post-construction
B-16		It is recommended that all Roads and Maritime and Contractor vehicles be subject to cleaning in accordance with Roads and Maritime hygiene policy to reduce the potential for spread of noxious weeds, plant pathogens or animal diseases into retained forested habitats (eg. vehicle washdown areas) in accordance with a hygiene management sub-plan.	Construction Contractor	Pre-construction Construction
B-17		Establish a protocol to prevent introduction or spread of *Phytophthora cinnamomi* and Myrtle Rust consistent with Roads and Maritime Biodiversity Guidelines - Guide 7 (Pathogen Management) (RTA, 2011) during construction.	Construction Contractor	Construction
B-18	Impact on native fauna and their habitat	Remove the minimum required amount of native vegetation to retain the maximum amount of habitat for native fauna	Construction Contractor	Pre-construction
B-19		Bush rock proposed for disturbance should be salvaged for relocation into suitable retained habitats in accordance with the Roads	Construction Contractor	Pre-construction Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		and Maritime Biodiversity Guidelines (RTA 2011).		
B-20		Identify hollow-bearing trees for retention	Construction Contractor	Pre-construction
B-21		Undertake staged habitat removal of hollow-bearing trees in accordance with the Roads and Maritime Biodiversity Guidelines (RTA 2011). A nest box strategy will be developed in accordance with the Roads and Maritime Biodiversity Guidelines.	Construction Contractor	Pre-construction Construction
B-22		A suitably qualified fauna ecologist/spotter catcher shall be present during clearing of native vegetation (ie. clearing supervision) to capture any injured fauna or fauna that does not naturally relocate. Injured fauna may be transferred to a local wildlife carer for rehabilitation prior to being released into suitable retained habitats.	Construction Contractor	Construction
B-23		Pre-clearing surveys shall be undertaken in accordance with the Roads and Maritime Biodiversity Guidelines (RTA 2011).	Construction Contractor	Pre-construction
B-24		Red-crowned Toadlet seasonal pre-clearance searches and relocation will be undertaken during optimal conditions by a suitably qualified fauna ecologist.	Construction Contractor	Pre-construction Construction

6.1.5 Biodiversity offsets

Roads and Maritime is committed to offsetting impacts associated with the proposal in line with its biodiversity offsetting guidelines (RMS 2016) and in general accordance with the OEH principles for the use of biodiversity offsets in NSW.

Offsetting would focus on the residual significant impacts on the following subject species and EECs: Duffys Forest Ecological Community

- *Grevillea caleyi*
- *Microtis angusii* (subject to taxonomic revision and conservation status)

- Red-crowned Toadlet.

Additional ecosystem credits for BVT ID ME106 will be considered to offset the impacts on habitat with the potential to support all other threatened species in accordance with the Roads and Maritime *Guideline for Biodiversity Offsets* (RMS 2016).

The following quantum of BioBanking credits have been determined using the major projects linear module of the Framework for Biodiversity Assessment (FBA 2014) to compensate for the residual impacts on these threatened species and communities:

- 225 ecosystem credits for DFEC (BVT ID: ME98)
- 26 species credits for *Microtis angusii* (subject to resolution of the taxonomic and conservation status of the species)
- 462 species credits for *Grevillea caleyi*
- 19 species credits for Red-crowned Toadlet.

An additional 654 ecosystem credits for BVT ID ME106 would be considered to offset the impacts on habitat with the potential to support all other threatened species in accordance with the Roads and Maritime *Guideline for Biodiversity Offsets* (RMS 2016).

The acquisition and retirement of the required ecosystem and species credits is currently under consideration by Roads and Maritime, and which will be the subject of a Biodiversity Offset Strategy.

6.2 Landform, geology and soils

6.2.1 Methodology

Landform, geology and soil landscape information was sourced from available reference material including soil landscape maps (Chapman & Murphy, 1989), geological maps (Herbert, 1983) and acid sulfate soil risk maps (Naylor, 1995). This was supplemented with observations from a site inspection undertaken in late 2014. Emphasis was placed on identifying relevant limitations that would affect the construction or operation of the proposal.

To assess the likelihood of contamination being present, SMEC undertook a Phase 1 Contamination Assessment (refer Appendix C). This involved:

- Review of the site history by reference online databases, previous studies and historical aerial photography
- Site inspection (6 November 2014)
- Identification of areas of concern as a result of previous land use, pathways and ecological / human receptors
- Evaluation of potential impacts resulting from the proposal and any need for further investigations.

6.2.2 Existing environment

Landform and geology

The proposal site traverses predominantly natural bushland with the north-western side of the road comprising Ku-ring-gai Chase National park and the southern side comprising a large component of Garigal National Park. The area to the north of Mona Vale Road contains light industrial and residential properties while land to the south is largely undeveloped. The regional groundwater flow direction is likely to be to the south and southeast following surface drainage patterns of local water bodies that drain into Narrabeen Lakes.

The site has an elevation range of 140 to 190 metres above sea level and slopes relatively steeply in a southeast direction towards the coast.

The majority of the proposal site is located atop Wianamatta Group medium to coarse grained quartz sandstones which contain very minor shale and laminate lenses. A small area located to the south of Mona Vale Road, in the vicinity of the Kimbriki Resource Recovery Centre, is identified as man-made fill consisting of dredged estuarine sand and mud, demolition rubble and industrial and household waste.

Soil landscapes

Table 6-8 provides a description of the soil landscape profiles mapped within the study area and their locations are shown in Figure 6-3.

Table 6-8 Soil landscape characteristics

Landscape	Soils	Limitations
Somersby	Moderately deep to deep red earths and yellow earths overlying laterite gravels and clays on crests and upper slopes; yellow earths and earthy sands on mid slopes; grey earths, leached sands and siliceous sands on lower slopes and drainage lines; gleyed podzolic soils in low lying poorly drained areas	Localised permanently high water tables, areas of laterite and stony soil, very low soil fertility, highly permeable soil
Lambert	Shallow, discontinuous earthy sands and yellow earths on crest and inside benches. Shallow siliceous sands on leading edges; shallow to moderately deep leached sands, grey earths and gleyed podzolic soils in poorly drained areas; localised yellow podzolic soils associated with shale lenses.	Very high soil erosion hazard, rock outcrop, seasonally perched water table, shallow, highly permeable soil, very low soil fertility.
Hawkesbury	Shallow soils associated with rock outcrop. Earthy sands, yellow earths and some podzolic soils on inside of benches and along joint and fractures. Localised yellow and red podzolic soils associated with shale lenses and siliceous sands and secondary yellow earths along drainage lines.	Extreme soil erosion hazard, mass movement (rock fall) hazard, steep slope, rock outcrop, shallow, stony, highly permeable, low soil fertility.

Landscape	Soils	Limitations
Oxford Falls	Moderately deep to deep earthy sands, yellow earths and siliceous sands on slopes. Deep leached sands and grey earths on valley floors.	Very high soil erosion hazard, perched water tables and swamps highly permeable soil, very low to low soil fertility, localised rock outcrop mass movement hazard, steep slopes, severe soil erosion hazards and occasional rock outcrop.

Source: (Chapman & Murphy, 1989)

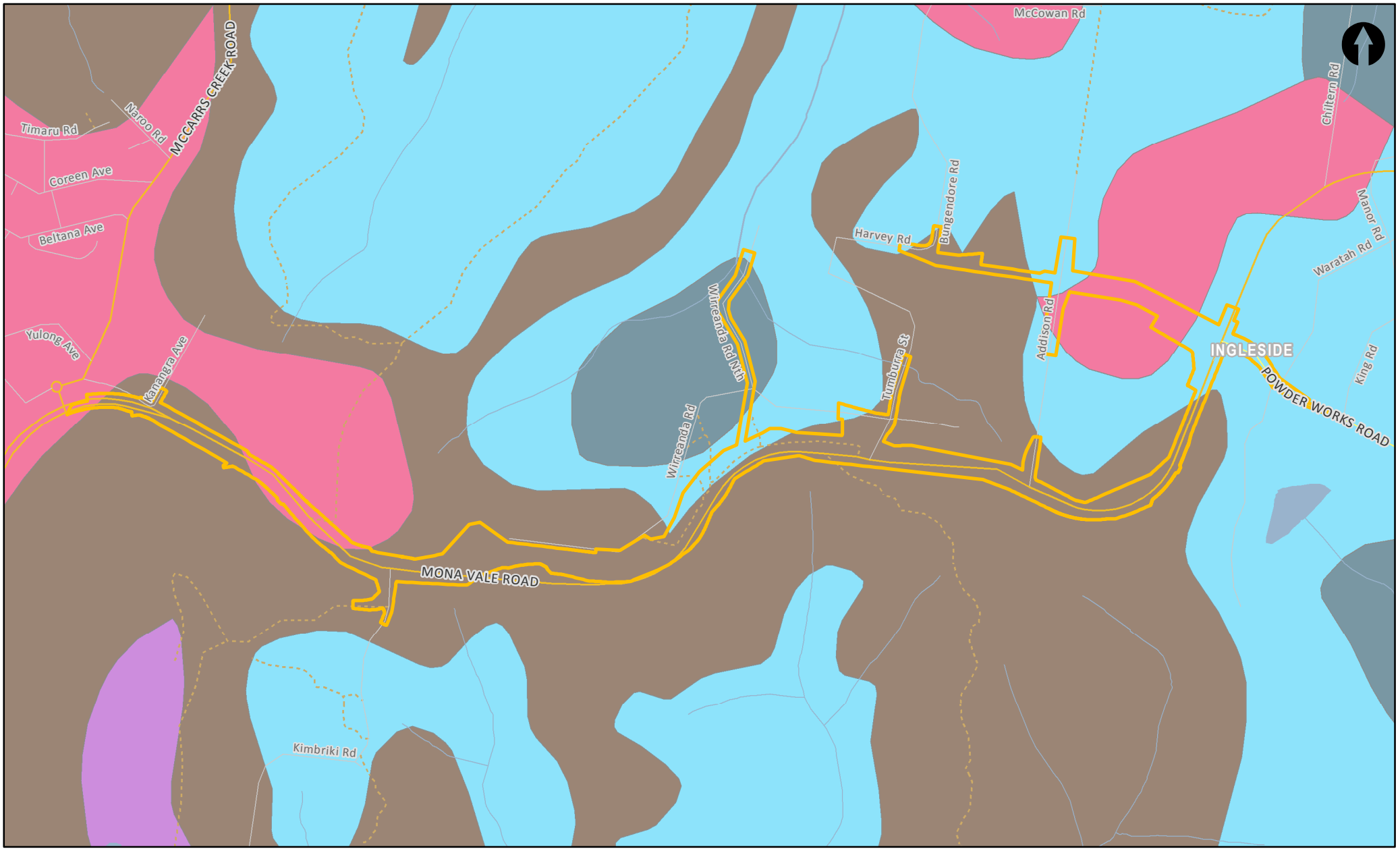
Acid sulfate soils

Acid sulfate soils (ASS) occur predominantly on coastal lowlands at elevations generally below five metres and are therefore not expected within the study area. The *New South Wales Natural Resource Atlas* (OEH, 2013) does not identify any ASS in the vicinity of the proposal.

Contaminated land

Several locations within the study area are considered potential sources of anthropogenic contamination (referred to as areas of environmental concern, AECs). They include (refer also to Figure 6-4):

- Former stockpiling area – Historical aerial photography suggests that a cleared section of land on the southern side of Mona Vale Road, about 200 metres northwest of Kimbriki Road intersection has been previously used to stockpile material (e.g. soil/ aggregates). The most recent available aerial imagery shows that stockpiles are no longer evident and landscaping / revegetation of the site has occurred. There is low potential for metals, Polycyclic Aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPHs), BTEX (benzene, toluene, ethylbenzene, xylene) and asbestos contaminants to be present within excavated soils given that the previous stockpiled material has been removed and landscaping / revegetation of the site has occurred
- Rural sheds and machinery yard - Aerial photography suggests the presence of a cleared section of land within the rural bushland setting to the south of Bungendore Road, comprising two sheds and parked heavy vehicle machinery. A potential above ground storage tank is present at the site. There is a potential for refuelling and vehicle maintenance activities historically and currently undertaken at the site. There is a high potential for metals, PAHs, TPHs, BTEX and solvent contaminants to be present within excavated soils given the site is evidently being used as a machinery storage yard. Potentially the sheds are used for maintenance activities
- Residential garage/shed - Historical aerial photography suggests the shed currently located within the footprint of the proposed local road extension between Bungendore Street and Powder Works Road is relatively new. There is a low potential for metals, PAHs, TPHs, BTEX and asbestos containing materials (ACM) to be present



