M2 Upgrade Project

05 May 2010

Flora and Fauna Assessment Report

M2 Motorway Upgrade

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Prepared for

M2 Upgrade Project

Prepared by

AECOM

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Prepared by	Calliope Adamos, Rochelle Lawson, Paul Rossington
Reviewed by	David Robertson, Ruth Baker, Louisa Rebec

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Table of Contents

List of Figures

List of Tables

Executive Summary

Introduction

The M2 Upgrade involves physical widening and associated works to improve the operational performance of the M2 Motorway. This Flora and Fauna Impact Assessment forms part of an Environmental Assessment and has been prepared to assess the potential impacts on ecological values associated with the proposed M2 Upgrade. The Assessment has been structured to comply with the Director General's Requirements. In particular, consideration is given to species, critical habitat, populations and ecological communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), *Threatened Species Conservation Act 1995* (TSC Act), *Threatened Species Conservation provisions of the Fisheries Management Act 1994* and the *Fisheries Management Amendment Act 1997*.

This flora and fauna Assessment also identifies suitable mitigation measures that would be implemented to ameliorate potential impacts on the environment.

Methods

The results of field surveys, a review of previous studies, a review of published information sources including the Commonwealth Government Species Profile and Threats (SPRAT) database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken in the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original Environment Impact Statements (EISs) for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992) as well as the Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area (DECC 2008).

Assessments of significance were conducted for threatened species listed under the TSC Act and followed the heads of consideration outlined in the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and the Department of Primary Industries, 2005) (now known as DECCW and I&INSW and referenced hereafter as the original document). For threatened species listed under the EPBC Act, assessments of significance were undertaken in accordance with the *Significant Impact Guidelines and Matters of National Significance* outlined by the Department of Environment and Heritage (DEH, 2006)(now known as DEWHA).

For the purposes of this assessment the 'M2 corridor' refers to the area bounded by the Hills M2 Motorway lease boundary, the study area was defined as the M2 corridor and any additional areas directly, or indirectly, affected by the proposed upgrade works and 'vicinity' refers to the surrounding neighbourhood areas adjacent to the project area.

Existing environment

The results of field surveys, a review of previous studies, a review of published information sources including the Commonwealth Government Species Profile and Threats (SPRAT) database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken in the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original Environment Impact Statements (EISs) for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992).

Much of the area surrounding the M2 corridor is highly urbanised and consists chiefly of residential properties, parkland, weed-infested areas and degraded riparian vegetation. Several larger areas of remnant native vegetation exist within and adjacent to the areas proposed to be directly, or indirectly, affected by the proposed upgrade works. The most significant of these include: Bidjigal Reserve; vegetation in the vicinity of Devlins Creek; vegetation surrounding Terrys Creek between Lucknow Park; Berriwerri Reserve and Sommerset Park and parts of Lane Cove National Park adjacent to the M2 corridor in Macquarie Park.

There are seven native vegetation communities mapped as occurring within the areas adjacent to the M2 Motorway (Coastal Sandstone Ridgetop Woodland, Coastal Sandstone Gully Forest, Hinterland Sandstone Gully Forest, Sydney Hinterland Transition woodland, Sandstone Riparian Scrub, Blue Gum High Forest and Sydney Turpentine-Ironbark Forest). Of these, Sydney-Turpentine Ironbark Forest and Blue Gum High Forest are listed as critically endangered ecological communities (EEC) under the TSC Act and EPBC Act. The M2 Upgrade has been designed to minimise vegetation clearing and in particular, to avoid any potential impacts to the Blue Gum High

Forest community identified adjacent to the M2 Motorway by the alignment of the proposed M2 Upgrade away from the community.

The areas of vegetation within and adjacent to the M2 corridor that have been mapped as Sydney Turpentine–Ironbark Forest were inspected and found to be less than one hectare in area, highly disturbed and consistent with the floristic composition of the larger patches of the adjacent Hinterland Sandstone Gully Forest vegetation community, which is not listed as an EEC. The dominant canopy species in these areas are Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*). No ironbark species were detected within these areas.

Neither the TSC Act nor EPBC Act Threatened Species Scientific Committee's advice regarding this community includes Blackbutt (*Eucalyptus pilularis*) as a dominant or frequently occurring species. While the understorey and ground layer vegetation observed shows a resemblance to that of Sydney Turpentine-Ironbark Forest, its composition and structure are more closely aligned with the Hinterland Sandstone Gully Forest community. Therefore, this EEC is not considered to occur within the areas to be affected by the M2 Motorway Upgrade.

Potential impacts

Approval under the EPBC Act is required where the Department of Environment, Water, Heritage and the Arts (DEWHA) determines if there is likely be a significant impact on a matter of NES. A referral has been submitted to DEWHA for their determination. The referral illustrates that there are unlikely to be any significant impacts on any matters of NES and therefore it recommends to DEWHA that the project is not a controlled action. DEWHA's final determination is currently pending.

Of the threatened terrestrial plant species that are considered to have potential to occur within the areas adjacent to the M2 Motorway, only *Epacris purpurascens var. purpurascens* was recorded during the field investigations conducted for the preparation of this report. This species is listed as vulnerable under the TSC Act. Within the M2 corridor, this species is restricted to translocated soils including earth mounds and rock armoured batter slopes. An assessment of significance (which followed the heads of consideration as outlined in the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) concluded the potential loss of approximately 20 individuals (observed within flora survey plots) is considered unlikely to significantly affect the viability of a local population of this species.

Habitat for a variety of fauna species exists within the remnant vegetation occurring within the M2 corridor and surrounding bushland areas. Threatened species that are known to use these areas include Grey-headed Flying-fox (*Pteropus poliocephalus*), Gang-gang Cockatoo (*Callocephalon fimbriatum*) and Powerful Owl (*Ninox strenua*).

Two migratory nectar-feeding birds Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) may use this resource sporadically or on a seasonal basis but are not considered likely to be regular or frequent visitors to the area based upon database records. In addition to the above, several threatened insectivorous bat species may forage in the air spaces within and around the vegetation adjacent to the M2 Motorway.

Based on assessments of significance conducted for the above threatened species, the proposed M2 Upgrade is not considered to have a significant adverse affect on these threatened species.

Vegetation removal for the M2 Upgrade would be required for the following areas: areas occupied by the widened Motorway and fill batters, construction access roads, site compounds, materials storage areas, new detention basins and access to detention basins.

The amount of native and exotic vegetation estimated to be cleared is approximately 21 ha in total. Of this, a conservative estimate of the amount of vegetation considered to be in good condition within the study area is approximately 10 ha. Approximately 11 ha of this total are considered to be poor condition as these areas are highly modified and characterised by high levels of weed invasion. Whilst removal of vegetation within the development footprint would be permanent, clearing for access and compound areas would be temporary. Approximately 3 hectares would be subsequently rehabilitated post-construction. The 10 ha of native vegetation required to be removed is chiefly found within the Hinterland Sandstone Gully Forest vegetation community that occurs throughout the M2 corridor. This vegetation community is not listed as an EEC under the EPBC Act or TSC Act and is widespread in the vicinity of the proposed M2 Upgrade.

The final construction methodology for access and compound sites will be determined during the detailed design phase. As the widening of the M2 Motorway is alongside the existing Motorway, vegetation fragmentation is not likely to be significantly increased.

Some of the areas with the largest potential impact by the proposal are chiefly areas near waterways. These areas are located within the Sandstone Riparian Scrub vegetation community that occurs along all creeks within and adjacent to the M2 corridor. Due to the restriction of this vegetation community to the edges of watercourses, it is considered to be regionally significant. These communities are currently infested with exotic vines and scramblers. Earthworks have the potential to spread these species to a greater extent. The proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation.

The presence of impervious surfaces such as roads within the catchments of the study area has resulted in alteration of the flow regime of creeks adjacent to the M2 Motorway. Detention basin works proposed are being designed with capacity for the additional stormwater from the Motorway therefore the increased road surface as a result of the works is not considered likely to further alter the natural flow regime of the creeks of the study area.

Mitigation measures

An Environmental Management Plan (EMP) would be developed that describes in detail how each of the management measures prescribed would be implemented during construction (CEMP) and operation (OEMP) of the works. This plan would be developed in consultation with Department of Environment, Climate Change and Water (DECCW), Industry and Investment (I&INSW) and other relevant stakeholders.

The EMP would include measures to minimise impacts on flora and fauna including weed management in areas affected by construction throughout the extent and duration of the project and vegetation rehabilitation and revegetation in areas bordering natural bushland. The extent of clearing for construction compounds will be minimised by retaining mature trees and other vegetation of conservation significance where feasible within compound sites.

Revegetation of disturbed areas as a result of construction activities adjacent to the construction areas and bordering natural bushland will be conducted by suitably qualified and experienced persons, using local provenance plant species that are representative of the relevant vegetation communities. This strategy would be documented in a landscape plan or bushland rehabilitation section of the CEMP. In areas bordering adjacent urban development, revegetation works would be undertaken in accordance with the principles of the RTA Landscape Guidelines.

Where available, seeds will be collected from local understorey and ground layer vegetation prior to clearing and where feasible, from felled trees and branches following clearing for use in revegetation.

Potentially hollow-bearing trees will be identified and marked and targeted measures to minimise potential harm to fauna during clearing will be implemented.

A revegetation strategy would be developed that takes into account the availability of light, moisture and the most suitable plant species.

Works around waterways would be managed to retain bank stability and prevent erosion. Water quality will be protected through the implementation of suitable sediment control measures in all relevant work areas.

Conclusion

It is not considered likely that the proposed works will have a significant effect on ecological communities, threatened flora or threatened fauna species. No threatened ecological communities, as listed under the EPBC Act or TSC Act will be impacted by the proposed works. This has been achieved through the design and alignment of the M2 Motorway Upgrade. Through the implementation of the mitigation measures proposed, there is an opportunity to provide a positive impact by improving habitat connectivity to larger areas of bushland through vegetation rehabilitation in areas suffering from habitat modification and high levels of weed invasion.

1.0 Background

The M2 Upgrade involves physical widening and associated works to improve the operational performance of the M2 Motorway. A detailed project description is provided in Section 6 of the Environmental Assessment. A summary is provided below.

The M2 Upgrade works will include the following:

- Widening eastbound from Windsor Road on-ramp to the Pennant Hills Road off-ramp by one additional lane.
- Widening eastbound and westbound from Pennant Hills Road to Beecroft Road by one additional lane in each direction. This will involve the removal of the Beecroft Road bus on/off ramp.
- Widening eastbound and westbound from Beecroft Road to Lane Cove Road by one additional lane in each direction. The widened lane east of Terry's Creek will be marked as a transit lane.
- Widening of Norfolk Tunnel just east of Beecroft Road eastbound and westbound by one additional lane in each direction.
- Provision of new west facing on/off-ramps at Windsor Road. Windsor Road will be widened to accommodate turning movements.
- Provision of new east facing on-ramp at Christie Road.
- Provision of new east facing off-ramp at Herring Road.
- Improvement and widening of Talavera Road between Christie Road and Alma Road to provide two through lanes in each direction.
- Widening of Christie Road Bridge to 5 lanes over the M2 Motorway including the provision of new traffic control signals on Christie Road.
- Bridge modifications on the M2 between Windsor Road and Christie Road to accommodate the widening works.
- Intelligent Traffic System (ITS) upgrades along the corridor including upgrade to the cableway.

Widening of the M2 Motorway has been designed to minimise the amount of vegetation removal required. Design options have been considered to reduce the amount of excavation and intensive earthworks that would be required and therefore minimise the potential impacts to the surrounding environment. Wherever practicable the proposed widening has been designed within the existing footprint of the M2 Motorway. This involves compound locations and proposed access and egress routes. At the Devlins Creek viaduct, approximately 60% of the additional road width requirements are proposed to be provided by joining the two adjacent bridge decks. This would minimise disturbance in the riparian zone. An already stripped site previously used as a construction compound has been chosen for the proposed main construction compound, within the Macquarie Park precinct.

This flora and fauna assessment considers the potential impacts on ecological values associated with the proposed M2 Upgrade. In particular, species, populations and ecological communities listed as threatened under NSW State and Commonwealth environmental legislation are assessed for potential significant impacts. The assessment is based on an examination of vegetation mapping, aerial photography, field investigations and desktop studies.

For the purpose of this report, the 'M2 corridor' refers to the area bounded by the Hills M2 Motorway lease boundary, the 'study area' refers to the M2 corridor and any additional areas directly, or indirectly, affected by the proposed upgrade works, and the 'vicinity' refers to the surrounding neighbourhood areas adjacent to the project area.

