Appendix J

Technical working paper:
Biodiversity

NorthConnex

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Technical working paper: Biodiversity

DOCUMENT TRACKING

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Abbreviations

Abbreviation	Description
CEEC	Critically Endangered Ecological Community
CMA	Catchment Management Authority
DGRs	Director-General's Requirements
DotE	Commonwealth Department of the Environment (formerly SEWPaC)
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now DotE)
EEC	Endangered Ecological Community
ELA	Eco Logical Australia Pty Ltd
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater Dependent Ecosystem
I&I NSW	Industry and Investment NSW
LGA	Local Government Area
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service (part of OEH)
NSW Department of Planning and Environment	NSW Department of Planning and Environment, formerly the Department of Planning and Infrastructure
NV Act	*Native Vegetation Act 2003*
NW Act	*Noxious Weeds Act 1993*
OEH	NSW Office of Environment and Heritage (formerly DECCW)
RCT	Red-crowned Toadlet
TEC	Threatened Ecological Community
TSC Act	*Threatened Species Conservation Act 1995*

Key terminology

Terminology	Description
Associated infrastructure	Associated infrastructure refers to the supporting infrastructure which includes stormwater detention, air vents and construction site.
BioBanking	A methodology developed by Office of Environment and Heritage (OEH) which provides a transparent, consistent and scientifically-based set of rules to assess biodiversity values. The BioBanking Assessment Methodology provides rules for the number and type of credits that a development site will require in order to offset its impacts and thus improve or maintain biodiversity values. The methodology also provides rules for the number and type of credits that can be created from undertaking conservation management at a biobank site.
Carriageway	The portion of a roadway used by vehicles including shoulders and ancillary lanes. Meaning the total number of lanes in one direction of travel (for example the northbound carriageway of the main alignment, which would consist of two lanes).
Clearing	The removal of vegetation or other obstacles at or above ground level.
Construction footprint	The area directly impacted upon by the construction of the project. 'Construction footprint' is used in this technical working paper as an alternative to 'subject site' as defined by DEC (2004). The construction footprint includes all components relating to construction and operation of the project including (but not limited to): • All excavations/construction, including ancillary equipment. • All stormwater/sediment control measures. • All access requirements for construction or ongoing infrastructure maintenance. • All spoil and construction material storage areas. • Sufficient allowance for all batters when excavating.
DGRs	Director-General's requirements. Requirements and specifications for an environmental assessment prepared by the Director-General of the NSW Department of Planning and Environment under the *Environmental Planning and Assessment Act 1979.*
Direct impacts	Those that directly affect species, populations or ecological communities and their associated habitats. Direct impacts include, but are not limited to, loss of individuals or ecological communities and removal of suitable habitat.
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
Hills M2 Motorway integration works	The works to join the project to the Hills M2 Motorway extending from the southern interchange to Windsor Road.

Terminology	Description
Indirect impacts	Those which occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. Indirect impacts include loss of individuals through starvation, exposure, predation by domestic and/or feral animals, loss of breeding opportunities, loss of shade/shelter, hydrological changes, increased soil salinity, erosion, weed invasion, increased noise and/or light, or increased human activity within or directly adjacent to sensitive habitat areas which include sites of known threatened species, endangered ecological communities or features that are potential habitat for threatened species eg. culverts.
Locality	The locality is defined by a 10 kilometre radius around the study area for the purposes of conducting database search.
M1 Pacific Motorway interchange	The current interchange between the Pacific Highway and the M1 Pacific Motorway at Wahroonga.
Main alignment tunnels	The two underground tunnels forming the principal carriageways of the project.
Northern interchange	The connections of the project with the M1 Pacific Motorway (formerly known as the F3 Freeway) and Pennant Hills Road. For the purpose of this report, the term also captures the M1 Pacific Motorway tie-in works, and the construction compounds that would support the construction of the northern interchange.
Off-ramp	A section of road which allows vehicles to exit the motorway or project.
On-ramp	A section of road which allows vehicles to enter the motorway or project.
Primary habitat	For the purposes of this technical working paper primary habitat for threatened species are those areas or resources that may be used or required by threatened species for breeding or roosting purposes.
Road reserve	A legally defined area of land within which facilities such as roads, footpaths and associated features may be constructed for public travel.
Secondary habitat	For the purposes of this technical working paper secondary habitat for threatened species are those areas or resources that may be used by threatened species for foraging purposes.
Site establishment works	Preliminary works carried out prior to the commencement of construction, including: • Installation of environmental controls. • Demolition of existing structures. • Vegetation clearing. • Establishment of construction facilities.
Southern interchange	The connections of the project with the Hills M2 Motorway and Pennant Hills Road. For the purpose of this report, the term also captures the construction compounds that would support the construction of the southern interchange.
Spoil	Surplus excavated material.
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.
Study area	The area of ecological survey investigation for this technical working paper. The study area can be seen in **Figure 1**.

Terminology	Description
The project	The NorthConnex project, as described in **Section 1.1**.
Tie-in	The works to join the project to existing roads, such as the M1 Pacific Motorway.

Executive summary

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5.1 of the *Environmental Planning and Assessment Act 1979* to construct and operate a tolled motorway linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills in northern Sydney (the project).

The majority of the project is underground and has avoided the extent of disturbance required at the surface and therefore, the extent of disturbance to any remnant vegetation or habitat. Opportunities to further avoid impacts in the design have also been explored, and as a result of investigations for this assessment, the following ecological values have been avoided:

- Blue Gum High Forest and Sydney Turpentine Ironbark Forest , listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) as a critically endangered ecological community (CEEC) and an endangered ecological community (EEC) at the Hills M2 Motorway (southern interchange)
- Habitat of the TSC Act listed vulnerable Red-crowned Toadlet at the northern interchange.
- Individuals of *Epacris purpurascens* var. *purpurascens*, a listed vulnerable flora species under the TSC Act, on the northern boundary of the Hills M2 Motorway integration works.

The assessed construction footprint covers all the areas required for construction and operation of the project, including excavation, spoil placement, machinery and access roads. ELA approached the assessment by conducting both desktop analysis and field assessment, using the biobanking assessment methodology to assess habitat and condition of ecological communities. Targeted survey was conducted for two threatened flora species. Potential indirect impacts that have been considered include disruptions to ecological connectivity, injury and mortality to flora and fauna, weeds, pathogens, hydrological changes, noise, vibration and light.

The project design and construction footprint of the project as assessed in this technical working paper represents the preferred tender design for the project. Sufficient flexibility has been provided in the preferred tender design to allow for refinement during detailed design, or to minimise environmental impacts, or in response to submissions received during the exhibition of the environmental impact statement. As such, the ecological impacts assessed as part of this technical working paper represent a worst case scenario.

A total of 5.87 hectares of direct impacts on native vegetation associated with the proposed construction footprint have been identified (see **Table 11**) comprising:

- 2.81 hectares of Blue Gum High Forest (CEEC TSC Act).
- 0.08 hectares of Blue Gum individuals (identification to be confirmed due to limited access)
- 0.01 hectares of Coastal Enriched Sandstone Dry Forest.
- 0.15 hectares of Coastal Enriched Sandstone Moist Forest.
- 0.03 hectares of Coastal Sandstone Gallery Rainforest.
- 1.71 hectares of Coastal Shale/Sandstone Forest.
- 0.72 hectares of Hinterland Sandstone Gully Forest.

- 0.10 hectares of Sydney Turpentine-Ironbark Forest (EEC TSC Act, identification to be confirmed due to limited access).
- 0.07 hectares of planted *Syzygium paniculatum* (Lilly Pilly).
- 0.19 hectares of native regenerated vegetation.

Blue Gum High Forest has been identified across the study area. Although these stands satisfy the definition for the CEEC under the TSC Act, none of the patches that would be impacted by the project met the EPBC Act definition. This includes Blue Gum High Forest at the southern and northern interchanges and at the ancillary facilities. The Blue Gum High Forest was predominately in "poor" condition due to exotic species, such as privet and lantana, with one area in the Southern Interchange rated as "moderate" condition due to a lesser abundance of exotic species and a higher diversity of native species.

Three TSC Act listed plant species have been identified within the study area, being *Epacris purpurascens* var. *purpurascens, Hibbertia superans* and *Syzygium paniculatum.* A summary of their assessment is as follows:

- The project would result in the clearance of an estimated 106 individuals *E. purpurascens* var. *purpurascens* on the southern side of the Hills M2 Motorway integration works area, based on previous detailed targeted surveys (Cumberland Ecology 2012). This population is associated with previous restoration, is fenced and within a previous construction footprint. Around 76 additional individuals are present intact on the northern side of the Hills M2 Motorway and would be avoided by the project. Areas outside the road corridor and study area also contain habitat that supports this species.
- Small patches of *Syzygium paniculatum* were found at the northern interchange (M1 Pacific Motorway) and Hills M2 Motorway in and around existing urban development. These individuals have been planted (commonly used in landscaping in the Sydney region) and no significant impact to the species is likely.
- Four *Hibbertia superans* plants occur on the northern side of the Hills M2 Motorway. These individuals are not within the construction footprint and would be retained.

A number of threatened fauna species have been identified as potentially occurring in the study area, and impacts on these species have been assessed. These species generally utilise terrestrial native vegetation as foraging habitat and no other important resources that would support them in the study area, except for Red-crowned Toadlet (*Pseudophryne australis*) and Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) which have specific habitat requirements. Significant impacts on all threatened fauna species can be avoided through sympathetic design, management and/or mitigation measures that reduce the frequency, intensity and/or duration of impacts.

The identified Red-crowned Toadlet (*Pseudophryne australis*) habitat is located on tributaries of Cockle Creek, the catchments of which are beyond the study area. While Cockle Creek would be impacted upstream of the habitat, there would be no direct impacts on the Red-crowned Toadlet.

A maternity colony of the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) is known to roost within the twin culverts on Devlins Creek under the Hills M2 Motorway. This culvert would not be impacted by the project. There are other culverts that while no bats were present, do provide suitable habitat for this species. These culverts were at the northern interchange near Junction Road and near Blue Gum Creek on the northern side of the Hills M2 Motorway integration works area. These culverts are likely to be impacted directly (eg. extension of culverts to accommodate additional carriageway) and indirectly (e.g. noise, vibration and light). A microbat management plan is recommended to address

these impacts and these three locations and may include monitoring of the culverts for bat activity and exclusion of works during breeding season if present at the time of construction. Disused buildings are also present at the Pioneer Avenue compound which have potential bat habitat, and will also be included in the microbat management plan.

A total of 62 hollow bearing trees were found, supporting a total of 89 hollows. Although there were four trees with very large hollows, no hollows of a sufficient size to support breeding and roosting for large forest owls would be removed. Up to thirty four trees with hollows would be removed or lopped, accounting for 53 hollows of a range of sizes that provide potential habitat for threatened microbats and other hollow dependent fauna.

Some riparian vegetation communities along the Hills M2 Motorway are likely to be Groundwater Dependent Ecosystems (GDEs). Trees in these communities have a high potential for using groundwater in a shallow aquifer perched above the main Hawkesbury Sandstone Aquifer. Surface water recharge patterns to these areas have been altered as a result of the Hills M2 Motorway, and further changes to these patterns as a result of the project are unlikely.

The project has substantially avoided biodiversity impacts largely in part via route selection and tunnelling. A number of mitigation measures to minimise ecological impacts would be implemented as part of the project in line with Roads and Maritime Biodiversity Guidelines – Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011). These measures would be detailed in the flora and fauna management plan for the project which includes: site-specific environmental induction; identification of clearing limits and protective fencing; vegetation clearance procedure; pre-clearance surveys; reuse of topsoil and habitat elements; erosion and sediment control; weed management; pathogen management and monitoring.

A range of project specific mitigation measures are also proposed to reduce the identified impacts further and to manage specific environmental values within the study area both during and post construction. They include:

- Supplementary habitat provision through the installation of nest boxes.
- Consideration of relocation of *Epacris purpurascens var. purpurascens*.
- A microbat management plan which would include: a bat exclusion and mitigation protocol for bats roosting within culverts or buildings, including pre-construction works, mitigation during construction via timing of works, roost management and bat roost boxes.
- Native vegetation management measures, detailed in a flora and fauna management plan, to prevent development impacts and identify how areas will be rehabilitated with native species include (but are not limited to): associated infrastructure site, the northern interchange, the southern interchange and areas of vegetation adjacent to Hills M2 Motorway integration works area.
- Riparian management measures to minimise the impacts on all riparian vegetation and aquatic environments, including water quality controls and retention of bank stability, as detailed in a flora and fauna management plan.

Residual impacts (the impacts that remain after avoidance and mitigation measures have been implemented) would be offset in accordance with the *NSW offset principles for major projects (state significant development and state significant infrastructure)* (OEH 2013n). Given that new methodology for the assessment of biodiversity offsets and the associated credit calculator had not been finalised at the time of preparation of this report, this technical working paper assessed the type and quantum of

credits which may be required using the BioBanking Assessment Methodology (BBAM) to quantify the impacts of the proposal. These calculations identified the following quantum of offsets for the project:

- Total of 280 ecosystem credits consisting of:
    - Blue Gum High Forest – 163 credits.
    - Coastal Enriched Sandstone Moist Forest / Coastal Enriched Sandstone Dry Forest / Coastal Sandstone Gallery Rainforest – 8 credits.
    - Coastal Shale-Sandstone Forest – 90 credits.
    - Hinterland Sandstone Gully Forest – 19 credits.
    - Sydney Turpentine-Ironbark Forest – to be confirmed as plots and transects could not be conducted
- 1,767 *Epacris purpurascens* var. *purpurascens* credits. The plants that would be impacted appear to have originated from soil seed bank translocation from previous Hills M2 Motorway works (which has proven successful) and a similar approach is proposed for this project.
- 67 credits for the endangered population of the Gang-gang Cockatoo in the Hornsby and Ku-ring-gai local government areas.
- Impacts on culverts with potential roosting habitat, hollow bearing trees, or nest boxes (placed as a mitigation measure for the recent Hills M2 Motorway upgrade works), would be mitigated by the relocation of nest boxes and provision of additional nest boxes such that offsets specific to microbat species would not be required.

It is anticipated that where possible offsets would be delivered via BioBanking Agreement(s), which provide for 'in perpetuity' ecological management of the offsets. Other options for delivery of some offsets may be pursued where BioBanking credits cannot be obtained or are not practicable to meet project or conservation objectives. An offset strategy would be prepared to compensate for the loss of native vegetation, endangered ecological communities and threatened species habitat which cannot be avoided or mitigated.

Native vegetation, in particular Blue Gum High Forest, that would be potentially impacted by the project does not meet EPBC Act condition criteria. Habitat for some threatened flora and fauna species listed under the EPBC Act would be impacted, but these impacts are not considered likely to be significant and it is therefore considered that a referral to the Commonwealth Department of the Environment (DotE) is not required.

1 Introduction

1.1 The project

Roads and Maritime Services (Roads and Maritime), is seeking approval under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate a tolled motorway linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at West Pennant Hills in northern Sydney (the project) (refer to **Figure 1**). The project would be located within the Hornsby, Ku-ring-gai and the Hills local government areas.

Key features of the project would include:

- Twin motorway tunnels up to around nine kilometres in length with two lanes in each direction. The tunnels would be constructed with provision for a possible third lane in each direction if required in the future.
- A northern interchange with the M1 Pacific Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps, which also facilitate access to and from the Pacific Highway.
- A southern interchange with the Hills M2 Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps.
- Integration works with the Hills M2 Motorway including alterations to the eastbound carriageway to accommodate traffic leaving the Hills M2 Motorway to connect to the project travelling northbound, and the provision of a new westbound lane on the Hills M2 Motorway extending through to the Windsor Road off-ramp.
- Tie-in works with the M1 Pacific Motorway extending to the north of Edgeworth David Avenue.
- A motorway operations complex located near the southern interchange on the corner of Eaton Road and Pennant Hills Road that includes operation and maintenance facilities.
- Two emergency smoke extraction outlet points along the main alignment.
- Ancillary facilities for motorway operation, such as electronic tolling facilities, signage, ventilation systems and fire and life safety systems including emergency evacuation infrastructure.
- Modifications to service utilities and associated works at surface roads near the two interchanges and operational ancillary facilities.
- Modifications to local roads, including widening of Eaton Road near the southern interchange and repositioning of the Hewitt Avenue cul-de-sac near the northern interchange.
- Ancillary temporary construction facilities and temporary works to facilitate the construction of the project.

Construction activities would generally include:

- Enabling and temporary works, including construction power, water supply, site establishment, demolition works, property and utility adjustments and public transport modifications (if required).
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure.
- Haulage of spoil generated during tunnelling and excavation activities.
- Fit-out of the road tunnels and support infrastructure, including ventilation and emergency response systems.
- Construction and fit-out of the motorway control centre and ancillary operations buildings.
- Realignment, modification or replacement of surface roads, bridges and/or underpasses.
- Environmental management and pollution control facilities for the project.

Construction of the project is anticipated to commence in early 2015 and is expected to take around four years to complete.

On 18 October 2013, the project was declared by the Minister for Planning and Infrastructure to be State significant infrastructure and critical State significant infrastructure.

The project description depicted in this technical working paper is consistent with the project description within the environmental impact statement and represents the preferred tender design. The project design and construction footprint of the project as assessed within this technical working paper represents the preferred tender design. Sufficient flexibility has been provided in the preferred tender design to allow for refinement during detailed design, or to minimise environmental impacts, or in response to submissions received during the exhibition of the environmental impact statement.

1.2 Purpose of this technical working paper

The Director-General's Requirements (DGRs) for the project were issued on 29 October 2013 (DPI, 2013) and re-issued with amendments on 11 April 2014. The DGRs informed the preparation of the environmental impact statement for the project. The DGRs include the following requirements specific to biodiversity.

Biodiversity – including, but not limited to:

An assessment of the potential ecological impacts of the project, with specific reference to vegetation, habitat clearing, connectivity, edge effects, weed dispersal, bushfire risk, riparian and aquatic habitat impacts and soil and water quality impacts. The assessment must:

- *Make specific reference to impacts on threatened species and endangered ecological communities;*
- *Have reference to the Draft Guidelines for Threatened Species Assessment (DEC/DPI, 2005), Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (DEC), the Guidelines for Aquatic Habitat Management and Fish Conservation (DPI, 1999) and any relevant draft or final recovery plans; and*
- *Include details of any off-set measures that may be required, including demonstration that the measures are consistent with the NSW offset principles for major projects (state significant development and state significant infrastructure) (OEH, 2013).*

This technical working paper has been prepared to directly address the biodiversity requirements of the DGRs and to support the preparation of an environmental impact statement. This technical working paper is primarily focused on the potential impacts on native vegetation, potential impacts on threatened flora and fauna species and fauna habitats associated with the proposed clearing, potential impacts on riparian and aquatic vegetation and habitats, and potential impacts on groundwater dependent ecosystems (GDEs).

1.3 Study aims

The main objective of this technical working paper is to provide sufficient information on the significance of ecological impact to inform the decision making process for this project. More specifically this technical working paper will:

- Address the set requirements of the DGRs (DPI, 2013).
- Describe the existing environment of the study area, focusing on protected and threatened flora and fauna species, populations and ecological communities and their habitats.
- Assess the potential direct and indirect impacts on flora and fauna species, populations and ecological communities.
- Assess the potential direct and indirect impacts on aquatic species and groundwater dependent ecosystems.
- Assess the significance of the potential impacts on threatened species and ecological communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) by following the heads of consideration as outlined in the Draft Guidelines for Threatened Species Assessment (DEC/DPI, 2005), and the Matters of National Environmental Significance- Assessment of Significance Guidelines (DoE, 2013).
- Recommend measures to be implemented to ensure potential impacts are avoided, minimised, mitigated or, if required, offset.

1.4 Study area

The project would be located within The Hills, Hornsby and Ku-ring-gai local government areas about 20 kilometres north-west of the central business district of Sydney. The study area includes existing motorways, residential areas and landscaped areas as well as patches of remnant native vegetation in varying condition and connectivity.

For the purposes of this study, the study area has been divided into a number of sections described below (**Table 1**).

Table 1: Study Area Sections

Site location	Site name
Hills M2 Motorway	Hills M2 Motorway integration works Further divided into (from east to west): • The Hills M2 Motorway integration works 1. • The Hills M2 Motorway integration works 2. • The Hills M2 Motorway integration works 3. • The Hills M2 Motorway integration works 4.
	Southern interchange Further divided into (from north to south): • Southern interchange 1. • Southern interchange 2.
M1 Pacific Motorway	Northern interchange Further divided into (from south to north): • Northern interchange 1. • Northern interchange 2. • Northern interchange 3. • Northern interchange 4.
Ancillary facilities (construction and/or operation)	Windsor Road compound (C1).
	Wilson Road compound (C6).
	Trelawney Street compound (C7).
	Pioneer Avenue compound (C8).