Construction Boundary

Soil landscape

DISTURBED TERRAIN

HAWKESBURY

LAMBERT

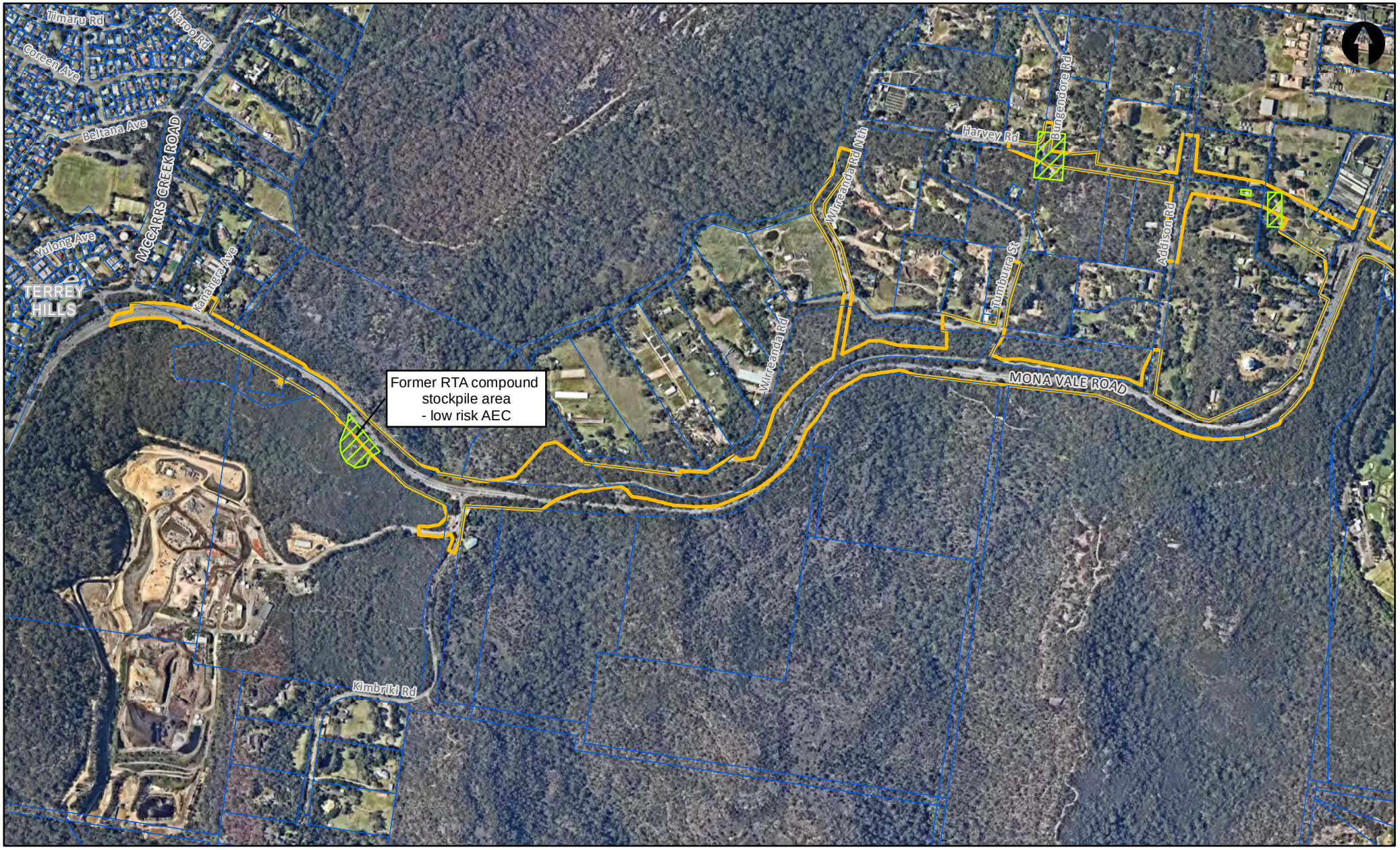
OXFORD FALLS

SOMERSBY

Soil landscapes in relation to the proposal area **Figure 6-3**

Vector base dataset RoadNet © MDS 2016

0 200 400 m



Identified AEC

Cadastral boundaries

Construction Boundary

Location of identified AEC **Figure 6-4**

Vector base dataset RoadNet © MDS 2016

0 200 400 m

- Equestrian yard – Aerial photography shows the presence of an equestrian arena to the west of the intersection of Mona Vale Road and Powder Works Road. The most recent available aerial imagery dated 2015 shows that filling and/ or levelling of the equestrian area may have occurred. There is a low potential for metals, PAHs, TPHs, BTEX and ACM to be present within excavated soils
- Redundant and active below ground services – There is potential for ACM to be present in below ground services within the study area. Services constructed with materials containing ACM may occur beneath existing pavements or other areas which are likely to be impacted from the construction of the proposal. Assuming there has been no or limited disturbance of services containing ACM, there is a low potential for ACM to be present within excavated soils in proximity to redundant and active underground services
- Illegal dumping of domestic or building waste in bushland
- Existing Mona Vale Road reserve – There is potential for contamination of shallow soils associated with the potential application of pesticides and/ or herbicides along the road reserve (GHD, 2012). There is low potential for Organochlorine pesticides (OCP) and Organophosphorus pesticides (OPP) contaminants to be present within the road reserve due to low exposure rates and natural attenuation
- Areas of filling within the Mona Vale Road reserve – There is potential for contamination in areas of filling associated with development of the existing road reserve. The existing Mona Vale Road is predominantly built at grade and only minor areas of filling are present within the road alignment. Where filling has occurred, material is likely to have been locally sourced and of engineering quality. For these reasons there is a low potential for heavy metals, PAHs, TPHs, BTEX and asbestos contaminants to be present within fill areas of the existing road reserve
- Coal tar, bitumen and road base within the existing road surface of the study area – Roads constructed prior to 1987 are typical areas where asphalt is likely to contain coal tar (DPC, 2012). The road pavement in this location may contain coal tar containing pavement layers. There is low potential for metals, PAHs, TPH and phenols contaminants to be present within old pavements and buried pavement alignments. The study area incorporates the immediate area where original pavement layers may exist.

These AECs provide sources of historical contamination and generate the following Contaminants of Concern (COC) to be included in the event that contamination is uncovered during the construction phase:

- Heavy metals
- Asbestos (in ACM)
- Petroleum hydrocarbons (BTEX/TPH)
- PAHs
- Organochlorine/organophosphate pesticides (OCP/OPP)
- Phenols

- Volatile organic compounds (VOCs)
- Elevated levels of nitrogen (N) and phosphorus (P) at leachable concentrations.

Sensitive receivers

Sensitive receivers in proximity to the study area which may be impacted by any potential contamination include the following:

- Residential, commercial, industrial and recreational land uses in proximity to the study area
- Places of worship and community centres (including the Baha'i Temple)
- Watercourses including McCarrs Creek, Wirreanda Creek, Deep Creek, Mullet Creek and associated tributaries.

Regional and local hydrogeology

Mona Vale Road is located along a ridgeline that separates two catchments. Land within the study area to the north of Mona Vale Road is located in the Hawkesbury-Nepean catchment within the Cowan Creek/Pittwater sub-catchment. Land to the south of Mona Vale Road is located in the Sydney Metropolitan catchment within the Northern Beaches sub-catchment.

There are steep slopes to the north and south of the road corridor and the ridgeline descends into the respective catchments of nearby creeks. There are no creek lines directly within the study area, however the following creeks are in the vicinity of the study area:

- McCarrs Creek – located on the northern side of Mona Vale Road to the east of McCarrs Road within the Ku-ring-gai Chase National Park. McCarrs Creek drains to Pittwater. This creek is located in the Cowan Creek/Pittwater sub-catchment of the Hawkesbury Nepean catchment
- Wirreanda Creek and a tributary – located on the northern side of Mona Vale Road along the eastern side Ku-ring-gai Chase National Park. This creek is a tributary of McCarrs Creek which drains to Pittwater. This creek is located in the Cowan Creek/ Pittwater sub-catchment of the Hawkesbury-Nepean catchment
- Deep Creek and a number of tributaries – located along the southern side of Mona Vale Road. Deep Creek drains to Narrabeen Lagoon to the east. This creek and its tributaries are located in the Northern Beaches sub-catchment of the Sydney Metropolitan catchment.
- Mullet Creek and a tributary – located to the east of Mona Vale Road to the south of Powder Works Road. Mullet Creek drains to Narrabeen Lagoon to the east. The upper reach of this creek is the dam located within the Monash Country Club. This creek and its tributaries are located in the Northern Beaches sub-catchment of the Sydney Metropolitan catchment.

The majority of Mona Vale Road within the study area does not contain any formal drainage system. Runoff drains off the road surface into surrounding bushland. The

exception is where formal kerbing or guttering is available to collect runoff at the following locations:

- Dish drains on either side of the roadway down Tumbledown Dick Hill to just west of Kimbriki Road
- Kerbing along the southern side of the roadway up the hill to the Baha'i Temple; this kerbing begins just north of the Addison Road intersection and finishes at the base of the hill
- Kerbing and guttering along the northern side of the roadway from the Addison Road intersection to Powder Works Road
- Kerbing and guttering along the eastern side of the roadway on the approach to Powder Works Road.

A search of the NSW Office of Water[1] Online Database on 15 April 2015 identified 11 groundwater bores in the vicinity of the study area. These groundwater bores show a standing water level between three and 58 metres below ground level.

6.2.3 Potential impacts

Construction

Potential impacts on soils, topography and geology from construction works would primarily be associated with the erosion of exposed soils and stockpiles, and associated sedimentation of surrounding land and drainage lines. Transportation and deposition of eroded material has potential to change topography both locally and, depending on the volume of eroded material and the distance transported, more widely. Transportation of eroded material into waterways could affect the hydrological behaviour of the waterway and initiate changes to the channel cross section. It could also affect water quality through increased turbidity and have consequent impacts on aquatic habitats.

Construction activities that have the potential to result in the exposure of soils which could potentially lead to erosion and sedimentation, as well as the exposure of contaminated soils include:

- Earthworks within the construction area
- Access track establishment
- Drainage works
- Construction of rock cuttings and retaining walls
- Construction of bridges
- Vehicle movements
- Removal and installation of general fill material
- Stockpiling
- Vegetation removal
- Grubbing processes

[1] DPI Water was formed on 3 July 2015 replacing the NSW Office of Water

- Landscaping.

Excavation would occur along the length of the proposal for construction of larger cuttings and the installation of retaining walls (refer to Section 3.2). Temporary access tracks would be required in some areas for construction of retaining walls.

Erosion and sedimentation

The proposal has the potential to generate sediment during rainfall events due to ground disturbing activities during construction, including excavation and vegetation removal. A further potential impact is sediment mobilisation from soil deposited on road pavements during works.

Rainfall erosivity and soil erodibility potential are consistent across the study area. The highest risk construction activities for erosion and sedimentation would generally be where the ground disturbance is greatest (areas of cut and fill), the slope gradient is at its steepest and drainage lines are in close proximity.

Construction soil loss rate estimates for catchments across the study area are between 13 and 141 cubic metres per hectare per year (refer to Appendix D). These are below the threshold of 150 cubic metres at which sediment basins are usually considered necessary. It is also noted that site topography, dense vegetation, presence of threatened flora and fauna species, location of National Parks and the number of outlets limit the opportunity to use sedimentation basins during construction.

To address potential erosion and sedimentation impacts safeguards and mitigation measures, including diversion drains and sediment fences, would be implemented during construction (refer Section 6.3.4).

Diversion drains would be installed to divert offsite water from the upstream catchment around the construction work site(s). Given the extent of rock across the proposal, consideration would be given to construction methods of diversion drains during detailed design as traditional earth bunds are not expected to be suitable. The location of temporary, construction diversion drains would correspond to permanent diversion drains at the top of cut batters. In this manner the diversion drains may be cut into the existing rock and be retained during the operational phase of the road upgrade.

Sediment fences would be installed on the low side of earthworks operations to filter sediment from stormwater runoff and limit impacts to downstream catchments. A traditional sediment fence key into the in situ soil is unlikely to be practical for the majority of the site due to elevated rock levels. Consideration would be given to alternative methods of ensuring that sediment laden water does not pass under the sediment fence untreated such as using a mesh and gravel inlet filter sausage, or similar, to provide a constant and uniform seal between the bottom of the sediment fence and the in situ rock.

Earthworks

Earthworks would be undertaken for the widening and adequate alignment of Mona Vale Road over the length of the proposal and for the proposed Harvey Road extension. These earthworks would not alter the existing topography from a regional perspective and would only be noticeable in the direct vicinity of the proposal.

Cuttings and retaining walls have been designed to allow the necessary carriageway widths while maintaining slope stability and minimising the construction footprint.

Contaminated land

There is potential for contaminated land to be encountered during construction activities. Table 6-9 identifies the AECs likely to present a risk of impact associated with construction of the proposal, details the potential impact associated with construction of the proposal, details the potential impacts on the proposal and the risk of occurrence identified from the AECs.

Table 6-9 Areas of environmental concern

AEC	Risk classification	Potential contaminants of concern	Comment
Stockpiling area	Low	Heavy metals, PAHs, TPH, BTEX and Asbestos	Surface soil impacted by pesticide spray applied to adjacent lands
Rural sheds and machinery yard	High	Heavy metals, PAHs, TPHs, BTEX and solvent contaminants	Surface layers impacted by spills from hydrocarbons, heavy metals and solvents which could potentially be exposed during excavation works
Residential garage/shed	Low	Heavy metals, PAHs, TPHs, BTEX and ACM	Unknown activities and/or storage undertaken in building located within the proposal alignment. Contaminants could potentially be exposed during demolition.
Equestrian yard	Low	Heavy metals, PAHs, TPHs, BTEX and ACM	Contaminants (if any) are likely to be present in fill beneath the upper most sand layer of the equestrian arena
Redundant and active below ground services	Low	Asbestos	Excavation works associated with the proposed road widening and service relocation could potentially expose soil impacted by ACM
Illegal dumping	Low	Heavy metals, PAHs, TPH, BTEX and Asbestos	Excavation works in proximity to illegal dump sites. Associated exposure may include direct contact or inhalation with soil and dust.
Existing Mona Vale Road reserve	Low	Pesticides	Surface soil impacted by pesticide spray applied to adjacent lands

AEC	Risk classification	Potential contaminants of concern	Comment
Areas of filling	Low	Heavy metals, PAHs, TPH, BTEX and Asbestos	Within the pavement formation and below raised pavements and drainage assets. Excavation could potentially expose soil impacted by uncontrolled fill material
Existing road pavement constructed prior to 1987	Low	Coal Tar, PAHs.	Contaminating road materials such coal tar asphalt may have been historically used within roads throughout the study area. The proposed road widening could potentially expose these materials.