1.1 Objectives of the Flora and Fauna Assessment

The objectives of the flora and fauna assessment are to:

- Produce an impact assessment of proposed works with respect to terrestrial and aquatic ecology based on existing information and additional field surveys.
- To assess potential impacts on flora and fauna in the area and determine the most appropriate mitigation measures to address flora and fauna impacts.
- Give particular attention to the impact on critical habitat, threatened species, populations and ecological communities, or their habitats (as defined under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the *Threatened Species Conservation Act* 1995 (TSC Act), the Threatened Species Conservation provisions of the *Fisheries Management Act* 1994 and the *Fisheries Management Amendment Act* 1997 (FM Act).
- To comply with the Director General's Requirements (DGR) (refer to section 2.1.1).
- To follow the heads of consideration as outlined in the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005) and the *Significant Impact Guidelines and Matters of National Significance* (DEH, 2006).

2.0 Legislative Requirements

2.1.1 Director General's Requirements

DGRs were issued for the project in April 2009 (see **Appendix A**), which identified the key impacts on ecology to be addressed in the environmental assessment, including:

- *The Environmental Assessment must include an assessment of the potential impacts of the project, with specific reference to the need for vegetation clearing, habitat and connectivity implications, edge effects, and stormwater and watercourse implications.*
- *The Environmental Assessment must make specific reference to impacts on threatened species, populations and communities, including the Sydney Turpentine-Ironbark Forest and Blue Gum High Forest Endangered Ecological Communities, and the native fauna that may utilise those communities.*
- *The Environmental Assessment shall demonstrate that the extent of vegetation clearing has been minimised through the design of the project, and shall include details of any off-set measures proposed.*

These issues are subject to specific assessment requirements as detailed in the DGRs. The issues relating to impacts on ecology are addressed in this report.

2.2 NSW Legislation

2.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) provide the statutory framework for the assessment of the proposal. The EP&A Act is supplemented by a number of Environmental Planning Instrument's (EPIs) including:

- State Environmental Planning Policies (SEPPs).
- Local Environmental Plans (LEPs).
- Other planning instruments such as Development Control Plans (DCPs).

2.2.2 Threatened Species Conservation Act 1995

The TSC Act outlines the protection of threatened species, communities and critical habitat in NSW. The Act is administered by the Department of Environment Climate Change and Water (DECCW). Section 91 of the TSC Act requires that a licence be obtained should a development result in one or more of the following:

- *Harm to any animal that is of, or is part of, a threatened species, population or ecological community.*
- *The picking of any plant that is of, or is part of, a threatened species, population or ecological community.*
- *Damage to critical habitat.*
- *Damage to habitat of a threatened species, population or ecological community.*

A Seven Part Test to determine the significance of the effect on a particular species or Endangered Ecological Community (EEC) is not required under Part 3A. However, assessments of significance for threatened species, populations or ecological communities (listed under the TSC Act) with a moderate to high likelihood of occurrence within the study area were carried out. These were in accordance with department of Environment, Climate Change and Water's *Draft Guidelines for Threatened Species Assessment under Part 3A* (DECCW, 2005).

2.2.3 National Parks and Wildlife Act 1974

The purpose of this the *National Parks and Wildlife Act* 1974 (NPW Act) is to provide the primary basis for protection and unwarranted destruction of relics of high cultural significance – both Indigenous and non-Indigenous value. In addition, the NPW Act also provides a framework to conserve native terrestrial flora and fauna species and manage areas of conservation value such as Nature Reserves and National Parks.

Under the NPW Act, it is an offence to harm, trade, possess or damage critical habitat or the habitat of any threatened species without obtaining a Section 120 licence.

2.2.4 Fisheries Management Act 1994

The FM Acts provide for the conservation, protection and management of fisheries, aquatic systems and habitats in NSW. Permits are required for any dredging or reclamation works, any harm to marine vegetation or any obstruction to fish passage. The proposal will not significantly affect aquatic ecosystems or block fish passage and no permits are required under either of these Acts.

2.2.5 Noxious Weeds Act 1993

The *Noxious Weeds Act* 1993 (NW Act) establishes a system for the identification and control of noxious weeds in NSW. The Act divides noxious weeds into four categories which determine the level of control required. Responsibility for the control of noxious weeds lies with the owner and/or occupier of private land and Crown land, local councils and other public authorities on land they occupy. Under the NW Act, the Minister for the Industry and Investment NSW (I&INSW) may declare a plant to be a noxious weed. Control notices can be issued by the Minister and local control authorities to ensure obligations are met.

2.3 Commonwealth Legislation

2.3.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act governs the Commonwealth Environmental Assessment process and provides protection for matters of National Environmental Significance (NES), which include:

- Nationally threatened species and ecological communities.
- Australia's World heritage properties.
- Ramsar wetlands of international importance.
- Migratory species listed under the EPBC Act (species protected under international agreements).
- Commonwealth marine areas.
- Nuclear actions, including uranium mining.
- National heritage.

Approval under the EPBC Act is required where the Department of Environment, Water, Heritage and the Arts (DEWHA) determines that there will or likely be a significant impact on a matter of NES. A referral has been submitted to DEWHA for their determination. The referral illustrates that there are no significant impacts on any matters of NES and therefore it recommends to DEWHA that the project is not a controlled action. DEWHA's final determination is currently pending.

3.0 Methodology

3.1 Overview

The information presented in this report is based on new field surveys, a review of previous studies, a review of published information sources including the SPRAT database, the NSW Government Atlas of NSW Wildlife and previous vegetation mapping undertaken for the locality were used to prepare the information presented in this report. The extensive flora and fauna studies and fauna monitoring surveys completed for the original EISs for the M2 Motorway have been referenced (Mount King Ecological Surveys, 1992).

Field surveys undertaken for this assessment included targeted searches for threatened species and were conducted in areas considered to contain suitable habitat for flora and fauna. Areas considered to contain suitable flora and fauna habitat include waterways, streamside vegetation and larger areas of remnant native vegetation that provide habitat connectivity (refer to Section 3.2)

3.2 Desktop Investigation and Review of Prior Studies

The M2 corridor is within an area of Sydney that has been extensively studied. The previous studies conducted within and adjacent to the M2 corridor that informed this assessment include the following:

- North West Transport Links Western Section Flora and Fauna Evaluation Mount King Ecological Surveys (1992a).
- North West Transport Links East Environmental Impact Statement Working Paper Flora and Fauna Evaluation (Bushland Effect and Management) Report (Eastern Section) Mount King Ecological Surveys (1992b).
- M2 Hills Motorway Fauna Monitoring Report (Gunninah 2000).

Searches of the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened flora or fauna species listed under the TSC Act or EPBC Act have been recorded or predicted to occur within a 10 km radius of the M2 corridor.

Information on fauna habitat contained in the Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area (DECC 2008) has been incorporated into this study where relevant.

The DECCW threatened species profiles (DECCW, 2009) and entries in the SPRAT database for threatened species, populations and ecological communities were reviewed and relevant information was extracted. This information was used to determine which threatened species, population and communities have potential to occur on the site based on a comparison of the habitat attributes observed within the study area and their known habitat associations. A complete list of threatened species, populations and ecological communities potentially occurring within the study area is provided in **Appendix C**.

3.3 Field Survey

3.3.1 Flora

Flora surveys were conducted between 26 November 2008 and 24 March 2009 by two AECOM ecologists. The purposes of the surveys were to assess the likely impact of the proposed action on the vegetation communities and significant flora species present or likely to occur within the study area. Survey sites were selected based on a preliminary investigation of the study area using aerial photography, topographic maps, vegetation mapping undertaken by Tozer *et al.* (2006) and the existing threatened species database searches (refer to Section 2.1). Flora surveys involved the recording of the structure, condition and composition of vegetation communities present and a targeted search for threatened flora species throughout the study area, targeting areas of greatest potential for the species to occur. The distribution of vegetation communities as per existing mapping (Tozer *et al.* 2006) was ground-truthed.

Plant species were identified within eight 20 m x 20 m survey plots and a random meander search for threatened flora species (refer to Section 4.4.3 for a list of targeted species) were conducted in the vicinity of each plot. Random meander transects targeting threatened flora species was also undertaken throughout the entire length of bushland potentially impacted.

3.3.2 Fauna

Fauna surveys were conducted between November 2008 and March 2009 by AECOM ecologists. The field survey methods used to detect and assess habitat for fauna species are listed in Table 1. The survey effort complies with the minimum survey effort based on the study area size, habitat types available on the site and seasonal factors, as recommended by the *Draft Guidelines for Threatened Species Assessment under Part 3A* (DEC and DPI, 2005).

Extensive fauna surveys including trapping surveys were conducted during the preparation of the environmental impact assessment reports for the existing M2 Motorway and were not repeated in this study. Field survey methods for the project were chosen in order to ensure that adequate information is available to fully assess the potential impacts of the proposal on fauna species of conservation significance. Fauna survey methods such as cage-trapping of mammals, pitfall trapping and detailed aquatic surveys were not undertaken.

In addition to fauna surveys, the following habitat assessments were undertaken:

- Observation of the location, extent and density of key habitat features such as mature, potentially hollow-bearing trees, waterways, seepages, rocky outcrops, vegetation types and soils.
- Assessment of the condition of aquatic habitats through noting factors including turbidity, rubbish, exotic fish species, surface films, submerged and emergent vegetation and substrates.
- Assessment of the condition of vegetation as habitat for fauna species through observation of factors including weed infestation, structural layering, species composition, nectar and fruit resources and maturity and condition of trees.

Table 1 Field survey methods and survey effort for fauna

Fauna Group	Survey Techniques Employed	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current Study (person hours)
Frogs (no area specified)	Systematic day habitat search	Conducted but effort unspecified	Conducted but effort unspecified	48 hours (8 hours per survey period)	3 hours in 3 locations
	Night habitat search of damp and watery sites	-	-	-	2 hours on 2 nights
	Nocturnal call playback	-	-	-	2 call playback sessions on separate nights at 2 locations
	Night watercourse search	Conducted but effort unspecified	Conducted but effort unspecified	-	2 hours
Reptiles (100 ha)	Habitat search	Conducted but effort unspecified	Conducted but effort unspecified	48 hours (8 hours per survey period)	1.5 hours
	Spotlighting	Conducted but effort unspecified	Conducted but effort unspecified	-	2 hours
Diurnal Birds (no area specified)	Area search	6 transect sites – number of inspections not specified	5 transect sites – number of inspections not specified	16 survey stations – (64 hours over six survey periods)	20 minute surveys conducted at each of 6 sites
Nocturnal Birds (no area specified)	Call playback	-	-	-	Three sites surveyed – 2 nights each
	Day habitat search	-	-	-	All potential riparian vegetation roost areas searched
	Spotlighting	Conducted but effort unspecified	Conducted but effort unspecified	Conducted as part of spotlighting targeting mammals	Conducted as part of spotlighting targeting mammals
Mammals (Excluding Bats) (50 ha)	Small Elliott traps – 100 trap nights over 3-4 consecutive nights	1200 trap nights	700 trap nights	-	-
	Wire cage traps – 24 trap nights	24 traps utilised – trap nights not specified	24 traps utilised – trap nights not specified	-	-

Fauna Group	Survey Techniques Employed	Mount King 1992b	Mount King 1992b	Fauna Monitoring (Gunninah 2000)	Current Study (person hours)
	Spotlighting on foot	6 transects	5 transects	8 transects (surveys twice yearly for 3 years)	3 transects each surveyed twice on separate nights for 1 hour each with two staff
	Call playback – 2 sites per stratification unit up to 200 hectares, plus an additional site per 100 hectares above 200 hectares. Each playback site must have the session conducted twice, on separate nights	-	-	-	Three sites surveyed – 2 nights each
	Search for scats and signs	Conducted but effort unspecified	Conducted but effort unspecified	-	Six sites specifically searched – opportunistic recordings throughout
	Track search – 1km of track search with emphasis on where substrate is soft	Conducted but effort unspecified	Conducted but effort unspecified	-	-
Bats (100 ha)	Harp trapping – Four trap nights over two consecutive nights (with one trap placed outside the flyways for one night)	-	-	-	Four harp trap nights in two locations
	Ultrasonic call recording – Two sound activated recording devices utilised for the entire night, starting at dusk for two nights	-	-	-	Two anabat devices used for static recording for 4 nights & four walking transects of 1 hour duration with two anabat devices
All Fauna	Opportunistic observations	Conducted but effort unspecified	Conducted but effort unspecified	Conducted but effort unspecified	Approximately 40 hours

3.3.3 Staff undertaking survey

The field survey, desktop investigations and impact assessment were conducted by Calliope Adamos and Paul Rossington.