In establishing the study areas, it is noted that:

- The Darling Mills Creek compound (C2), Barclay Road compound (C3) and the Yale Close compound (C4) are located within Hills M2 Motorway integration works study area 3 and Hills M2 Motorway integration works study area 4.
- The southern interchange compound (C5) as well as the motorway operations complex and associated ancillary facilities (such as the southern ventilation facility and operational water treatment plant) are located in the southern interchange 1 and southern interchange 2 study areas.
- The northern interchange compound (C9) is located in the northern interchange study area 1.
- The Bareena Avenue compound (C10) / northern ventilation facility are located within the northern interchange 3 study area.
- The Junction Road compound (C11) is located within the northern interchange 3 and northern interchange 4 study area.

The M1 Pacific Motorway

The M1 Pacific Motorway study area starts around one kilometre north of the junction of Junction Road and M1 Pacific Motorway. The study area continues south following the M1 Pacific Motorway and crosses the Pacific Highway, ending around 500 metres south from the junction of M1 Pacific Motorway and Pennant Hills Road (as known as the Cumberland Highway). The study area encompasses vegetated land adjacent to the M1 Pacific Motorway and residential areas (**Figure 1**).

Hills M2 Motorway

The Hills M2 Motorway is located between the Pennant Hills interchange to the east and the Windsor Road interchange to the west. The study area is divided into two main sections; southern interchange and the Hills M2 Motorway integration works (**Figure 1**).The southern interchange study area is focused around the Pennant Hills Road interchange. It expands out from the intersection along the two roads around 600 metres north, 800 metres east, 300 metres south and 1.2 kilometres west. The Hills M2 Motorway integration works study area extends around three kilometres west of the southern interchange and ends approximately 500 metres east of the Windsor Road interchange.

Ancillary facilities

A number of smaller areas are included in the overall study area; these would contain ancillary facilities such as construction ancillary sites and tunnel support facilities (**Figure 1**). These areas are:

- Windsor Road compound (construction only).
- Wilson Road compound / Wilson Road tunnel support facility.
- Trelawney Street compound / Trelawney Street tunnel support facility.
- Pioneer Avenue compound (construction only).

The project includes additional ancillary facilities associated with construction and / or operation stages of the project. Given the proximity of the facilities to the northern or southern interchange, these facilities have been incorporated into those relevant study areas.

1.4.1 Construction footprint

The study area encompasses the construction footprint which is the area proposed to be impacted, cleared and/or disturbed during the construction of the project (refer to **Figure 2**).

The construction footprint represents the area that would be physically impacted by construction works, including all construction ancillary infrastructures, whereas the operational footprint for the project represents the area that would be physically impacted by the operation of the project, including all operational ancillary infrastructure. The footprints include both above ground and underground elements of the project.

The operational footprint is fully contained within the construction footprint of the project, and in some areas, has a reduced footprint. For example, the ancillary construction compound at the northern interchange would be rehabilitated and landscaped upon completion of construction.

For the purposes of this technical working paper, the construction footprint of the project has been used for impact assessment purposes, as the operational footprint sites are within the construction footprint.

The assessment assumed complete vegetation clearance within the construction footprint and impacts were assessed accordingly. Realistically total clearance would not be required, however given that the final detailed design is yet to be finalised, and clearance was assumed to ensure ecological impacts complied with regulatory requirement including the precautionary principle (EP&A Act).

No vegetation clearance was assumed within the remaining areas of the study area not covered by the construction footprint.

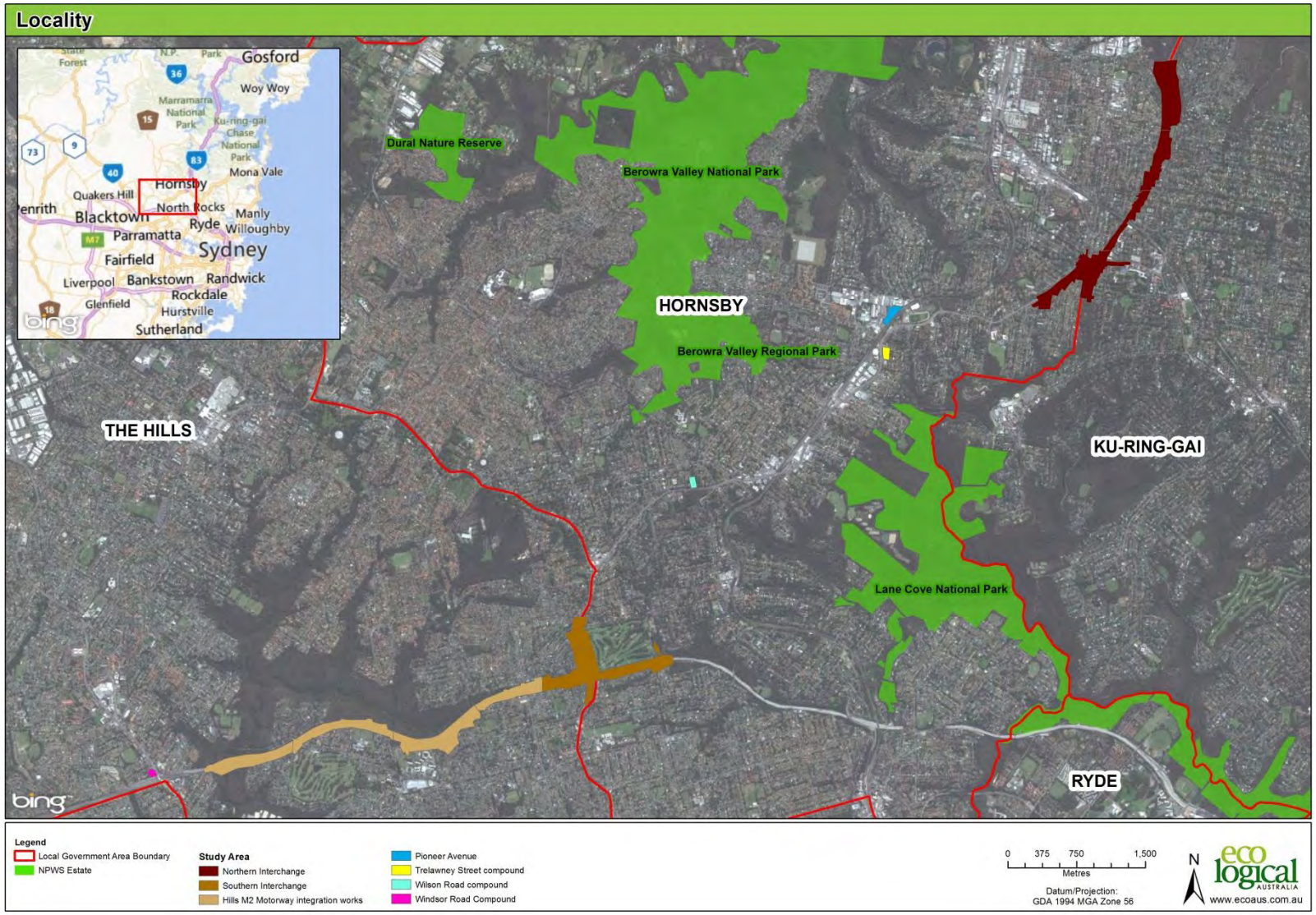

Figure 1: Locality

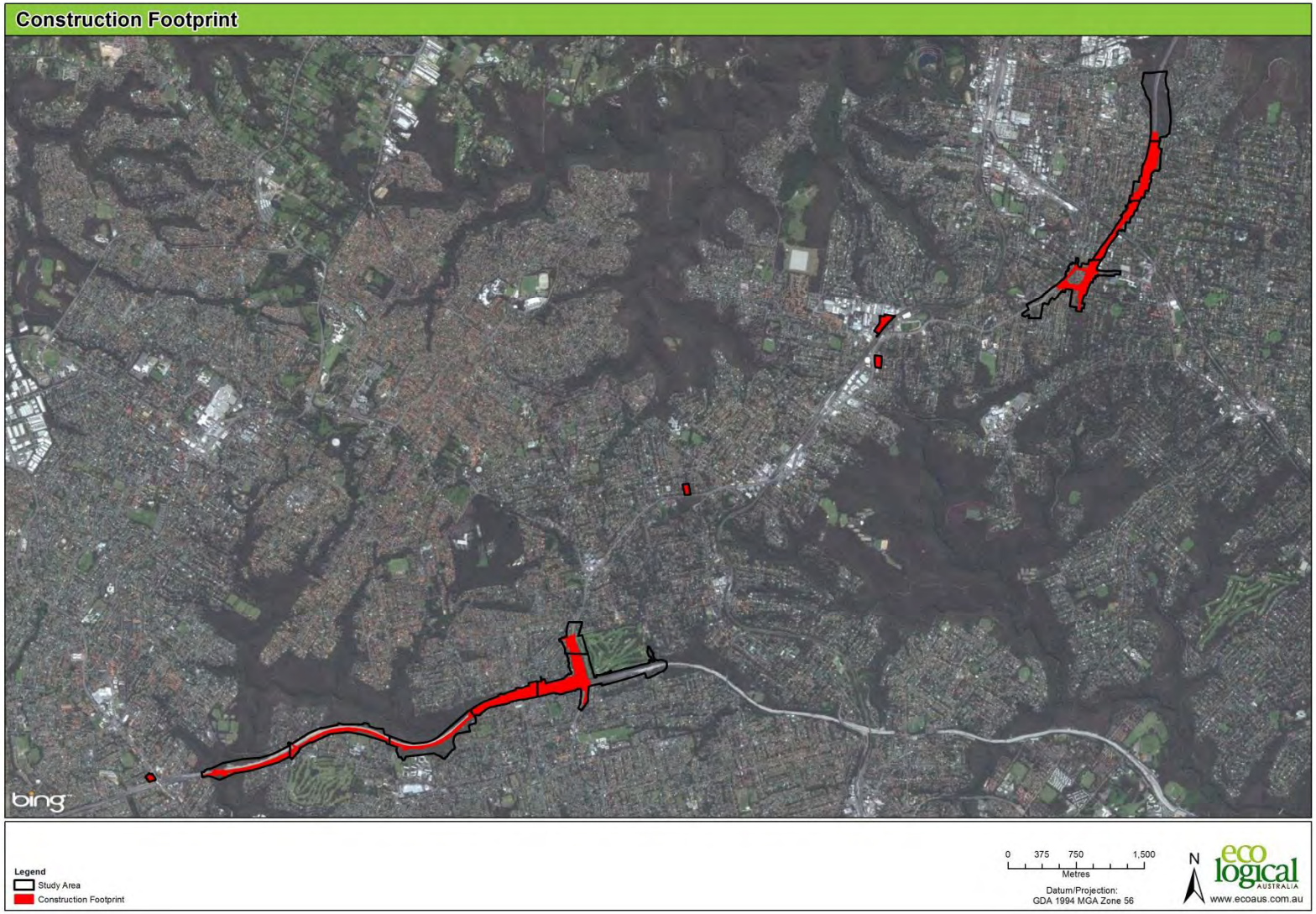

Figure 2: The construction footprint

1.5 Legislative context

Commonwealth and State legislation and policies apply to the assessment, planning and management of biodiversity issues within NSW. The following are relevant for the assessment of the project:

- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).
- *NSW Environmental Planning and Assessment Act 1979.*
- *NSW Threatened Species Conservation Act 1995.*
- *NSW Noxious Weeds Act 1993*.

The following legislation does not apply to this biodiversity impact assessment but has been considered:

- *NSW National Parks and Wildlife Act 1974.*
- *NSW Protection of Environment Operations Act 1997.*
- *Native Vegetation Act 2003.*
- *Fisheries Management Act 1994.*
- *NSW Water Management Act 2000.*

Section 115ZF of the EP&A Act excludes the application of environmental planning instruments to State significant infrastructure projects except as they may apply to the declaration of infrastructure as State significant infrastructure or critical State significant infrastructure. However, the provisions of the following relevant State Environmental Planning Policies to this biodiversity impact assessment have also been considered:

- *State Environmental Planning Policy No.19 – Bushland in Urban Areas.*
- *State Environmental Planning Policy No.44 – Koala Habitat Protection.*

The following sections provide an outline of abovementioned legislation and policies, and how the requirements of the legislation or policies have been considered in this assessment.

1.5.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects matters of National Environmental Significance (MNES) such as threatened species and ecological communities, migratory species (protected under international agreements China-Australia Migratory Bird Agreements (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and Republic of Korea-Australia Migratory Bird Agreement (RoKAMBA)) and National Heritage places (among others). Any actions that will, or are likely to have, a significant impact on matters of NES requires referral and approval from the Australian Government Minister for Environment. Significant impacts are defined by the Commonwealth for matters of NES.

Matters of National Environmental Significance (MNES) that have been identified on or near the study area have been considered in this technical working paper.

1.5.2 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) provide the framework for environmental planning in NSW and include provisions to ensure that proposals that have the potential to impact on the environment are subject to assessment.

The project is permissible without consent under clause 94(1) of the *Environmental Planning Policy (Infrastructure) 2007* which states that development for the purpose of a road or road infrastructure facilities may be carried out by or on behalf of a public authority without consent on any land.

On 25 October 2013, the project was declared, by Ministerial Order, to be State significant infrastructure and critical State significant infrastructure under sections 115U (4) and 115V of the EP&A Act. When declaring the project to be State significant infrastructure and critical State significant infrastructure, the Ministerial Order amended Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011*. As such, Roads and Maritime is seeking approval for the project under Part 5.1 of the *Environmental Planning and Assessment Act 1979*.

The Director-General's environmental assessment requirements (DGRs) for the project were issued on 29 October 2013 and re-issued with amendments on 11 April 2014. The relevant DGRs for biodiversity are listed below.

Biodiversity – including, but not limited to:

An assessment of the potential ecological impacts of the project, with specific reference to vegetation and habitat clearing, connectivity, edge effects, weed dispersal, bushfire risk, riparian and aquatic habitat impacts and soil and water quality impacts. The assessment must:

- *make specific reference to impacts on threatened species and endangered ecological communities*
- *have reference to the Draft Guidelines for Threatened Species Assessment (DEC/DPI, 2005), Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (DEC), the Guidelines for Aquatic Habitat Management and Fish Conservation (DPI, 1999) and any relevant draft or final recovery plans*
- *include details of any offset measures that may be required, including demonstration that the measures are consistent with the NSW offset principles for major projects (state significant development and state significant infrastructure) (OEH, 2013).*

The DGRs relevant to biodiversity have been addressed in this document. However, the Guidelines for Aquatic Habitat Management and Fish Conservation (DPI, 1999) have been replaced by Policy and guidelines for fish habitat conservation and management Update 2013 (DPI, 2013). The more recent policy has been considered in this assessment.

1.5.3 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) lists and protects threatened species, populations and ecological communities that are under threat of extinction in NSW. The NSW Office of Environment and Heritage (OEH) is responsible for administering the TSC Act.

Section 5A of the EP&A Act outlines factors that must be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats as a result of a proposed development or activity. This is commonly referred to as the '7-part test'. This determines if a Species Impact Statement (SIS) is required under section 94 of the TSC Act when seeking approval for a proposed development or activity.

Section 5A of the EP&A Act does not refer to Part 5.1 of the EP&A Act, and as such, does not apply to projects that are subject to Part 5.1 of the EP&A Act. Instead, the DGRs have specified that the assessments for threatened species, populations or communities listed under the TSC Act refer to the *Draft Guidelines for Threatened Species Assessment* (DEC/DPI, 2005), *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004), and the *Guidelines for Aquatic Habitat Management and Fish Conservation* (DPI, 1999). The conclusions of the significance assessments undertaken in accordance with the DGRs are used to determine the level of significance of impact; but they do not determine the need for a SIS.

1.5.4 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act) provides for the identification, classification and control of noxious weeds with the aim of reducing the negative impact of weeds on the economy, community and environment. It establishes control mechanism to prevent, eliminate and restrict the spread of weeds and effectively manage widespread weeds in NSW. The NSW Act is relevant during assessment and through the course of construction and operation of the project.

1.5.5 National Parks and Wildlife Act 1974

The National Parks and Wildlife Act 1974 (NPW Act) is administered by the Director-General of the National Parks and Wildlife Service (part of the Office of Environment and Heritage), who is responsible for the control and management of all national parks, historic sites, nature reserves and Aboriginal areas (among others). The main aim of the NPW Act is to conserve the natural and cultural heritage of NSW. A breach of the NPW Act is a criminal offence which carries heavy penalties.

The proposed development is not within a National Park and therefore a permit under the NPW Act is not required.

1.5.6 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes a regulatory framework for environment protection. This includes a licencing requirement for certain activities. An environment protection licence would be required for the project as it meets the definition of a scheduled activity under the POEO Act.

1.5.7 Native Vegetation Act 2003

The *Native Vegetation Act 2003* aims to encourage and promote the management of native vegetation within NSW. Clause 115ZG of the EP&A Act states that an authorisation under section 12 of the *Native Vegetation Act 2003* to clear native vegetation or State protected land is not required for approved State significant infrastructure.

1.5.8 Fisheries Management Act 1994

Section 115ZG of the EP&A Act states that permits under section 201, 205 or 219 of the *Fisheries Management Act 1994* do not apply to State significant infrastructure. These permits relate to dredging work, harm to marine vegetation and blocking of fish passage. However, potential impacts on freshwater aquatic environments have been considered in this assessment.

1.5.9 Water Management Act 2000

The *Water Management Act 2000* (WM Act) objective is to manage NSW water in a sustainable and integrated manner that will benefit today's generations without compromising future generations' ability to meet their needs. The WM Act is administered by NSW Office of Water (NOW).

Approvals under section 89 (water use approval), section 90 (water management work) and section 91 (activity approval, except for aquifer interference) of the WM Act do not apply to State significant infrastructure by virtue of section 115ZG of the EP&A Act. Further, the need for aquifer interference approvals has not yet commenced under the WM Act.

Nonetheless, this assessment has considered the potential impacts on water quality, riparian areas and groundwater dependent ecosystems (GDEs) as a result of the construction and operation of the project. Further, alteration of native riparian vegetation and natural flow regimes are listed as key threatening processes under the TSC Act.

1.5.10 State Environmental Planning Policy 19 – Bushland in Urban Areas

State Environmental Planning Policy No 19 – Bushland in Urban Areas (SEPP 19) aims to protect and preserve bushland within urban areas for its natural heritage, aesthetic, recreational, educational and scientific values. SEPP 19 applies to all bushland within the Sydney Metropolitan Area which is zoned or reserved for public open space. Bushland for the purposes of SEPP 19 is defined as vegetation that is either a remainder of the natural vegetation of the land or, if altered, is still representative of the structure and floristics of the natural vegetation.

Under this policy, a person shall not disturb bushland zoned or reserved for public open space purposes without the consent of the local council. This does not apply to the disturbance of bushland where it is being disturbed for the purposes of constructing or maintaining main roads by virtue of clause 6(2) of SEPP 19. However, under clause 7 of the SEPP 19, a public authority must not disturb bushland for a purpose listed under clause 6(2) unless it has first had regard to the aims of this policy.

SEPP 19 also applies to development on land which adjoins bushland zoned or reserved for public open space purposes unless the consent authority or a public authority proposing to carry out the development has given consideration to matters such as impacts of clearing on soil erosion, siltation of waterways and the spread of weeds and exotic plants within the bushland.

A small area of around 700 square metres to the west of Oakes Road in the Hills M2 Motorway integration works is zoned RE1 Public Recreation under the *Hills Local Environmental Plan 2012*. This area is within the road reserve for the Hills M2 Motorway and contains stormwater infrastructure.

A park located off Lisle Court and Savoy Court in West Pennant Hills which is approximately 0.47 hectares, and is also zoned RE1 Public Recreation under the *Hills Local Environmental Plan 2012*. This area contains native vegetation, and is within the southern interchange area.

There are also a number of areas zoned for open space purposes that are located adjacent to the construction footprint that contain or are likely to contain bushland for the purposes of SEPP 19. These include Bidjigal Reserve and Carrington Park in North Wahroonga.

The potential indirect impacts on adjoining stands of native vegetation as a result of construction activities associated with the project have been assessed in this technical working paper.

1.5.11 State Environmental Planning Policy 44 – Koala Habitat Protection

State Environmental Planning Policy 44 – Koala Habitat Protection (SEPP 44) aims to encourage the conservation and management of areas of natural vegetation that provide habitat for koalas. This identifies matters that must be considered by a consent authority when determining a development application under Part 4 of the EP&A Act for certain development within specified local government areas. This includes the consideration of presence or otherwise of potential koala habitat and core koala habitat. This policy applies to the Hornsby and Ku-ring-gai local government areas.

The project is not a development application and therefore SEPP 44 does not apply. Nevertheless, the potential for the koala (listed as a threatened species) to occur within the study area has been assessed in this technical working paper.

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2 Methodology

2.1 Personnel

This assessment was carried out by appropriately qualified and experienced ecologists and environmental professionals as demonstrated in **Table 2**.