Potential environmental impacts associated with encountering contaminated land during construction include:

- Increased waste volumes from excavated (potentially contaminated) materials
- Adverse effects on human health (construction personnel, travelling public or nearby communities)
- Movement of contaminated sediments via surface runoff into stormwater systems.

During construction, groundwater quality could also potentially be affected by infiltration of pollutants into the soils. If not appropriately managed, these pollutants could reach perched groundwater. General sources of potential groundwater pollution during construction works include infiltration or runoff from identified AECs and hydrocarbon or chemical spills during construction.

Further Stage 2 investigations are considered necessary for the rural sheds and machinery yards site (AEC2) as the proposed local road extension would pass directly over this site, located at 8 Tumburra Street, Ingleside, which currently and/ or previously used for heavy machinery storage, maintenance and potential refuelling activities.

No further investigations are considered necessary for any the other identified AECs within the study area. However, during construction in areas within or in proximity to the identified AECs, visual inspections would be required to confirm there were no matters of concern or, conversely, to identify any relevant issues and inform development and implementation of an appropriate management responses. This would apply to the following activities:

- Pavement removal
- Underground service relocation
- Ancillary site preparation and operation
- Excavation

- Generation of construction waste
- Importing, handling, stockpiling and transporting material resources.

The risk of contaminated material being engaged during asset maintenance is low.

Ancillary sites

Ancillary sites required during the construction of the proposal may include activities that have a potential to impact soil and water quality through spills of pollutants. The following construction activities present a risk of impact on soil and water quality:

- Storage of fuels and chemicals
- Vehicle wash-down areas
- Vehicle refuelling areas
- High frequency of vehicle movements
- Material storage and stockpile areas
- Office compounds.

Acid sulfate soil

As previously noted, ASS was not identified as a risk within the study area. ASS are not expected to be exposed during the proposed construction activities.

Operation

There is expected to be minimal impact on landform and soils following completion of construction and once disturbed areas have been stabilised/landscaped. The design includes provision of level spreaders and scour protection at diversion drain outlets. Level spreaders and scour protection would limit downstream impacts by acting as an energy dissipater and providing uniform, sheet flow discharge to the downstream catchment.

Where cut batters are proposed, a catch drain of suitable size would be provided to collect and discharge runoff from the upstream catchment. The catch drain would be lined to minimise scour potential. Stormwater from the upstream catchment would generally be discharged to the proposed cross drainage where feasible, and designed to mimic existing flows and reduce potential for erosion and scour.

It is not expected that the proposal would have any ongoing contaminated land impacts after the completion of construction as any identified contaminated material would be removed off site for disposal at a suitable licenced facility.

6.2.4 Safeguards and mitigation measures

Table 6-10 lists the safeguards and mitigation measures that have been proposed to address potential impacts on landform, geology and soils. Table 7-1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-10 Safeguards and mitigation measures - landform, geology and soils

ID	Impact	Environmental safeguards	Responsibility	Timing
SO-1	Erosion and sedimentation	A Soil and Water Management Plan (SWMP) would be prepared as part of the CEMP prior to the commencement of construction. The SWMP would address the following: • Roads and Maritime Code of Practice for Water Management. • The Blue Book - Managing Urban Stormwater: Soils and Construction, Volumes 1 and 2. • Roads and Maritime Technical Guidelines – Temporary Stormwater Drainage for Road Construction. The SWMP would include: • Stockpile management plan • Identification and a diagram of catchment and subcatchment area high risk areas and sensitive areas. • Sizing of each of the above areas and catchment. • The likely runoff from each road sub-catchment. • Direction of flow of on-site and off-site water. • Separation of on-site and off-site water. • Direction of runoff and drainage points during each stage of construction. • Dewatering plan which includes process for monitoring flocculating and dewatering water from site (i.e. any	Construction contractor	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		sediment basins and sumps). • A process to routinely monitor the Bureau of Meteorology weather forecasts. • Preparation of a wet weather (rain event) plan which includes a process for monitoring potential wet weather and identification of controls to be implemented in the event of wet weather. • An inspection and maintenance schedule for ongoing maintenance of temporary and permanent erosion and sedimentation controls.		
SO-2	Erosion and sedimentation	A soil conservationist from the Roads and Maritime Erosion, Sedimentation and Soil Conservation Consultancy Services Register is to be engaged to review the proposed erosion and sedimentation controls and conduct routine inspections of the construction works.	Construction contractor	Construction
SO-3	Erosion and sedimentation	All stockpiles would be designed, established, operated and decommissioned in accordance with the Roads and Maritime Stockpile Management Procedures.	Construction contractor	Construction
SO-4	Erosion and sedimentation	Controls would be implemented at construction zone exit points to minimise the tracking of soil and particulates onto pavement surfaces.	Construction contractor	Construction

SO-5	Disturbance of contaminated land	A Contaminated Land Management Plan will be prepared for the proposal and will include: • A procedure for identifying potentially contaminated land through monitoring: – for discolouration or staining of soil – bare soil patches both on-site, and off-site adjacent to site boundary – visible signs of plant stress – presence of drums or other waste material – presence of stockpiles or fill material – odours. • Unexpected finds procedure will be developed to address the management of potentially contaminated material if encountered during works • Compliance with contaminated land legislation and guidelines including obtaining any relevant licences and approvals • Identification of locations of known or potential contamination and preparation of a map showing these locations • Identification of rehabilitation requirements, classification, transport and disposal requirements of any contaminated land within the study area • Excavated material that is not suitable for on-site	Construction contractor	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		reuse or recycling, such as contaminated material, should be transported to a licensed facility that may reuse or dispose of that material. A classification system should be used to control the excavation, stockpiling and disposal of all potentially contaminated materials • Contamination management measures, including waste classification and reuse procedures • Capture and manage any surface runoff contaminated by exposure to the contaminated land. • Assess any requirement to notify relevant Authorities, including the EPA. • Manage any remediation and subsequent validation, including any certification required. • Review and update the plan.		
SO-6	Disturbance of ACM	An Asbestos Management Plan will be prepared and implemented.	Construction contractor	Pre-construction
SO-7	Potentially contaminated land	Stage 2 investigations, including a Dangerous Goods search to investigate the potential above ground storage tank located at 8 Tumburra Street, Ingleside would be conducted.	Roads and Maritime	Detailed design
SO-8	Contaminated land	Any construction activity in the vicinity of identified AECs would require inspection and verification of assumed conditions during the following activities:	Construction contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		• Pavement removal • Underground service relocation • Ancillary site preparation and operation • Excavation Importing, handling, stockpiling and transporting material resources.		

6.3 Hydrology and water quality

The *Surface Water Strategy Hydrology and Hydraulics Report* (Aurecon, 2016) (refer Appendix D) outlines the pavement drainage, cross drainage, construction water quality and operational water quality designs and requirements for the proposal. A summary of the main findings and other relevant information is provided as follows.

6.3.1 Methodology

The approach to the hydrology and water quality assessment included the following:

- Review of existing site conditions including a detailed ground survey and reference to information about drainage infrastructure held by Roads and Maritime and Northern Beaches Council
- Hydrological modelling (XP-RAFTS hydrological model) to understand runoff behaviour from the catchment
- Hydraulic analyses (using SOBEK software) of existing cross drainage structures to understand capacity and identify the need for any improvements
- Development and modelling of a pavement drainage concept design (using Drains software)
- Site investigations by Cardno engineers in July 2014 to refine the assessment approach and to visually identify key features of the area
- Identification of suitable drainage outlet treatments to help mimic existing flows to the receiving environment
- Identification of water quality controls for construction and operation.

6.3.2 Existing environment

Catchments and watercourses

The proposal is located along a ridgeline separating two regional catchments (refer Figure 6-5). Steep grades on both sides of Mona Vale Road drain into:

- McCarrs Creek catchment to the north, which discharges to Pittwater Estuary
- Deep Creek catchment to the south which drains to Narrabeen Lagoon.

There are some minor external catchments that discharge to Mona Vale Road. These catchments have been excluded from the assessment undertaken by Cardno (2014a; 2014b) due to their small size (i.e. less than 1.5 hectares) and lack of significant cross drainage structures. These small catchment areas are typically adjacent to the road reserve and include rock outcrops and heavily vegetated bushland.

Cross drainage

There is no significant existing cross drainage within the study area. The existing pavement is generally drained via a series of semi-formal catch drains that run parallel to the road pavement and which discharge at irregular intervals. into surrounding bushland. The exception is where formal kerbing or guttering is available to collect runoff at the locations listed in Section 6.3.2.

Groundwater

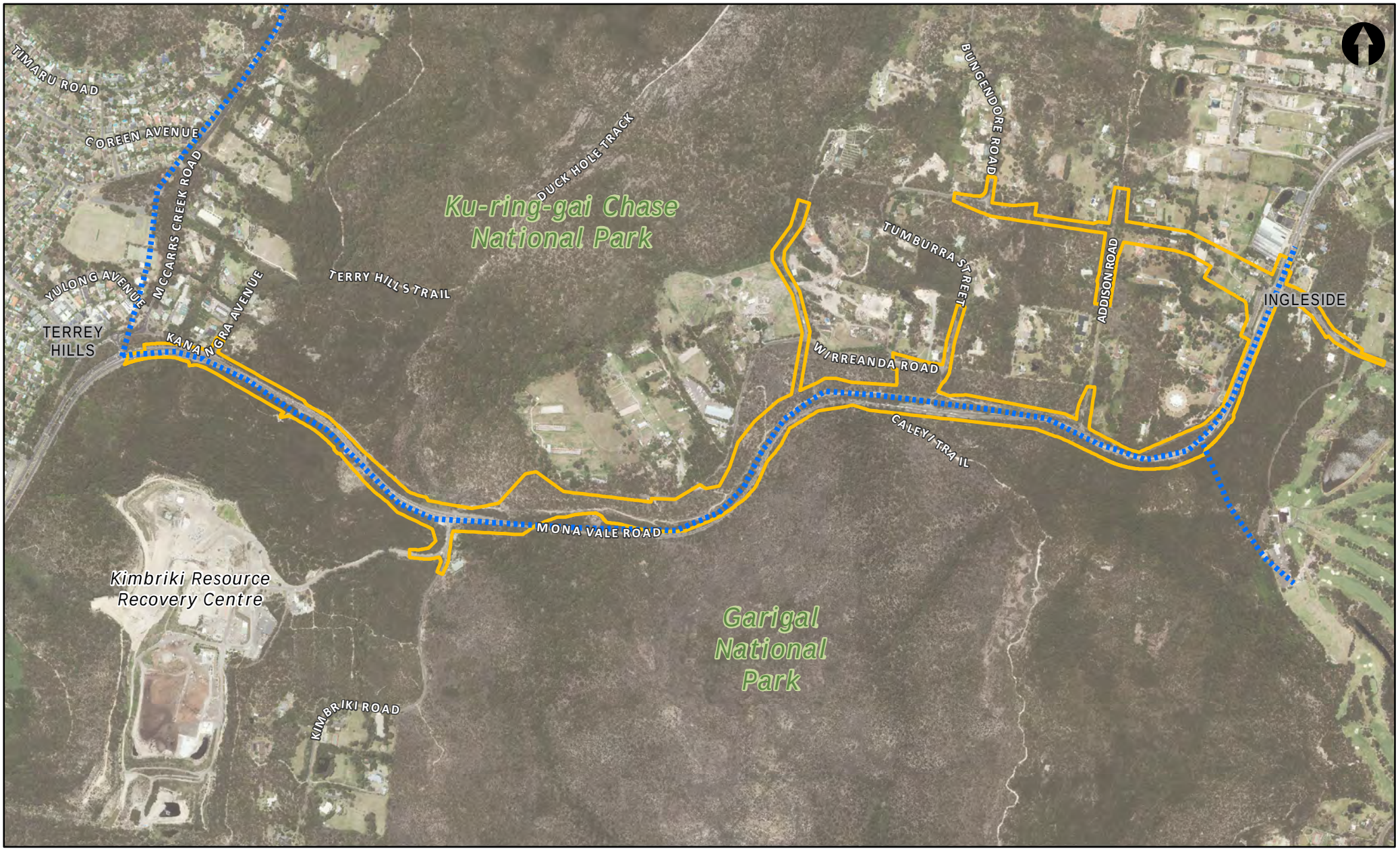
There are seven groundwater bores within 250 metres of the study area. Standing water data is available for only one of the seven groundwater bores, GW107194 north of Mona Vale Road, northwest of the intersection with Kimbriki Road. At this location standing water level has been recorded at 18 metres.

The regional groundwater flow direction is likely to be to the south and southeast following drainage patterns of local waterways that drain to Narrabeen Lagoon.

The potential for perched groundwater is associated with the Oxford Falls and Lambert soil landscapes. There is only a small area of the Oxford Falls soil landscape in the study area, this occurring to the north of Mona Vale Road in the vicinity of Wirreanda Road/Wirreanda Road North. There are two areas of the Lambert soil landscape in the study area that would have the potential to encounter perched groundwater during construction, one at the eastern end extending to the general vicinity of the National Baha'i Centre on the northern side of Mona Vale Road and the second area also to the of Mona Vale Road in the vicinity of Wirreanda Road/Wirreanda Road North and adjacent to the Oxford Falls soil landscape.