Paul Rossington has completed a Bachelor of Science Degree, majoring in botany, zoology and ecology and a Post-graduate Diploma of Wildlife Management and has over five years experience in bushland restoration and wildlife management. Paul holds a current DECCW Scientific Licence for flora and fauna studies.

Calliope Adamos has completed a Bachelor of Environmental Science Degree and a Diploma of Natural Resource Management and has over five years experience in bushland restoration.

3.3.4 Survey Limitations

The environmental field surveys and assessments conducted are based on environmental conditions at the time of survey and therefore the absence of threatened species recorded is not indicative of the lack of threatened species inhabiting the study area. For those threatened flora species that are difficult to detect outside of their flowering time (such as *Tetratheca glandulosa*, which flowers July to November and *Hibbertia superans*, which flowers July to December) a precautionary approach was taken and species were assumed to be present if suitable habitat was observed. Therefore, assessments of significance are based on the appropriateness of habitats on the site for threatened flora and fauna species and the presence of key habitat features as listed in the relevant DECCW species profiles.

3.3.5 Impact Assessment Approach

Fauna surveys were conducted in areas that were considered potential habitat for threatened species, populations and communities. The M2 corridor is within an area of Sydney that has been extensively studied. Ecological survey efforts conducted over the years have not necessarily been specifically related to the M2 Motorway but rather have been conducted to gather accurate and relevant database information relating to bushland and biodiversity in the various LGAs, National Parks and Reserves in the locality. Hence, the database information is considered to be relatively reliable and reflective of the current ecological context of the study area.

3.4 Assessment of Significance

Assessments of significance for threatened flora and fauna species listed under the TSC Act were undertaken following the heads of consideration outlined in the *Draft Guidelines for Threatened Species Assessment under Part 3A* ((DEC and DPI, 2005). For threatened species listed under the EPBC Act, assessments of significance were undertaken in accordance with the *Significant Impact Guidelines and Matters of National Significance* outlined by the Department of Environment and Heritage (DEH, 2006). Ecological communities and flora and fauna species considered potentially sensitive to the impacts of the project were assessed in terms of the potential to have a significant impact on the survival of the species or community at the local scale.

4.0 Results

4.1 Overview

A description of the ecological context of the study area is provided in the following sections below. Included is a description of the various vegetation communities occurring within the study area. These include:

- Coastal Sandstone Ridgetop Woodland.
- Coastal Sandstone Gully Forest.
- Hinterland Sandstone Gully Forest.
- Sydney Hinterland Transition Woodland
- Sandstone Riparian Scrub.
- Blue Gum High Forest.
- Sydney Turpentine-Ironbark Forest.

Sydney Turpentine-Ironbark Forest and Blue Gum High Forest are both critically endangered ecologically communities listed under the TSC Act and EPBC Act. The condition of the vegetation communities listed above is described in Section 4.4.

Threatened flora and fauna species which are considered to have a moderate to high likelihood of occurring within the study area on the basis of distribution and habitat requirements is summarised in Section 4.4.3. Of the listed species, the following flora species have been recorded in the vicinity of the proposed upgrade works:

- *Callistemon linearifolius*
- *Darwinia biflora*.
- *Epacris purpurascens var. purpurascens*.
- *Pimelea curviflora var. curviflora*.
- *Tetratheca glandulosa.*

Threatened fauna species likely to occur within the study area include:

- Green and Golden Bell Frog
- Red-crowned Toadlet
- Swift Parrot
- Regent Honeyeater
- Gang-gang Cockatoo
- Glossy Black Cockatoo
- Powerful Owl
- Grey-headed Flying-Fox
- Eastern Freetail-bat
- Yellow-bellied Sheathtail-bat
- Greater Broad-nosed Bat
- Eastern Bentwing-bat
- Large-footed Myotis
- Large-eared Pied Bat.

A variety of noxious weeds occur within the M2 corridor. The species recorded and the control requirements required for each weed class under the NW Act are shown in Section 4.4.4. Fauna species of conservation significance and the likelihood of occurrence of these species based on previous records and habitat attributes is summarised in Section 4.5.5. Whilst aquatic habitat of the study area is described (Section 4.7), no aquatic plant species of conservation significance were recorded or considered likely to occur within the M2 corridor or surrounds.

4.2 Topography, Geology and Soils

The M2 Motorway is chiefly located on a series of plateaux that are dissected by eroded sandstone-dominated valleys. The relatively deep and fertile soil of the plateaux is chiefly clay derived from the weathering of Wianamatta shales. These flat areas have been almost entirely cleared for urban development and little native vegetation remains. The valleys that dissect these plateaux are moderately to extremely steep. Valley soils vary from moderately deep sandy soils in areas of shallower slope to shallow, skeletal sands and rock outcropping in steeply sloping locations.

Near the boundary between these plateaux and valleys, there exists a zone of sandstone-derived soil which is enriched with clay from the adjacent shale-derived soils.

4.3 Ecological Context of the Study Area

4.3.1 Urban areas and the urban bushland interface

Much of the area surrounding the study area is highly urbanised and consists chiefly of residential properties, parkland, bushland areas with varying levels of weed infestation and riparian vegetation. Fauna habitat within these areas of the route is largely limited to streams and streamside vegetation and the canopies of remnant and planted trees. Only native and exotic fauna species that are able to utilise highly modified habitat are likely to exist in these parts of the route.

Due to their mobility and ability to cope with habitat fragmentation, highly mobile native fauna species typical of open environments such as birds and bats would be able to exploit feeding, nesting and roosting opportunities that exist within these habitats. Highly adaptable native mammal species which are capable of utilising a wide variety of habitats such as the Brush-tailed Possum (*Trichosurus vulpecula*) and Common Ring-tailed Possum (*Pseudocheirus peregrinus*) persist here. Several bat species, such as the White-striped Mastiff Bat (*Tadarida australis*), Chocolate Wattle Bat (*Chanlinolobus morio*) and the threatened Grey-headed Flying Fox (*Pteropus poliocephalus*), are also found in these environments.

A larger diversity of native bird species inhabits urban areas such as the Noisy Miner (*Manorina melanophrys*), Pied Currawong (*Strepera graculina*), Laughing Kookaburra (*Dacelo novaeguineae*), Sulphur-crested Cockatoo (*Cacatua galerita*), Rainbow Lorikeet (*Trichoglossus haematodus*), Red Wattlebird (*Anthochaera carunculata*), Australian Magpie (*Gymnorhina tibicen*) and Tawny Frogmouth (*Podargus strigoides*). The threatened Powerful Owl (*Ninox strenua*) is also sometimes seen in urban areas in the vicinity of bushland.

Exotic mammal species such as the European Rabbit (*Oryctolagus cuniculus*), Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), European Red Fox (*Vulpes vulpes*) and feral Domestic Cat (*Felis catus*) are found in the study area, along with exotic bird species such as Common Myna (*Acridotheres tristus*), Spotted Turtle-dove (*Streptopelia chinensis*), Starling (*Turdus merula*) and Red-whiskered Bulbul (*Pycnonotus jocosus*).

As a result of habitat loss and competition, and predation by exotic and over-abundant native species, fauna species that require a diverse understorey, disturbance-sensitive species, species which are susceptible to predation by pets and feral animals, and species with very specific habitat requirements are unlikely to exist in urban environments.

A combination of small area, isolation and high edge-to-area ratio of many small remnants within the urban areas has left these areas particularly susceptible to weed invasion, altered fire regimes and local extinctions of flora and fauna species.

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, polluted catchment runoff and the presence of exotic fish species (such as *Gambusia holbrooki*). As a result, frogs, fish and aquatic invertebrates that are sensitive to disturbance are unlikely to persist in the waterways. Nonetheless, a variety of disturbance tolerant frog species (e.g. Striped Marsh Frog (*Limnodynates peronii*), Common Eastern Froglet (*Crinia signifera*), Eastern Dwarf Tree-frog (*Litoria fallax*), Green Stream Frog (*Litoria phyllochroa*) and Peron's Tree Frog (*Litoria peronii*)) are likely to use these habitats. A number of native fish species are also likely to persist.

Vegetated wildlife corridors within the urban environment are chiefly confined to these waterways which connect the bushland remnants that are largely located in the steep sandstone valleys.

4.3.2 Larger vegetation remnants

Several larger areas of remnant native vegetation exist within and adjacent to the study area. The most significant of these include:

- Bidjigal Reserve (formerly Excelsior Reserve and Darling Mills State Forest).
- Vegetation in the vicinity of Devlins Creek including Beecroft Reserve, Beecroft Reserve South, Chilworth Reserve and Cheltenham Park.
- Vegetation surrounding Terrys Creek between Lucknow Park, Berriwerri Reserve and Sommerset Park.
- Parts of Lane Cove National Park adjacent to the M2 corridor in Macquarie Park.

These areas have greater potential as habitat for a wider variety of fauna species due to their larger size, greater habitat diversity, more natural vegetation condition and connectivity to other areas of wildlife habitat. These areas have more potential to support viable populations of flora and fauna species as they are larger and better connected. These features make these areas more resistant to local extinction of flora and fauna species due to events such as fires and disease outbreaks and processes such as changing vegetation characteristics and predation by feral animals.

As a result of the size, connectivity and complexity of these areas, populations eliminated from part of their range may become re-established from refugia that were unaffected. The conservation and management of these areas and the corridors that connect them is important to the conservation of biodiversity in the locality.

4.4 Terrestrial Vegetation of the Study Area

4.4.1 Vegetation communities

There are seven native vegetation communities that occur within the study area. Each community and its conservation significance are described below.

The distribution of these vegetation communities, as well as the other vegetation communities occurring in the region (as described in the predictive vegetation mapping datasets) is shown in Figure 1.

Appendix B shows detailed vegetation mapping for the entire M2 Upgrade route in ten maps. The vegetation maps in **Appendix B** are derived from the existing vegetation mapping for the area (Figure 1) and field survey efforts. A summary of the conservation significance for each vegetation community to be impacted is provided below.

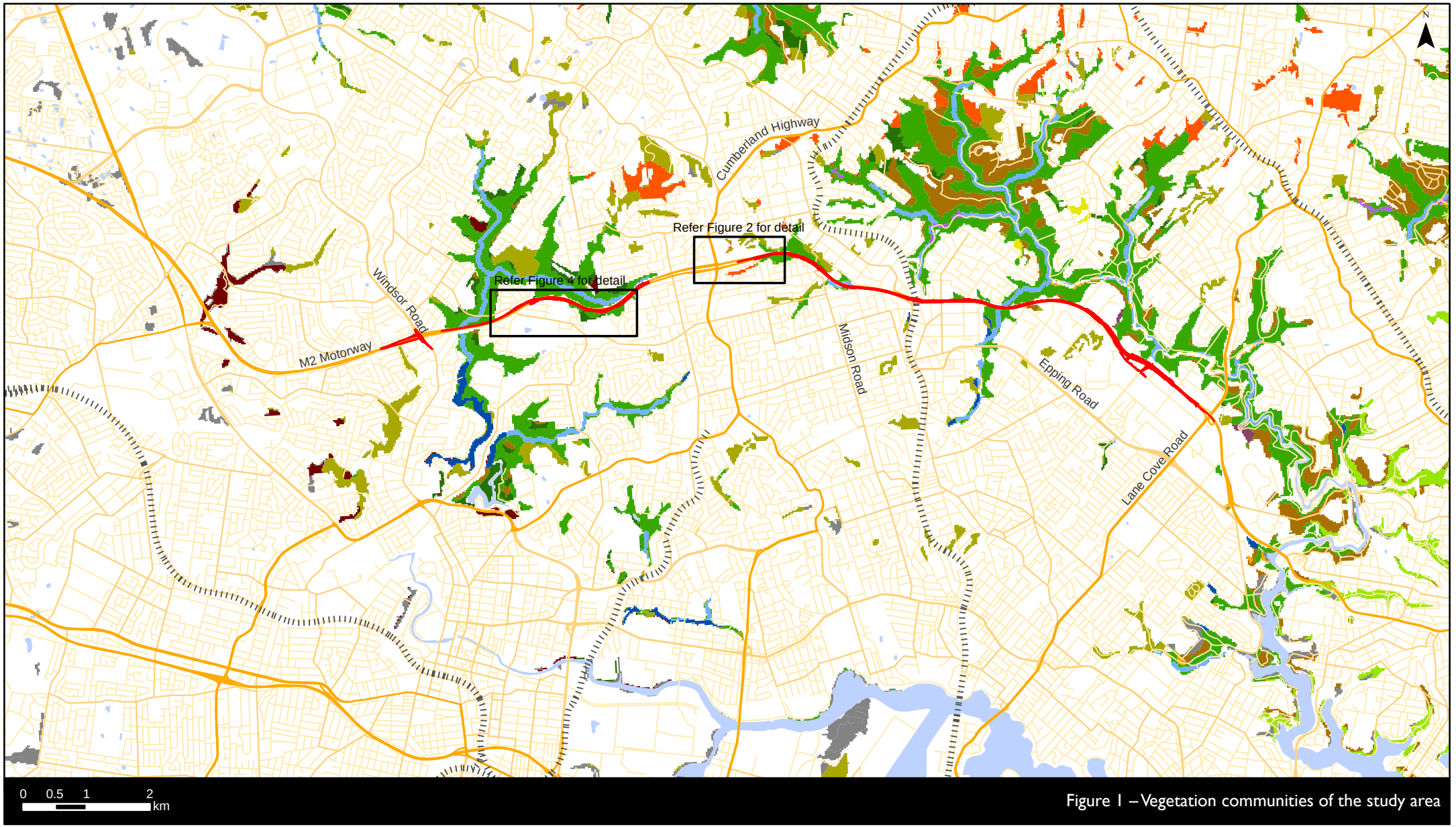
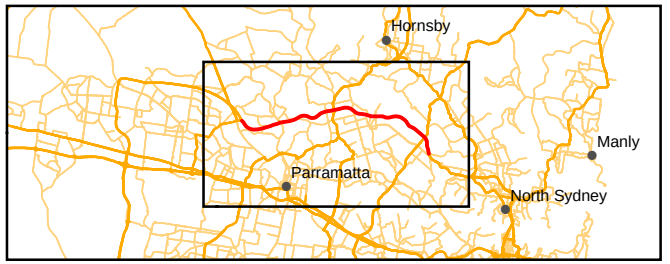