Table 2: Personnel and qualifications

Name	Role	Qualifications
Mark Adams	Project Director	Bachelor Of Science (Resources and Environmental Management) ANU, 1994 Masters of Environmental Law, ANU, 2003
Dr Steven Ward	Project Manager	Ph.D., University of Western Sydney, 2002 Honours, University of Wollongong, 1999 BSc (Botany / Zoology), University of Western Australia, 1987
Rob Mezzatesta	GIS and project support	Master Of Environmental Planning, Graduate School of the Environment, Macquarie University, 1997 Bachelor of Science, University Of New South Wales, 1987 (Geography)
Robert Humphries	Offsets	Bachelor of Applied Science, Ballarat C.A.E 1983-85. Master of Applied Science (Research) University of Ballarat 1986-89.
Dr Peter Hancock	GDE assessment	Bachelor of Natural Resources, Freshwater Ecology - University of New England PhD, Hyporheic Ecology - University of New England
Dr Meredith Henderson	Ecology assessment	PhD, Victoria University, Melbourne. BSc (Hons), University of Wollongong.
Ryan Smithers	Quality Assurance	BEnvSc (Hons) (Land Resources Management), University of Wollongong
Will Introna	Ecology assessment	Master of Science, University of Technology, Sydney Bachelor of Arts (Languages) (Hons), University of Sydney, Bachelor of Science (Environmental Biology), University of Technology
Ian Dixon	Aquatic Assessment	AUSRIVAS Accreditation (Australian River Assessment System), 2011 Master of Tropical Environmental Management, Charles Darwin University, 2006 Graduate Diploma of Tropical Environmental Management, Charles Darwin University, 2001 Bachelor of Landscape Architecture, 1999
Danielle Bennett-Adams	Ecology assessment	Bachelor of Animal Science- Major in Wildlife Studies, University Of Western Sydney, 2007

Name	Role	Qualifications
Kristina Rajkovic	Report writing	Bachelor of Science (Hons) in Environmental Forensics, University of Technology Sydney, 2011 Diploma in Business Management, NSW TAFE, 2007
Katrina Cousins	Report writing	Bachelor of Science (Hons) Resource and Environmental Management, Australian National University
Jo Daly	GIS	Bachelor of Environmental Science (Hons) Attended BioBanking Assessor Accreditation training Course
Bec South	Formatting	Graduate Certificate in Commerce, Charles Stuart University

2.2 Assessment Guidelines

The assessment presented in this technical working paper was undertaken in accordance with the survey guidelines specified by the DGRs. Updated versions of the guidelines were used if available and were confirmed with Department of Planning and Environment. These include:

- Draft Guidelines for Threatened Species Assessment (DEC/DPI 2005).
- Policy and guidelines for fish habitat conservation and management (update 2013). This guideline supersedes the Guidelines for Aquatic Habitat Management and Fish Conservation (DPI, 1999).
- EPBC Act Environmental Offsets Policy (DSEWPaC 2012a).
- NSW offset principles for major projects (State significant development and State significant infrastructure) (OEH 2013n).

2.3 Database searches

ELA reviewed aerial photography as well as the following vegetation and soil datasets which overlap within the study area:

- Hornsby Shire Council vegetation mapping (Smith and Smith 2008).
- Western Sydney vegetation mapping (NSW National Parks and Wildlife Service (NPWS) 2002).
- Sydney Metropolitan Catchment Management Authority vegetation mapping (DECCW 2009).
- Southeast NSW Native Vegetation Classification and Mapping – SCIVI (NSW Department of Environment and Conservation, and NSW Department of Natural Resources, 2006).
- Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman and Murphy 1989).

The following threatened species and predicted species databases were reviewed for the locality:

- NPWS Atlas of NSW Wildlife (10 kilometre radius search) (OEH 2013a).
- EPBC Act Protected Matters Search Tool (10 kilometre radius search) (DSEWPaC 2014).
- Fisheries NSW Threatened & Protected Species – Records Viewer (search within The Hills, Hornsby, Ku-ring-gai, Parramatta and Ryde local government areas) (I&I NSW 2014).

The ten kilometre radius meets the minimum search area requirements outlined in the Roads and Maritime guideline. Searches were undertaken for threatened species listed under State and

Commonwealth legislation, migratory and marine species as well as species under international agreements. A full list of flora and fauna species identified from the database searches is presented in **Appendix A**.

To determine if any known groundwater dependent ecosystems (GDEs) occur in the study area, a search was made of the National Atlas of Groundwater Dependent Ecosystems (Bureau of Meteorology, accessed 16 December 2013).

2.3.1 Vegetation mapping

All vegetation mapping products have limitations. For example, different approaches to vegetation condition may be utilised depending on the purpose of the mapping product. NPWS (2002) mapping includes vegetation which may comprise remnant trees within urban areas such as street trees, or which is otherwise highly disturbed. The different approaches by different mapping products mean that different vegetation communities can be mapped as occurring at the same location. In this context, a brief review of the vegetation mapping datasets referred to in this assessment is provided below.

Mapping for Hornsby local government area (Smith and Smith 2008) provides detailed and recently validated vegetation mapping. However this mapping is primarily limited to areas of intact native vegetation and does not attempt to map fragmented vegetation located within urban areas, such as that which occurs within the study area of this assessment. Smith and Smith (2008) cover much of the northern study area but only limited parts of the southern extent of the study area.

The Western Sydney vegetation mapping (NPWS 2002b) and Sydney Metropolitan Catchment Management Authority vegetation mapping (DECCW 2009) are map portions of the Sydney region and their accuracy at a site specific level is likely to be less than the Smith and Smith (2008) mapping. NPWS (2002) covers the full extent of the study area; however some areas which have been cleared for infrastructure and development are mapped as native vegetation. NPWS (2002) did not map vegetation within most of the gullies within the study area. DECCW (2009) covers both ridge tops and gullies however; there are some attribution errors for some listed vegetation communities types, specifically where vegetation is mapped along riparian corridors. DECCW (2009) does not cover those parts of the study area north of the Pacific Highway. Both projects have identified fragmented patches of Blue Gum High Forest throughout the study area.

The Southeast NSW Native Vegetation Classification and Mapping (SCIVI) dataset (NSW Dept. of Environment and Conservation, and NSW Department of Natural Resources, 2006) is a regional-scale mapping product from Sydney south to the Victorian border. The SCIVI datasets utilises a number of existing larger scale vegetation mapping products i.e. NPWS (2002). A key limitation of the SCIVI dataset in the context of this assessment is the positional accuracy of vegetation boundaries, which is estimated to be generally 20 to 50 metres.

For the purposes of scoping the field survey and the indicative number of vegetation plots required for this assessment, DECCW (2009) has been used. Where DECCW (2009) did not cover vegetation within the study area, mapping conducted by Smith and Smith (2012) and NSW NPWS (2002) was used.

2.3.2 Threatened flora search

A total of 68 threatened flora species and one endangered flora population were recorded within a ten kilometre radius search of the study area (**Appendix A**). A desktop review was undertaken to assess the likelihood of occurrence for each species within the project area based on flora record location, date of last recording and habitat association.

- "Known" = the species was or has been observed on the site.
- "Likely" = a medium to high probability that a species uses the site
- "Potential" = suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur.
- "Unlikely" = a very low to low probability that a species uses the site.
- "No" = habitat on site and in the vicinity is unsuitable for the species.

This criteria assessment was used to generate a likelihood of occurrence table for field surveys (refer to **Appendix A**). It is noted that field surveys may identify additional species or suitable habitat for threatened species or confirm that habitat for certain species is not present within the study area. The surveys are discussed in **section 2.5** and **section 4**. The field surveys resulted in a number of species being excluded because of a lack of suitable habitat in the study area (refer to **Appendix A**) and the inclusion of one species thought to be unlikely to occur in the study area, which was *Hibbertia superans*.

2.3.3 Threatened fauna search

Database records identified 120 threatened or migratory fauna species recorded within a ten kilometre radius of the study area. This includes ten faunal groups consisting of six amphibians, 37 diurnal birds, five nocturnal birds, ten non-flying mammals nine flying mammals, one invertebrate, three fish, 47 migratory species and one endangered bird population (see **Appendix A** for the likelihood of occurrence table). A desktop review was undertaken to assess the likelihood of occurrence of each species within the study area based on record location, date of last recording and habitat association. The criteria to assess the likelihood of occurrence were the same as for threatened flora.

No threatened fish species have been recorded within the catchments of the study area (I&I NSW 2014). Threatened fish and macroinvertebrates listed under the NSW *Fisheries Management Act 1994* and EPBC Act were also considered unlikely to occur in the creeks downstream of the study area.

A threatened fauna species list was generated for habitat assessment surveys (refer to **section 4**).

2.4 Literature review

A number of previous reports and studies as well as other relevant literature were reviewed, including:

- F3-M2 State significant infrastructure application report (Roads and Maritime, 2013).
- F3 to Sydney Orbital Link Study Main Report (SKM, 2004) and Technical Paper Number 4
- M3 Ecological Services, Preliminary Assessment (ELA, 2013a).
- Results of Ecological Survey for F3 – M2 (ELA, 2013b).
- M2 Upgrade Environmental Assessment – Technical Paper 3 Flora and Fauna Report (AECOM, 2010).
- M2 Upgrade Project, Microchiropteran Bat Survey Report (Cumberland Ecology, 2011).
- *Epacris purpurascens* var. *purpurascens* survey results (Cumberland Ecology, 2012).
- North Wahroonga B2-B3 corridor – Flora and Fauna Assessment (ELA, 2012b).

2.4.1 F3-M2 State significant infrastructure application report (Roads and Maritime, 2013)

The State significant infrastructure (SSI) application report has been prepared to identify potential environmental constraints relating to the project. At the time of that report, the project was referred to as the F3-M2. The report and the DGRs are intended to inform the detailed environmental impact assessment for the project. The application report has flagged that biodiversity is one of the main environmental concerns. Biodiversity concerns relate to:

- Vegetation communities
    - Blue Gum High Forest
    - Shale/Sandstone Transition Forest
    - Turpentine-Ironbark Forest
    - Western Sydney Dry Rainforest and Moist Woodland.
- Migratory species (47 bird species, five turtle species, and one shark species) which have been identified within ten kilometres of the study area.
- Listed flora species considered to have potential to occur within the study area:
    - *Darwinia biflora*
    - *Epacris purpurascens* subsp. *purpurascens*
    - *Eucalyptus camfieldii*
    - *Genoplesium baueri*
    - *Lasiopetalum joyceae*
    - *Persoonia hirsuta*
    - *Tetratheca glandulosa*.
- Listed fauna species considered to have potential to occur within the study area:
    - *Callocephalon fimbriatum* (Gang Gang Cockatoo)
    - *Calyptorhynchus lathami* (Glossy Black-Cockatoo)
    - *Chalinolobus dwyeri* (Large-eared Pied Bat)
    - *Miniopterus schreibersii oceanensis* (Eastern Bent-wing Bat)
    - *Ninox strenua* (Powerful Owl)
    - *Pseudophryne australis* (Red-crowned Toadlet)
    - *Pteropus poliocephalus* (Grey-headed Flying Fox)
    - *Saccolaimus flaviventris* (Yellow-bellied Sheathtail-bat).

The SSI application report stated that the presence of groundwater dependent ecosystems (GDEs) would be confirmed as part of any future environmental assessment. The presence of GDEs and potential impacts are assessed as part of this technical working paper.

No major local or regional fauna corridors are present within the project corridor, primarily due to the fragmented nature of remnant native vegetation in the area.

2.4.2 Preliminary Assessment (ELA, 2013a)

An initial desktop assessment was undertaken by ELA of the study area defined at that time. The assessment outlined reviews of relevant literature, results of database searches and vegetation mapping, identified key potential ecological constraints and proposed a methodology for initial flora and fauna surveys for the project. The project area was divided into the following sections:

- Site 1 – Carrington Road Wahroonga to Jasmine Road Normanhurst (now part of the northern interchange study area).
- Site 2 – Brickpit and Kenley Park Thornleigh.
- Site 3 – Aiken Road – Hills M2 Motorway North Rocks (now part of the southern interchange study area).

Results of this preliminary study have been used in this technical working paper.

2.4.3 Results of Ecological Survey (ELA 2013b)

This letter report presented the results of a preliminary ecological survey within the potential footprint for the project (referred to as F3 – M2 project in the letter report). The letter report lists potential threatened species and communities that could occur within parts of the study area, and was used to inform the tendering process for the project. These have been included in the likelihood table in **Appendix A**.

2.4.4 M2 Motorway Upgrade Ecological Assessment, Technical Paper 3 (AECOM 2010)

The M2 Motorway Upgrade study area extended from Windsor Road in the west to Lane Cove Road in the east. The Ecological Assessment included both flora and fauna and aquatic and riparian impact assessment. The study area for this report was broader in length, and included the Hills M2 Motorway assessed in this study. The findings relevant included:

- The waterways in the vicinity of the study area are degraded as a result of a number of factors including increased erosion due to the concentration of stormwater flows, weed invasion and polluted catchment runoff.
- Native aquatic submerged and emergent vegetation is not abundant within the creeks of the study area. This is likely to be as a result of the chiefly rocky substrate found here, high water velocity during heavy rainfall and competition from introduced species. The only commonly encountered native aquatic plants were Bull Rush (*Typha orientalis*) and knotweeds (*Persicaria* spp.), which were found in small patches along the creeks and primarily in disturbed areas.
- The detention basins within the M2 Upgrade corridor contained an artificial assemblage of emergent native aquatic plants including *Eleocharis sphacelata*, Marsh Club-rush (*Bolboschoenus fluviatilis*) and Jointed Twig-rush (*Baumea articulata*), which were planted when the basins where constructed. No assemblages of native aquatic plants were found that could be described as native vegetation communities.
- The presence of exotic fish species (such as *Gambusia holbrooki*).

- A variety of disturbance tolerant frog species (for example, Striped Marsh Frog (*Limnodynastes peronii*), Common Eastern Froglet (*Crinia signifera*), Eastern Dwarf Tree-frog (*Litoria fallax*), Green Stream Frog (*Litoria phyllochroa*) and Peron's Tree Frog (*Litoria peronii*).
- Large and medium-sized tree hollows particularly in mature Blackbutt (*Eucalyptus pilularis*) within the lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material.
- The bushland of the Darling Mills Creek corridor, adjacent to Bidjigal Reserve and Baulkham Hills Park is considered to be the most significant regional habitat link with Berowra Valley National Park in Hornsby and further on to Ku-ring-gai Chase National Park and Brisbane Waters (Upper Parramatta River Catchment Trust, 1999).
- The Sandstone Riparian Scrub vegetation type occurs along creeks within and adjacent to the M2 Upgrade corridor with the most intact occurrences at Darling Mills Creek. Much of this vegetation is highly modified as a result of alteration to natural flow regimes, increased nutrients and especially weed invasion.
- The section of Darling Mills Creek crossed by the M2 Upgrade corridor appears to be in moderate condition with low turbidity, little evidence of sedimentation, and a low level of weed invasion with minimal to moderate fish habitat (**Table 3**). Using a more recent classification scheme for fish habitat (Fairfull 2013), Darling Mills Creek is classed as Type 1 (highly sensitive key fish habitat). The upper reaches and tributaries (Stevenson Creek and Blue Gum Creek) are not classed as key fish habitat. This drainage line is likely to provide habitat for a range of native species such as Short and Long finned eel (both protected in NSW) and a range of Gudgeon fish species and the Eastern snake-necked Tortoise (*Chelodina longicollis*).
- Prior to the 1980s the Platypus (*Ornithorhynchus anatinus*) was regularly observed within Darling Mills Creek in Bidjigal Reserve but has not been seen in recent times. The Water Rat (*Hydromys chrysogaster*) has previously been recorded and may still occur in the waterways of the study area.

Table 3: Classification of creeks for fish habitat along the Hills M2 Motorway

Classification	Key fish habitat type	Characterisation of waterway type	Creek
Class 2 – Moderate Fish Habitat	Type 1 (highly sensitive key fish habitat)	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.	Darling Mills Creek
Class 3 – Minimal Fish Habitat	Not a key fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (for example, fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Blue Gum Creek, Devlins Creek and Terry Creek

Classification based on: Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Source: AECOM, 2010 Key fish habitat type based on Fairfull, S. (2013) Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update).

2.4.5 M2 Upgrade Project, Microchiropteran Bat Survey Report (Cumberland Ecology 2011)

Cumberland Ecology contracted by Leighton Contractors Pty Ltd conducted a microbat survey to satisfy the Minister's Conditions of Approval relating to the surveying and translocation of microbats detected within the impacted areas along the M2 Upgrade.

A total of 17 bridge or culvert sites that may be affected by the M2 Upgrade were identified as containing potential habitat for threatened microbats. Anabat analysis recorded several bat species in the vicinity of the southern interchange, three of which are listed as vulnerable under the TSC Act, namely:

- *Miniopterus schreibersii oceanensis* (Eastern Bent-wing Bat).
- *Saccolaimus flaviventris* (Yellow-bellied Sheathtail Bat).
- *Falsistrellus tasmaniensis* (Eastern False Pipistrelle).

2.4.6 *Epacris purpurascens* var. *purpurascens* survey results (Cumberland Ecology 2012)

The report details the number, location and size of the current sub-populations of a threatened plant species *E. purpurascens* var. *purpurascens,* located within the Hills M2 Motorway. The report has identified approximately six locations within the Hills M2 Motorway where numerous individuals of *E. purpurascens* var. *purpurascens* were recorded.

2.4.7 North Wahroonga B2–B3 corridor – Flora and Fauna report (ELA 2012b)

ELA was engaged by the Office of Strategic Lands (OSL) to update previous flora and fauna studies of the B2/B3 Corridor North. This project covered a small part of the southern area of northern interchange study area.

Vegetation mapped within northern interchange study area included Blue Gum High Forest in a highly disturbed condition. No hollow bearing trees were recorded within the small part of the southern area of the northern interchange. Anabat survey results confirmed the presence of one threatened species listed under the TSC Act *Miniopterus schreibersii oceanensis* (Eastern Bent-wing Bat) and a possible recording of *Chalinolobus dwyeri* (Large-eared Pied Bat) listed as vulnerable under the EPBC Act.

2.5 Field survey for this assessment

ELA employed a series of field survey methods to undertake the field assessment of the biodiversity values of the study area for this report. The surveys conducted considered the relevant survey guidelines for species. Survey periods for this assessment also did not align with seasonality for a number of species. In a number of instances data from previous surveys had been utilised to build on ecological information to inform this assessment. These are identified in **section 2.4**. If information was not available on whether or not threatened species occurred within the study area, then a precautionary approach was adopted, whereby the presence of the species was assumed. This approach is consistent with the DGRs and relevant impact assessment guidelines.

The methods used, and rationale behind their selection, are described below:

- Assessment of vegetation mapping according to DECCW (2009): verification of vegetation communities occurring within the study area to confirm the presence of natural vegetation communities including presence of threatened ecological communities. Where the study site was not covered by this vegetation mapping, other mapping sources were used (NPWS 2002b). Once vegetation communities were identified from a combination of floristic surveys and transect traverses, biometric vegetation types (BVT) were assigned to vegetation mapping units from the published BVT for each CMA. This was done by comparing the dominant canopy species recorded through the traverses or floristic surveys, the general description of location, soil type and other attributes as described in the profiles (DECCW 2009) and BVT database (OEH 2013m).
- Vegetation polygons were assigned to a condition class: poor, moderate or good.
    - Poor condition vegetation had predominantly exotic species in the mid storey and ground cover layers, with very few native species in any stratum.
    - Moderate condition vegetation had predominantly native species in the mid storey and ground cover layers but had some exotic incursions.
    - Good condition sites had very few exotic species in any stratum and were predominantly native and species diverse.
- Floristic surveys (20 metres by 20 metres quadrats): targeted survey to identify flora species within the vegetation communities which were identified through inspection of existing mapping. These surveys are conducted in conjunction with BioBanking plots to determine the number of native species in each plot and to further confirm identity of vegetation communities by comparing characteristic species. This method meets the minimum required as per DEC (2004) survey guidelines. Where a 20 metres by 20 metres quadrat could not fit into a heterogeneous patch of vegetation, e.g. along a creek, 40 metres by 10 metres quadrats were used. Quadrats of these dimensions were required at one site on the southern side of the Hills M2 Motorway integration works area.

- Random meander survey technique (Cropper 1993) for threatened flora species: targeted searches for threatened species potentially occurring in the study area with focus on *Epacris purpurascens* var. *purpurascens*. This is because this species had the highest probability of occurrence or is known from within the study area. While conducting the random meander, an additional threatened plant was found in the study area at the Hills M2 Motorway integration works area. When threatened species were encountered, an estimation of population size was undertaken and locations were marked using a hand held GPS. This technique is used in preference to systematic, plot based surveys when attempting to detect threatened plants. Random meander in suitable habitat is more likely to detect threatened species than plot or transect based survey used in floristic surveys. This technique is considered preferable in terms of searching large areas of potential habitat and generally allows for greater area coverage than a plot based survey.

- BioBanking plots and vegetation mapping: condition assessment and mapping of vegetation within the study area using the BioBanking methodology. This technique maps vegetation types and condition states using a method which enables a quantitative assessment of impacts and appropriate offsets. These plots were undertaken in accordance with the BioBanking methodology.