Water quality

Water quality in local waterways/waterbodies is influenced by land use and activities within the upstream catchment. As previously noted, Mona Vale Road generally follows the ridgeline separating the McCarrs Creek catchment and the Deep Creek catchment (refer Figure 6-5). Water quality in the receiving waterways would be influenced by runoff from the road but this would be moderated by the relatively small catchment areas associated with the road compared to the larger catchment areas for the two catchments. Both catchments are also relatively undeveloped and water quality would be expected to be better than for a more urbanised catchment.



Approximate regional catchment boundaries

Construction Boundary

Regional catchments **Figure 6-5**

Vector base dataset RoadNet © MDS 2016

0 250 500 m

Some water quality data is available for McCarrs Creek through the Streamwatch program. This is a long running water monitoring program initiated by Sydney Water and the Sydney Catchment Authority (SCA), and now managed by the Australian Museum. Data is available from the following three sites:

- McCarrs Creek downstream confluence of Wirreanda Creek (records available for the period 26 July 2014 to 13 December 2014)
- McCarrs Creek, The Duck Holes (records available for the period 26 July 2014 to 13 December 2014)
- McCarrs Creek, northern tributary, McCarrs Creek Road (records available for the period 15 January 2011 to 26 June 2011)

Water quality parameters sampled at these locations include temperature, pH, turbidity, dissolved oxygen (DO), electrical conductivity (EC), and nutrients (available phosphate). The available data from these three sites indicates:

- DO is variable with several records being outside the range specified for aquatic ecosystems in the ANZECC guidelines for lowland streams
- Turbidity is below the range specified in the ANZECC guidelines for lowland rivers
- Available phosphorus is generally below the trigger value for aquatic ecosystems
- EC (only recorded at the third site) is below the range specified in the ANZECC guidelines for lowland rivers.

The native vegetation occurring on both sides of Mona Vale Road would likely also play a significant role in influencing water quality in receiving waterways and waterbodies through acting as filtering medium for macro-particles and through uptake of nutrients.

6.3.3 Potential impacts

Construction

Surface water

Construction activities that could directly or indirectly affect water quality include:

- Removal of vegetation and associated disturbance of soils resulting in transportation of sediments and other material into waterways/waterbodies
- Cut and fill works
- Works within drainage lines (such as installing energy dissipation devices)
- Leaks from construction machinery and plant
- Accidental spills of concrete, chemicals or hazardous materials/liquids
- Litter
- Disturbance of and runoff from contaminated land
- Tannin leachate from cleared/mulched vegetation.

Potential impacts on surface water quality from construction activities include lower dissolved oxygen levels, increased nutrients, increased turbidity and altered pH.

Pollution from fuel, chemicals, oils, grease, petroleum hydrocarbons, metals and gross pollutants is a further issue. Migration of contaminants to waterways, deeper soils or to areas of perched groundwater may occur during construction as a result of infiltration of spills on the surface. Given the low permeability of the surrounding soils, the significant depth to regional groundwater, the safeguards and management measures identified for the proposal regarding stockpiling and emergency spill response (refer Section 6.3.4), the potential migration for contaminants (if any) from the construction impact area to surface water or groundwater is considered low.

Provided appropriate controls are implemented during construction (refer Table 6-11), short term impacts are expected to be manageable and similarly have no material impact on downstream locations and on receiving water quality. As noted in Section 6.2.2, the existing vegetation downslope of Mona Vale Road would also assist in preventing/mitigating water quality impacts on downstream waterways/waterbodies.

Groundwater

There is potential for localised bodies of perched groundwater to be intercepted by cutting works or excavation resulting in some dewatering within perched aquifers. Excavation works with the potential to intercept perched aquifers would potentially include locations of retaining walls and bridge construction and associated piling. One groundwater-dependent ecosystem (Coastal Upland Swamp) has been identified in the study area in the vicinity of Addison Road. Flora surveys identified that the 0.08 hectares of Coastal Upland Swamp in the survey area of Addison Road would not be cleared as part of the current concept design (Ecosure, 2015). Potential impacts upon this ecosystem, including those relating to interception of groundwater, have been considered in Section 6.1.

Groundwater quality could also potentially be affected by construction activities from infiltration of contaminants/pollutants into the soils. If not appropriately managed, pollutants could reach perched groundwater. General sources of potential groundwater pollution during construction works include infiltration/runoff of fuels or oils from plant and machinery within excavation areas, particularly at locations of retaining wall construction, any associated contaminated soil stockpiles and the other areas of environmental concern identified in Table 6-3. Given the physical setting of the proposal (i.e. on a ridgeline), and depth to regional groundwater, impacts would be expected to be localised and temporary.

Operational impacts

Drainage

The pavement drainage system would comprise gutters, pits, pipes and channels to collect, convey and discharge stormwater from the road pavement. The proposal would include new kerb and gutter changing the overland flow paths from diffuse to controlled flows to and from outlets. The concept drainage design provides for seven pavement drainage discharge outlets along Mona Vale Road. Drainage outlet locations and discharge volumes would be finalised during detailed design.

The greater road pavement area would result in an increase in drainage peak flows and volumes from the road. The principal potential impact with regard to the hydraulic behaviour of drainage flows would be greater potential for scour at drainage outlets

from increased flow rates. Consequent impacts could include erosion, removal of vegetation and increased potential for slope failure (e.g. slips).

Development of the pavement drainage design has been carried out with regard to the following key constraints:

- The presence of the Angus's Onion Orchid, a listed endangered species, which is sensitive to changes in runoff volumes and frequency
- The close proximity of Ku-ring-gai Chase National Park and Garigal National Park.

The general design strategy was to mimic the existing drainage regime as closely as possible to minimise impacts on these sensitive areas. This was balanced against the design objective of ensuring at least one traffic lane would not be inundated and remained available for safe passage during a 100 year ARI design rainfall event.

To mitigate potential impacts, where cut batters are proposed a catch drain of suitable size would be provided to collect and discharge flows from the upstream catchment. The catch drain would be lined to minimise scour potential during storm events. Where feasible, stormwater from the upstream catchment would generally be discharged to the cross drainage system rather than the pavement drainage system. This would distribute drainage flows along the length of the roadway, minimising concentration of flows in individual locations.

Drainage outlets would incorporate appropriate design features to minimise the potential for scour and consequent downstream impacts. At each outlet, consideration was given to the suitability of:

- Energy dissipation, to reduce discharge velocities and resulting potential for scour
- Level spreader, to provide uniform distribution of flows over a level weir. Level spreaders serve to convert a concentrated flow into sheet flow before it is discharged it onto areas already stabilised by vegetation.
- Downstream scour protection, to minimise erosion potential of discharged water after flowing over the level spreader.

These would avoid or reduce impacts to an acceptable level.

Surface water quality

Following completion of construction, including rehabilitation of exposed areas where vegetation and/or impervious surfaces have been removed, there would be minimal risk of soil erosion and transport of eroded sediments to receiving waterways.

Scour, resulting from increased flow velocity at and downstream of drainage discharge points, has the potential to erode soils resulting in material being transported to receiving waterways. Measures to reduce the potential for scour have been included in the design (specifically the installation of level spreaders at outlets).

The provision of an additional traffic lane in each direction would increase the road surface area, creating the potential for an increase in runoff volume and pollutant load. Pollutants typically associated with road runoff are:

- Particles from the paved surface from pavement wear and atmospheric deposition

- Heavy metals such as lead, zinc, copper, cadmium, chromium and nickel attached (adsorbed) to particles washed off the road pavement
- Oil and grease and other hydrocarbon products
- Rubber particles from wearing of tyres on the road pavement
- Brake pad dust which could potentially include asbestos from older brake pads
- Nutrients (nitrogen and phosphorus).

These deposits build up on road surfaces and pavement areas during dry weather and can be washed off and transported to waterways during rainfall periods.

Material discarded by motorists, such as non-biodegradable litter and food wastes, could also impact water quality, amenity and aquatic ecosystems if transported into receiving waterways.

The steep topography constrains opportunities to install water quality basins. However, the design provides for grassed drainage swales adjacent to the westbound carriageway in the vicinity of Tumburra Street for the following three pavement drainage outlets:

- Outlet W2040 – about 70 metres in length
- Outlet W2140 – about 15 metres in length
- Outlet W2400 – about 55 metres in length.

In addition to these three swales, the pavement drainage design includes the provision of oil and grit separators at each outlet discharging upstream of the frog habitats to manage the risk of oil spills and to reduce the pollutant loads entering the habitats.

As is currently the case, during operation there would be a risk of accidental spillage of fuel, chemicals or other hazardous liquids as a result of vehicle leakage or road accidents on Mona Vale Road. The proposal would however reduce this risk by providing a higher standard of road, including a concrete safety barrier and upgraded intersections.

Groundwater

Potential impacts on groundwater would largely be restricted to the construction phase. Permanent impacts on perched groundwater may occur where cuttings intersect recharge pathways/areas and/or subsurface drainage lines. However, as previously noted, minimal cutting works would be required in identified sensitive areas and accordingly the likelihood of this is low.

Groundwater quality could also be affected by spillage of hazardous materials from vehicles, as might occur during a traffic incident. The upgraded road would provide a safer environment for vehicles reducing the potential for such incidents.

6.3.4 Safeguards and mitigation measures

Table 6-11 lists the safeguards and mitigation measures that have been proposed to address potential impacts on hydrology, hydraulics and water quality (refer also to erosion and sedimentation control measures detailed in Table 6-10). Table 7-1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-11 Safeguards and mitigation measures - Hydrology, hydraulics and water quality

ID	Impact	Environmental safeguards	Responsibility	Timing
WQ-1	Concrete and other materials from construction activities entering waterways	Vehicle wash down and concrete wash out would occur in a bunded location(s).	Construction contractor	Construction
WQ-2	Spills during construction	All fuels, chemicals and liquids would be stored in an impervious bunded area and at least 50 metres from creek and other waterways and slopes with a gradient above 10 per cent.	Construction contractor	Construction
WQ-3	Spills during construction	Refuelling of plant and equipment would occur either off-site or on relatively level ground at least 50 metres from waterways, drainage lines and sensitive areas. The refuelling machinery would have spill management equipment and there would be a person in attendance during refuelling.	Construction contractor	Construction
WQ-4	Spills during construction	A Spill Management Plan would be prepared for the proposal. If a spill or incident occurs, the Roads and Maritime *Environmental Incident Classification and Management Procedure* (Roads and Maritime Services, 2014) would be followed and the Roads and Maritime Contract Manager notified immediately.	Construction contractor	Pre-construction, Construction
WQ-5	Pollution from the road during operation	Consideration would be given to planting the drainage swales with suitable species to provide nominal water quality treatment	Design contractor	Detailed design
WQ-6	Spills during operation	Opportunities to improve the management of spills would	Design contractor Roads and Maritime	Detailed design

ID	Impact	Environmental safeguards	Responsibility	Timing
		be investigated during detailed design.		
WQ-7	Scouring of downstream channels	The drainage design would seek to mimic the existing pattern of drainage from the roadway. Drainage outlets would include appropriate scour protection.	Design contractor Roads and Maritime	Detailed design
WQ-8	Impacts on amphibian habitat	The pavement drainage design includes the provision of oil and grit separators at each outlet discharging upstream of the frog habitat	Design contractor Roads and Maritime	Detailed design

6.4 Traffic and transport

A traffic and transport assessment has been prepared for the proposal (AECOM, 2016). The following sections summarise the main findings of the assessment and the full report is included in Appendix E.

6.4.1 Methodology

The traffic and transport assessment considered the following:

- Traffic impacts of the proposal compared to a 'do nothing' scenario
- Traffic impacts of proposal both in isolation, and in conjunction with the proposed Mona Vale Road East upgrade and with the full development of the Ingleside Precinct
- Impacts of the proposal on travel time and travel speed traffic, including public transport
- Operational performance of key intersections along the corridor
- Impacts to public transport, pedestrians and cyclists
- Impacts of construction activities of the proposal along the corridor.

A two-stage traffic modelling approach was adopted:

- Stage 1 – Strategic traffic demand modelling. The model estimated future traffic demand on Mona Vale Road and the surrounding road network as a result of expected future population and employment growth (including the currently planned Ingleside Precinct) as well as planned and committed road and public transport infrastructure improvements in the region
- Stage 2 – Micro-simulation modelling. The model quantified the performance of the corridor and its intersections, as well as the benefits of the proposal, such as travel time improvements.

As part of the assessment the following scenarios were considered:

- 2014 represents the base year
- 2019 represents the estimated opening year of the proposed Mona Vale Road Upgrade East
- 2021 represents the estimated opening year of the proposed Mona Vale Road Upgrade West
- 2031 represents 10 years since the completion of the both upgrades
- 2036 represents ultimate development (full development of the Ingleside Precinct) and the highest level of forecast future year background traffic growth assessed as part of this study.

This methodology allows an assessment of the impacts of the Mona Vale Road Upgrade West on its own, as well as with the complimentary Mona Vale Road Upgrade East against the 'do nothing' scenario where no road upgrade is provided.

Section 3 of the Traffic and Transport Assessment prepared for the proposal (refer Appendix E) provides further details on the approach to modelling and the assumptions used.

6.4.2 Existing environment

Road network

Mona Vale Road is an important arterial road connector for north-eastern Sydney. The 20 kilometre route connects Pittwater Road at Mona Vale in the north east, to the Pacific Highway at Pymble to the west. The Mona Vale Road Upgrade West area extends for approximately 3.4 kilometres from McCarrs Creek Road in the west, to Powder Works Road/Baha'i Temple Way in the east. Lane configuration along Mona Vale Road at the location of the proposal varies from two to three lanes (refer Table 6-12).