Figure 1 – Vegetation communities of the study area

Vegetation type

- Blue Gum High Forest
- Coastal Sandstone Plateau Heath
- Coastal Sandstone Gully Forest
- Coastal Sandstone Ridgetop Woodland
- Coastal Warm Temperate Rainforest
- Cumberland Shale Sandstone Transition Forest
- Hinterland Sandstone Gully Forest
- Lower Blue Mountains Wet Forest
- Sandstone Riparian Scrub
- Sydney Hinterland Transition Woodland
- Sydney Shale - Ironstone Cap Forest
- Sydney Swamp Forest
- Sydney Turpentine Ironbark Forest
- Other vegetation
- Extent of works



Source: RTA (2009), Tozer et. al. (2006) The vegetation extents shown in these maps are from predictive vegetation mapping datasets and may not represent the vegetation actually present at these locations

Coastal Sandstone Ridgetop Woodland

The shallow sandy soil of ridgetops and dry exposed slopes in the locality support an open dry sclerophyll vegetation type known as Coastal Sandstone Ridgetop Woodland (unit p131) in Tozer *et al*. (2006). This community is mapped as Sydney Sandstone Ridgetop Woodland (unit 10ar) in Benson and Howell (1994). This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

The structure of this vegetation is quite variable, ranging from open woodland, open scrub to heathland. Coastal Sandstone Ridgetop Woodland is composed of a diverse array of species and substantial floristic variation also exists within this complex of vegetation types (Smith and Smith 2008).

A number of vegetation communities within this vegetation type have been described by Smith and Smith (2008). These communities have not been mapped consistently across the region and hence these communities are all considered under the label Coastal Sandstone Ridgetop Woodland. The distribution of this vegetation type is quite restricted within the M2 corridor and consists chiefly of the small patches of Bloodwood-Scribbly Gum Woodland. The characteristic species of this variant are listed in Table 2.

Table 2 Coastal Sandstone Ridgetop Woodland Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
Narrow-leaved Apple	*Angophora bakeri*
Smooth-barked Apple	*Angophora costata*
Red Bloodwood	*Corymbia gummifera*
Scribbly Gum	*Eucalyptus haemastoma*
Sydney Peppermint	*Eucalyptus piperita*

Within the M2 corridor, Coastal Sandstone Ridgetop Woodland is found as thin bands of vegetation, transitional with Hinterland Sandstone Gully Forest on or near the ridgetops north of the M2 Motorway between Darling Mills Creek in the west and Oakes Road in North Rocks. Patches of the community are also found to the east of Terrys Creek in Marsfield. While much of this vegetation is continuous with that of Bidjigal Reserve, narrow bands of this vegetation also occur between the M2 Motorway and adjacent residential properties in this area.

In areas that are adjacent to broad bands of intact vegetation, minimal disturbance and weed invasion is evident. The narrow bands of this vegetation adjacent to urban areas and some areas that were subject to disturbance during construction of the M2 Motorway show moderate to high levels of disturbance, particularly weed invasion.

Coastal Sandstone Ridgetop Woodland is a common vegetation community in the Sydney region and is represented in local conservation reserves such as Lane Cove National Park, Garigal National Park, Berowra Valley Regional Park and Ku-ring-gai Chase National Park.

Coastal Sandstone Gully Forest

Coastal Sandstone Gully Forest (unit p140) in Tozer *et al.* (2006) is found in coastal areas where the erosion of overlying solids has exposed the underlying sandstone resulting in the formation of thin sandy soils. In the Sydney region this vegetation has been mapped as a part of a single variable vegetation type, including a number of variants as Sydney Sandstone Gully Forest (Benson and Howell 1994) but has been classified as a separate vegetation community in Smith and Smith (2008) and in the Southeast NSW Native Vegetation Classification and Mapping Project (SCIVI) mapping (Tozer *et al.* 2006). This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

The local occurrence of this vegetation type is an open forest in which the dominant tree species are Sydney Peppermint (*Eucalyptus piperita*) and Smooth-barked Apple (*Angophora costata*) with a variety of other tree species occurring at lower frequency. A typically sparse sub-canopy of small trees and large shrubs such as *Allocasuarina littoralis*, *Banksia serrata*, *Ceratopetalum gummiferum* is found over a diverse understorey of shrubs that varies from sparse (particularly where rock outcropping is abundant) to dense. The structure and composition of this understorey layer is variable and reflects localised soil conditions (particularly moisture and nutrient levels) and disturbance events such as fires, weed invasion and mechanical disturbance. Typical understorey species

include *Acacia suaveolens*, *Dillwynia retorta*, *Dodonaea triquetra*, *Grevillea linearifolia*, *Leptospermum trinervium*, *Persoonia levis, Platysace linearifolia* and *Pultenaea flexilis*.

The ground layer vegetation also varies in structure and composition due to soil conditions and disturbance events, tending to be less diverse and less dense in areas of thicker understorey. Typical understorey species include *Actinotus minor*, *Caustis flexuosa*, *Dianella caerulea*, *Entolasia stricta*, *Lomandra longifolia*, *Pteridium esculentum*, *Stylidium productum*, *Xanthosia pilosa* and *X. tridentata*.

This vegetation is typically found on the upper to lower slopes of gullies often immediately down slope of Coastal Sandstone Ridgetop Woodland. In areas with more productive soils, this variant may grade into Hinterland Sandstone Gully Forest and often grades into Sandstone Riparian Scrub in the vicinity of waterways.

Within and in the vicinity of the M2 corridor, Coastal Sandstone Gully Forest is found as small patches in the vicinity of Devlins Creek and on the gully slopes between Terrys Creek and Busaco Road in Marsfield where it is transitional with Hinterland Sandstone Gully Forest and Sandstone Riparian Scrub.

This variant of Coastal Sandstone Gully Forest is a common vegetation community in the Sydney region which is represented in local conservation reserves such as Lane Cove National Park, Garigal National Park, Berowra Valley Regional Park and Ku-ring-gai Chase National Park.

The characteristic tree species of this community are listed in Table 3.

Table 3 Coastal Sandstone Gully Forest Variants and Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Sydney Peppermint	*Eucalyptus piperita*
+Smooth-barked Apple	*Angophora costata*
*Turpentine	*Syncarpia glomulifera*
*Red Bloodwood	*Corymbia gummifera*
#Grey Gum	*Eucalyptus punctata*
#Blackbutt	*Eucalyptus pilularis*
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Hinterland Sandstone Gully Forest

In the Sydney region, this vegetation type has been mapped as Hinterland Sandstone Gully Forest (unit p142) by Tozer *et al.* (2006) has been classified as Blackbutt Gully Forest in Smith and Smith (2008).

This vegetation is a subset of the Sydney Hinterland Dry Sclerophyll Forests vegetation class of Keith (2004). Most of the native vegetation within the project area conforms to the description of this community.

This vegetation type is a tall open forest in which Blackbutt (*Eucalyptus pilularis*), Smooth-barked Apple (*Angophora costata*) and in some locations, Turpentine (*Syncarpia glomulifera*) are usually the dominant species. This variant occurs in gullies on Hawkesbury Sandstone with enriched soils as a result of influence from nearby Wianamatta Group shales or shale lenses within the sandstone bedrock (Smith and Smith 2008).

This vegetation type typically has a moderately dense sub-canopy of small trees and large shrubs such as *Allocasuarina littoralis*, *A. torulosa*, *Banksia serrata*, *Ceratopetalum gummiferum* and *Elaeocarpus reticulatus*. The sparse to moderately dense understorey of this variant often includes *Acacia linifolia*, *Dodonaea triquetra*, *Elaeocarpus reticulatus*, *Grevillea linearifolia*, *Leptospermum trinervium*, *Persoonia linearis*, *Pittosporum undulatum* and *Pultenaea flexilis*.

The ground layer vegetation also varies in structure and composition due to soil conditions and disturbance events, tending to be less diverse and less dense in areas of thicker understorey. Typical understorey species include *Calochlaena dubia*, *Dianella caerulea*, *Entolasia stricta*, *Lomandra longifolia*, *Microlaena stipoides*, *Pratia purpurascens*, *Pteridium esculentum* and *Xanthosia pilosa*.

Within and in the vicinity of the M2 corridor, Hinterland Sandstone Gully Forest is chiefly found within the eastern arm of Bidjigal Reserve and on the valley slopes and valley floors around Blue Gum Creek in Carlingford. It is also found around Devlins Creek in Beecroft and Cheltenham.

This vegetation type is considered by Campbell (2006) to be locally significant as, although it is relatively common in the Hornsby Shire, it is not common or well-represented in conservation reserves in other parts of the Sydney region.

The characteristic tree species of this community are listed in Table 4.

Table 4 Hinterland Sandstone Gully Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Blackbutt	*Eucalyptus pilularis*
+Smooth-barked Apple	*Angophora costata*
*Turpentine	*Syncarpia glomulifera*
*Red Bloodwood	*Corymbia gummifera*
*Sydney Peppermint	*Eucalyptus piperita*
*Red Mahogany	*Eucalyptus resinifera*
#Grey Gum	*Eucalyptus punctata*
#Sydney Blue Gum	*Eucalyptus saligna*
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Sydney Hinterland Transition Woodland

Sydney Hinterland Transition Woodland (unit p146) in Tozer *et al.* (2006) and has been described as Upper Georges River Sandstone Woodland (Tozer *et al.* 2003).This community has also been described elsewhere as Hinterland Sandstone Transition Grey Gum Forest (DECCW, 2009a), with the most extensive stands occurring within the Campbelltown and Liverpool LGAs. This vegetation type is part of the Sydney Hinterland Dry Sclerophyll Forest Class (DECCW, 2009) and is primarily found on the broad ridges associated with Mittagong Formation sandstone. The presence of shale soil is not obvious as sites often include sandstone benching or outcropping (DECCW, 2009b).

Dominant canopy trees include Red bloodwood (*Corymbia gummifera*) and Grey Gum(*Eucalyptus punctata*) with a number of stringybarks such as Narrow-leaved Stringybark (*E.oblonga*) common., In sheltered gullies *Angophora costata* (Sydney red gum), *Eucalyptus agglomerata* (blue-leaved stringybark), *E. deanei* (mountain blue gum), *E. pilularis* (blackbutt) and *Syncarpia glomulifera* (turpentine) may be common (DECCW, 2009).

Dominant shrub species include Prickly Moses (*Acacia ulicifolia suaveolens*), Sunshine Wattle (*Acacia terminalis*), Broad-leaved Geebung (*Persoonia levis*), Narrow-leaved Geebung (*P. linearis*),Hair-pin Banksia (*Banksia spinulosa var. spinulosa*), Flaky-barked Teatree (*Leptospermum trinervium*).