- Opportunistic sightings of fauna: identification of faunal species occurring within the study area. The fauna surveys undertaken by ELA consisted of opportunistic sightings whilst conducting other surveys i.e. targeted flora surveys, random meanders and transects. Evidence of fauna usage was noted, for example diggings, chewed plant cones, scats. No targeted fauna surveys were undertaken.

- Fauna habitat assessments identifying potential habitat for threatened fauna species, including marking of habitat features ie. culverts, disused buildings, rock habitats and foraging substrates, presence of termite mounds and presence of hollow bearing trees and coarse woody debris were recorded as part of the BioBanking plots. In the absence of fauna surveys, habitat assessments identify important habitat features that may provide potential habitat for threatened fauna. Where culverts were encountered, they were inspected using torches and checking cracks and other features to determine if threatened bats were present and whether the culverts contained suitable cracks that may provide potential roosting habitat for threatened bats. Four culverts were inspected and an additional culvert could not be safely accessed. Limited additional habitat data was collected whilst undertaking Biometric plots. A hollow bearing tree survey was conducted by AECOM (2014).

- Aquatic surveys: rapid assessment of reaches within and downstream of the footprint where it is proposed for groundwater discharge, and/or increased surface runoff. Reaches were characterised by their hydrology, physical form water quality, aquatic habitat and streamside vegetation to determine an overall condition rating (slightly modified, moderately modified, largely modified, substantially modified or severely modified), and to gain sufficient information to identify key fish habitat type, sensitivity and class based on NSW Fisheries' *Policy and Guidelines for Fish Habitat Conservation and Management (2013 update)* (Fairfull 2013). Reaches were assessed in a downstream direction until it became evident that the hydrological influence from other creeks dominated the stream, likely initiating a dilution effect for any potential indirect impacts. Surveys did not include fish trapping, macroinvertebrate surveys or water sampling.

The survey effort was focused according to the vegetation communities and potential habitat for threatened flora and fauna species within the study area. The number of sites assessed within each survey area varied according to vegetation type, number of potential threatened species occurring and accessibility. Survey effort for each component is described in **Table 4**.

2.6 Survey effort

A summary of the field survey effort for each survey method is provided in **Table 4**. All surveys were diurnal surveys conducted over a four week period, one in July / August 2013, two weeks in early December 2013, and one day in April 2014. Weather conditions were cool in July / August, generally warm to hot and humid in December, and cool in April 2014. No significant rainfall was experienced during the survey period.

Table 4: Summary of survey effort

Method	Total Person hours	Dates	Time of day	Weather
Floristic surveys	58	July – August 2013 12 – 20 December 2013 2 April 2014	Morning and afternoon	Cool Warm to hot and humid Cool
Bio-metric plots	52	July – August 2013 12 - 20 December 2013 2 April 2014	Morning and afternoon	Cool Warm to hot and humid Cool
Random meander	130.5	July – August 2013 9 – 20 December 2013 2 April 2014	Morning and afternoon	Cool Warm to hot and humid Cool
Fauna habitat assessment	4*	July – August 2013 10 – 20 December 2013	Morning and afternoon	Cool Warm to hot and humid
Aquatic surveys	62	14 – 17 January 2014	Morning and afternoon	Warm to very hot

*Note: conducted concurrently with Biometric plots

Transects are marked on the map series in **Appendix D**.

2.7 Riparian and ground dependent ecosystems (GDE)

The groundwater dependent ecosystem assessment was undertaken from a review of the geological features, tunnel location and groundwater atlas. This review was undertaken by ELA Senior Ecologist Dr Peter Hancock, a recognised national expert in groundwater dependent ecosystems in particular stygofauna (fauna that live in ground water systems such as aquifers).

Riparian values were characterised from local Council state of the environment (SoE) reporting and other web based searches. Water quality impacts are referenced from relevant public health and environmental water quality criteria, namely those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) and NSW Aquifer Interference Policy (DPI, 2012).

The assessment of hydrogeology impacts, namely the drawdown and discharge volumes, have been assessed as part of the environmental impact statement (refer to section 7.8 of the environmental impact statement).

2.8 Limitations

Some areas were inspected by rapid visual inspection only due to site access restrictions which are shown in **Figure 3**. These areas were not subject to any comprehensive survey. Species were noted where they could be identified and a qualitative assessment of condition was made by noting disturbance or presence of exotic species. The species indicated, were based on visual inspection only, and no data was collected to verify the presence of these species. These areas were generally in urban areas but some sites had biodiversity values that will need to be verified if access is granted (see **Appendix E** for all site descriptions).

Some areas within the construction footprint were not surveyed. Of the total construction footprint of 59.09 hectares, approximately 4.04 hectares (or 6.8 per cent) was not surveyed. This figure also includes the existing carriageways which have been mapped as cleared. The areas not surveyed include areas with no access and no feasible way to inspect from roadsides. The areas not surveyed were typically in urban areas where there is likely to be little biodiversity value due to the current use and high levels of disturbance. The sites not surveyed are shown in **Figure 3**. While these areas were not surveyed, it is not anticipated that their absence will affect the outcome of the significance assessments.

For flora species, surveys occurred during the time of year in which the potentially occurring threatened flora species are detectable. Survey effort for most fauna consisted of incidental observations and habitat assessment.

A hollow bearing tree survey was conducted for the study area by AECOM (2014) to determine the number and extent of hollow bearing trees that may be important for hollow dependent fauna, and any data referred to in this report is subject to the limitations stated in the AECOM (2014).

In the absence of targeted surveys for most threatened fauna species with the potential to occur within the proposed footprint, this technical working paper assumes the presence of the species and potential impacts are addressed in the mitigation section. On the basis that threatened species are present, the significance assessments (and conclusions of non-significant impact) adopt a worst case scenario. It is possible that the results and conclusions of this assessment could change after proposed targeted surveys are undertaken. This was relevant to Powerful Owl, and for cave-dwelling bats which might potentially utilise culverts along the Hills M2 Motorway integration works area and at the northern interchange or in the disused buildings at the Pioneer Avenue compound. However, the project design and construction footprint have sufficient flexibility to allow for refinement during detailed design, or to minimise environmental impacts, or in response to submissions received during the exhibition of the environmental impact statement. As such the final design may therefore vary from the project as described and assessed within this technical working paper in order to minimise impacts.

For the purposes of this impact assessment, it was considered that vegetation and trees on top of the tunnel will not be affected, as the majority of tree roots and roots systems for other vegetation predominantly occurs in the first two metres of the soil profile, due to the limited availability of oxygen at greater depths (Schenk and Jackson, 2002).

Aquatic surveys were limited by site access on private property. Specifically, access was not obtained along sections of creek near Arianna Avenue, Normanhurst and Exeter Road, Wahroonga; a small section of private land on Coups Creek; and a short section of creek in Pennant Hills High School. In these cases, visual inspection was gained from the road or adjacent land.

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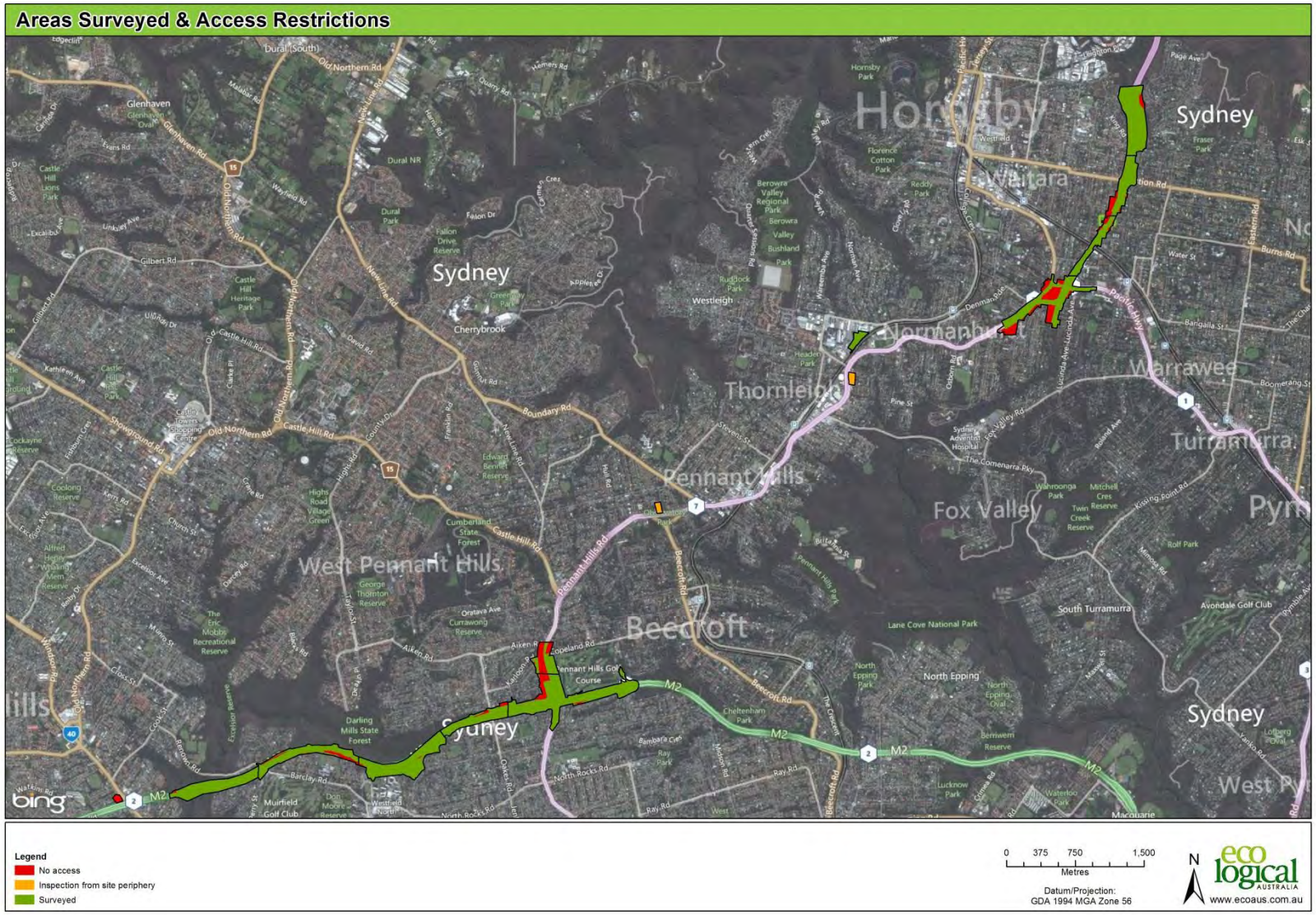

Figure 3: Areas surveyed and access restrictions

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3 Existing environment

This chapter describes the existing environment and biodiversity values within the study area. Impacts on biodiversity values are discussed in **section 4** and the recommended mitigation measures are listed in **section 5**.

The chapter has been divided to correspond to study area locations.

3.1 Landscape context

The project is located within the Sydney Basin Bioregion which extends north to the Hunter Valley, west to Mudgee and south to Batemans Bay. The study area occurs within a highly urbanised setting being surrounded by extensive areas of established urban development. However, pockets of remnant vegetation are common along the borders of the study area, particularly within gullies, in association with local riparian corridors and to a lesser extent along the road corridor itself. The geology of the study area is shown in **Figure 4** and the soil profile for the study area is shown in **Figure 5**.

3.1.1 Northern interchange

The northern interchange study area traverses two distinct areas: a suburban setting to the south and a heavily vegetated area to the north which marks the start of the vegetation contiguous with Ku-ring-gai Chase National Park.

The northern interchange study area is found on the boundary of the Cumberland and Pittwater sub-region of the Sydney Basin Bioregion. Geology of the Cumberland sub-region is characterised by Triassic Wianamatta groups shales and sandstones while the geology of the Pittwater sub-region is characterised by Triassic Hawkesbury Sandstone with thin ridge capping of Ashfield Shale and Narrabeen sandstones exposed in valleys (OEH, 2013b).

The topography of the northern interchange study area slowly transitions from rolling to steep slopes in the south of the study area to a steeper, more rugged Hawkesbury landscape to the north. This topography includes Cockle Creek which flows north and joins Cowan Creek at the end of Bobbin Head Road.

The soils of the northern interchange study area are a mix of Glenorie soil landscape to the south, Lucas Heights in the middle and Gymea and Hornsby to the north. A small section to the south of the study area also falls within the West Pennant Hills soil landscape (Chapman and Murphy, 1989).

3.1.2 Southern interchange

The southern interchange study area is found within Cumberland sub-region of the Sydney Basin Bioregion. The study area traverses heavily urbanised areas, although some areas of remnant vegetation are associated with the Hills M2 Motorway and Pennant Hills Golf Club.

The geology of the Cumberland sub-region is characterised by Triassic Wianamatta group shales and sandstones with a quaternary alluvium along Devlins Creek (OEH, 2013b).

The soils of the southern interchange study area are a mix of Glenorie, Hawkesbury and Gymea soil landscapes. The topography of the southern interchange study area varies predominantly from undulating to steep slopes.

3.1.3 Hills M2 Motorway integration works

The Hills M2 Motorway integration works study area is found within the Cumberland sub-region of the Sydney Basin Bioregion. The Hills M2 Motorway integration works study area traverses through some suburban areas with the exception of the most western extent which is the valley of the Darling Mills Creek and Bidjigal Reserve.

The topography of the Hills M2 Motorway integration works study area varies predominantly from undulating to steep slopes, with large sandstone outcrops. The soils of the Hills M2 Motorway integration works study area are a mix of Hawkesbury and Gymea and Lucas Heights soil landscapes.

3.1.4 Ancillary facilities

The locations for the ancillary facilities are scattered throughout suburban and industrial areas. The vegetation within these areas is heavily disturbed and has typically been cleared for residential dwellings or other uses. However some remnant vegetation, typically remnant trees, can be found as part of landscaping or in small remnant patches of vegetation.

The study areas for the Trelawney Street compound, Wilson Road compound and Windsor Road compound are part of the Cumberland sub-region of the Sydney Basin Bioregion and all are found on the Glenorie soil profile (Chapman and Murphy, 1989).

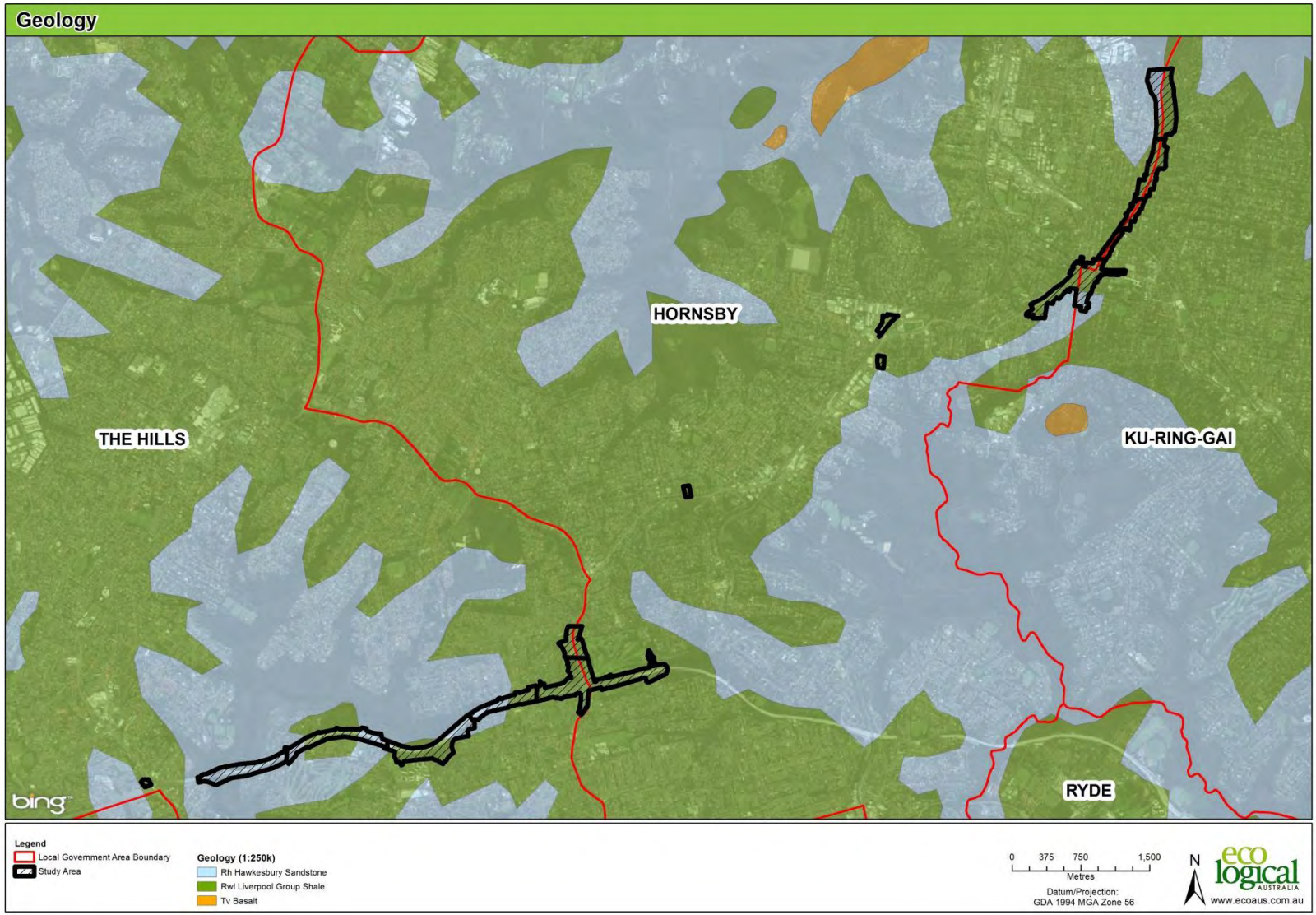

Figure 4: Geology of the study area

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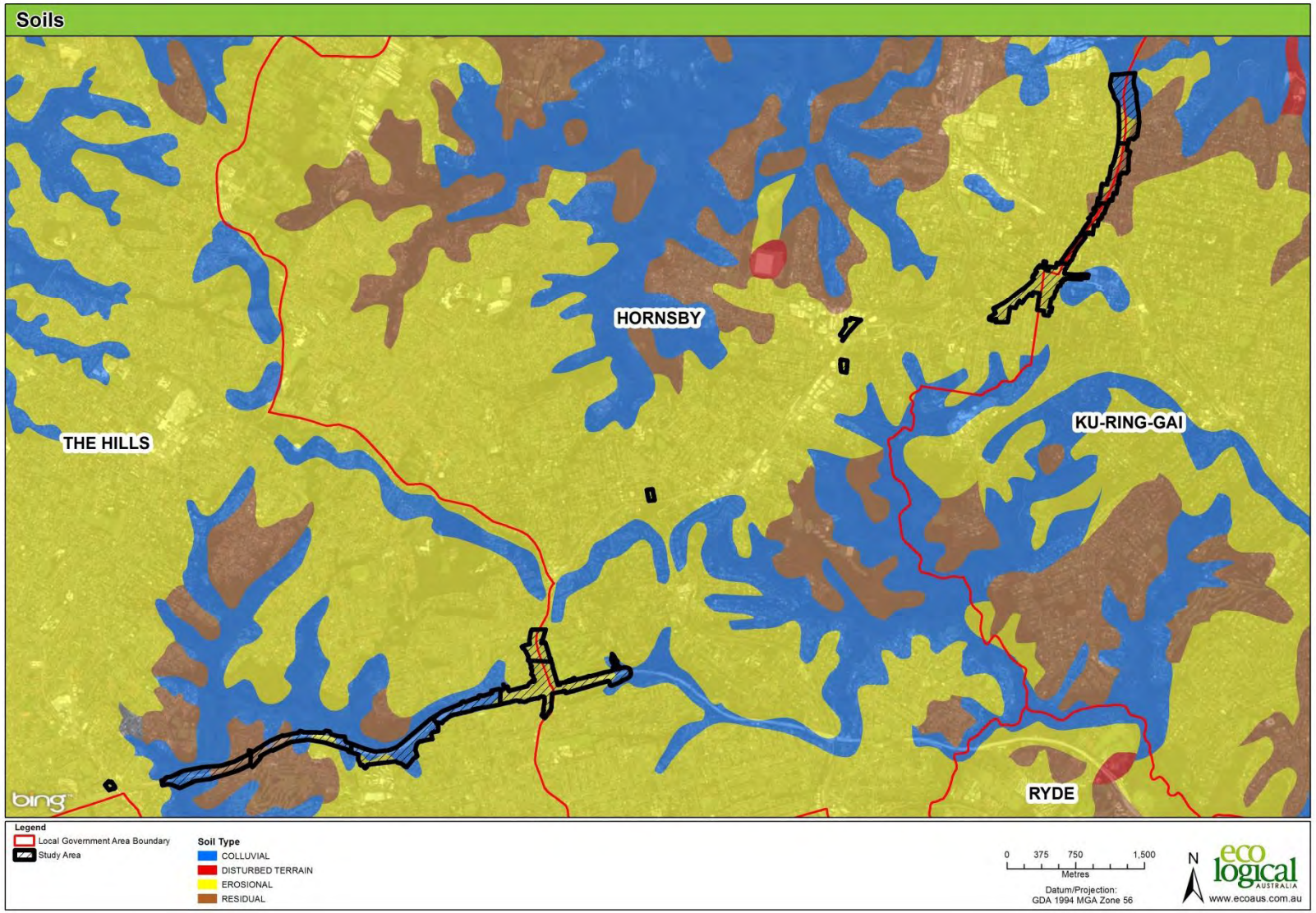

Figure 5: The soil profile of the study area

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3.2 Climate

The Sydney Basin Bioregion is characterised by a temperate climate, warm summers, mild winters and no dry season (OEH 2013b). Average historic meteorological data for the site was acquired from Pennant Hills (Yarrara Road) weather station which is central to the study area. Data was sourced from the Bureau of Meteorology (BOM) and is displayed in **Table 5** below.