Mona Vale Road is the main east-west connector in northern Sydney for heavy goods vehicles. As a designated B-Double route it is capable of accommodating large heavy goods vehicles. Key connecting B-Double routes include Pittwater Road, Barrenjoey Road, Forest Way and the Pacific Highway.

Table 6-12 Number of lanes along Mona Vale Road within the study area

Mona Vale Road	Number of lanes
McCarrs Creek Road – Kimbriki Road	3 lanes (1 lane eastbound, 2 lanes westbound)
Kimbriki Road – Tumburra Street	2 lanes (1 lane in each direction)
Tumburra Street – Powder Works Road / Baha'i Temple Way	3 lanes (2 lanes eastbound, 1 lane westbound)

There is currently a 70 kilometres per hour speed limit along the study area. As it is a principal arterial, the new design speed of the Mona Vale Road Upgrade West would be 80 kilometres per hour providing a consistent speed limit along Mona Vale Road.

There are five local road intersections with Mona Vale Road that would be modified as a result of the proposal and as well as a new local road connection provided. Works and traffic modifications that would be undertaken include:

- Provision of a new traffic signal intersection at Kimbriki Road including additional dedicated turning lanes and a truck climbing lane
- Restricting traffic movements at the intersection of Mona Vale Road and Tumburra Street to left-in and left-out only
- Relocating the Mona Vale Road and Tumburra Street intersection locally to the west by about 40 metres to improve the existing steep grade on Tumburra Street
- Providing a new local road connection between Bungendore Street and Powder Works Road utilising the existing Harvey Road corridor and extending the new local road east of Addison Road to meet with the intersection of Mona Vale Road and Powder Works Road
- Relocating the existing access to the National Baha'i Centre by about 120 metres west along the new connecting road
- Closing the existing intersection at Mona Vale Road and Addison Road to general traffic and making future access at this intersection restricted to emergency vehicles only
- Minor widening of Powder Works Road for a distance of about 160 metres east from the intersection with Mona Vale Road

These intersection upgrades are expected to improve the performance of the corridor. Key intersections are shown in Figures 3-1 to 3-5.

The intersection of Mona Vale Road with McCarrs Creek Road was not considered as part of the road upgrade and would not be modified by the proposal.

Traffic volumes

Traffic surveys were undertaken in between 3 December 2013 and 9 December 2013 to measure current traffic volumes at one representative location along Mona Vale Road. This location was 150 metres east of the intersection of Tumburra Street and Mona Vale Road. Both eastbound and westbound traffic volumes were surveyed. Table 6-13 shows the overall weekday and average daily traffic volumes.

Table 6-13 2013 traffic survey results – two-way traffic volumes

Average Weekday Traffic (veh/day)	Average Daily Traffic (veh/day)	AM weekday peak hour traffic (veh/hr)(hour beginning)	PM weekday peak hour traffic (veh/hr)(hour beginning)
36,907	36,071	2,778 (08:00)	3,009 (16:00)

The daily volume of traffic on Mona Vale Road, 150 metres east of Tumburra Street, is 36,907 vehicles during an average weekday. The peak hours for traffic movements are between 8am and 9am in the morning and between 4pm and 5pm in the afternoon. The split between eastbound and westbound movements over a day was 50 per cent eastbound and 50 per cent westbound.

The average weekday traffic volume was very similar to the average daily traffic volume (which includes weekends) implying that Mona Vale Road was carrying similar traffic volumes on both weekdays and weekends.

A review of available historical traffic data (1999–2013) from Roads and Maritime traffic counters located near Tumburra Street and Kimbriki Road show that the average annual historical traffic growth for Mona Vale Road is very low ranging from -0.34 per cent to 0.45 per cent per annum.

Travel times

Travel time surveys were undertaken along Mona Vale Road between McCarrs Creek Road and Foley Street for both the eastbound and westbound directions during the AM peak and PM peak periods. Travel times were recorded during weekdays between 2 and 8 April 2014. Table 6-14 shows the average travel times for cars and buses. The differences in car and bus travel times are likely to due to bus dwelling times at bus stops and/or buses slowing down at steep sections of Mona Vale Road.

Table 6-14 Surveyed car and bus travel times between McCarrs Creek Road and Foley Street

Peak period	Direction	Average car travel time	Average bus travel time
AM peak	Eastbound	8 mins 49 sec	9 mins 15 sec
	Westbound	9 mins 42 sec	11 mins 19 sec
PM peak	Eastbound	8 mins 38 sec	9 mins 11 sec
	Westbound	9 mins 17 sec	9 mins 27 sec

Travel speeds

The posted speed limit for Mona Vale Road is 70 kilometres per hour between McCarrs Creek Road and Powder Works Road/Baha'i Temple and there are no school zones along the study area. Vehicle travel speeds along Mona Vale Road have been estimated using the traffic surveys commissioned in December 2013.

Table 6-15 2013 average weekday travel speeds

Posted speed (km/h)	AM peak		PM peak	
Eastbound/ Westbound	Eastbound	Westbound	Eastbound	Westbound
70	70.4	46.6	74.1	69.8

Table 6-15 shows that average speeds measured in the eastbound direction are slightly higher than the 70 kilometres per hour posted speed limit. Lower average vehicle speeds for the westbound traffic in the AM peak period were observed due to the higher volumes of traffic.

Mid-block capacity

The volume to capacity (V/C) ratio is a method of assessing congested conditions on road links, with a V/C ratio greater than 1.00 indicating capacity of the road is exceeded and it would not operate efficiently. Table 6-16 presents 2013 mid-block peak hour traffic flows and corresponding V/C ratios based on traffic survey data for the location150 metres east of Tumburra Street.

Table 6-16 2013 mid-block peak hour traffic flows and capacity

AM peak hour (veh/hr)		PM peak hour (veh/hr)	
Peak direction flow (westbound)	**Volume / capacity ratio**	**Peak direction flow (eastbound)**	**Volume / capacity ratio**
1,781	0.99	1,826	1.01

The results indicate that during the AM peak, Mona Vale Road is operating at or over capacity with congestion problems in the westbound direction. In the PM peak, traffic volumes are generally higher in the eastbound direction and congestion is experienced at this location.

Intersection performance

The performance of an intersection can be characterised by its Level of Service (LoS) using a six point scale (A to F), measuring the extent of the average delay experienced at the intersection (refer Table 6-17). LoS A represents the best operating condition and LoS F the worst.

Table 6-17 Level of Service criteria for intersections

Level of Service	Average delay per vehicle	Traffic signals / Roundabouts	Give way / Stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delay	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays	At capacity; requires other control mode
F	>70	Extra capacity required	At capacity; requires other control mode

Intersection turning count surveys were used as inputs to the modelling of intersections to estimate the existing traffic demands along the road corridor.

Table 6-18 shows the average delay and LoS for intersections within and either side of the study area.

Table 6-18 Intersection performance summary

Intersection	AM peak		PM peak	
	Average delay (seconds)	LoS	Average delay (seconds)	LoS
Mona Vale Road | McCarrs Creek Road	21.9	B	34.0	C
Mona Vale Road | Kimbriki Road	28.4	B	11.1	A
Mona Vale Road | Tumburra Street	7.4	A	39.4	C
Mona Vale Road | Powder Works Road / Baha'i Temple Way	20.0	B	15.2	B

All intersections in the study area operate at an acceptable level of service (LoS C or better).

Crash history

Between 2011 and 2015, a total of 48 crashes have been recorded along Mona Vale Road between McCarrs Creek Road and Powder Works Road / Baha'i Temple Way, including 25 injury-related crashes and 23 tow-away crashes. No fatal crash was recorded during this period.

This section of Mona Vale Road has an average crash rate of 20 per 100 million vehicle kilometres (MVKM). The latest available Roads and Maritime data (Roads and Traffic Authority, 2009) shows an average crash rate of 110 per 100 MVKM for urban undivided road (less than 4 lanes) and 35 per 100MVKM for rural undivided roads.

Analysis of crash statistics for this section of Mona Vale Road indicates:

- About 52 per cent of crashes occurred within 10 metres of an intersection
- The two main manoeuvre types of crashes were rear-ended and right-through with about 33 per cent and 19 percent respectively
- About 77 per cent of crashes involved more than one vehicle
- About 69 per cent of crashes occurred in fine and dry weather conditions
- About 79 percent of crashes occurred in daylight and 15 percent occurred in darkness. The remaining 6 per cent occurred during dawn and dusk
- A fatal crash was recorded in 2008 involving a car and semi-trailer. The crash occurred in daylight and caused one fatality.

Public transport

Public transport accounts for less than ten per cent of the mode share in the former Pittwater LGA, and about 15 per cent of transport mode share in the former Warringah LGA. These are both well below the Greater Sydney average of 25 per cent.

There is currently limited public transport along, and in the vicinity of the Mona Vale Road study area. The 2012 *NSW Long Term Transport Master Plan* identified no mass transit corridors connecting to the Northern Beaches. The plan identified an Intermediate transit corridor connecting from Mona Vale towards the Sydney CBD via Dee Why, but no connections to the east or west.

Forest Coach Lines operates bus route 196/197 between Macquarie University and Mona Vale. This route travels along the entire length of Mona Vale Road.

Pedestrians and cyclists

The existing facilities for pedestrians and cyclists in study area are limited. This is a reflection of both the challenging nature of the terrain as well as the low intensity land use areas through which the study area passes, with much of the road passing through Ku-ring-gai chase and Garigal National Parks. Pedestrian and cyclist activity is concentrated at either end of the proposal corridor; at Terrey Hills in the west, and to a lesser extent at Ingleside in the east.

Near Ingleside, existing pedestrian linkage is limited to short lengths of footpath along Mona Vale Road at the Lane Cove Road/Manor Road intersection, and the Powder Works Road/Baha'i Temple Way intersection. There are no footpath provisions in the surrounding low density rural and residential streets, or at bus stops along Mona Vale Road.

At Terrey Hills, footpaths are provided in the Terrey Hills Village Centre, with limited linkages to surrounding residential areas. Pedestrian links are provided on the key connector and bus links of Booralie Road (to Laitoki Road), and Myoora Road (to Aumuna Road).

Mona Vale Road is part of a regional cycle route. Specific areas along the route have been identified posing a safety risk to cyclists. This includes Mona Vale Road between Kimbriki Road and Powder Works Road / Baha'i' Temple Way, which has been identified as deficient. Other safety 'hotspots' identified are east of Kimbriki Road and at McCarrs Creek Road, and the steep grade between Kimbriki Road and McCarrs Creek Road.

Northern Beaches Council's proposed cycle network is included in the former Warringah Council's *Bike Plan for 2010-2015*. While many of the links have been constructed, there is a lack of high quality links to Mona Vale Road.

6.4.3 Potential impacts

Construction

Construction traffic

Impacts on traffic during construction would occur as a result of the movement of construction and service vehicles along Mona Vale Road and access roads, for the haulage of construction materials. Also there may be temporary speed limit

restrictions adjacent to construction areas and partial closures of roads to allow construction works to be undertaken. General use of Mona Vale Road and access to existing properties within the proposal construction area would be maintained throughout the construction phase.

Truck movements during the construction phase are expected to increase. Around 50 construction vehicles per day are expected during the peak construction period.

The addition of additional construction traffic is anticipated to increase the proportion of heavy goods vehicles along Mona Vale Road from 7.7 per cent to 10.3 per cent of AM peak hour traffic and from 6.0 per cent to 8.6 per cent of PM peak hour vehicles. The increase of 50 vehicles during the construction period would add to existing congestion along Mona Vale Road. Given that traffic conditions are already expected to be congested during peak periods along Mona Vale Road West, traffic management would be required in order to minimise the impact of construction traffic and minimise vehicle movements during peak traffic periods.

Potential impacts caused by construction vehicle traffic would include:

- Increased travel times due to reduced speed limit around construction sites
- Increased travel times due to increased truck and construction machinery movements
- Temporary partial or complete closure of roads and altered property accesses during construction.

Property and local access

Access to individual properties would be temporarily affected by construction activities, either through the loss of existing access arrangements, or the alteration of access arrangements. For the duration of construction, existing property access would be maintained at all times or alternatives access arrangements would be provided, and any impacts would be short-term. Traffic and access requirements to all existing properties along Mona Vale Road, Wirreanda Road and Tumburra Street would be included as part of the detailed traffic management plan.

Construction at intersections of Mona Vale Road and adjoining roads may result in temporary impacts upon access. Traffic management plans would be developed during the detailed design phase to minimise traffic disruption.

Public transport

The proposal would involve changing the access and egress functions at junctions with adjoining roads, mainly at Tumburra Street. As a result, some bus routes would need to be modified both during construction and operation. While buses would continue to be able to use Mona Vale Road, other potential construction impacts on bus services include reduced speeds and temporary relocation of bus stops.

Cumulative construction traffic impacts

Construction of the proposal is expected to commence, at the earliest, in the second half of 2020 following completion of the Mona vale Road East Upgrade project. It is anticipated that the construction of the proposal would take about 30 months, weather permitting.

There are currently a number of major developments and road upgrade projects underway in the broader Northern Beaches area including the Northern Beaches Hospital and the related supporting road works. These projects are scheduled for completion by the end of 2018 so have not been considered here.

Development associated with the Ingleside Precinct may have potential to interact with the proposal. The nature of this would be dependent on timing, location and scale, however, specific details are not known at this point in time.

Northern Beaches Council is currently preparing a Precinct Structure Plan for the area around the new Northern Beaches Hospital, to guide future development. The Draft Structure Plan is on display until February 2017. The timing for adoption of the Structure Plan is not known, however, given the distance between the Northern Beaches Hospital Precinct and the Mona Vale Road West Upgrade proposal, the likelihood of interaction between future development in the Northern Beaches Hospital precinct and the proposal is considered unlikely.