The ground layer species such as Common Ground Fern (*Calochlaena dubia*) and Bracken (*Pteridium esculentum*) are common in sheltered sites,

Within and in the vicinity of the M2 corridor, Sydney Hinterland Transition Woodland is mapped as occurring on the western edge of Bidjigal Reserve and opposite Bidjigal Reserve however due to a lack of characteristic canopy trees, these areas closely resemble Hinterland Sandstone Gully Forest.

The characteristic tree species of this community are listed in Table 5.

Table 5 Hinterland Sandstone Gully Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
*Blackbutt	*Eucalyptus pilularis*
*Smooth-barked Apple	*Angophora costata*
#Turpentine	*Syncarpia glomulifera*
+Red Bloodwood	*Corymbia gummifera*
+Narrow-leaved Stringybark	*Eucalyptus oblonga*
+Grey Gum	*Eucalyptus punctata*
#Black She-oak	Allocasuarina littoralis
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Sandstone Riparian Scrub

Sandstone Riparian Scrub (unit p58) in Tozer *et al.* (2006) is found along creeks within sandstone gullies. In the Sydney region this vegetation has been mapped as a part of a single variable vegetation type, including a number of variants as Sydney Sandstone Gully Forest (Benson and Howell 1994) but has been classified as a separate vegetation community in Smith and Smith (2008) and in the Southeast NSW Native Vegetation Classification and Mapping Project (Tozer *et al.* 2006) mapping. This vegetation is a subset of the Sydney Coastal Dry Sclerophyll Forests vegetation class of Keith (2004).

This low closed forest variant occurs in small patches and narrow bands along creeks in sandstone gullies. In its natural state, the dominant canopy species usually includes Coachwood (*Ceratopetalum apetalum*), Water Gum (*Tristaniopsis laurina*), Black Wattle (*Callicoma serratifolia*) and Pittosporum (*Pittosporum undulatum*) with a variety of other chiefly mesophilic shrub and small tree species. The understorey is composed largely of ferns species including *Adiantum aethiopicum*, *Blechnum ambiguum*, *Calochlaena dubia*, and *Sticherus flabellatus* with additional fern species (*Hymenophyllum cupressiforme* and *Pyrrosia rupestris*) often growing on rocks and tree trunks. *Lomandra longifolia* is also a common element of the understorey.

This vegetation type occurs along all creeks within and adjacent to the M2 corridor with the most intact occurrences at Darling Mills Creek and Terrys Creek. Much of this vegetation is highly modified as a result of alteration to natural flow regimes, increased nutrients and especially weed invasion. Riparian vegetation is of most value in stabilising waterways, rather than contributing to the biodiversity of the site.

Due to the restricted distribution of this vegetation community to the edges of watercourses, the tendency of these areas to be affected by altered hydrology, pollution and weed invasion, and the scarcity of this vegetation type in the Sydney region, it is considered to be regionally significant (Campbell 2006).

The characteristic tree species of this community is listed in Table 6.

Table 6 Sandstone Riparian Scrub Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Coachwood	*Ceratopetalum apetalum*
+River Gum	*Tristaniopsis laurina*
*Black Wattle	*Callicoma serratifolia*
*Pittosporum	*Pittosporum undulatum*

Native Canopy Species	
Common Name	**Botanical Name**
*Water Gum	*Tristaniopsis laurina*
#Lilly Pilly	*Acmena smithii*
#Christmas Bush	*Ceratopetalum gummiferum*
#Crabapple	*Schizomeria ovate*
The Sandstone Riparian Scrub vegetation type often also includes emergent trees typical of the other Sandstone Gully Forest vegetation types that adjoin it.	
+ = dominant canopy species, * = moderately frequent species, # = less frequent species	

Blue Gum High Forest

This community is listed as a critically endangered ecological community (CEEC) under the TSC Act as Blue Gum High Forest and under the EPBC Act as Blue Gum High Forest of the Sydney Basin Bioregion.

This is a moist tall open forest community in which Sydney Blue Gum (*Eucalyptus saligna*) is a dominant species together with a combination of other species including Smooth-barked Apple (*Angophora costata*), Grey Ironbark (*Eucalyptus paniculata*), Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*). This vegetation is referred to as Blue Gum High Forest (unit p153) in Tozer *et al.* (2006).

Trees within this vegetation community can form large hollows. Threatened fauna species known to occur in remnant Blue Gum High Forest include Sugar Glider (*Petaurus breviceps*), Powerful owl (*Ninox strenua*), Grey-headed Flying-fox (*Pteropus poliocephalus*), Glossy Black Cockatoo (*Calyptorhynchus lathami*), Swamp Wallaby (*Wallabia bicolour*) and Brush-turkey (*Alectura lathami*) (DECC 2008).

This vegetation type is restricted to ridgetop plateaus and upper slopes on clay soils derived from Wianamatta shales. Prior to clearing for urban development and road construction, a number of areas along the M2 corridor may have contained this vegetation community or the closely allied Sydney Turpentine-Ironbark Forest. The extent and condition of this community has been verified through on ground inspection and the present distribution within the study area is restricted to a narrow band between the M2 Motorway and Pennant Hills Golf Course to the north. This area is approximately 1.36 ha in area and in moderate to poor condition (Figure 2).

The species composition of this patch shows affinities with Turpentine-Ironbark Forest. The dominance of Sydney Blue Gum and Grey Ironbark, the lack of Turpentine and the composition of the understorey and ground layers suggest that this vegetation patch is more closely aligned with the definition of Blue Gum High Forest. A gradation into vegetation more similar to Turpentine-Ironbark Forest occurs at the western extent of the patch as indicated by a drier understorey and an increasing dominance by Rough-barked Apple (*Angophora floribunda).*

The characteristic species of this community are listed in Table 7.

Table 7 Blue Gum High Forest Canopy Species

Native Canopy Species	
Common Name	**Botanical Name**
+Smooth-barked Apple	*Angophora costata*
+Grey Ironbark	*Eucalyptus paniculata*
+Blackbutt	*Eucalyptus pilularis*
+Sydney Blue Gum	*Eucalyptus saligna*
+Turpentine	*Syncarpia glomulifera*
#Grey Gum	*Eucalyptus punctata*
#Red Mahogany	*Eucalyptus resinifera*
+ = dominant canopy species, *, # = less frequent species	

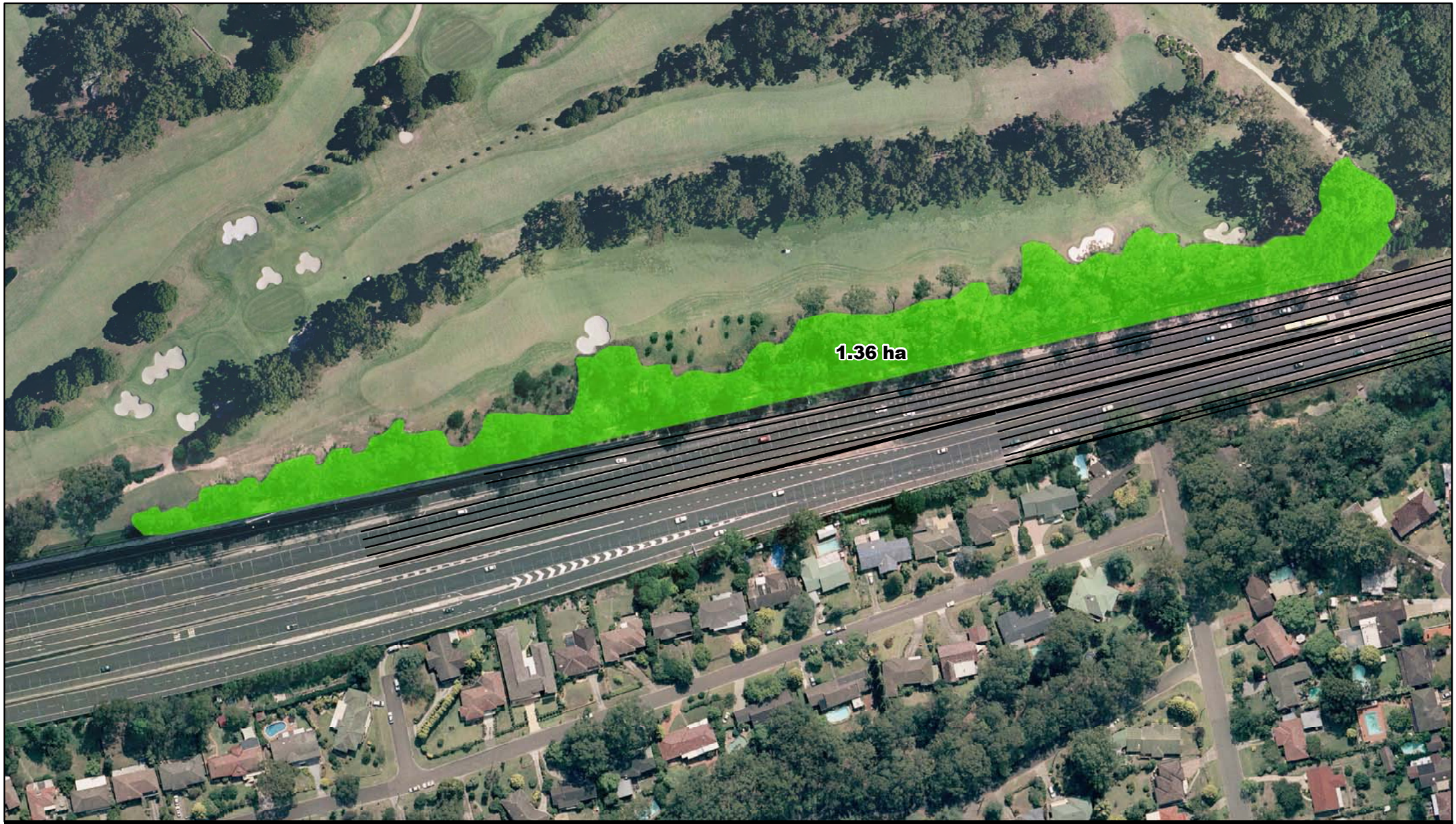
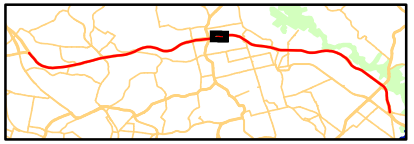


Figure 2 – Blue Gum High Forest at Pennant Hills Golf Course

Blue Gum High Forest

Proposed Design



Source: MapData Sciences 2009

Sydney Turpentine-Ironbark Forest

Sydney Turpentine-Ironbark Forest is listed as a critically endangered ecological community (CEEC) (Turpentine–Ironbark Forest of the Sydney Basin Bioregion) under both the EPBC Act and the TSC Act.

EPBC Act Definition

Sydney Turpentine-Ironbark Forest is an open-forest of mixed and varying canopy species composition in which Turpentine (*Syncarpia glomulifera*) and ironbarks (*Eucalyptus* spp.) are dominant. Other tree species include Red Bloodwood (*Corymbia gummifera*), Sydney Blue Gum (*E. saligna*), Grey Gum (*E. punctata*), Narrow-leaved Ironbark (*E. crebra*), Mountain Grey Gum (*E. cypellocarpa*), Round-leaved Gum (*E. deanei*) and Red Ironbark (*E. fibrosa*) (DEWHA 2009).

Low tree and shrub species include *Acacia parramattensis*, *Breynia oblongifolia*, *Dodonaea triquetra*, *Leucopogon juniperinus, Notelaea longifolia, Ozothamnus diosmifolius, Pittosporum revolutum, P. undulatum, Polyscias sambucifolia* and *Maytenus silvestris*. Ground layer species include *Adiantum aethiopicum, Austrostipa pubescens, Dianella caerulea, Dichondra repens, Entolasia stricta, Lomandra longifolia, Poa affinis, Pseuderanthemum variabile* and *Themeda australis*. Climbers include *Eustrephus latifolius, Glycine clandestina* and *Pandorea pandorana* (DEWHA 2009).

The Commonwealth listing for the CEEC includes vegetation in the following condition:

- The vegetation contains some characteristic components from all structural layers (tree canopy, small tree/shrub midstorey, and understorey).
- Tree canopy cover is greater than 10% and remnant size is greater than one hectare. These areas have the greatest conservation value and their high quality and size makes them most resilient to disturbance.
- Remnants with tree canopy cover less than 10% are also included in the ecological community, if the fragments are greater than one hectare in size and occur in areas of native vegetation in excess of 5 hectares in area. These areas enhance the potential for connectivity and viability of the ecological community. They support native flora and fauna species by facilitating gene flow among remnants and buffering against disturbance (DEH 2005).