The mean monthly temperatures at Pennant Hills weather station (066047, Lat. 33.73°S, Lon. 151.08°E) range from a maximum of 27.6 degrees in January to a minimum of 5.2 degrees in July (BoM, 2013). The mean annual rainfall for the region is 1077.1 millimetres with the highest rainfall being in March. The drier months are typically August to October.

Table 5: Climate data summary from Pennant Hills weather station

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)													
Mean Max Temp.	27.6	27.3	25.5	22.2	19.1	16.3	15.8	17.9	20.9	23.4	25.1	27.0	22.3
Mean Min Temp.	16.1	16.1	14.8	11.8	8.6	6.3	5.2	6.1	8.1	10.8	13.1	15.0	11.0
Rainfall (mm)													
Mean Rainfall (mm)	100.6	115.8	121.7	104.5	81.9	111.4	80.6	63.5	56.3	69.0	80.7	92.1	1077.1
Decile 5 (median)	75.7	92.3	87.1	73.6	50.2	66.8	48.6	39.4	46.4	50.8	59.2	63.4	1045.9
Mean # of days of rain*	7.3	8.14	8.5	7.6	6.4	7.4	6.0	6.0	6.1	6.7	7.1	7.3	84.5

*Mean number of days of rain ≥1 mm

3.3 Land use

The study area falls within the local government areas of Hornsby, Ku-ring-gai and The Hills. Land use of each part of the site is different and discussed separately below.

3.3.1 Northern interchange

The northern interchange study area traverses a diverse area and therefore encompasses a mix of land uses, the main land use being for the purpose of a motorway. Other land uses include residential dwellings and areas of remnant native vegetation.

3.3.2 Southern interchange

The major land use of the southern interchange study area is associated with the use of the Hills M2 Motorway. However residential areas as well as Pennant Hills Golf Club are also encompassed as part of the study area. Urban development surrounds the outside of the study area.

3.3.3 Hills M2 Motorway integration works

A large portion of the Hills M2 Motorway integration works study area is bounded by remnant roadside vegetation. The vegetation is part of a much larger vegetation patch which incorporates a number of local reserves to the north of the Hills M2 Motorway integration works study area.

Only a small portion of the Hills M2 Motorway integration works study area encompasses residential areas. The remainder of the Hills M2 Motorway integration works study area is maintained for the use of a motorway.

3.3.4 Ancillary facilities

The ancillary facilities are predominantly residential, except for the Pioneer Avenue compound site which is an industrial site.

3.4 Hydrology

The study area crosses two catchment management authority (CMA) regions: Hawkesbury-Nepean CMA (part of the northern interchange) and Sydney Metropolitan CMA (Hills M2 Motorway and part of the northern interchange).

The Land & Property Information, Digital Topographic Database (DTDB) mapping and the field survey conducted by ELA identified a number of watercourses that either traverse or are in the vicinity of the study area (refer to **Figure 6**). They include:

- Darling Mills Creek, Stevenson Creek and Blue Gum Creek (Hills M2 Motorway integration works).
- Devlins Creek (around 4.5 kilometres from the southern interchange).
- Cockle Creek (northern interchange) also referred to as Spring Gully Creek.

In addition to the watercourses in the immediate surrounds of the footprint, the headwaters of several creeks begin nearby and would receive runoff or discharge from the works. They include:

- Tedbury Creek (downstream of Wilson Road compound).
- Tributary of Lane Cove River, termed Butterfield Street Creek for the purposes of this assessment (downstream of Trelawney Street compound).
- Coups Creek and two of its tributaries (downstream of the northern interchange).

There are no wetlands protected under *State Environmental Planning Policy No 14 – Coastal Wetlands* (SEPP 14) in the vicinity of the study area.

All creek systems in the upper catchment are characteristic of many urban watercourses on Sydney's sandstone, which exhibit highly incised channels and increased erosion due to the concentration of stormwater flows with subsequent weed invasion and pollution from urban runoff. The sections below provide summary details of each creek system. See **Appendix J** for detailed results of the aquatic field assessment, and photographs of the creeks.

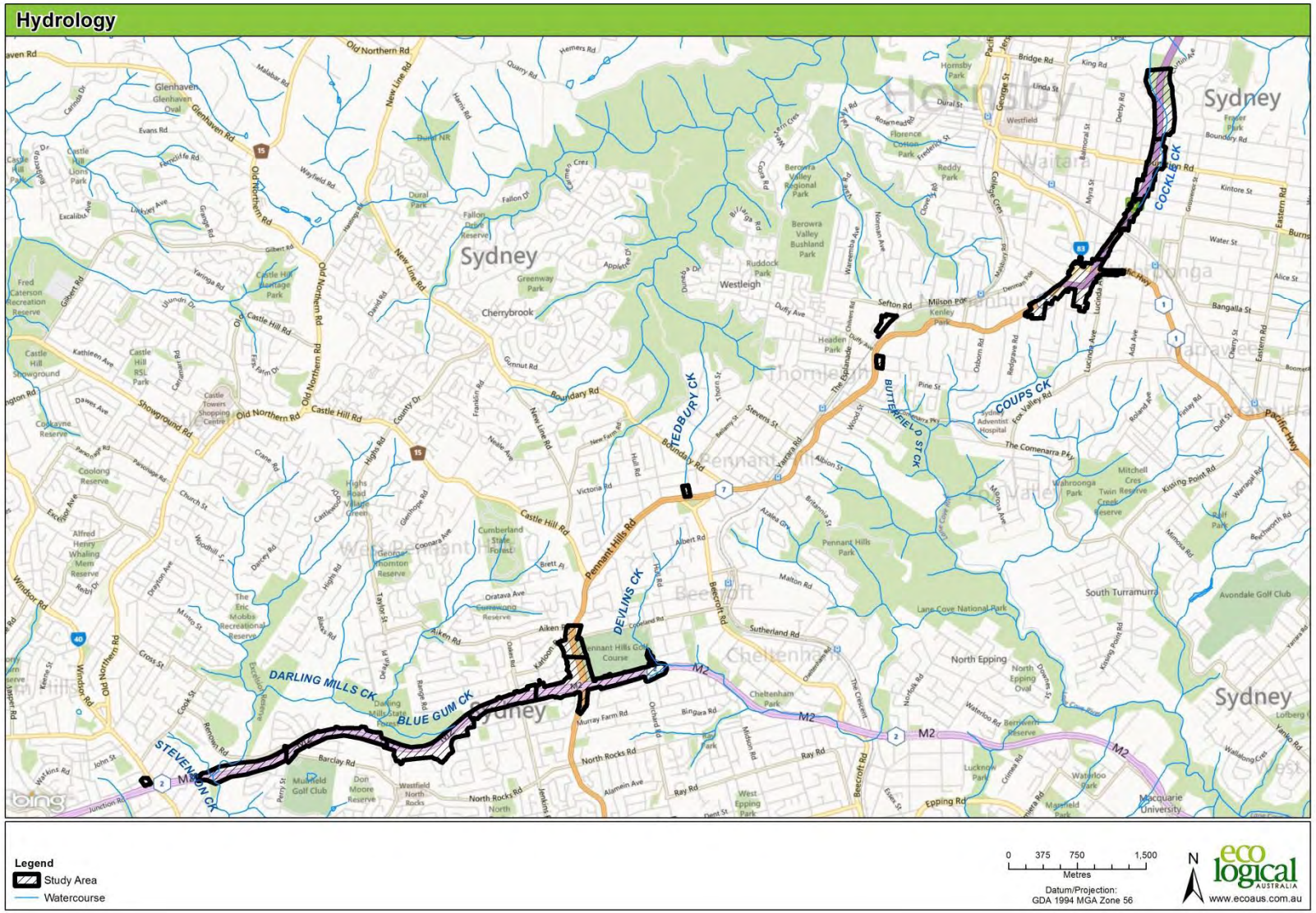

Figure 6: Main waterways in the study area

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3.4.1 Darling Mills Creek and Stevenson Creek

Darling Mills Creek is a 4th order stream (Strahler classification) that passes under the Hills M2 Motorway at the Darling Mills Creek bridge. Darling Mills Creek flows from West Pennant Hills, through North Rocks and Northmead to join the Parramatta River. Blue Gum Creek and Stevenson Creek are short tributaries of Darling Mills Creek.

The sandstone riparian scrub vegetation that occurs along creeks within and adjacent to the Hills M2 Motorway is highly modified as a result of altered flow regimes, increased nutrients and weed invasion. Where bridge structures span Darling Mills Creek, the vegetation underneath forms the only habitat connection between bushland areas on either side of the Hills M2 Motorway. These areas are of particular importance to fauna movement.

The vegetation underneath these structures is degraded due to previous earthworks, the impacts of shading and the interception of rainfall by the roadway overhead. Darling Mills Creek flows through vegetated areas, although current disturbances such as weed invasion, services installation (sewer) and bushwalking trails have caused moderate changes to the creek line.

Bed sediments are dominated by cobble and gravel upstream of the Hills M2 Motorway, and by sand deposited over cobble downstream. The creek is slow flowing along its whole length. Pools linked by occasional riffles or runs, are the dominant feature of the creek.

Fish habitat is minimal in the upper reaches, and fish habitat availability increases further downstream. There are no major barriers for fish passage during all flows; however, the constructed fish passage at the Loyalty Road flood retarding basin at North Rocks was blocked by a debris dam at the time of survey.

Constructed detention basins along the existing Hills M2 Motorway were planted with emergent aquatic native plants with the intention of slowing stormwater flows to minimise pollution. These emergent aquatic plants also provide wildlife habitat. Emergent plants currently found growing in the detention basins include *Eleocharis sphacelata*, *Bolboschoenus fluviatilis*, and *Typha orientalis*. Four frog species were recorded within the detention basins: *Litoria peronii*, *L. fallax*, *Limnodynastes peronii* and *Crinia signifera* (AECOM 2010). Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface and low flow. Basins that are isolated from other water bodies are unlikely to be inhabited by fish though other fauna such as freshwater turtles, snakes and wading birds may occur.

Stevenson Creek is a short 2nd order stream (Strahler classification) that flows into Darling Mills Creek beneath the Darling Mills Creek bridge. This ephemeral creek is highly disturbed near its confluence with Darling Mills Creek, where it appears to be partially piped to prevent erosion of the bridge footings. The upstream portion of this creek follows a natural route, but is outside the study area.

3.4.2 Blue Gum Creek

Blue Gum Creek is a relatively narrow and shallow 1st order stream (Strahler classification) on the eastern side of the Hills M2 Motorway integration works. Blue Gum Creek originates on the north-west corner of Oakes Road and the Hills M2 Motorway and flows for approximately 1.5 kilometres before entering Darling Mills Creek.

The creek is dominated by pools, with the occasional riffle/run sequences. Substrate in the upper reaches is dominated by boulders and pebbles, while downstream it constituted mostly of cobble and gravel. The creek is around one to three metres wide and 10 to 20 centimetres deep. Water is moderately turbid and slow flowing.

Aquatic vegetation has low diversity, while the riparian vegetation is largely weed dominated with some regeneration work apparent. Minor barriers to fish passage are present during all flows however fish habitat is low in this creek due to an absence of deep pools.

3.4.3 Devlins Creek

Devlins Creek is a large tributary of Lane Cove River that dissects Beecroft, Cheltenham and North Epping. It connects several bushland reserves with Lane Cove National Park. Devlins Creek and the surrounding reserves have a long history of bush regeneration and recreation.

The most recent impacts to the creek are due to the construction and upgrade of the Hills M2 Motorway, which traverses several reaches and follows the southern bank. The riparian zone of Devlins Creek is in a moderate condition and has high potential for restoration. The aquatic habitat was not assessed as part of this assessment, as it is not being impacted, but a previous study found the creek to be in good condition and to also have a high restoration potential (ELA, 2012c).

3.4.4 Tedbury Creek

Tedbury Creek is a mostly disturbed 1st order stream (Strahler classification). The creek is located downstream of the Wilson Road compound and originates in Pennant Hills High School. The creek flows into Zig Zag Creek approximately 1.5 kilometres downstream, which joins Berowra Creek.

Erosion, undercutting of banks and weed invasion are common along the upper reaches of Tedbury Creek where the dominant substrate is silt. A distinct change in form occurs in the bushland where the creek drops down a series of rocky falls. The riparian vegetation in this section is in good condition and rarely dominated by weeds.

Parts of the creek were dry during the survey. One large pool with potential for fish habitat occurs in the lower reaches of Tedbury Creek (refer to **Figure 16**).

Zig Zag Creek is a 2nd order stream around one to three metres wide and 20 to 30 centimetres deep with medium velocity flow. The substrate of the creek is dominated by cobbles and pebbles and has little sedimentation.

3.4.5 Butterfield Street Creek

The unnamed tributary of Lane Cove River south of the Trelawney Street compound originates from a culvert off Butterfield Street (termed Butterflied Street Creek for this assessment **Figure 15**). The creek is a 1st order stream in the upper reach and a 2nd order stream in the lower reach. The creek is relatively short (around 600 metres) and moderately modified. The creek crosses The Comenarra Parkway under a large culvert where it continues for a short distance before flowing into Lane Cove River.

Butterfield Street Creek is unlikely to contain native fish habitat, however, it contained moderate frog habitat in the upstream reach. Tadpoles were observed and *Limnodynastes peronii* (Striped Marsh Frog) was heard calling.

Lane Cove River downstream of the confluence with Butterfield Street Creek is a relatively large watercourse, with average width of five to eight metres although a large part of the river was dry during the survey. Large boulders dominated the river substrate. Riparian vegetation was in good condition and there were few exotic species.

3.4.6 Coups Creek

Coups Creek and two of its unnamed tributaries located south of the northern interchange were assessed (named Arianne Avenue Creek and Exeter Street Creek for the purpose of this assessment). Coups Creek is a relatively long creek which later flows into Lane Cove River.

Both Arianne Avenue Creek and Exeter Street Creek are around 350 metres long and flow north-south. Both creeks were on private property and could not be accessed along their entire length but the areas that were assessed are modified.

Coups Creek is a moderately modified 2nd order stream with bedrock and cobble as the dominant substrate. Fish habitat is patchy and restricted to small pools, and there was frog habitat present. Large parts of the creek were dry during the field survey. Coups Creek enters Lane Cove River at the confluence of an unnamed creek south of The Comenarra Parkway.

3.4.7 Cockle Creek

Cockle Creek (also known as Spring Gully Creek and Gibberagong Creek) flows into Ku-ring-gai Chase National Park where a walking track follows the lower sections of the creek down to Bobbin Head and Cowan Creek. The creek originates in an urban area from a culvert on Woniora Avenue, Wahroonga, east of the M1 Pacific Motorway and is an artificially stabilised channel until it passes Carrington Oval (Coonanbarra Road).

The upper section of the creek in the study area, between the residential development and the M1 Pacific Motorway, has a large amount of litter, is dominated by weeds, and contains no aquatic plant assemblages (macrophytes or fringing aquatic vegetation). The channel is approximately around one to three metres wide with a base flow water depth of 10-20 centimetres, and the bed is dominated by bedrock and cobble. *Anguilla reinhardtii* (Long-finned Eel) was observed in the creek adjacent to Carrington Park. The lower reaches (north of Carrington Park) are found in vegetated areas and are only slightly modified, except for a large culvert beneath the M1 Pacific Motorway.

The channel is around three to five metres wide, with a base flow depth of 20-30 centimetres. Flow is of a medium velocity and the creek bed is dominated by cobble. Habitat availability varies along the length of the creek with complexity increasing downstream. Fish, frog and bird habitat quality also improves downstream. A pool occurs downstream of Hornsby Creek. The upper section of the tributaries of Cockle Creek is suitable habitat for the Red-crowned Toadlet.

3.5 Vegetation communities and habitat

The literature review identified a number of vegetation communities previously recorded within the study area, some of which are threatened ecological communities. These are discussed in the following sections. It is noted that the use of underground tunnels avoids impacts along much of the route.

3.5.1 Northern interchange

As part of the desktop and preliminary survey design, ELA mapped the vegetation communities along Pennant Hills Road and the M1 Pacific Motorway. These mapping units were verified during field survey.

A number of areas could not be accessed during the field surveys due to the sites being privately held with no access arrangements. In general, however, these areas were urban and are likely to contain vegetation that has been planted or is managed.

The following vegetation types were identified in this assessment:

- Blue Gum High Forest (in varying conditions and CEEC under TSC Act).
- Patches of Blue Gum (a component of Blue Gum High Forest).
- Hinterland Sandstone Gully Forest (in varying conditions).

- Roadside batter/spoil vegetation.
- Roadside cutting.
- Urban/street planting.

Blue Gum High Forest in the Sydney Basin Bioregion is a critically endangered ecological community (CEEC) under both the EPBC Act and the TSC Act. However the condition of the Blue Gum High Forest at this site is highly modified and does not meet the EPBC Act definition, which is more limiting than the TSC Act definition. This is discussed further in **section 3.6.1**.

3.5.2 Southern interchange

As part of the desktop and preliminary survey design, ELA mapped the vegetation communities along the Hills M2 Motorway and the southern end of the Pennant Hills Road. These mapping units were verified during field survey.

A number of areas could not be accessed during the field surveys due to the sites being privately held with no access arrangements. In general, these areas were urban and are likely to contain vegetation that has been planted or is managed.

The following vegetation types were identified in this assessment:

- Blue Gum High Forest (in varying conditions and CEEC under TSC Act)
- Coastal Enriched Sandstone Moist Forest (disturbed understorey)
- Sydney Turpentine Ironbark Forest (highly disturbed understorey and EEC under TSC Act)
- Hinterland Sandstone Gully Forest (in varying conditions)
- Landscaped vegetation
- Regrowth on disturbed land.

Blue Gum High Forest in the Sydney Basin Bioregion is a critically endangered ecological community (CEEC) under both the EPBC Act and the TSC Act. However the condition of the Blue Gum High Forest at this site is predominately highly modified and is devoid of a native understorey. As such, it does not meet the EPBC Act definition. A small area of Blue Gum High Forest mapped as being in moderate condition is present at a site off Lisle Court, but the small area of this site means that it also does not meet the EPBC Act definition. This is discussed further in **section 3.6.2**.

Sydney Turpentine Ironbark Forest is an endangered ecological community under the TSC Act and critically endangered ecological community under the EPBC Act. However, the condition of the Sydney Turpentine Ironbark Forest is highly modified as the native midstorey and groundcover have been largely removed or replaced by exotic species and does not meet the EPBC Act definition. This is because the EPBC Act definition of the ecological community excludes patches where either the native midstorey/understorey or native canopy trees are absent. Occurrences of isolated single trees or shrubs characteristic of the ecological community also are excluded from the ecological community. This is discussed further in **section 3.6.2**.

3.5.3 Hills M2 Motorway integration works

As part of the desktop and preliminary survey design, ELA mapped the vegetation communities along the Hills M2 Motorway integration works on the southern side and to the west of the Pennant Hills Road intersection. These mapping units were verified during field survey.

A number of vegetation types were identified:

- Hinterland Sandstone Gully Forest (in varying conditions)
- Regeneration area *Epacris purpurascens* var. *purpurascens* (vulnerable under TSC Act)
- Regrowth on disturbed land
- Cleared.

This study conducted vegetation surveys and validation of the vegetation mapped by DECCW (2009). ELA mapped or confirmed the following vegetation types:

- Blue Gum High Forest (CEEC under TSC Act).
- Coastal Enriched Sandstone Moist Forest.
- Coastal Enriched Sandstone Sheltered Forest.
- Coastal Sandstone Gallery Rainforest.
- Coastal Shale-Sandstone Forest.
- Cumberland Riverflat Forest (EEC under TSC Act as River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions).
- Weeds/exotics.

The Blue Gum High Forest encountered at this site meets the TSC Act definition but not the EPBC Act definition. This is discussed further in **section 3.6.3**.

3.5.4 Ancillary facilities

Wilson Road compound

No previous survey or mapping of this area had been completed. This study conducted a limited survey via visual inspection of this site. The following vegetation has been mapped at the Wilson Road compound:

- Sydney Turpentine Ironbark Forest (EEC under TSC Act).
- Blue Gum individuals (CEEC under TSC Act).