A construction traffic management plan would be developed and implemented; and would include consideration of potential cumulative impacts. The plan would focus on maintaining general traffic flow and specifying appropriate site accesses and construction traffic routes.

Operation

Future travel demand scenarios for the traffic modelling were based on the land use assumptions presented in A Plan for Growing Sydney (DPE 2014a). In addition to the NSW Government land use projections, there are specific development proposals that are expected to have direct impacts to the Mona Vale Road study area. These developments have been considered specifically in terms of trip generation and impacts to the Mona Vale Road study area. These developments include Ingleside Precinct and the Northern Beaches Hospital.

Information on the traffic impacts in the following sections is based upon the full upgrade of Mona Vale Road being undertaken. As discussed previously, Mona Vale Road East Upgrade is planned for completion in 2020 and therefore would be operational before Mona Vale Road West Upgrade is completed.

Traffic modelling and assessment was also undertaken for only the Mona Vale Road Upgrade West being completed and is presented in the traffic and transport assessment in Appendix B. The traffic and transportation impacts in the study areas of only completing Mona Vale Road West Upgrade proposal would be very similar to undertaking the full Mona Vale Road upgrade. However, the full Mona Vale Road Upgrade would address traffic issues in the eastern section and increase the overall capacity and safety of the arterial road..

Forecast mid-block performance

Table 6-19 shows the modelled mid-block peak hour traffic flows and corresponding V/C ratios for the Do Nothing and full Mona Vale Road upgrade scenarios in 2019, 2021, 2031 and 2036.

Table 6-19 Mid-block peak hour traffic flows and capacity

Location on Mona Vale Road	AM peak hour (veh/hr)		PM peak hour (veh/hr)	
	Peak direction flow (westbound)	Volume / capacity ratio	Peak direction flow (eastbound)	Volume / capacity ratio
2021 (Do nothing)				
East of Kimbriki Road (1 lane each way)	1874	1.04	1861	1.03
2021 (with full Mona Vale Road upgrade)				
East of Kimbriki Road (2 lanes each way)	2438	0.72	2491	0.73
2031 (Do nothing)				
East of Kimbriki Road (1 lane each way)	2050	1.14	2041	1.58
2031 (with full Mona Vale Road upgrade)				
East of Kimbriki Road (2 lanes each way)	2589	0.76	2646	0.78
2036 (Do nothing)				
East of Kimbriki Road (1 lane each way)	2027	1.13	2109	1.17
2036 (with full Mona Vale Road upgrade)				
East of Kimbriki Road (2 lanes each way)	2664	0.78	2723	0.80

The current road corridor (two lane undivided road) would not be able to satisfactorily cater for the forecast increases in peak period traffic with V/C ratios greater than one and increasing over time. With the full upgrade, Mona Vale Road would have sufficient capacity to cater for forecast 2021, 2031 and 2036 AM and PM peak hour traffic demand.

Future year intersection performance

With the proposal all the intersections within the study area are expected to perform adequately up to 2036. The following sections highlight the detailed intersection and travel time performances of the Do Nothing scenario compared to the 2021 and the Mona Vale Road Full Upgrade scenarios.

2021 intersection performance

Table 6-20 summarises the AM and PM peak hour intersection delays and queuing along the Mona Vale Road study area in 2021 for the Do nothing and full upgrade of Mona Vale Road scenarios.

For the AM peak, the proposal would at least maintain the existing LoS at B for all intersections and at the Kimbriki and Mona Vale Road intersection improve the LoS from B to A.

For the PM peak, the LoS at the Powder Works Road and Kimbriki Road intersections with Mona Vale Road would be maintained at B or improved to A.

In the PM peak, the delay at the intersection of Mona Vale Road and McCarrs Creek Road decreases substantially with the removal of the southbound merge and subsequent higher utilisation and effectiveness of the kerbside lane. However the intersection would still operate at LoS E with the upgrade.

Table 6-20 2021 AM/PM intersection performance

Intersection	Delay (s)		LoS		Queue Max (Worst leg) (m)	
	AM	PM	AM	PM	AM	PM
Mona Vale/Powder Works						
Do nothing	18.2	19.1	B	B	92 Est	128 Sth
Full MVR Upgrade	17.7	14.3	B	B	102 Est	142 Sth
Mona Vale/Kimbriki						
Do nothing	26.1	12.2	B	A	160 Wst	34 Wst
Full MVR Upgrade	9.6	7.6	A	A	62 Wst	60 Wst
Mona Vale/McCarrs Creek						
Do nothing	25.7	101.2	B	F	134 Wst	497 Wst
Full MVR Upgrade	21.2	58.2	B	E	144 Wst	462 Nth

2031 intersection performance

Table 6-21 summarises the 2031 (10 years after opening) AM and PM peak hour intersection delay and queuing along the Mona Vale Road corridor under the Do Nothing and Full Mona Road Upgrade.

The Mona Vale Road Full Upgrade results in acceptable and/or improved levels of performance for all intersections during the 2031 AM peak. In the 2031 AM peak hour, modelling suggests that all forecasted demands are able to access the road network.

In the PM peak, the LoS at the Powder Works Road and Kimbriki Road intersections with Mona Vale Road would be acceptable and/or improved by the Mona Vale Road Full Upgrade.

Table 6-21 2031 AM/PM intersection performance

Intersection	Delay (s)		LoS		Queue Max (Worst leg) (m)	
	AM	PM	AM	PM	AM	PM
Mona Vale/Powder Works						
Do nothing	181.1	23.9	F	B	506 Nth	141 Sth
Full MVR Upgrade	37.8	21.6	C	B	307 Nth	186 Sth
Mona Vale/Kimbriki						
Do nothing	44.0	11.7	D	A	211 Wst	13 Sth
Full MVR Upgrade	11.5	7.4	A	A	145 Est	89 Wst
Mona Vale/McCarrs Creek						
Do nothing	23.5	101.8	B	F	195 Nth	497 Wst
Full MVR Upgrade	29.1	75.6	C	F	305 Est	510 Wst

The intersection of Mona Vale Road and McCarrs Creek Road would operate at LoS F in all scenarios in the 2031 PM peak hour. The existing intersection creates a capacity constraint that allows downstream intersections to artificially operate with improved levels of service. This is most evident in the Do Nothing scenario. However the Mona Vale Road Full Upgrade would allow a higher number of vehicles to utilise the intersection due to the removal of capacity constraints, such as the southbound merge, on Mona Vale Road to the east of the intersection.

2036 intersection performance

Table 6-22 summarises the morning peak hour intersection delay and queuing along the Mona Vale Road West Upgrade study area in 2036 under the various upgrade scenarios. This scenario assumes the full development of the Ingleside Precinct.

For the AM peak, the Mona Vale Road/Kimbriki Road and Mona Vale Road/McCarrs Creek Road intersections operate at satisfactory and/or improved level of service with no LoS worse than B under the Full Mona Vale Road Upgrade scenario. However, the Mona Vale Road/Powder Works Road would operate at LoS F, albeit with a substantially reduced delay time. As in 2031, heavy congestion is experienced as a result of high development flows around the Ingleside Precinct area.

For the PM peak, the LoS at the Powder Works Road and Kimbriki Road intersections with Mona Vale Road would be acceptable and/or improved by the Mona Vale Road Full Upgrade.

Table 6-22 2036 AM/PM intersection performance

Intersection	Delay (s)		LoS		Queue Max (Worst leg) (m)	
	AM	PM	AM	PM	AM	PM
Mona Vale/Powder Works						
Do nothing	188.2	20.0	F	B	504 Nth	98 Sth
Full MVR Upgrade	88.5	21.8	F	B	494 Nth	187 Sth
Mona Vale/Kimbriki						
Do nothing	72.0	14.6	F	B	337 Wst	35 Sth
Full MVR Upgrade	9.7	8.1	A	A	84 Est	77 Est
Mona Vale/McCarrs Creek						
Do nothing	23.5	125.0	B	F	212 Nth	512 Nth
Full MVR Upgrade	21.0	75.9	B	F	211 Nth	510 Wst

The intersection of Mona Vale Road and McCarrs Creek Road would operate at LoS F) in all scenarios in the 2036 PM peak hour. The existing intersection creates a capacity constraint that allows downstream intersections to artificially operate with improved levels of service. This is most evident in the Do Nothing scenario. However the Mona Vale Road Full Upgrade would allow a higher number of vehicles to utilise the intersection due to the removal of capacity constraints, such as the southbound merge, on Mona Vale Road to the east of the intersection.

Travel time savings

Typically travel time for the Mona Vale Road Full Upgrade section is about 10 minutes and would be reduced by about two minutes for both westbound and eastbound traffic in the AM peak with the full upgrade and for all future scenarios. In the PM peak, travel time for eastbound and westbound traffic would be reduced by about one minute with the full upgrade and for all future scenarios

Freight efficiency

The upgrade of Mona Vale Road West is expected to provide improved safety and efficiency for B-double and freight access along this corridor. The widening of this section of Mona Vale Road to two lanes in each direction would provide safe opportunities for vehicles to overtake slow vehicles, improving travel times along this corridor.

The proposed traffic signals at Kimbriki Road would provide safe and efficient access to approved B-double and freight vehicles to the expanded Kimbriki Resource Recovery Centre.

Public transport

There is expected to be some impact to existing bus routes (Routes 196 and 197) due to the proposal. There are existing westbound and eastbound bus stops located at Kimbriki Road and it was originally planned to retain only the westbound bus stop. The westbound and eastbound bus stops near Tumburra Street were also proposed to be removed and new bus stops and a turnaround facility provided on Tumburra Street/ Harvey Road.

However, Roads and Maritime has undertaken further discussions with the bus operator and have agreed to relocate the bus stops to more suitable locations either on Mona Vale Road or another agreed off corridor location.

Mona Vale Road is one of the main access arterial roads to Mona Vale Town Centre and its proposed bus interchange. Once the bus interchange is operational it is likely that additional bus routes would service development along the Mona Vale Road corridor including new developments such as the Ingleside Precinct. The proposal would minimise risk of congestion and over saturation on the road network. This would improve the efficiency of public transport operations and travel time reliability along Mona Vale Road.

Pedestrians and cyclists

The proposal would improve access and safety for pedestrians and cyclists through the provision of new facilities including:

- three metre wide shared path catering for cyclists and pedestrians on the northern side of Mona Vale Road
- Extension of road shoulders over the length of the proposal to provide 3.0 metre width shoulders on both sides of Mona Vale Road.

While the study area is not a popular route for pedestrians, it is a regional cycle route and is popular with cyclists.

Safety

The proposal is expected to result in a 15 per cent average annual reduction in the number of crashes occurring between the McCarrs Creek Road and Powder Works Road intersections. This includes a reduction in injury crashes by 22 per cent.

In addition to the reduction in the number of crashes, the following improvements to safety would generally be realised with the proposal:

- Concrete or other median barriers would separate eastbound and westbound traffic
- Wide road shoulders would allow vehicles to pull over safely and cyclists to be separated from traffic lanes.
- Safer operations of B-double and freight vehicles
- Two lanes in each direction would provide opportunities for vehicles to safely slow vehicles
- Traffic signals at Kimbriki Road would provide safe and efficient access to approved B-doubles and freight vehicles to the expanded Kimbriki Resource Recovery Centre

- Congestion and over saturation on the road network would be lower, reducing the number of crashes
- Improved safety for pedestrians and cyclists with the provision of an off-road shared path

Redistribution of vehicle traffic due to changed access to Addison Road and Tumburra Street

The intersection of Tumburra Street with Mona Vale Road would be reconfigured to left in, left out only to improve the performance and safety of Mona Vale Road. Access via Addison Road would be similarly reconfigured but restricted to emergency vehicles only.

Consequently, vehicles that currently access Mona Vale Road via a right turn will be required to take alternate routes. To offset these access changes, the proposal includes the extension of Harvey Road connecting to Mona vale Road at the Powder Works Road intersection.

Based on strategic traffic modelling and assumed traffic redistributions, this section of Harvey Road would be anticipated to carry in the order of 1000-1200 vehicles per day, with the majority being redistributed local traffic. Traffic volumes on other roads within the west Wirreanda Valley area are anticipated to be relatively consistent (overall) with existing volumes.

Alternative routes to the Harvey Road extension are as follows:

- Vehicles currently undertaking a right turn into Tumburra Street/Addison Road from westbound Mona Vale Road: vehicles would utilise the signalised right turn at Powder Works Road and would travel along Harvey Road to access both roads. This is considered a minor route diversion and would not result in any substantial travel distance.
- Vehicles currently undertaking a right turn out of Tumburra Street/Addison Road into westbound Mona Vale Road: vehicles would travel north, turn right at the new Harvey Road and travel to the intersection of Mona Vale Road / Powder Works Road. Following a right turn, vehicles would access westbound Mona Vale Road. The total distance of this route diversion would be approximately 2.5 kilometres (depending on street).

These routes provide safe and adequate alternative travel paths for residents on Tumburra Street and Addison Road as a result of the proposed left in, left out access arrangements.