Areas mapped as Sydney-Turpentine Ironbark Forest within the M2 corridor were inspected and found to be:

- Less than one hectare in area, highly disturbed and lacking an intact ground layer or understorey; and/or
- Consistent with the floristic composition of the larger patches of the adjacent Hinterland Sandstone Gully Forest vegetation community.

TSC Act Definition

Under the NSW definition, Sydney Turpentine-Ironbark Forest is an open forest community and the dominant canopy trees are Turpentine (*Syncarpia glomulifera*) and Grey Ironbark (*Eucalyptus paniculata*). Common understorey shrubs include Sweet Pittosporum (*Pittosporum undulatum*), Hop Bush (*Dodonaea triquetra*), Elderberry Panax (*Polyscias sambucifolia*) and Sickle Wattle (*Acacia falcata*).

Sydney Turpentine-Ironbark Forest occurs on fertile soils in an area of moderate rainfall. It is transitional between Cumberland Plain Woodland in drier areas and Blue Gum High Forest on adjacent higher rainfall ridges. As a transitional community, the species composition varies according to the influence of sandstone and aspect.

The areas of vegetation within and adjacent to the M2 corridor that have been mapped as Sydney Turpentine–Ironbark Forest under the alternative vegetation classifications described below have all been inspected and were subject to detailed flora surveys. The soil on which this vegetation is growing is sandy and contains frequent outcropping of sandstone and also shows a relatively minor yet noticeable clay influence in upper slope areas. The dominant canopy species in these areas are Blackbutt (*Eucalyptus pilularis*) and Turpentine (*Syncarpia glomulifera*) with only occasional specimens of other tree species including Smooth-barked Apple (*Angophora costata*) and Red Bloodwood (*Corymbia gummifera*) present. No ironbark species were detected within these areas.

The moderately dense understorey in these areas consists of a mix of sclerophyllous and mesophilic shrubs of a range of species that are found in a variety of soil types and vegetation communities. The patterns in the relative abundance of the shrub species observed appear to be correlated with the variation in moisture levels due to aspect. The sparse to moderately dense ground layer vegetation here is a mixture of low shrubs, herbs, grasses and sedges.

Vegetation Mapping Schemes

In the mapping of Tozer *et al.* (2006) as shown in Figure 1, small isolated occurrences of this community are mapped in the Beecroft and Carlingford North areas.

Other vegetation mapping schemes have labelled vegetation as Sydney Turpentine-Ironbark Forest inconsistently across the locality of the M2 corridor. The Native Vegetation of the Cumberland Plain maps (NPWS 2002) show extensive areas (including developed areas such as roads, residences) as this community, however these maps have limitations in their applicability to fine scale assessment of vegetation due to a number of factors described in the associated interpretation guidelines (NPWS 2002).

A recently released draft vegetation community mapping scheme for the Sydney metropolitan catchment area (DECCW 2009 a) shows some areas as Sydney Turpentine–Ironbark Forest which are mapped as Hinterland Sandstone Gully Forest by Tozer *et al.* (2006) and as Blackbutt Gully Forest by Smith and Smith (2008). The new mapping scheme is currently a draft open to comment and subject to change and the Sydney Metropolitan CMA provides the following advice regarding its status:

> *The product is a draft, and therefore is subject to change. For that reason, the product is not intended to be used for planning or decision making purposes until the review period has ceased and the final version of the product has been released.*

Neither the TSC Act nor EPBC Act Threatened Species Scientific Committee's advice regarding this community includes Blackbutt (*Eucalyptus pilularis*) as a dominant or frequently occurring species. While the understorey and ground layer vegetation observed shows a resemblance to that of Sydney Turpentine-Ironbark Forest, its composition and structure are more closely aligned with the Hinterland Sandstone Gully Forest community.

In light of these factors, this vegetation within the study area is considered to be Hinterland Sandstone Gully Forest with a slightly higher than typical clay soil influence and not Sydney Turpentine-Ironbark Forest.

The results from flora surveys conducted within areas mapped as Sydney Turpentine-Ironbark Forest adjacent to the M2 Motorway is presented in **Appendix D** and summarised below in Table 8.

Table 8 Flora survey data within the M2 corridor

Native Canopy and Shrub Species		Location of flora quadrat		
Common Name	**Botanical Name**	**5- (Bidjigal Reserve)**	**11- (Devlins Creek, Cheltenham)**	**12- (Devlins Creek, North Epping)**
Narrow-leaved Apple	*Angophora bakeri*	X		
Smooth-barked Apple	*Angophora costata*	X	X	X
Forest Oak	*Allocasuarina torulosa*	X		
Old Man Banksia	*Banksia serrata*	X		
Blackbutt	*Eucalyptus pilularis*	X	X	X
*Lantana	*Lantana camara*	X	X	X
Paperbark Tea-tree	*Leptospermum trinervium*	X		
*Broad-leaf Privet	*Ligustrum lucidum*		X	
*Small-leaf Privet	*Ligustrum sinense*	X	X	X
Sweet Pittosporum	*Pittosporum undulatum*	X		
Turpentine	*Syncarpia glomulifera*	X		
*=exotic species				

4.4.2 Highly disturbed and artificial vegetation

Highly disturbed, weed-dominated vegetation within the corridor is chiefly found in:

- Areas that have been subjected to a high degree of mechanical disturbance (e.g. fill batters, fill mounds, scalped areas, some detention basins) and subsequent weed invasion.
- The vicinity of waterways that receive nutrient-rich stormwater and weed seeds from urban areas.
- The interface between bushland and residential areas affected by nutrient-rich runoff, dumping of green waste and encroachment of garden plants.

Modified vegetation consists of exotic grasslands (mown areas) and revegetated areas created after the completion of the M2 Motorway. The exotic grasslands contain little if any native vegetation.

Revegetated areas adjacent to the Motorway have canopies composed of immature to semi-mature native trees (chiefly eucalypts) with a sparse to moderate density shrub layer. This shrub layer consists of a mixture of locally indigenous native plants, other native species which would not naturally occur in the locality and woody weeds such as Lantana (*Lantana camara*) and Blackberry (*Rubus* spp). The ground layer in revegetated areas is dominated by introduced grasses, perennial and annual herbs and occasional specimens of native species such as *Lomandra longifolia*.

These areas have very low plant species diversity, simplified vegetation structure and minimal natural seedling recruitment and are not of conservation significance.

These areas do have some value as fauna habitat however they contain a very low density of important habitat features such as tree hollows and large mature heavily-flowering trees and have low structural diversity. These areas are therefore considered to be marginal habitat for the threatened species with potential to occur in the locality and are unlikely to be important to the long-term viability and recovery of local populations of these species.

4.4.3 Terrestrial plant species of conservation significance

Searches of the NPWS Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened plant species listed under the TSC Act or EPBC Act are likely to occur in the vicinity of the project. The database search revealed that there are a number of threatened species recorded in the vicinity of the site (Figure 3). The conservation status of the listed flora and fauna species is provided in **Appendix C**.

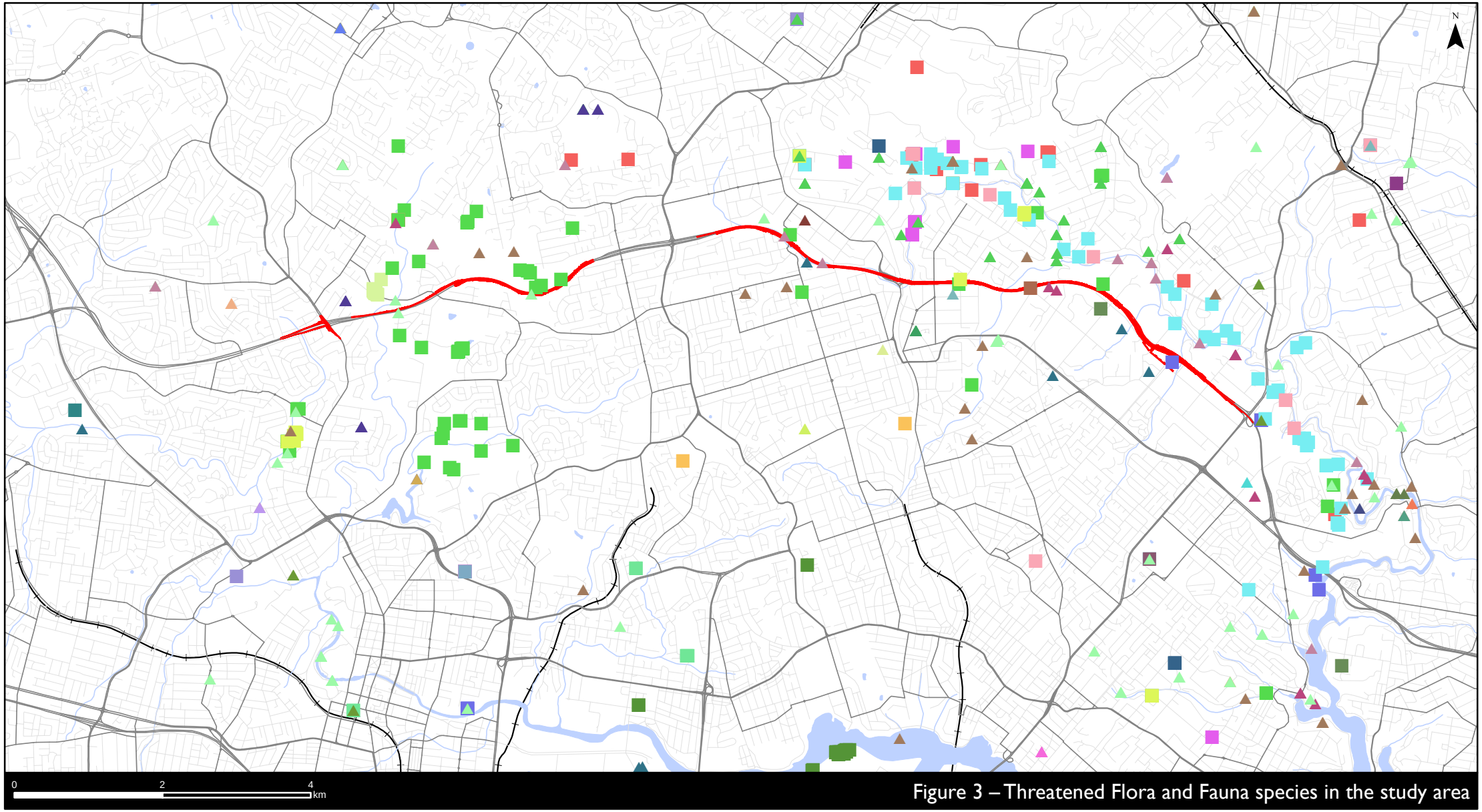


Figure 3 – Threatened Flora and Fauna species in the study area

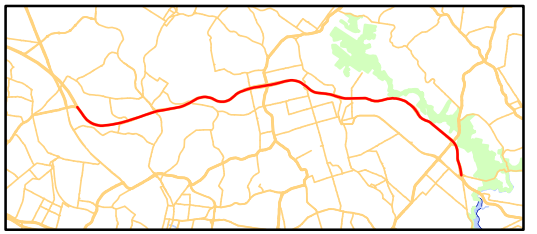
Extent of Works

Threatened Fauna

- Australasian Bittern
- Barking Owl
- Black Bittern
- Black-necked Stork
- Black-tailed Godwit
- Cotton Pygmy-Goose
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Gang-gang Cockatoo
- Glossy Black-Cockatoo
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Little Lorikeet
- Osprey
- Pink Robin
- Powerful Owl
- Red-crowned Toadlet
- Regent Honeyeater
- Southern Myotis
- Spotted-tailed Quoll
- Superb Fruit-Dove
- Superb Parrot
- Swift Parrot
- Yellow-bellied Glider

Threatened Flora

- Acacia pubescens
- Callistemon linearifolius
- Darwinia biflora
- Darwinia peduncularis
- Epacris purpurascens var. purpurascens
- Eucalyptus nicholii
- Genoplesium baueri
- Grammitis stenophylla
- Haloragodendron lucasii
- Hibbertia superans
- Leptospermum deanei
- Melaleuca deanei
- Persoonia hirsuta
- Persoonia nutans
- Pimelea curviflora var. curviflora
- Pimelea spicata
- Pomaderris prunifolia
- Prostanthera marifolia
- Syzygium paniculatum
- Tetratheca glandulosa
- Triplarina imbricata
- Wilsonia backhousei



Source: DECC, 2009; MapData Sciences 2009; Tozer et.al (2006) Native vegetation of southeast NSW

The likelihood of occurrence of these species based on previous records and habitat attributes is summarised in **Appendix C**. Those species which were considered to have a moderate to high likelihood of occurring within the study area on the basis of distribution and habitat requirements are shown in Table 9. Assessments of significance for these species are presented in **Appendix F**.