Due to access constraints, it was not possible to determine whether the vegetation at the Wilson Road compound meets the TSC Act definitions for the above communities, and further fieldwork will be required to confirm this once full site access is available. Despite this limitation, the current use of this site for residential purposes means that the vegetation is likely to be managed and the threatened ecological communities are unlikely to meet EPBC Act criteria. This is discussed further in **section 3.6.4**

Trelawney Street compound

No previous survey or mapping of this area had been completed. In December 2013, ELA conducted a limited survey via visual inspection of this site. Urban trees (native and exotic) vegetation was observed and have been mapped at Trelawney Street compound.

Pioneer Avenue compound

In April 2014 ELA conducted a floristic and fauna habitat survey of this site. Blue Gum High Forest which meets the TSC Act definition but not the EPBC Act definition, as well as weeds and exotics have been mapped at Pioneer Avenue compound.

Windsor Road compound

No previous survey or mapping of this area had been completed. This site has been previously used as a construction compound as part of the M2 Upgrade project. Weeds and exotic vegetation was mapped at this compound.

3.6 Threatened ecological communities (TEC)

Roads and Maritime (2013) listed the following threatened ecological communities (TECs) as potentially occurring with the general study area in the SSI application report:

- Blue Gum High Forest of the Sydney Basin Bioregion/ Blue Gum High Forest (critically endangered) (EPBC Act and TSC Act)
- Shale/Sandstone Transition Forest (endangered) (EPBC Act and TSC Act)
- Turpentine-Ironbark Forest in the Sydney Basin Bioregion / Sydney Turpentine-Ironbark Forest (endangered TSC Act and critical endangered under the EPBC Act)
- Western Sydney Dry Rainforest and Moist Woodland (critically endangered) (EPBC Act and TSC Act).

This assessment has identified two threatened ecological communities to be present within the study area namely:

- Blue Gum High Forest (critically endangered under the TSC Act, vegetation does not meet EPBC Act definitions).
- Sydney Turpentine-Ironbark Forest / Turpentine-Ironbark Forest in the Sydney Basin Bioregion (critically endangered under the TSC Act, vegetation does not meet EPBC Act definitions).

The definition of Blue Gum High Forest and Turpentine-Ironbark Forest in the Sydney Basin Bioregion under the EPBC Act is more limiting than the definition of these communities under the TSC Act. The definitions for these communities under the EPBC Act are provided in **Table 6**.

As discussed in **section 3.6.1** to **section 3.6.5**, none of the threatened ecological communities within the study area satisfy EPBC Act definitions.

Table 6: EPBC Act definition of Blue Gum High Forest and Turpentine-Ironbark Forest

Community	EPBC listing criteria	TSC Act listing criteria
Blue Gum High Forest of the Sydney Basin Bioregion*	• Will have components representing the characteristic native species of all structural layers (tree canopy, small tree/shrub midstorey, and understorey); and • Requires a minimum canopy coverage of 10 per cent where it is part of a patch greater than one hectare, or • Is part of a patch that is greater than one hectare and occurs in areas of native vegetation in excess of five hectares in area, if the canopy is less than 10 per cent.	• Occurs within the Sydney basin bioregion • Includes areas with highly modified understory. • Highly modified relics of the community also persist as small clumps of trees without a native understorey.

Community	EPBC listing criteria	TSC Act listing criteria
Turpentine-Ironbark Forest in the Sydney Basin Bioregion**	• Will have components representing the characteristic native species of all structural layers (tree canopy, small tree/shrub midstorey, and understorey); and • Requires a minimum canopy coverage of 10 per cent where it is part of a patch greater than one hectare, or • Is part of a patch that is greater than one hectare and occurs in areas of native vegetation in excess of five hectares in area, if the canopy is less than 10 per cent.	• Occurs within the Sydney basin bioregion • Includes areas with highly modified understory. • Remnant trees may comprise the community.

* Threatened Species Scientific Committee, 2005a. http://www.environment.gov.au/node/14558, Accessed 11/3/2014

TSC Act Scientific Committee, 2007. http://www.environment.nsw.gov.au/determinations/BlueGumHighForestEndSpListing.htm Accessed 11/3/2014

** Threatened Species Scientific Committee, 2005b. http://www.environment.gov.au/node/14559. Accessed 11/3/2014

TSC Act Scientific Committee, 1998. http://www.environment.nsw.gov.au/determinations/SydneyTurpentineIronbarkForestEndComListing.htm Accessed 11/3/2014

3.6.1 Northern interchange

Blue Gum High Forest occurs in varying condition states within the northern interchange study area. The amount of Blue Gum High Forest within the study area at the northern interchange is 1.14 hectares in poor condition with exotic dominated understorey.

No Blue Gum High Forest or individual Blue Gum trees encountered during the survey meet the EPBC Act criteria as a critically endangered community given that these areas are devoid of native understorey. Nevertheless, they are likely to be consistent with the TSC Act criteria and are considered to present a considerable constraint to the project as very little of this vegetation type remains, and most remnants are heavily disturbed.

3.6.2 Southern interchange

Blue Gum High Forest (in varying conditions) and Sydney Turpentine Ironbark Forest (highly disturbed understorey) occur within the southern interchange study area. The patch size of Blue Gum High Forest in the study area was 0.13 hectares in poor condition with exotic dominated understorey.

Again, no Blue Gum High Forest encountered during the survey meet the EPBC Act criteria as a critically endangered community given that these areas are devoid of native understorey. Nevertheless, they are likely to be consistent with the TSC Act criteria and are considered to present a considerable constraint to the project as very little of this vegetation type remains, and most remnants are heavily disturbed.

3.6.3 The Hills M2 Motorway integration works

Blue Gum High Forest (in varying conditions) or individual Blue Gum trees occurs within the Hills M2 integration works study area in varying condition. The amount within the study area was 1.21 hectares of poor condition Blue Gum High Forest with an exotic dominated understorey.

The Blue Gum High Forest encountered at this site meets the TSC Act definition but not the EPBC Act definition despite the large patch size and a canopy cover greater than ten per cent. This is because the community at this location has an understorey and ground cover dominated by exotic species, with very few native species. The EPBC Act criteria require components representing the characteristic native species of all structural layers.

Blue Gum High Forest listed under the TSC Act is considered to present a constraint to the project as very little of this vegetation type remains, and most remnants are heavily disturbed.

3.6.4 Ancillary facilities

Wilson Road compound

ELA conducted a limited survey via visual inspection of Wilson Road compound due to restricted site access. The following vegetation types were mapped:

- Sydney Turpentine Ironbark Forest – EEC under TSC Act.
- Blue Gum Individuals.

The patch of Sydney Turpentine Ironbark Forest in the study area is 0.1 hectares and the Blue Gum individuals are estimated to cover 0.07 hectares.

Sydney Turpentine Ironbark Forest within the study area consisted of a number of *Syncarpia glomulifera* and *Eucalyptus saligna* individuals in an urban area with mown/managed understorey. While the survey was limited to a visual inspection from the roadside, the current use of this site as a residential area suggests that the site is unlikely to contain native species in the understorey.

This community does not meet EPBC Act criteria because the patch size is less than one hectare and the site is unlikely to contain species in the understorey that are characteristic of this community. This community does meet the TSC Act definitions for the Sydney Turpentine Ironbark Forest.

The Blue Gum individuals may be remnants of either Blue Gum High Forest or Sydney Turpentine Ironbark Forest. They do not meet the criteria under the EPBC Act but do meet the criteria for Blue Gum High Forest or Sydney Turpentine Ironbark Forest under the TSC Act.

Trelawney Street compound

No threatened ecological communities were found at the Trelawney Street compound study area.

Pioneer Avenue compound

Blue Gum High Forest was mapped at Pioneer Avenue compound in two small areas: in the northwest corner, and along the eastern boundary adjoining the railway.

This community does not meet EPBC Act criteria because the patch size is less than one hectare and the site is unlikely to contain species in the understorey that are characteristic of this community. This community does meet the TSC Act definitions for the Blue Gum High Forest.

Windsor Road compound

No previous survey or mapping of this area had been completed. This site has been previously used as a construction compound as part of the M2 Upgrade project. No native vegetation has been mapped at this compound.

3.7 Threatened species and populations

The list below combines the species from the NSW Wildlife Atlas and Protected Matters (DSEWPaC 2014) database searches (**Appendix A**), with other records identified from the literature search into one list of species that have the potential to occur (includes species known to occur) within the study area. A total of five threatened flora species, 20 threatened fauna species and one endangered populations have been identified as having the potential to occur within the total study area.

Flora:

- *Callistemon linearifolius* (Netted Bottlebrush) (vulnerable TSC Act).
- *Darwinia biflora* (vulnerable TSC Act and EPBC Act).
- *Epacris purpurascens* var. *purpurascens* (vulnerable TSC Act).
- *Hibbertia superans* (endangered TSC Act).
- *Syzygium paniculatum* (Magenta Lilly Pilly) (vulnerable TSC Act and EPBC Act).

Fauna:

- *Pseudophryne australis* (Red-crowned Toadlet) (vulnerable TSC Act).
- *Varanus rosenbergi* (Rosenberg's Goanna) (vulnerable TSC Act).
- *Callocephalon fimbriatum* (Gang-gang Cockatoo) (vulnerable TSC Act).
- *Calyptorhynchus lathami* (Glossy Black-Cockatoo) (vulnerable TSC Act).
- *Daphoenositta chrysoptera* (Varied Sittella) (vulnerable TSC Act).
- *Petroica boodang* (Scarlet Robin) (vulnerable TSC Act).
- *Petroica phoenicea* (Flame Robin) (vulnerable TSC Act).
- *Ninox connivens* (Barking Owl) (vulnerable TSC Act).
- *Ninox strenua* (Powerful Owl) (vulnerable TSC Act).
- *Tyto novaehollandiae* (Masked Owl) (vulnerable TSC Act).
- *Cercartetus nanus* (Eastern Pygmy-possum) (vulnerable TSC Act).
- *Chalinolobus dwyeri* (Large-eared Pied Bat) (vulnerable TSC Act and EPBC Act).
- *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) (vulnerable TSC Act).
- *Miniopterus australis* (Little Bent-wing Bat) (vulnerable TSC Act).
- *Miniopterus schreibersii oceanensis* (Eastern Bent-wing Bat) (vulnerable TSC Act).
- *Mormopterus norfolkensis* (Eastern Freetail-bat) (vulnerable TSC Act).
- *Myotis macropus* (Southern Myotis) (vulnerable TSC Act).

- *Pteropus poliocephalus* (Grey-headed Flying-Fox) (vulnerable TSC Act and EPBC Act).
- *Saccolaimus flaviventris* (Yellow-bellied Sheathtail-bat) (vulnerable TSC Act).
- *Scoteanax rueppellii* (Greater Broad-nosed Bat) (vulnerable TSC Act).

Populations:

- Callocephalon fimbriatum (Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas) (endangered population TSC Act).

No threatened fish species have been recorded within the catchments of the study area (I&I NSW 2014). Threatened fish and macroinvertebrates listed under the NSW *Fisheries Management Act 1994* and EPBC Act are considered unlikely to occur in the creeks downstream of the study area.

3.8 Critical habitat

No critical habitat has been declared for any of the species or ecological communities present within the study area.

3.9 Fauna habitat

There were a range of fauna habitats encountered across the study area. These are described in **Table 7** and for a description of where these habitats occur, refer to **Appendix E**.

Table 7: Fauna habitats occurring in the study area

Type	Vegetation	Area (hectares)	Likely fauna / attributes
Forest	Blue Gum High Forest Blue Gum Individuals	5.39 0.12	• This vegetation types exists in the study area in a disturbed to highly disturbed condition, with usually a large complement of exotic species in the understorey and ground layer. • Tree coverage is usually greater than 10 per cent. • Trees have a diverse range of hollow sizes. • Likely to be used by forest birds, arboreal mammals, hollow dependent fauna. These include the Grey-headed Flying Fox, Yellow-bellied Sheathtail-bat, Glossy black-cockatoo and the Powerful Owl.
Forest	Sydney Turpentine Ironbark Forest	1.08	• This vegetation type exists as highly disturbed remnants with exotic dominated understorey or as canopy trees with mown / managed understorey. • Tree coverage is usually greater than 10 per cent except where it exists as single trees. • Canopy foraging bird species, hollow dependent fauna and arboreal mammals may utilise this community.

Type	Vegetation	Area (hectares)	Likely fauna / attributes
Forest	Coastal Enriched Sandstone Dry Forest Coastal Enriched Sandstone Moist Forest	3.35 1.80	• These vegetation types were generally in good condition and contained structural complexity with abundant native shrubs, herbs and grasses. • Weed species were few and were more often encountered where these vegetation types were close to watercourses, pipe outlets or other infrastructure such as detention basins. • Tree canopy coverage was generally above 30 per cent and there were many hollows in all size classes, but predominantly small to medium (AECOM 2014). • In some areas there was abundant and deep leaf litter and large areas of sandstone rock outcrop and denatured sandstone. • Coarse woody debris (ie. fallen logs) was present. • There are likely to be a wide range of fauna utilising these habitats including reptiles, hollow dependent fauna (eg. birds and bats).
Forest	Coastal Sandstone Gallery Rainforest	0.22	• This vegetation type was generally in good condition and contained structural complexity with trees, small trees, native shrubs, vines, herbs, ferns and grasses. • Weed species were few but present. • Tree canopy coverage was generally above 30 per cent and there were some hollows. • In some areas there was abundant and deep leaf litter and some areas of rock outcrop and denatured sandstone. • Coarse woody debris (ie. fallen logs) was present. • There are likely to be a wide range of fauna utilising these habitats including reptiles, hollow dependent fauna (eg. birds and bats) and those fauna that require access to water for foraging.
Forest	Coastal – Shale Sandstone Forest Hinterland Sandstone Gully Forest Cumberland Riverflat Forest	12.80 9.29 0.16	• These vegetation types were in good condition except where the forest edges were close to infrastructure (eg. batter, spoil piles or noise walls). • The vegetation was structurally complex but the tree height was generally less than other forest types in the study area. • There were native shrubs, herbs and grasses encountered in this habitat. • There were some rocky outcrops but these were fewer than the enriched sandstone forests. • Coarse woody debris was present but generally less abundant than in the enriched or rainforest types. • Fauna expected to use this habitat would include forest and woodland birds, hollow dependent bats and blossom feeding birds, bats and arboreal mammals.

Type	Vegetation	Area (hectares)	Likely fauna / attributes
Regenerating	Regeneration – native (disturbed form of forest)	0.29	• Regenerating vegetation of Coastal – Shale Sandstone Forest. • Habitat features such as exposed rock, deep leaf litter and hollows are usually few in number. • The types of fauna expected to utilise this habitat includes those that are urban tolerant and may include invasive species.
Urban	Urban native / exotic Weeds and exotics Regeneration – exotic Syzygium paniculatum (Lilly Pilly) (planted)	12.45 13.82 0.63 0.13	• This vegetation type was common across the whole study area. The vegetation is not a naturally occurring remnant type. • The vegetation is generally managed landscaped vegetation or occurs as a result of clearing (eg. spoil piles). • The vegetation is generally in poor condition and usually dominated by exotic species. • Habitat features such as exposed rock, deep leaf litter and hollows are usually few in number. • The types of fauna expected to utilise this habitat includes those that are urban tolerant and may include invasive species.
Water	Water	0.05	• Detention basins. • The types of fauna expected to utilise this habitat are those that can utilise intermittent water (eg. birds).
Cleared	Cleared	61.01	• Cleared areas with houses, concrete, or exotic dominated grassland. Minimal fauna habitat.
Not surveyed	Area where access was not available	17.29	• Unknown, but will be similar to other habitats within the study area.
Total		**139.89**	

3.9.1 Hollow bearing trees

A hollow bearing tree study was completed in late December 2013 (AECOM 2014). This report (AECOM 2014) identified 62 hollow bearing trees with 89 hollows within the study area. Of these hollow bearing trees, four trees contained hollows of sufficient size (very large) to support fauna such as large forest owls or Glossy Black Cockatoo. Three of the very large hollows were at the Hills M2 Motorway integration works area and the fourth very large hollow was in Blue Gum High Forest at the northern interchange.

The hollow bearing tree study identified that a number of hollows appear to be used by fauna because nesting material, scratching marks and presence of fauna were found. The hollow bearing tree study did not find any threatened fauna using these hollows (AECOM 2014).

3.9.2 Culvert and abandoned building assessments

During the field survey six culverts were found in five locations and five of the six culverts were assessed for potential microbat habitat (**Figure 7**). Abandoned buildings were also present in the Pioneer Avenue compound and were assessed for their potential microbat habitat (**Figure 7**).

One culvert along the Hills M2 Motorway integration works area near Blue Gum Creek (marked as culvert 3 in **Figure 7**) could not be assessed for safety reasons due to the presence of deep and flowing water. This culvert consists of three separate drains underneath the motorway, with deep flowing water surrounded by both native and exotic vegetation. This culvert is likely to contain habitat for microbats due to the presence of the water, the length of the culvert and its height.

Of the remaining five culverts inspected, four contained features that would be suitable for microbats. These features are described in **Table 8**, with photographs provided after the table.

Buildings at the Pioneer Avenue compound were not inspected for microbats, but due to the disused nature of the buildings and the multiple potential entry points it was considered that the buildings could provide potential microbat habitat.

No microbats were observed roosting in any of the culverts when assessed by ELA ecologists. Four culverts along the Hills M2 Motorway integration works area are approximately six to eight kilometres west of a known Eastern Bent-wing Bat maternity roost at Devlins Creek.

Table 8: Culverts and abandoned buildings found, their features and likelihood for microbat habitat

Culvert / Building	Dimensions length, width, height (metres)	Habitat for microbats?	Habitat features	Microbats present
1	50 x 5 x 4	No	• This culvert ran underneath the M1 Pacific Motorway at North Wahroonga. • The culvert was surrounded by fringing vegetation. • Water was present and flowing. • Cracks were not suitable for microbats.	None seen
2	20 x 2.5 x 1.5	Yes	• This culvert ran under Junction Road at North Wahroonga and parallel to the M1 Pacific Motorway. • The culvert was surrounded by fringing vegetation. • Water was present. • Cracks were suitable for microbats.	None seen

Culvert / Building	Dimensions length, width, height (metres)	Habitat for microbats?	Habitat features	Microbats present
3	35 x 2 x 2.5 (3 openings of the dimensions above)	Potentially	• This culvert ran under the Hills M2 Motorway near West Pennant Hills. • The culvert was surrounded by fringing vegetation. • Water was present. • Height and length of the culvert suitable for habitat.	Unknown – culvert could not be inspected
4 & 5	35 x 7 x 4	Yes	• This culvert ran under the Hills M2 Motorway near West Pennant Hills. • The culvert was surrounded by fringing vegetation. • Water was present but not flowing. • Cracks were suitable for microbats.	None seen
6	35 x 1.5 x 1.5 (2 openings of the above dimensions)	Yes	• This culvert ran under the Hills M2 Motorway near North Rocks. • The culvert was surrounded by fringing vegetation. • Water was present but not flowing. • Cracks were suitable for microbats.	None seen
Pioneer Avenue buildings	Various sizes	Potentially	• Disused industrial buildings, with various openings and crevices which could be potential microbat entry points	None seen

Culvert Photo 1: Culvert 1 east of M1 Pacific Motorway

Culvert Photo 2: Culvert 2 under Junction Road

Culvert Photo 3: Culvert 2

Culvert Photo 4: Culvert 3 north of Hills M2 Motorway

Culvert Photo 5: Culvert 4 northern side, the southern side is mapped as culvert 5