6.4.4 Safeguards and mitigation measures

Table 6-23 lists the safeguards and mitigation measures that have been proposed to address potential traffic and transport impacts. Table 7-1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-23 Safeguards and management measures – traffic and transport

ID	Impact	Environmental safeguards	Responsibility	Timing
TT-1	Construction traffic impacts	A traffic management plan (TMP) will be prepared prior to construction and would be included in the Construction Environmental Management Plan. The TMP would: • Identify the traffic management requirements during construction. • Describe the general approach and procedures to be adopted when producing specific traffic control plans. • Determine temporary speed restrictions to ensure safe driving environment around work zones. • Provide for access to local roads and properties, including the use of temporary turn-around bays where appropriate. • Include methods for implementing the traffic management plan and minimising road user delays. • Provide temporary works and traffic signals. • Determine the number and width of traffic lanes in operation. • Identify traffic barrier requirements and placement. • Provide for appropriate warning and advisory signposting. • Consider other developments in the wider area that may also be under construction, to minimise traffic conflict	Construction contractor	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		and congestion that may occur due to the cumulative increase in construction vehicle traffic.		
TT-2	Construction traffic impacts	Consultation on construction activities will occur with emergency service authorities including NSW Rural Fire Service and NSW Fire and Rescue.	Roads and Maritime	Detailed design
TT-3	Construction traffic impacts	A detailed construction staging plan will be developed to maintain existing peak flow capacity.	Construction contractor	Pre-construction
TT-4	Access to bus services	Access to appropriate bus stop locations will be maintained during construction in consultation with bus operators. Any changes will be appropriately communicated to bus users.	Construction contractor	Construction
TT-5	Access to bus services	Further consultation will be undertaken with bus operators to identify new locations for re-located bus stops	Roads and Maritime	Pre-construction

6.5 Aboriginal heritage

Kelleher Nightingale Consulting was engaged to prepare an Aboriginal archaeological survey report for the proposal in accordance with the Stage 2 requirements of the *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (Roads and Maritime Services, 2011) and the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (Department of Environment, Climate Change and Water, 2010). The following sections summarise the main findings of the survey report, while the report is included in Appendix F.

6.5.1 Methodology

Preparation of the Aboriginal archaeological survey report involved the following:

- Review of heritage registers and databases including the Aboriginal Heritage Information Management System (AHIMS). A search of the AHIMS was carried out on 24 August 2015 to identify registered (known) Aboriginal sites within or adjacent to the study area. The search results are contained in Appendix F and discussed in Section 6.5.2

- Review of other sources of information including heritage registers and lists for known Aboriginal heritage in the vicinity of the study area; these included:
  - Pittwater Local Environment Plan 2014
  - Warringah Local Environment Plan 2011
  - Roads and Maritime Services Heritage and Conservation Register
  - Transport for NSW Heritage and conservation register
  - Sydney Water Heritage Register
  - State Heritage Register and State Heritage Inventory
  - Commonwealth Heritage List
  - National Heritage List
  - Australian Heritage Places Inventory
  - Historic Heritage Information Management System (HHIMS)
- Review of the Department of Main Roads Mona Vale Road Strategic Design Plan, which plotted eight Aboriginal heritage locations within 200 metres of the existing Mona Vale Road corridor
- Review and consideration of previous archaeological investigations
- Review of the landscape context, previous land use and regional character of the area surrounding the proposal site
- Identification of the types of sites likely to occur based on information from previous archaeological investigations, landscape context and regional character.

The study area was divided into 13 survey units, with field surveys being undertaken across two periods. Eleven of the survey units were arbitrarily delineated in the field during the initial survey from 23 to 25 May 2011, while survey units 12 and 13 (encompassing areas where concept design changes had exceeded the original survey units) were inspected on 6 May 2015. Representatives of the Metropolitan Local Aboriginal Land Council participated in the surveys.

All survey units were inspected on foot. The survey team compiled detailed notes on the condition of each survey unit including an assessment of surface visibility, vegetation coverage, frequency of sandstone outcrops, modern disturbance and current land use. Where previously recorded Aboriginal sites were relocated, additional notes were taken describing the site and current condition. Photographs were taken of each survey unit and relocated Aboriginal site. Coordinates were logged using a GPS receiver.

Following the identification of the need to extend Harvey Road to Mona Vale Road at the Powder Works Road intersection, an addendum assessment was conducted comprising updated desktop searches (17 August 2016) and additional field survey carried out on 4 and 9 July 2016. Access was not available for the area between Mona Vale Road and Addison Road due to this section being on private properties. This area will need to be surveyed at a later date once access is secured.

6.5.2 Existing environment

Database search results

The AHIMS search results identified 42 Aboriginal sites recorded in or near the study area including rock engravings, axe grinding grooves, and a shelter with art.

Two sites (AHIMS: 45-6-0100 and 45-6-1228) are listed on the AHIMS database as being located within the study area. Site 45-6-1617 is listed as being within 10 metres of the project area boundary.

A plan of a strategic design for Mona Vale Road developed by the then Department of Main Roads (DMR) dating to sometime before 1970 provided locations of a number of Aboriginal sites marked on the plan. Many of these were simply dots while others were dots accompanied by brief information such as 'Aboriginal Carvings'. Three of the sites indicated on the DMR plan are located within the study area.

The study area incorporates a portion of the Ku-ring-gai Chase National Park which, along with Lion, Long and Spectacle Island Nature Reserves, is a listed place on the National Heritage List. The presence of Aboriginal sites is noted in the listing and forms a key component of the National Park's value to the community. The listing states that:

> *Extensive evidence of Aboriginal use and occupation occurs in the place, with over 800 sites or locations with physical evidence of Aboriginal use recorded. Shell middens along the foreshore are the most common type of evidence recorded. Other evidence includes rock engravings and paintings, grinding grooves, stone arrangements, burials and occupation sites. No systematic survey has been undertaken across the park, and it is likely that additional sites occur within the park.*

Site predictions

Based on information from previous archaeological investigations, landscape context and regional character, the most likely site types to occur within the study area would be:

- Engraving sites: likely to occur where suitable outcrops of bedrock occur
- Shelter sites (art and/or occupation): likely to occur where suitable overhangs have formed in the sandstone bedrock. Aboriginal art is likely to occur at these sites where suitable surfaces are present within the shelter. Occupation deposits are likely in shelters with access to resources where sediment has accumulated
- Grinding groove sites: may occur on suitable outcrops of bedrock with access to flowing or standing water
- Open artefact scatters/isolated artefacts: less likely to occur than other site types but may occur in locations close to water sources within relatively flat areas with high surface visibility. The majority of the study area contains steep slopes and dense vegetation with limited access to water. The eastern half of the study area is closer to permanent water with significantly less slope and vegetation.

Survey results

Two Aboriginal archaeological sites were identified within the study area by the survey. Site MVRW 1 was previously unknown while site 45-6-1228 is registered on the AHIMS.

Site MVRW 1 comprises a single rock engraving north west of the intersection of Mona Vale Road and Addison Road. The engraving consists of a ground oval measuring 18.5 x 10.5 centimetres that is situated close to the edge of a narrow sandstone bench.

Site 45-6-1228 comprises a cluster of engravings on a single rock surface on the northern side of Mona Vale Road. The rock platform is located on a ridge crest context with wide district views to both the south and north. The engravings are located across the eastern half of the platform.

Engraved motifs identified during the current study included:

- A large whale or shark, aligned due north-south, with its head to the north and tail fin at southern end; one dorsal fin, two lower fins and mouth one;
- A male figure at the mouth of the whale/shark; the figure's feet point to the north and the head is obscured, appearing to go into the mouth of the whale/shark
- A male figure less than one metre west of the whale/shark's belly; there is a large protuberance on the figure's left side, possibly a dilly bag; the left arm is held up, and appears to hold a club; the figure is oriented with its head to the north
- A partially engraved small macropod, possibly a wallaby, three metres west of the whale/shark; the head and front paw are visible in side profile.

The survey revisited previously registered site 45-6-1617 (Tumble-down-dick) in order to confirm the site's location in relation to the study area boundary. The site was located and confirmed to be outside the study area.

Other sites indicated on the pre-1970 DMR plan of Mona Vale Road were not found within the proposal's impact area.

The archaeological survey included a portion of the National Heritage Listed Ku-ring-gai Chase National Park that falls within the proposal study area. No Aboriginal objects were identified in the portion of Ku-ring-gai Chase National Park that falls within the study area.

Landscape context

The proposal is located across a ridge landform context that forms a watershed between the McCarrs Creek catchment to the north and the Deep Creek catchment to the south. The gradient into McCarrs Creek is generally less than the steep to precipitous slopes on the southern side of Mona Vale Road.

Archaeologically, shelters are most likely to occur on the break in slope. This to be outside the study area (to the north and south east) while engraving sites associated with open rock platforms occur on the ridge line within the study area.

The portion of the study area east of Addison Road has been extensively modified by vegetation clearance, landscaping and the construction of structures, utilities and roads. West of Addison Road the study area has limited modern land use disturbance and contains remnant native vegetation.

Regional character

Rock engravings are by far the most predominant recorded site type within and in the vicinity of the study area. Those engravings generally occurred across exposed sandstone platforms in ridge crest and slope contexts. During a study of recorded Aboriginal sites within the Garigal National Park, Gunn (1992:19) noted that 66 per cent of engraving sites occurred on ridge tops and 33 per cent in upper slope contexts.

Shelter sites also occur in the vicinity (outside) of the study area. Natural shelter formations occur in Hawkesbury Sandstone where overhangs have formed on ridge slopes, or beneath large exposed rock outcrops in ridge crest contexts. Archaeological investigations have demonstrated that shelters were utilised for a variety of different purposes. Remaining evidence of those activities might include stone artefacts, shell midden material, pigment art, stencils and engravings.

Aboriginal settlement history of the study area

The principal remaining evidence of Aboriginal activity within the study area are engravings. Site 45-6-1228 exhibits tangible significance as it is an important and dramatic symbol of Sydney's Aboriginal past. Large engravings evoke a special emotional attachment as they are attention-grabbing and generally placed in awe-inspiring locations. The cluster of engravings at Site 45-6-1228 is located in a prominent location over the surrounding area with views to the north and south. The engravings are also located roughly equidistant on the main ridge line between the higher elevation to the west at Terrey Hills and to the east at the Baha'i Temple. The positioning of the engravings at that location may demonstrate the significance of that ridge line to the original Aboriginal inhabitants of the area.

The motifs depicted at Site 45-6-1228 also demonstrate the connection between the Aboriginal inhabitants of the area and the surrounding region. One of the engravings depicts a large whale or shark, while another depicts part of a macropod. Estuarine and ocean resources are a significant feature of the region with Narrabeen Lagoon to the south, Pittwater to the north and the Pacific Ocean to the east of the study area. Land resources such as macropods would have been, and still are, common in the surrounding area.

Engraving sites have cultural, social and educational importance as they offer a visual bridge between current and past peoples. Moreover, Site 45-6-1228 is not an isolated engraving; it is part of a large cultural complex connecting engraving sites in Garigal and Ku-ring-gai Chase National Parks. As with most cultural sites, the connections between sites contains a greater significance than any one site in isolation. In Aboriginal culture the entire landscape is greater than the sum of the parts. Site 45-6-1228 is significant in itself, but its ties to the greater rock art landscape enhance its palpable cultural value. MVRW 1 is also tied to this wider cultural landscape and provides further physical links to Aboriginal heritage and land use within the study area.

It is possible that any number of the natural shelter formations identified within the study area may have been utilised by Aboriginal people but no material evidence of that use remains today. The lack of material evidence remaining may be due to the nature of activity, such as using the overhang as a short-term shelter for resting only. The other factor to consider is the south-facing perspective of the majority of those shelters and their exposure to the prevailing south-westerly weather conditions within

the Sydney Basin. Those weather conditions would possibly weather shelter walls comparatively faster than more protected overhangs thus removing pigment art.

Statement of Significance

Site 45-6-1228 comprises a cluster of engravings on a large sandstone outcrop on a ridge crest. The southern portion of the outcrop has been removed for the original construction of Mona Vale Road and the northern side of the platform is bounded by an unformed vehicle track beneath power lines. The prominent location of the engravings, size of the main engraving and relatively good condition of the engravings demonstrate that Site 45-6-1228 exhibits high scientific significance.

Site MVRW 1 comprises an oval engraving situated on a sandstone bench. Rock engravings are the most common site type found in the study area and immediate vicinity; however, MVRW 1 is in good condition and the isolation of the motif is relatively uncommon in the local and regional area. Overall, MVRW 1 displays high scientific significance.

No Aboriginal archaeological objects or potential archaeological deposits were identified by the field survey within the addendum study area for the area that was able to be accessed. Further archaeological investigation is required on sandstone outcropping between Bungendore Street and Addison Road and within the portion of the addendum study area between Mona Vale Road and Addison Road to determine if any Aboriginal objects or sites are present before a complete significance assessment can be made.

6.5.3 Potential impacts

Construction

While one AHIMS registered site and one previously unknown site are located within and close to the works area, these sites would not be directly affected by the proposal. Both sites are of high cultural and archaeological significance and would be specifically protected during construction.

No other potential impacts on Aboriginal cultural heritage were identified. However, as noted, a section of the proposed Harvey Road extension was not accessible at the time of the addendum field survey and would need to be surveyed prior to construction and any identified impacts assessed.

Operation

Impacts on Aboriginal heritage sites following completion of construction (such as increased visibility or exposure) are not expected.