Table 9 Threatened flora species with potential to occur in the M2 Corridor

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
Acacia bynoeana	Bynoe's Wattle	Shrub	E	V	Moderate
Callistemon linearifolius		Shrub	V	-	High
Darwinia biflora		Shrub	V	V	Moderate-High
Epacris purpurascens var. *purpurascens*		Shrub	V	-	High-recorded
Persoonia hirsuta	Hairy Geebung	Shrub	E	E	Moderate
Pimelea curviflora var. *curviflora*		Shrub	V	V	High
Tetratheca glandulosa		Shrub	V	V	Moderate
V = Vulnerable, E = Endangered, - = Not listed					

The threatened terrestrial plant species that are considered to have potential to occur within the study area are chiefly those species which are associated with sandstone soils, particularly where these soils are somewhat enriched due to their proximity to areas of shale-derived soil.

Of the above-listed species, the following species have been recorded in the locality and are associated with woodland or open forest on clay-enriched sandstone soils:

- *Callistemon linearifolius.*
- *Darwinia biflora.*
- *Epacris purpurascens* var. *purpurascens.*
- *Pimelea curviflora* var. *curviflora.*
- *Tetratheca glandulosa*.

Of these species, only *Epacris purpurascens* var. *purpurascens* was recorded during the field investigations conducted for the preparation of this report. *Epacris purpurascens* var. *purpurascens* is an erect shrub, 50-180 cm high that is found in a range of habitat types, most of which have a strong shale soil influence (DECCW 2009). Within the M2 corridor, individuals of this species are located in translocated soils including earth mounds and rock armoured batter slopes.

Pimelea curviflora var. *curviflora* was recorded during the EIS for the western section of the M2 Motorway (Mount King 1992). However the specific location and the population size of this species were not reported. The species has been recorded in Lane Cove National Park and in Epping near the M2 corridor (DECCW 2009). The species was not recorded during recent flora surveys within the M2 corridor however it is possible that this species may exist within the M2 corridor.

Callistemon linearifolius is known to occur in the Hornsby, Lane Cove and Ryde local government areas and has been recorded near the M2 corridor at Marsfield (DECC, 2001). The species usually grows in dry sclerophyll forest on the coast and adjacent ranges. The species was not recorded during the flora survey of the M2 corridor however there is a high likelihood that it occurs here.

Darwinia biflora grows in heath on sandstone or in the understorey of woodland on shale-capped ridges. There are records of this species occurring in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai local government areas. The bushland of the M2 corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove Valley) are not included in the lists of known important populations.

The species was not recorded during flora surveys however it is possible that this species may exist within the M2 corridor.

Tetratheca glandulosa grows in sandy or rocky heath or scrub. The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the M2 corridor.

Several parts of the M2 Motorway are located on ridgetop areas on or adjacent to areas underlain by shale-derived soils. *Persoonia hirsuta* and *Acacia bynoeana* are associated with woodland or open forest on sandstone soils but are not particularly associated with soils which have a clay influence. Important populations of these species are not considered likely to exist within the M2 corridor.

4.4.4 Introduced flora

A wide variety of introduced plant species are found within the M2 corridor and within adjacent urban and bushland areas. The most abundant and detrimental types of weeds include woody weeds (e.g. *Lantana camara*, *Rubus* spp., *Ligustrum* spp.), vine weeds (e.g. *Cardiospermum grandiflorum*, *Ipomoea* spp.) grasses (e.g. *Eragrostis curvula*, *Chloris gayana*) and herbs (e.g. *Tradescantia fluminensis*, *Bidens pilosa*). A variety of aquatic weeds are also found in the waterways of the study area, particularly within Devlins Creek. See **Appendix D** for a list of species recorded during field surveys.

Highly weed-infested vegetation within the corridor is chiefly found in:

- Areas that have been subjected to a high degree of mechanical disturbance (e.g. fill batters, fill mounds, scalped areas).
- The vicinity of waterways that receive nutrient-rich stormwater from urban areas.
- The interface between bushland and residential areas.

A variety of noxious weeds occur within the M2 corridor. The species recorded are shown in Table 10 with the control requirements for each weed class under the NW Act shown in Table 11.

Table 10 Noxious weeds noted within the M2 Corridor and adjacent lands and weed class

Noxious Weed Species		Weed Class for each Local Government Area			
Scientific Name	Common Name	Hills Shire	Hornsby	Ryde	Parramatta
Acetosa sagittata	Turkey rhubarb	-	4	-	-
Ageratina adenophora	Crofton weed	4	-	-	-
Anredera cordifolia	Madeira vine	-	4	4	4
Arundo donax	Giant reed	-	4	4	4
Asparagus aethiopicus	Asparagus fern	-	4	4	4
Asparagus asparagoides	Bridal creeper	5	4	4	4
Asparagus plumosus	Climbing asparagus fern	-	4	4	4
Bryophyllum species and hybrids	Mother-of-millions	3	-	-	-
Cardiospermum grandiflorum	Balloon vine	-	4	4	4
Cestrum parqui	Green cestrum	3	3	3	3
Chrysanthemoides monilifera subsp. *monilifera*	Boneseed	-	-	3	3
Cinnamomum camphora	Camphor laurel	-	4	4	-
Cortaderia species	Pampas grass	3	3	3	3
Delairea odorata	Cape ivy	-	4	4	4
Genista monspessulana	Cape broom	-	3	3	3

Noxious Weed Species		Weed Class for each Local Government Area			
Scientific Name	Common Name	Hills Shire	Hornsby	Ryde	Parramatta
Ipomoea indica	Morning glory (purple)	-	4	4	4
Lantana species	Lantana	5	4	4	4
Ligustrum lucidum	Privet (Broad-leaf)	4	4	4	4
Ligustrum sinense	Privet (Narrow-leaf/Chinese)	4	4	4	4
Ludwigia longifolia	Long-leaf willow primrose	3	3	3	3
Ludwigia peruviana	Ludwigia	3	3	3	3
Ochna serrulata	Ochna	-	4	4	-
Olea europaea subsp. *cuspidata*	African olive	-	-	4	-
Parietaria judaica	Pellitory	4	4	4	4
Phyllostachys species	Rhizomatous bamboo	-	4	4	4
Ricinus communis	Castor oil plant	-	4	4	4
Rubus fruticosus aggregate species	Blackberry	4	4	4	4
Sagittaria platyphylla	Sagittaria	5	5	5	5
Senna pendula	Senna	-	-	4	-
Toxicodendron succedaneum	Rhus tree	4	4	4	4
Tradescantia fluminensis	Trad	-	4	4	-
Xanthium species	Bathurst/Noogoora/Californian/cockle burrs	4	-	-	-

Table 11 Control requirements for each weed class under the Noxious Weeds Act 1993

Weed Class	Control requirements
1	The plant must be eradicated from the land and the land must be kept free of the plant
2	The plant must be eradicated from the land and the land must be kept free of the plant
3	The plant must be fully and continuously suppressed and destroyed
4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with

4.5 Terrestrial Fauna and Fauna Habitat of the Study Area

4.5.1 Large patches of native vegetation

Habitat for a variety of fauna species exists within the remnant vegetation occurring within the M2 corridor and surrounding bushland areas. Trees (e.g. *Eucalyptus* spp., *Angophora* spp., *Syncarpia* spp. and *Corymbia* spp.), Wattles (*Acacia* spp.) and Banksias (*Banksia* spp.) in particular provide a food source in the form of leaves, sap, nectar, pollen and seed for a number of bird, mammal and insect species. Threatened species known to use these resources include Grey-headed Flying-fox (*Pteropus poliocephalus*) and Gang-gang Cockatoo (*Callocephalon fimbriatum*). The migratory nectar-feeding birds Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Anthochaera phrygia*) may use this resource sporadically or on a seasonal basis but are not considered likely to be regular or frequent visitors to the area based upon database records.

The Powerful Owl (*Ninox strenua*) is also known to hunt and roost in the bushland of the study area and contiguous areas of bushland in the locality and may nest in large tree hollows in the locality. Nest sites are considered most likely to be located in areas containing very large mature hollow-bearing trees, particularly in core bushland areas which are less subject to human disturbance.

Large and medium-sized tree hollows are likely to exist within the larger, more mature trees particularly in mature Blackbutt (*Eucalyptus pilularis*). These larger trees are chiefly found on lower slopes of gullies and along streams where soils are deeper, moister and enriched by silt and organic material that are not considered likely to be affected by the proposed works. Small hollows, fissures and decorticating bark exist within the trees of the study area. These hollows provide potential den, nest and roost sites for a number of small bird, mammal and reptile species.

Smaller hollows may be used by threatened hollow-roosting microbats including Eastern Freetail-bat (*Mormopterus norfolkensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*).

In addition to the microbat species listed above, several other threatened, non hollow-roosting species may forage in the air spaces within and around the vegetation including Large-eared Pied Bat (*Chalinolobus dwyeri*), Little Bentwing-bat (*Miniopterus australis*), Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Large-footed Myotis (*Myotis adversus*).

The leaf-litter, fallen logs and ground layer vegetation of the ecology study area form potential habitat for ground-dwelling fauna including Echidna (*Tachyglossus aculeatus*), Long-nosed Bandicoot (*Perameles nasuta*), Swamp Wallaby (*Wallabia bicolor*) and a variety of reptile species. These habitat features are also likely to be used for sheltering and foraging for some locally occurring frog species.

4.5.2 Rocky outcrops

Rocky outcrops provide potential sheltering sites for reptiles (lizards and snakes), frogs and small terrestrial mammals. If environmental conditions are conducive, crevices within larger rock outcrops may provide roosting habitat for some species of cave-roosting microbats. Large rock outcrops are abundant within Bidjigal Reserve including some locations on the edge of the M2 corridor. Microbats are also known to use the bridge abutments and culverts associated with the M2 Motorway as roosting habitat.

4.5.3 Wildlife corridors

The bushland of the Darling Mills Creek corridor is considered to be the most significant regional habitat link with Berowra Bushland Park in Hornsby and further on to Ku-ring-gai Chase National Park and Brisbane Waters (Upper Parramatta River Catchment Trust, 1999).

Due to its relatively large size and its connectivity with other bushland areas, the bushland of the Darling Mills Creek corridor retains high biodiversity value and potential for fauna movements and genetic exchange.

The more intact bushland areas of the sandstone valleys are likely to have the greatest importance as corridors for terrestrial fauna, particularly for species which are less tolerant of disturbed environments.

Despite extensive weed invasion, the narrow bands of riparian vegetation that persist along creeks within cleared areas, are also important as they provide the continuous vegetation cover that is required by some fauna species which do not readily cross cleared lands.

Narrow bands of vegetation, such as those often found along roadways, also have some value as movement corridors for more mobile fauna species.

The following disturbance events within the bushland of the corridor may have had negative impacts on wildlife corridors:

- Increased residential development, which results in altered hydrology, increased nutrient loads and weed invasion along waterways.
- The installation of mains sewerage lines along the creek, including overflow points, which results in water pollution during high rainfall events.
- The construction of roads, which creates disturbance to soils and vegetation and barriers to wildlife movement within the corridor (Upper Parramatta River Catchment Trust, 1999).

The main wildlife corridors within the M2 corridor include the bushland and disturbed vegetation surrounding Blue Gum Creek, Devlins Creek, Darling Mills Creek and Terrys Creek.

Where bridges span Darling Mills Creek, Devlins Creek and Terrys Creek, the vegetation underneath forms the only habitat connection between bushland areas on opposite sides of the Motorway. These areas are considered to be of particular importance to fauna movement. The vegetation underneath these structures is somewhat degraded due to previous earthworks and the impacts of shading and the interception of rainfall by the roadway overhead.

Patches of bare soil are apparent under these bridges. Around the abutments, in particular, the soil lacks vegetation cover and is loose and dry. Shading, a lack of suitable soil covering post-construction and low water availability may be the cause of this condition. The dry soil and lack of vegetation cover here is likely to limit the use of these areas as movement corridors by species (e.g. frogs) that require cover from predators or moist conditions (e.g. frogs).