Culvert Photo 6: Culvert 6 at the northern side of the Hills M2 Motorway

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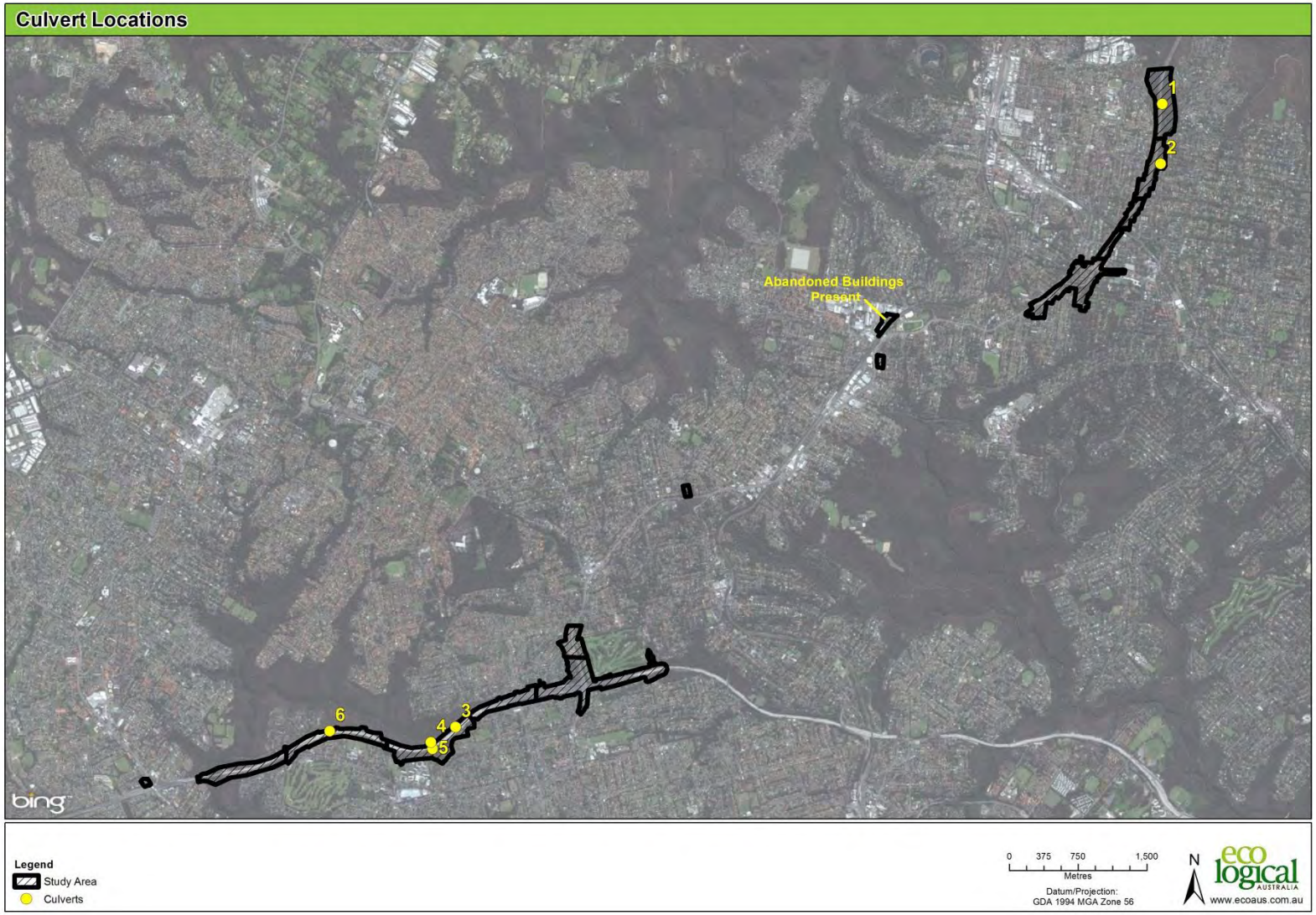

Figure 7: Culvert and disused buildings location (Pioneer Avenue)

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3.10 Wildlife connectivity corridors

No regional fauna corridors are present within the total study area, primarily due to the fragmented structure of vegetation in the area. Furthermore, areas of potential impact are in proximity to existing infrastructure (Roads and Maritime 2013). However local wildlife corridors do exist at a smaller scale (**Figure 8**). At a local scale there are riparian corridors linked to regional parks, namely:

- Cockle Creek (also known as Spring Gully Creek) at the M1 Pacific Motorway at top of the catchment of Ku-ring-gai Chase National Park.
- Devlins Creek on the Hills M2 Motorway at the top of the Lane Cove National Park catchment.
- Blue Gum, Darling Mills and Stevenson Creeks in former Darling Mills State Forest and Excelsior Reserve – now Bidjigal Reserve on the upper tributaries of the Parramatta River catchment.

Small areas of these riparian corridors will be affected by the construction footprint (refer to **Appendix D**).

At a local scale, Ku-ring-gai Municipal Council identified local corridors (KMC, 2011). Within Ryde local government area, there is a 'River to River Wildlife Corridor' project funded by the NSW Environmental Trust, with the City Of Ryde and Hunters Hill Councils in partnership with the Sydney Metropolitan Catchment Management Authority (SMCMA). The project aims to assist the long term survival and conservation of small birds. This project is active in Devlins Creek and Bidjigal Reserve.

At a local scale to the project study area, connectivity has been affected due to the existing Hills M2 Motorway and the M1 Pacific Motorway. For the Hills M2 Motorway, the height of the Darling Mills Creek bridge and vegetation growth under the bridge has minimised impacts on wildlife connectivity in a north-south direction associated with Stevenson Creek.

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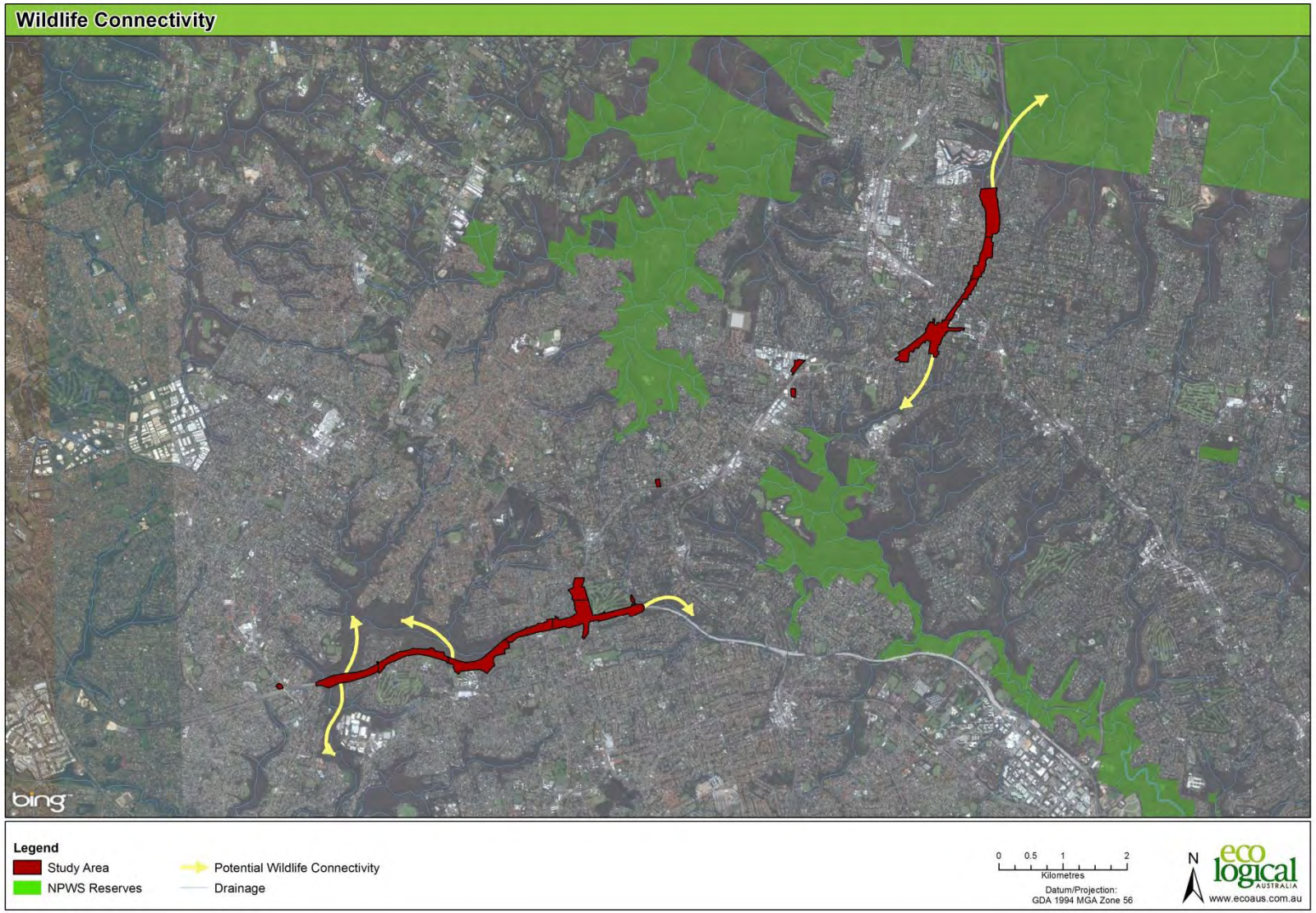

Figure 8: Wildlife connectivity corridors

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3.11 Groundwater dependent ecosystems

Groundwater Dependant Ecosystems (GDEs) are defined as ecosystems whose current species composition, structure and function are reliant on a supply of groundwater as opposed to surface water supplies from overland flow paths. The frequency of groundwater influence may range from daily to inter-annually, however it becomes clearly apparent when either the supply of groundwater or its quality (or both) is altered for a sufficient length of time to cause changes in plant function. Groundwater use by an ecological community or individual species does not necessarily imply groundwater dependence.

In Australia, the majority of ecosystems have little to no dependence on groundwater, although the full understanding of the role of groundwater in maintaining ecosystems is generally poor. The exception to this is wetland communities, for which it is thought that most have some level of dependence on groundwater resources.

GDEs are generally classified into six categories (SCCG 2006, SKM 2001):

- **Terrestrial vegetation** – forests and woodland which develop a permanent or seasonal dependence on groundwater, often by extending roots into the water table,
- **Base Flow in streams** – aquatic and riparian ecosystems that exist in or adjacent to streams that are fed by groundwater base flow,
- **Aquifer and cave systems** – aquatic ecosystems that occupy caves or aquifers,
- **Wetlands** – aquatic communities and fringing vegetation that depend on groundwater fed lakes and wetlands,
- **Estuarine and near shore marine ecosystems** – various ecosystems including mangroves, salt marsh and seagrass, whose ecological function has some dependence on groundwater discharge
- **Terrestrial fauna** – fauna species assemblages reliant on groundwater for drinking water.

A final category is also recognised **'**not apparently dependant'. This category acknowledges that some ecosystems, particularly wetland and riparian vegetation, might superficially appear to be groundwater dependent while in fact they are dependent entirely on surface flows and or rainfall.

The Groundwater Dependent Ecosystems Atlas (2013) shows potential groundwater dependent ecosystems (GDE) within 200 metres of the study area (**Figure 9**). There were five different vegetation communities with at least some potential for groundwater dependence that ranged from low to high (**Table 9**).

Three vegetation types had high potential for groundwater dependence along the existing Hills M2 Motorway: Hinterland Sandstone Gully Forest, Sandstone Riparian Scrub and Sydney Hinterland Transition Forest. All of these occupy low areas of topography. Vegetation communities are described in more detail in **section 3.5** and their potential for groundwater dependence is listed in **Table 9**.

Potential GDEs in the Hills M2 Motorway integration works study area are generally in a moderate to good ecological condition, maintaining a high biodiversity value and acting as important habitat for fauna (AECOM 2013). During aquatic surveys in January 2014 for this project, large deposits of sediment (sand) downstream of the Hills M2 Motorway along Darling Mills Creek for at least one kilometre to the Loyalty Road flood retarding basin were detected, which have in-filled the natural cobble substrate. The Sandstone Riparian Scrub that is alongside Darling Mills Creek is highly modified (AECOM 2013).

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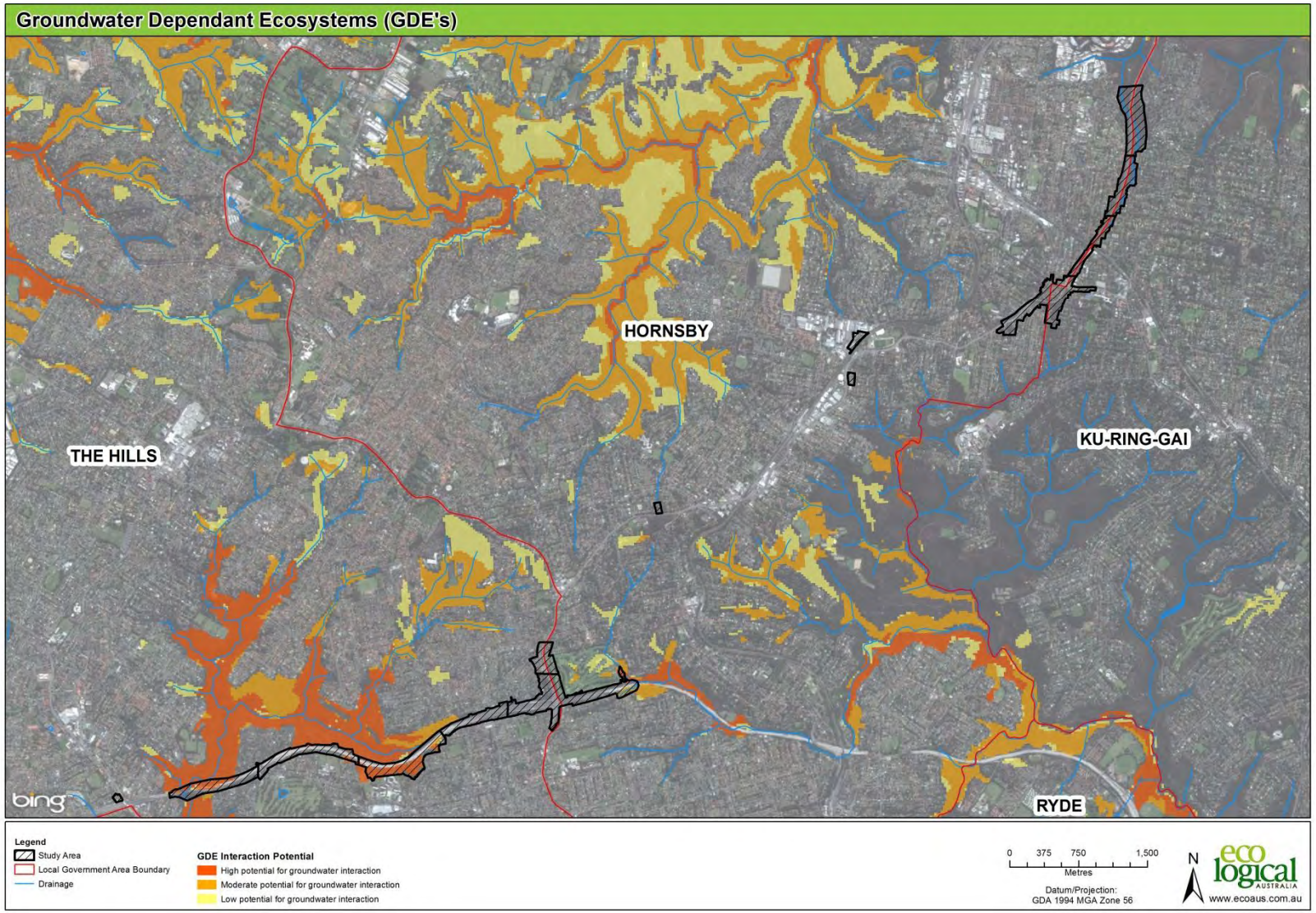

Figure 9: Ground Water Dependent Ecosystems Atlas results for the study area

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Table 9: Potential groundwater dependent ecosystems in the project study area*

	Southern interchange 1			Hills M2 Motorway integration works 2			Hills M2 Motorway integration works 3			Hills M2 Motorway integration works 4		
Potential for dependence:	L	M	H	L	M	H	L	M	H	L	M	H
Hinterland Sandstone Gully Forest												
Coastal Sandstone Ridgetop Woodland												
Sydney Turpentine Ironbark Forest												
Sandstone Riparian Scrub												
Sydney Hinterland Transition Woodland												

* Yellow represents low potential for groundwater interaction, orange represents moderate potential for groundwater interaction, red represents high potential for groundwater interaction. The presence of a colour in the table means that the footprint in that area intersects with vegetation with potential for groundwater dependence. It is noted that the ancillary sites do not intersect with vegetation identified as having potential for groundwater dependence.

A search of the NSW Natural Resource Atlas provided water levels from four bores within two kilometres of the Hills M2 Motorway (**Figure 10**). Water levels in three of the four bores were recorded at 65 to 90 metres below ground level (**Table 10**). The fourth bore, GW110252, is a monitoring bore that had a static water level of eight metres below ground. The shallower bore enters a superficial aquifer near Northmead Gully that may extend eastward to Darling Mills Creek. The other three bores enter a deeper regional aquifer in the Hawkesbury Sandstone, which underlies the shallower aquifer. The shallow aquifer is unlikely to be very extensive, although is likely to be the main source of groundwater for the vegetation communities and provide some base flow to Darling Mills Creek. It is unlikely that potential GDEs in these project areas are dependent on the deeper Hawkesbury Sandstone Aquifer.

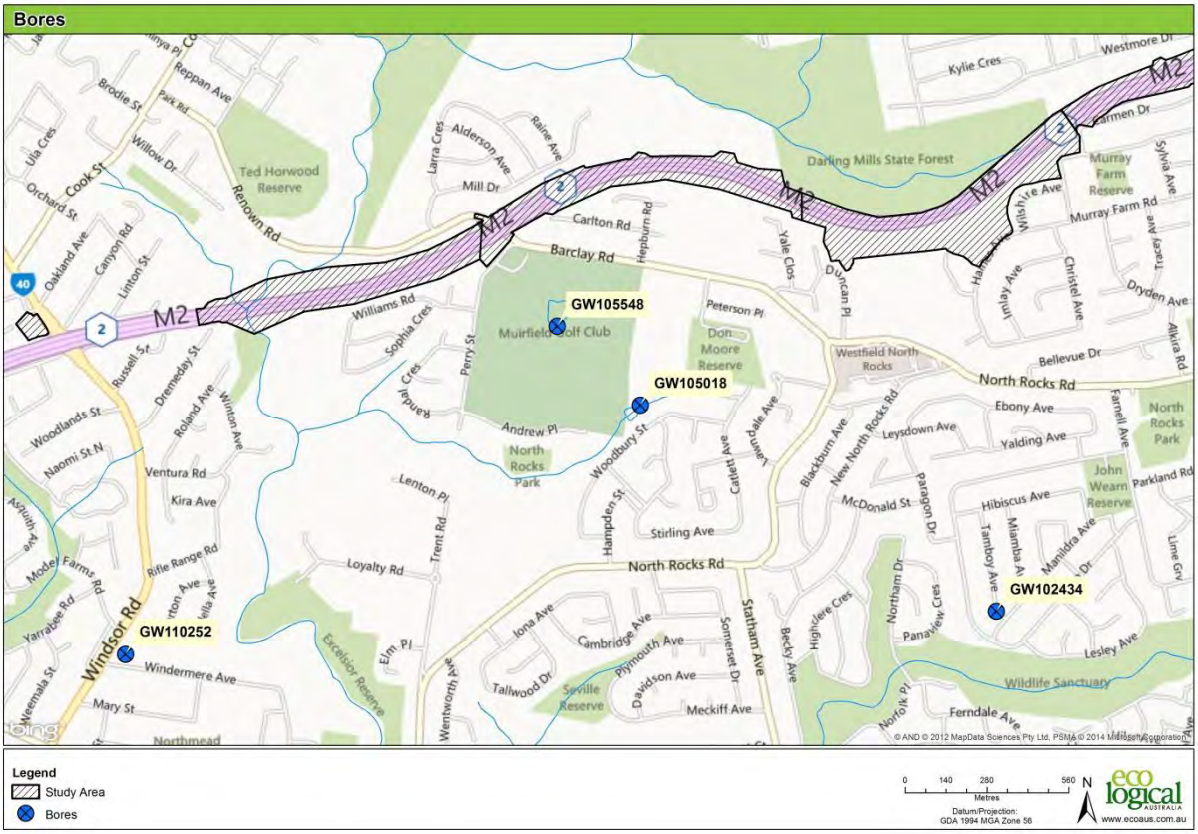

Figure 10: Location of bores near the Hills M2 Motorway integration works study area 1 to 4

Table 10: Depths to water table for bores near the project area along the Hills M2 Motorway

Registered number	Purpose	Static water level (metres below ground level)	Date installed
GW 105548	Irrigation Golf Course	90	2004
GW105018	Irrigation Golf Course	80	2003
GW110252	Monitoring Bore	8	2009
GW102434	Domestic Stock	65	1999

4 Potential impacts

The potential impacts on biodiversity are discussed in this chapter. Impacts have been identified as both direct, such as direct clearing of vegetation, and indirect such as increases in noise, lighting and downstream riparian impacts.

The use of underground tunnels avoids impacts along much of the route. The project would have both direct and indirect impacts on a range of biodiversity values during both the construction and operational phases of the project. Impacts are mainly associated with the construction footprint. The level of indirect impacts is considered to be minimal given the mitigation measures to be implemented (**section 5.2**).

The impact assessment has considered both construction and operational impacts, and has included:

- Twin motorway tunnels.
- Northern interchange with the M1 Pacific Motorway, the Pacific Highway and Pennant Hills Road.
- A southern interchange with the Hills M2 Motorway and Pennant Hills Road.
- Integration works with the Hills M2 Motorway.
- Tie-in works with the M1 Pacific Motorway.
- Motorway Control Centre located near the southern interchange on the corner of Karloon Road and Pennant Hills Road.
- Two tunnel support facilities.
- Modifications to service utilities and associated works at surface roads near the two interchanges and operational ancillary facilities.
- Modifications to local roads, including widening of Eaton Road and repositioning of the Hewitt Avenue cul-de-sac.
- Ancillary temporary construction facilities and temporary works to facilitate the construction of the project.
- Water treatment plant discharges during construction and operation.