6.5.4 Safeguards and mitigation measures

Table 6-24 lists the safeguards and mitigation measures that have been proposed to address identified potential impacts on Aboriginal cultural heritage. Table 7-1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-24 Safeguards and mitigation measures – Aboriginal Heritage

ID	Impact	Environmental safeguards	Responsibility	Timing
AH-1	Damage to known Aboriginal sites	Fencing and signage will be used to establish exclusion areas around nearby Aboriginal sites.	Construction contractor	Pre-construction
AH-2	Damage to known Aboriginal sites	During site inductions and toolbox talks, all site staff will be made aware of the location of known Aboriginal sites and associated responsibilities under the *National Parks and Wildlife Act 1974*.	Construction contractor	Construction
AH-3	Damage to known Aboriginal sites	Potential impacts of construction vibration on nearby Aboriginal sites will be investigated prior to the commencement of construction. Construction methods would be selected and safeguards would be prescribed. Monitoring would occur where necessary.	Construction contractor	Pre-construction, Construction
AH-4	Unexpected impacts on Aboriginal heritage	The *Standard Management Procedure: Unexpected Archaeological Finds Procedure* (Roads and Maritime Services, 2012) will be followed in the event of uncovering a potential Aboriginal heritage item.	Construction contractor Roads and Maritime	Construction
AH-5	Damage to unknown Aboriginal sites	Further survey is required, when access is available, for the section of the Harvey Road extension between Mona Vale Road and Addison Road to determine if any Aboriginal objects or sites are present within the area and the potential impact from the proposed works.	Roads and Maritime	Pre-construction
AH-6	Damage to unknown Aboriginal sites	Further survey, using oblique lighting, is required for potential rock engravings on the large rock platform and sandstone benching identified within the road easement between Bungendore Street and	Roads and Maritime	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
		Addison Road to determine if any Aboriginal objects or sites are present within the area and the potential impact from the proposed works.		

6.6 Historic heritage

A Statement of Heritage Impact (SoHI) has been prepared by RPS for the proposal. The SoHI is provided in Appendix G and a summary of the main findings is provided as follows.

6.6.1 Methodology

The SOHI was prepared in accordance with *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Burra Charter) (2013) and associated Guidelines as well as best practice standards set by the NSW Heritage Branch. Best practice guidance followed includes *Assessing Heritage Significance* (NSW Heritage Office, 2001) and *Statements of Heritage Impact* (Heritage Office and Department of Urban Affairs & Planning, 1996, 2002).

Preparation of the SOHI involved the following:

- Review of heritage registers and databases
- Review of other sources of information including:
  - Pittwater Local Environmental Plan 2014
  - Warringal Local Environmental Plan 2011
  - Roads and Maritime Services Heritage and Conservation Register
  - Transport for NSW Heritage and Conservation Register
  - State Heritage Register and State Heritage Inventory
  - Commonwealth Heritage List
  - National Heritage List
- Research into the history of the area
- Review of previous heritage assessments adjacent to or near the study area, including a preliminary heritage assessment prepared by JCIS Consultants (2012)
- Site investigation of the study area on 28 October 2015 to identify any additional items of potential heritage significance
- Analysis of and reporting on potential historical heritage impacts
- Provision of recommendations to address identified potential impacts.

6.6.2 Existing environment

Historical context

Timeline of Mona Vale Road

Mona Vale Road is an old thoroughfare linking the Northern Beaches with the Lane Cove area and in its history has been known by many names. There is some conjecture that prior to European colonisation it was an existing Aboriginal pathway, many of which in the Sydney Basin followed ridgelines.

A brief history of Mona Vale Road is as follows:

- Pre 1830 – Many of Sydney's important arterial roads followed paths previously established by Aboriginal people. Many of these followed ridgelines which, given Sydney's topography, represented the easiest way to traverse large area. Evidence of Aboriginal use of the area remains in the form of rock engravings in bushland either side of Mona Vale Road
- Circa 1820-1830 – Mona Vale Road was previously known as Stoney Creek Road and was constructed by one of the area's earliest settlers, Daniel Matthew, to take his timber to market from his saw mill (constructed in 1824 on the corner of Cowan Road, St Ives), about eight kilometres to the south west of the McCarrs Creek Road/Mona Vale Road intersection
- 1869 – The first survey of Mona Vale Road was undertaken in 1868; by 1872, Lane Cove Road was established formally as a road
- 1880s - Mona Vale Road was upgraded and realigned to cater to a growing population in the Mona Vale and Ingleside areas
- 1939 - In 1939, a newspaper article noted that the road, now called Mona Vale Road, was a road of five names (Lane Cove Road, Ryde Road, Gordon Road, Stoney Creek Road and Pittwater Road) depending on the council area; the road was provided with a single name, Mona Vale Road
- 20th and 21st century upgrades – In 1978-79, the section between Highlands Avenue, Pymble and Richmond Avenue North, St Ives was upgraded to six lanes; the alignment of Tumbledown Dick Hill was change to remove a sharp bend on the descent.

These stages are discussed in further detail in Section 3.2.1 of the SOHI.

Development of Terrey Hills and Ingleside

The area now comprising Terrey Hills and Ingleside falls within the traditional lands of the Guringai (or Ku-ring-gai) people. Their traditional lands stretched from Sydney Harbour to the south, north to Broken Bay, and were bounded by the Pacific coast to the east and the Lane Cove River to the west. Evidence of their inhabitation of the land can be found in bushland near Mona Vale Road in the form of artefact scatters, shelters and rock engravings.

While early maps note the land in the area has been owned since the early 1800s, it wasn't until later that century that people began moving to the area. Mona Vale Road (Lane Cove Road, Stoney Creek Road) was the only evidence of European occupation until the 1800s, when land began to be taken up by selectors. A total of four people owned all land adjoining the Mona Vale Road study area, being Samuel

Hills, Richard Hardman, John Charles Edwards and James Jones. A paucity of surviving structures confirms oral history that the area surrounding the study area was largely remote bushland with the road itself being the most important feature.

Heritage items in the study area

Investigations identified two heritage items of local significance in the study area (refer to Table 6-25) and one site about 950 metres to the north of the study area. There are no other heritage items located within or in close proximity to the study area.

Table 6-25 Local heritage items within or in the vicinity of the study area

Item	Address	LEP*	Significance	In study area
Group of Monterey Pines	169 and 169A Mona Vale Road, Ingleside	Pittwater	Local	Yes
Baha'i House of Worship	173 Mona Vale Road, Ingleside	Pittwater	Local	Yes
Laurie Short House	307 McCarrs Creek Road, Terrey Hills	Warringah	Local	No (about 950 metres north of the intersection with Mona Vale Road)

* As previously noted, the former Pittwater and Warringah LGAs are now part of the Northern Beaches LGA, however, the respective LEPs are still in effect.

Group of Monterey Pines

The group of Monterey Pines (*Pinus radiata*) comprises five mature trees located at the northeast corner of the intersection of Baha'i Temple Way and Mona Vale Road, Ingleside (refer to Plate 1). Four of the pines are on the western side of a driveway leading to 169A Mona Vale Road, Ingleside, with the remaining tree located on the driveway's eastern side.

A heritage significance assessment for the trees identified their historical significance relates to their attachment to the former Waratah farm, which was a historically significant orchard in the local area owned by the Larkin family, their rarity and their representativeness of the use of such trees in marking entrances for rural properties. Their grading is assessed as being of moderate local significance.

Baha'i Temple

The Baha'i Temple is located to the west of Baha'i Temple Way and occupies high ground on the northern and western sides of Mona Vale Road (refer to Plate 2 and Plate 3). The temple is a striking white building with middle-eastern motifs surrounded by formal gardens and native bush vegetation. Construction of the temple began in 1957 and finished in 1961; no dome of such proportions had been built in Australia prior to this structure. The grounds include a visitor's centre and picnic area.

A heritage significance assessment concluded that the temple is an important cultural item with high local aesthetic heritage significance.

Plate 1 Group of Monterey Pines, facing north from Baha'i Temple Way

Plate 2 Baha'i Temple, showing three of the nine entrances

Plate 3 Temple grounds, visitor's centre in the right middle ground

Potential items in the study area

In a preliminary heritage assessment undertaken for the project by JCIS Consultants (2012), 11 potential heritage items were identified in the study area. The JCIS assessment JCIS concluded that none of these items would seem to be of such significance as to act as a serious constraint to the proposed widening.

A significance assessment was conducted for each of the items. Apart from the quarry marks and previous road alignments, the locations of the remaining items were not established during the field investigation. Several items including the cairn, memorial, engraved rock and shelter which were not able to be located, occur within dense bushland and excessive vegetation prevented any intensive survey of the sites of the potential items.

The conclusion of the significance assessments for each of the previously identified items is summarised in Table 6-26.

Table 6-26 Conclusion of the significance assessments for previously identified heritage items

Potential heritage item	Significance assessment conclusion
Previous road alignment	Two areas of the prior Mona Vale Road alignment were identified by JCIS; one at the Ingleside end and one at the Terrey Hills end. The Ingleside end is located to the south west of the Baha'i Temple. It is now covered with bitumen and used as a bike path and as an electricity easement to the north of the current alignment. It is part of the original alignment of Mona Vale Road. As previous road alignment is known and well mapped, it is not considered to be of heritage significance with regard to the proposal.
Cairn	The cairn marked a trigonometrical point used for surveying. The cairn is not considered to be of heritage significance with regard to the proposal.
Quarried area	The SOHI investigation did not find any independent historical sources elucidating the quarried area's provenance however the JCIS study's suggestion that it may have been part of the 1939-1942 road works is consistent with its appearance. If this is correct, it is not a heritage item but a work and therefore not of historical or heritage significance. The quarried area is not considered to be of heritage significance with regard to the proposal.
Quarry marks on cutting faces	Quarry marks on cutting faces are noted at three locations on the verge of Mona Vale Road, near Addison Road and about 120 metres west of the intersection with Tumburra Street. These marks evidence the drilling and cutting through rock during road construction. Given the number of times Mona Vale Road has had its alignment changed, it is uncertain when these marks were made. The SOHI investigation did not find any independent historical sources confirming when the quarry marks were made on the cuttings. These marks are consistent with mechanical quarrying which would therefore mark it as a work associated with the construction of Mona Vale Road and therefore not of historic or heritage significance. The quarry marks are not considered to be of heritage significance with regard to the proposal.
Memorial	This modern memorial comprises a metal crucifix attached to a wooden stake, located on a bush track near the Kimbriki Road junction with Mona Vale Road. The memorial is not considered to be of heritage significance with regard to the proposal.
Artefact scatter	The scatter of modern ceramics is located about 170 metres west of the culturally significant rock outcrop, eroding out of an access track. The JCIS study notes that the artefacts appear to be part of modern fill.

Potential heritage item	Significance assessment conclusion
	The artefact scatter is not considered to be of heritage significance with regard to the proposal.
Engraved rock	An engraved sandstone boulder located about 130 metres west of the Tumburra Street junction with Mona Vale Road. It appears to be from 1942 and a form of graffiti. The engraved rock is not considered to be of heritage significance with regard to the proposal.
Engraving in shelter	The rock shelter is located about 117 metres west of the intersection with Kimbriki Road and 30 metres south. The engraving is similar to that of the rock except that it is older. It is a form of graffiti. The engraving is not considered to be of heritage significance with regard to the proposal.

Summary

The Group of Monterey Pines and the Baha'i Temple are the only heritage items within the study area. No additional heritage items were identified as part of the site inspection. No areas of historical archaeological interest were noted.

The area is known for its Aboriginal rock engravings and many rock platforms were noted during this survey, particularly in the western end of the study area. The significance of these rock engravings, impact from the proposal and avoidance and mitigation measures are discussed in the Aboriginal heritage section of this REF (Section 6.5).

6.6.3 Potential impacts

The proposal would require the complete removal of all of the local heritage-listed Monterey Pines at the intersection of Baha'i Temple Way and Mona Vale Road, this being associated with the proposed Harvey Road extension. The Statement of Heritage Impact identifies this as a major impact in the context of the ICOMOS definitions for impact.

The proposed works include the relocation of the existing access to the temple by about 120 metres west along the new road. These works would potentially impact the setting of the item including views and vistas to and from the temple. The relocation of the access would only have a minor impact to the setting of the temple as the approach would be similar to the existing approach. The new local road connection would encroach slightly on the northern boundary of the Baha'i Temple curtilage, and is also considered a minor impact.

6.6.4 Safeguards and mitigation measures

Table 6-27 lists the safeguards and mitigation measures that have been proposed to address identified potential impacts on historic heritage. Table 7 1 in Section 7.2 presents a consolidated list of all the safeguards and mitigation measures included as part of the proposal.

Table 6-27 Safeguards and mitigation measures - historic heritage

ID	Impact	Environmental safeguards	Responsibility	Timing
HH-1	Impacts on known heritage values	All team members should be made aware of their legislative obligations for heritage under the *National Parks and Wildlife Act 1974* and *Heritage Act 1977*, which may be implemented as a cultural heritage induction. The induction should be presented prior to the commencement of any activity within the study area and include information about local heritage (Baha'i Temple).	Construction Contractor	Construction
HH-2	Unexpected finds	The Roads and Maritime Standard Management Procedure *Unexpected Heritage Items* (Roads and Maritime Services, 2012) is to be followed in the event of uncovering a potential historic heritage item not considered by the REF	Construction contractor	Construction
HH-3	Impact on known heritage items	An exclusion zone should be established and maintained during construction to prevent inadvertent impacts to the item and its surrounding curtilage. The original vegetation and landscaping should be retained within the curtilage where possible. If vegetation is to be removed it should be replaced with plantings of a similar type and maturity.	Construction contractor	Pre-construction
HH-4	Loss of heritage item	Roads and Maritime should consult with the Northern Beaches Council with respect to the impacts on the 'Group of Monterey Pines' listed under the Pittwater LEP.	Roads and Maritime	Detailed design

6.7 Urban design and visual amenity

A Landscape Character/Visual Impact Assessment and Urban Design Report has been prepared for the proposal. A copy of the assessment is provided in Appendix H and a summary is provided as follows.