The key ecological impacts of the project relate to:

- Loss of vegetation/habitat.
- Weed spread.
- Changed hydrology.

Secondary impacts relate to:

- Pathogens and animal pests.
- Impact on relevant Key Threatening Processes.
- Wildlife connectivity and habitat fragmentation.
- Injury and mortality.

Negligible impacts relate to:

- Bushfire.
- Noise, vibration and light.
- Groundwater dependent ecosystems.
- Cumulative impacts.

4.1 Loss of vegetation/habitat

Loss of vegetation and fauna and flora habitat is a necessary consequence of the project. The field survey validated the type and extent of vegetation and various habitats present throughout the study area. A total of:

- Two endangered ecological communities have been recorded within the study area.
- Five threatened flora species have potential to occur within the study area, one was recorded in the construction footprint and another within the study area.
- Twenty threatened fauna species have potential to occur within the study area, none were recorded within the study area.

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

The amount of vegetation (native and exotic) estimated to be cleared is around 20.59 hectares in total (excluding areas not surveyed and cleared lands), with a total of 5.87 hectares of native vegetation to be cleared. **Table 11** provides a detailed breakdown of vegetation that would be impacted directly or indirectly for each section of the study.

A hollow bearing tree study was completed (AECOM, 2014), and the hollow bearing trees were found to be predominately clustered at Darling Mills Creek (Hills M2 Motorway) and at the northern interchange. This report (AECOM, 2014) identified 62 hollow bearing trees with 89 hollows within the study area. Of these hollow bearing trees, four trees contained hollows of sufficient size to support fauna such as large forest owls or Glossy Black Cockatoo. The construction footprint contains 34 hollow bearing trees which may be removed, lopped or trimmed, which may result in up to 53 hollows being removed.

The hollow bearing tree study identified that a number of hollows appear to be used by fauna because nesting material, scratching marks and presence of fauna were found. The hollow bearing tree study did not find any threatened fauna using these hollows (AECOM, 2014). As a result of design alterations, the project would avoid all of the four very large hollows, which are likely to be used by threatened fauna, especially in the Darling Mills Creek area of the Hills M2 Motorway integration works area.

Table 11: Native vegetation impacted by the project

Vegetation Community	Condition	Northern Interchange	Southern Interchange	Hills M2 Motorway integration works	Pioneer Avenue	Trelawney Street Compound	Wilson Road Compound	Windsor Road Compound	Grand Total*
Blue Gum High Forest	Moderate		0.37	0.00					0.37
	Poor	1.14	0.10	1.20	0.00				2.44
	Total	*1.14*	*0.47*	*1.20*	*0.00*				*2.81*
Blue Gum Individuals	Low	0.00		0.01			0.07		0.08
Coastal Enriched Sandstone Dry Forest	Good			0.01					0.01
Coastal Enriched Sandstone Moist Forest	Good			0.15					0.15
Coastal Sandstone Gallery Rainforest	Moderate			0.03					0.03
Coastal Shale-Sandstone Forest	Good			0.55					0.55
	Moderate			0.30					0.30
	Poor			0.85					0.85
	Total			*1.71*					*1.71*
Hinterland Sandstone Gully Forest	Poor	0.72							0.72
Sydney Turpentine Ironbark Forest	Poor						0.10		0.10
Syzygium paniculatum (Lilly Pilly) (planted)	Poor	0.03	0.02	0.02					0.07
Regeneration - Native	Moderate			0.19					0.19
Total Native Vegetation		***1.89***	***0.48***	***3.33***	***0.00***	***0***	***0.16***	***0***	***5.87***
Regeneration - Exotic	Low			0.56					0.56
Urban Native/Exotic	Low	1.77	3.01	1.58					6.37
Weeds and Exotics	Low	5.87	0.09	0.95	0.46			0.04	7.79
Not surveyed	N/A	0.74	2.35	0.94					4.04
Cleared	N/A	10.44	7.83	12.64	1.41	0.93	0.61	0.59	34.46
Total Construction Footprint		**20.72**	**14.15**	**20.00**	**1.87**	**0.93**	**0.78**	**0.64**	**59.09**

* Based on footprint dated 11th April 2014.

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Two threatened ecological communities listed under the TSC Act occur within the study area: Blue Gum High Forest and Sydney Turpentine Ironbark Forest.

Blue Gum High Forest

Blue Gum High Forest has been identified within the construction footprint along sections of the Hills M2 Motorway integration works, the southern interchange and the northern interchange (see map series in **Appendix D**). A number of ancillary sites have individual *Eucalyptus saligna* trees that also meet the definition of Blue Gum High Forest under the TSC Act. ELA is cognisant of NSW Land and Environment Court decisions in protecting very small patches of Blue Gum High Forest and individual *E. saligna* trees and as such has adopted a precautionary approach to the classification of this community under the TSC Act in including areas dominated by *E. saligna* as part of this CEEC.

The project would remove areas of TSC Act listed Blue Gum High Forest near the Hills M2 Motorway integration works, the southern interchange and the northern interchange. Small areas of Blue Gum individuals which may potentially meet the TSC Act listed Blue Gum High Forest would also be removed at the Hills M2 Motorway integration works, Wilson Road compound and the northern interchange. Areas to be removed are quantified in **Table 11**. The project is likely to have a potentially significant impact on this community because of the extent of clearing relative to the remaining extent of Blue Gum High Forest.

Remnant patches of vegetation that are part of the Blue Gum High Forest listed under the EPBC Act must have component plants representing the characteristic native plant species in all structural layers (DotE 2013a). EPBC Act Blue Gum High Forest is found on the north shore and northern suburbs of Sydney and has a highly restricted and fragmented geographic distribution comprised of a series of small remnant patches. The area of extant EPBC Act Blue Gum High Forest remaining in 2005 was estimated to be 136 hectares consisting of small fragmented remnants (DotE, 2013a). The EPBC Act Blue Gum High Forest community is a subset of the TSC Act Blue Gum High Forest community and as such under comparable pressures.

The EPBC Act Blue Gum High Forest community definition is narrower than the TSC Act definition, in that EPBC Act Blue Gum High Forest:

- Occurs only on sandstone derived soils.
- Requires minimum canopy coverage of 10 per cent.
- Must be part of a patch greater than one hectare.
- Must be dominated by native plants in all structural layers of the community.

Although ELA identified Blue Gum High Forest across the study area, none of the patches being impacted by the project meet the EPBC Act definition. This includes Blue Gum High Forest at the southern and northern interchanges and at the ancillary facilities sites.

There is a strip of Blue Gum High Forest along the northern side of the Hills M2 Motorway integration works that is large enough and has adequate canopy coverage to meet the EPBC Act definition. However the understorey of the Blue Gum High Forest at this location is dominated by *Lantana camara* (Lantana) and *Rubus* sp. (Blackberry) with little or no remnant native plants present. The weedy understory was in excess of two metres tall and at a density that has shaded out most groundcovers. Areas of mown grass and broadleaf exotics beyond the study footprint may have some restoration potential if there is a residual seed bank, however are not part of the construction footprint or study area.

Blue Gum High Forest occurs at the Lisle Court Reserve within the southern interchange. Some vegetation mapped as moderate condition has representative plants in the groundcover, midstorey and overstorey layers, but due to the small size does not meet EPBC Act defintions. There is additional Blue Gum High Forest mapped as poor condition which consists of remnant Blue Gums with a mown understorey. A small number of remnant Blue Gums were found at the Wilson Road compound.

Blue Gum High Forest is present at the Pioneer Avenue compound site, but would be avoided.

The amount of Blue Gum High Forest to be removed constitutes approximately 1.7 per cent of the extant community which for the TSC Act is about 170 hectares (Tozer, 2003), not including 0.08 hectares of Blue Gum individuals.

Mitigation of impacts includes early avoidance of high quality patches at the detailed design stage. Further mitigation measures can be found in **section 5**.

An impact assessment under the TSC Act was undertaken (**Appendix F**) and assessed the unavoidable impacts to Blue Gum High Forest. The assessment concludes that despite provision of some mitigation measures a significant impact to Blue Gum High Forest is expected because of the extent of the vegetation type to be removed relative to the extent remaining.

Sydney Turpentine Ironbark Forest

Sydney Turpentine-Ironbark Forest is listed as a CEEC under the TSC Act and EPBC Act. Sydney Turpentine Ironbark Forest is an open forest with dominant canopy trees including *Syncarpia glomulifera* (Turpentine), *Eucalyptus punctata* (Grey Gum), *E. paniculata* (Grey Ironbark) and *E. eugenioides* (Thin-leaved Stringybark). Other characteristic tree species are *E. resinifera*, *Angophora costata* and *A. floribunda*, and species composition varies between sites due to local conditions such as topography, rainfall and exposure. In areas of high rainfall (over 1050 millimetres per annum) *E. saligna* is more often dominant. The shrub stratum is usually sparse and may contain mesic species such as *Pittosporum undulatum* (Sweet Pittosporum) and *Polyscias sambucifolia* (Elderberry Panax).

Within the study area, Sydney Turpentine-Ironbark Forest is found to the east of the Hills M2 Motorway (southern interchange) but does not occur within the construction footprint. This remnant patch meets the TSC Act definition but did not meet the EPBC Act definition. There is another patch of potential Sydney Turpentine-Ironbark Forest that occurs within the Wilson Road compound. This patch comprises scattered individual trees with no native understorey or ground cover. This remnant patch meets the TSC Act definition but did not meet the EPBC Act definition.

The design of the project avoids the patch of Sydney Turpentine-Ironbark Forest at the southern interchange, but will result in the removal of 0.1 hectares at the Wilson Road compound.

A significance assessment was conducted for Sydney Turpentine Ironbark Forest under the TSC Act (**Appendix F**). It concluded that a significant impact on this ecological community was unlikely.

4.1.1 Threatened Flora

Five threatened flora species are considered to have the potential to occur within the study area. Three of these flora species have been recorded during the field survey *Epacris purpurascens* var. *purpurascens, Syzygium paniculatum* and *Hibbertia superans.*

***Callistemon linearifolius* (Netted Bottlebrush)**

Callistemon linearifolius is listed as vulnerable under the TSC Act. It typically occurs within dry sclerophyll forest on the coast and adjacent ranges (Harden 1991). *C. linearifolius* is threatened by a continued loss of habitat from urban expansion and by stochastic events due to the small size of known populations. There are 121 records for *Callistemon linearifolius* on the Wildlife Atlas within ten kilometres of the study area.

No individuals of *C. linearifolius* were found in the study area, however suitable habitat was found within the construction footprint of the Hills M2 Motorway integration works where there is dry sclerophyll forest vegetation (Coastal Shale-Sandstone Forest, Coastal Enriched Sandstone Dry Forest, Hinterland Sandstone Gully Forest). A significance assessment was undertaken (refer to **Appendix F**) and concluded that the project is unlikely to result in a significant impact on *C. linearifolius* because there were no individuals detected within the construction footprint and that impacts to potential habitat were minimal, given the extent of potential habitat existing outside the construction footprint.

Darwinia biflora

Darwinia biflora is listed as vulnerable under the TSC Act and EPBC Act. *D. biflora* occurs on the edges of weathered shale-capped ridges, where they intergrade with Hawkesbury Sandstone. The vegetation structure is usually woodland, open forest or scrub-heath.

There are 904 records for *D. biflora* on the Wildlife Atlas within ten kilometres of the study area. Potential habitat for *D. biflora* exists within the study area of the Hills M2 Motorway integration works. However no individuals of *D. biflora* were found within the study area. Whilst the surveys were conducted outside of the optimal season when flowers are typically present and identification is easier, the species is readily detected outside of this period by experienced observers. A significance assessment was undertaken for this species (refer to **Appendix F** and **Appendix G**) and it was concluded that that the proposal is unlikely to result in a significant impact on *D. biflora* given that the species was not detected within the construction footprint and that potentially suitable habitat for the species within the study area occurs beyond the construction footprint.

Epacris purpurascens* var. *purpurascens

E. purpurascens var. *purpurascens* is listed as vulnerable under the TSC Act. *E. purpurascens* var. *purpurascens.* Although restricted to the Sydney Basin Bioregion, the species is found in a range of habitat types and these habitats frequently have a strong shale influence (OEH, 2013g). The species is strongly associated with Sydney Turpentine Ironbark Forest and Shale/Sandstone Transition Forest (Friends of Berowra Valley Regional Park, 2004). There are 328 records for *E. purpurascens* var. *purpurascens* on the Wildlife Atlas within ten kilometres of the study area. The species is identified as being sensitive to clearing of habitat, alteration of habitat, frequent burning for fire hazard reduction, increased human access, and increased rubbish dumping and weed invasion (NPWS 2002a).

The M2 Upgrade project found *E. purpurascens* var. *purpurascens* located on relocated soils including earth mounds and rock armoured batter slopes (AECOM, 2010). The recent field assessment found located 88 individuals of *E. purpurascens* var. *purpurascens*, while 180 plants are known from the study area along the Hills M2 Motorway (Cumberland Ecology, 2012). Appendix K provides a comparison of the results from this survey and Cumberland Ecology (2012).

Taking a precautionary approach, the project would result in the clearance of approximately 106 plants which were identified in sites 2 and 3 shown in Cumberland Ecology (2012), affecting the majority

(59 per cent) of the known population along the road corridor.

A significance assessment was undertaken for this species (refer to **Appendix F**) and it concluded that there would be a significant impact on the local population of *E. purpurascens* var. *purpurascens* given the number of plants to be cleared. This is based on a worst case scenario and assumes complete clearance of the plants within the construction footprint.

Additional surveys during flowering season from July to September are recommended to determine more precisely the extent of the local population of *E. purpurascens* var. *purpurascens*. As noted earlier, a worst case scenario has been assessed, and opportunities to minimise the extent of disturbance would be explored during detailed design. As this may reduce the level of impact, the suite of mitigation measures would need to be established and it is recommended that further survey is completed on the final disturbance footprint to better determine population extent and size and relocation of soil or plants.

Hibbertia superans

Hibbertia superans is listed as endangered under the TSC Act. It occurs in open woodland and heathland on sandstone ridgetops, often near the shale/sandstone boundary (OEH, 2013i). It may prefer open disturbed areas, including tracksides, yet is highly sensitive to both frequent and infrequent fire and other disturbance regimes (OEH, 2013i). There are 218 records for *H. superans* on the NSW Wildlife Atlas within ten kilometres of the study area.

A population of four *H. superans* (confirmed by the National Herbarium of NSW on 10 February 2014) was identified on the northern side of the Hills M2 Motorway integration works area on the edge of an informal pedestrian track and adjacent to a stormwater inspection pit. This location is beyond the construction footprint but within 30 metres of the footprint. This species was found in an area of vegetation identified as Coastal Shale-Sandstone Forest. The project footprint has been altered to avoid these plants and there is ample other suitable habitat adjacent to the construction footprint, which while not surveyed, may contain this species.

Standard Roads and Maritime mitigation measures would be put into place to minimise the impact on the adjacent potential habitat, these would be outlined in the flora and fauna management plan, and include measures to reduce effects of increased sedimentation, trampling and inadvertent clearing. Although a significance assessment was undertaken for this species (refer to **Appendix F**) and it was determined that a significant impact is unlikely to result as part of the project, further survey is recommended to identify the location of the local population and to confirm impacts have been avoided by implementing the flora and fauna environmental plan.

Syzygium paniculatum (Magenta Lilly Pilly)

S. paniculatum is listed as endangered under the TSC Act and vulnerable under the EPBC Act. Small patches of this species were found at the northern and southern interchanges in and around existing urban development. There are 20 records for *S. paniculatum* on the Wildlife Atlas within ten kilometres of the study area. The individuals of this species found during the field assessment are planted individuals. Of the four patches located within the study area, three would be removed as a result of the project. A significance assessment was conducted (refer to **Appendix F** and **Appendix G**) and it concluded that because *S. paniculatum* has been planted, no significant impact is likely.

4.1.2 Threatened Fauna

Twenty threatened fauna species are considered to have the potential to occur within the study area based on database search results and the background literature review.

Red-crowned Toadlet

Pseudophryne australis (Red-crowned Toadlet (RCT)) is listed as vulnerable under the TSC Act. The species breeding habitat in the Sydney metropolitan region has been defined as ephemeral or intermittent low order drainage lines with a build-up of litter or other debris within heath or eucalypt forest on sandstone (OEH 2013e). The Red-Crowned Toadlet will forage within 50 metres of breeding habitat.

There are 314 records for the Red-crowned Toadlet on the Wildlife Atlas within ten kilometres of the study area. Potential habitat was identified during the field survey at tributaries of Cockle Creek (**Figure 11**) at the northern most extent of the study area but no targeted surveys were conducted. The tributaries are downstream of the construction footprint however foraging habitat may be impacted indirectly through variations in runoff and movement of weed propagules. The impact on the habitat of this species is not likely to be significant because the habitat is outside the construction footprint and no potential breeding or foraging habitat is to be impacted.

Measures to mitigate indirect impacts such as sedimentation and weed invasion should be incorporated into the proposal. These measures would be outlined in the flora and fauna management plan, which would be prepared prior to the commencement of construction.

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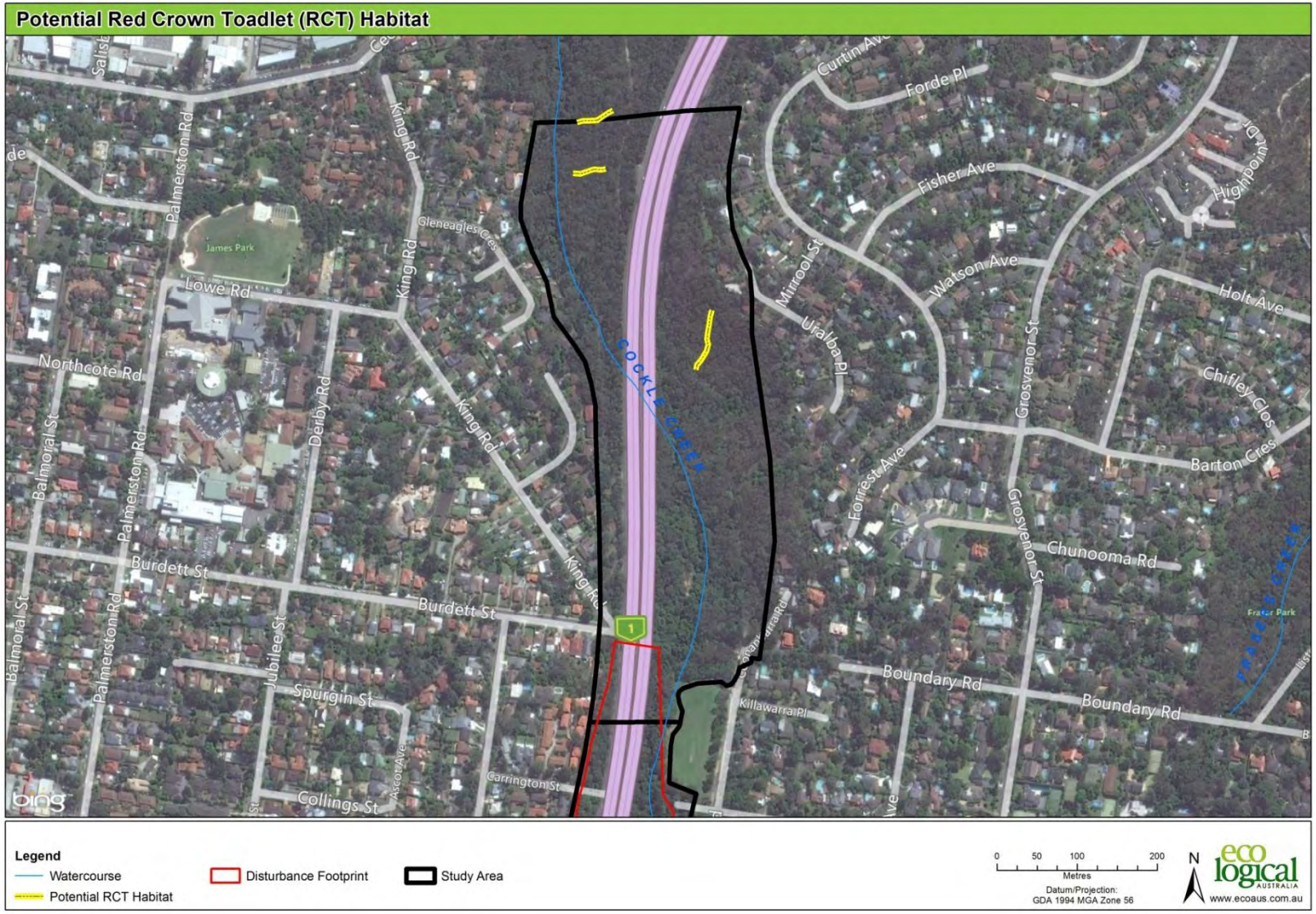

Figure 11: Red-crowned Toadlet potential habitat (northern interchange study area– M1 Pacific Motorway)

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