The vegetation between Blue Gum Creek and the intersection of the M2 Motorway and Pennant Hills Road, and the vegetation along the southern boundary of Pennant Hills Golf Course also provides some connectivity between Bidjigal reserve and bushland areas to the east.

4.5.4 DECC Rapid Fauna Habitat Assessment

Part of the M2 corridor comprises four sites considered to be moderate to very high in fauna value (DECC 2008). The vegetation north of the M2 Motorway to the Cumberland Highway is part of the Lane Cove Valley (Figure 1). Darling Mills Creek is to the north-west (Bidjigal Reserve area), Devlins Creek is to the north of the M2 at the Chilworth Recreation Reserve, Cheltenham and Quarry Branch Creek is south west of the M2 at Winston Hills. In the DECC study, the fauna significance of a site was determined by the following features:

- Habitat connectivity;
- Habitat state or condition;
- Presence of tree hollows;
- Below canopy structural attributes;
- Habitat present considered to comprise priority fauna habitat;
- Future prospects;
- Presence of threatened species and regionally significance species;
- Potential presence of further significant fauna;
- Presence of feral bird species; and
- Presence of additional fauna attributes.

Lane Cove Valley (very high habitat value)

Table 12 shows the scores assigned by DECC for the Lane Cove Valley site for each of the above features.

Table 12 Rapid Fauna Habitat Assessment for Lane Cove Valley (DECC 2008)

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	0	0-20	Not connected
Habitat State	10	0-15	Little Bisected
Tree Hollows	15	0-20	Moderate
Below Canopy Attributes	10	0-15	Moderately Modified

Fauna Habitat Feature	Score	Score Range	Criteria
Priority Fauna Habitat	15	0-30	Moderate
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	10	0-30	Moderate
Threatened Species	150	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	160	5 per species	
Feral Bird Species	2	0-5	Moderate
Additional fauna Values	20	Various	
Total	392	(Very High)	

DECC's Lane Cove Valley site contains six priority fauna habitats: forested wetland, rainforest, alluvial forest and woodland, grassy woodland, freshwater wetland and saltwater wetland. These habitats are known to support 231 native fauna species, including ten endangered fauna species and one endangered population. The following threatened fauna have been recorded in the Lane Cove Valley site:

- Red-crowned Toadlet (*Pseudophryne australis*);
- Black Bittern (*Ixobrychus flavicollis*);
- Osprey (*Pandion haliaetus*);
- Gang-gang Cockatoo (*Callocephalon fimbriatum*) (endangered population);
- Glossy Black-cockatoo *(Calyptorhynchus lathami)*
- Swift Parrot (*Lathamus discolour*);
- Powerful Owl (*Ninox strenua*);
- Barking Owl (*Ninox connivens*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- East-coast Freetail-bat (*Mormopterus norfolkensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Little Bentwing-bat (*Miniopterus australis*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

Darling Mills Creek (high habitat value)

Table 13 shows the scores assigned to the Darling Mills Creek site for each of the above features.

Table 13 Rapid Fauna Habitat Assessment for Darling Mills Creek (DECC 2008)

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	0	0-20	Not connected
Habitat State	5	0-15	Moderately Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	5	0-15	Mostly Modified
Priority Fauna Habitat	5	0-30	Little
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	20	0-30	High
Threatened Species	70	10 per Vulnerable sp	

Fauna Habitat Feature	Score	Score Range	Criteria
		30 per Endangered sp	
Regionally Significant Species	90	5 per species	
Feral Bird Species	0	0-5	Widespread
Additional fauna Values	0	Various	
Total	210	(High)	

The site supports three priority fauna habitats: rainforest, alluvial forest and woodland and grassy woodland. There have been six threatened species recorded at the site, including:

- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- East-coast Freetail-bat (*Mormopterus norfolkensis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

These species are assessed in **Appendix C** for their potential to occur within the M2 corridor.

Devlins Creek (moderate fauna value)

Table 14 shows the scores assigned to the Devlins Creek site for each of the above features.

Table 14 Rapid Fauna Habitat Assessment for Devlins Creek

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	5	0-20	Little connected
Habitat State	0	0-15	Highly Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	10	0-15	Moderately Modified
Priority Fauna Habitat	0	0-30	Nil
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	30	0-30	Very High
Threatened Species	60	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	5	5 per species	
Feral Bird Species	2	0-5	Moderate
Additional fauna Values	40	Various	
Total	162	(Moderate)	

The site supports no priority fauna habitats. The endangered population of Gang-gang Cockatoo in the Hornsby and Ku-ring-gai LGAs was recorded near this site, but its actual status within the site is uncertain. The following threatened species have been recorded at the site:

- Powerful Owl (*Ninox strenua*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*); and

- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

Quarry Branch Creek (moderate fauna value)

Table 15 shows the scores assigned to the Quarry Branch Creek site for each of the above features.

Table 15 Rapid Fauna Habitiat Assessment for Quarry Branch Creek

Fauna Habitat Feature	Score	Score Range	Criteria
Habitat Connectivity	5	0-20	Little connected
Habitat State	10	0-15	Little Bisected
Tree Hollows	10	0-20	Some
Below Canopy Attributes	10	0-15	Moderately Modified
Priority Fauna Habitat	0	0-30	Nil
Future Prospects	0	-10-10	Little Change
Further Significant Fauna	20	0-30	High
Threatened Species	40	10 per Vulnerable sp 30 per Endangered sp	
Regionally Significant Species	10	5 per species	
Feral Bird Species	0	0-5	Widespread
Additional fauna Values	20	Various	
Total	125	(Moderate)	

The site supports no priority fauna habitats. Four threatened species are recorded within the habitat at the site:

- Powerful Owl (*Ninox strenua*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- Southern Myotis (*Myotis macropus macropus*).

These species are assessed in **Appendix C** for their potential to occur within the M2 Corridor.

4.5.5 Fauna Species of Conservation Significance

Searches of the NPWS Atlas of NSW Wildlife and EPBC Act Protected Matters Search Tool were conducted to determine if any threatened fauna species listed under the TSC Act or EPBC Act have been recorded or are likely to occur in the vicinity (Figure 3). The database revealed that there are a number threatened species recorded or predicted to occur within 10 km of the site. The likelihood of occurrence of these species based on previous records and habitat attributes is summarised in **Appendix C**. Those species which are assessed to have a moderate to high likelihood of occurring on the site on the basis of distribution and habitat requirements are shown in Table 16. Assessments of Significance for these species are presented in **Appendix F**.

Table 16 Potential threatened fauna species and populations in the M2 Corridor

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
Anthochaera phrygia	Regent Honeyeater	Bird	E	E	Moderate
Callocephalon fimbriatum	Gang-gang Cockatoo	Bird	V	-	High - recorded
Callocephalon fimbriatum	Gang-gang Cockatoo population in the Hornsby	Bird	E	-	High - recorded

Scientific Name	Common Name	Type of species	TSC Act Status	EPBC Act Status	Likelihood of Occurrence
	and Ku-ring-gai Local Government Areas				
Calyptorhynchus lathami	Glossy Black-cockatoo	Bird	V	-	Moderate
Chalinolobus dwyeri	Large-eared Pied Bat	Mammal	V	V	Moderate
Lathamus discolor	Swift Parrot	Bird	E	E	Moderate – seasonal migrant
Litoria aurea	Green and Golden Bell Frog	Frog	E	V	Moderate
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Mammal	V	-	Moderate to High
Mormopterus norfolkensis	Eastern Freetail-bat	Mammal	V	-	Moderate to High
Myotis adversus	Large-footed Myotis	Mammal	V	-	Moderate to High
Ninox strenua	Powerful Owl	Bird	V	-	Moderate to High
Pseudophryne australis	Red-crowned Toadlet	Frog	V	-	Moderate to High
Pteropus poliocephalus	Grey-headed Flying-fox	Mammal	V	V	High - recorded
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Mammal	V	-	Moderate
Scoteanax rueppellii	Greater Broad-nosed Bat	Mammal	V	-	Moderate to High
V = Vulnerable, E = Endangered, - = Not listed					

The threatened fauna species listed in Table 16 above are discussed in further detail in Section 5.2.

4.5.6 Feral animals and over-abundant native species

Introduced feral and domestic predatory mammal species such as the European Red Fox (*Vulpes vulpes*), Domestic Cat (*Felis catus*) and Black Rat (*Rattus rattus*) compete with and prey upon native fauna and may have lead to the local depletion or extinction of small to medium-sized terrestrial mammals, ground-foraging birds and reptile species.

Other introduced species such as the European Rabbit (*Oryctolagus cuniculus*) may damage plants and fauna habitat through their feeding and digging activities. A number of introduced birds such as the Red-whiskered Bulbul (*Pycnonotus jocosus*), Spotted Turtle Dove (*Streptopelia chinensis*) and Common Myna (*Acridotheres tristis*) spread the seeds of environmental weeds.

Common Myna (*Acridotheres tristus*), Starling (*Turdus merula*) and European Honey Bee (*Apis mellifera*) compete with native species for nesting hollows.

Several native bird species are believed to have increased markedly in their abundance and have been implicated in the decline in some common native species due to competition and predation. Noisy Miner (*Manorina melanophrys*), Rainbow Lorikeet (*Trichoglossus haematodus*) and Red Wattlebird (*Anthochaera carunculata*) are aggressive nectar-feeding species which may exclude other nectar-feeding birds from flowering trees and shrubs. Pied Currawong (*Strepera graculina*) have been implicated in the decline of populations of small birds as a result of the predation, particularly of eggs and nestlings and also spread the seeds of environmental weeds. Parrots such as Sulphur-crested Cockatoo (*Cacatua galerita*) and Rainbow Lorikeet (*Trichoglossus haematodus*) compete with other birds for scarce nesting opportunities in tree hollows.

Many of these species have been able to establish and proliferate in bushland areas as a result of human-induced changes to the environment such as vegetation clearing and the cultivation of introduced plant species.

4.6 Aquatic Vegetation of the Study Area

4.6.1 Vegetation communities and condition

The Sandstone Riparian Scrub vegetation type occurs along all creeks within and adjacent to the M2 corridor with the most intact occurrences at Darling Mills Creek and Terrys Creek. Much of this vegetation is highly modified as a result of alteration to natural flow regimes, increased nutrients and especially weed invasion.

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, chiefly in disturbed areas.

The detention basins within the M2 corridor contain 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.

4.6.2 Aquatic plant species of conservation significance

No aquatic plant species of conservation significance were recorded or considered likely to occur within the M2 corridor or surrounds.

4.6.3 Introduced flora

A variety of aquatic weeds (e.g. Water Milfoil (*Myriophyllum aquaticum*) and Watercress (*Rorippa nasturtium-aquaticum))* are found along the waterways of the study area. Of these, three species are listed as noxious weeds. Noxious aquatic species recorded include:

- Long-leaf willow primrose (*Ludwigia longifolia*).
- Ludwigia (*Ludwigia peruviana*).
- Sagittaria (*Sagittaria platyphylla*).

4.7 Aquatic Fauna Habitat

4.7.1 Waterways

Prior to residential development in surrounding areas, the creeks of the locality are likely to have supported a diverse community of insects, fish, frogs, birds and mammals. The creeks are degraded to varying degrees as a result of a number of factors including increased erosion due to the concentration of stormwater flows, weed invasion, polluted catchment runoff and the presence of exotic fish species. As a result of this condition, frogs, fish and aquatic invertebrates that are sensitive to these forms of disturbance are unlikely to persist in these waterways. Nonetheless, a variety of disturbance tolerant fauna species remain.

The present condition of the creeks of the M2 corridor varies from highly modified to near-natural. Classification of the creeks within the study area is listed below in Table 17.

Table 17 Classification of waterway crossings within the study area

Classification	Characteristics of waterway type	Creek/drainage line
Class 2 – Moderate 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	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's Creek

Source: Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road?

The section of Darling Mills Creek crossed by the M2 corridor appears to be in relatively moderate condition, with low turbidity, little evidence of sedimentation and a low level of weed invasion. This area is likely to be inhabited by all of the native fish species listed in **Appendix D**. It is also likely to be inhabited by the introduced Plague Minnow (*Gambusia holbrooki*), though the population density of this species is likely to be relatively low due to the higher water quality and intact riparian vegetation which favour native fish species. The Eastern snake-necked Tortoise (*Chelodina longicollis*) is also likely to be found here.

Recent frog surveys conducted along this section of Darling Mills Creek detected the Green Stream Frog (*Litoria phyllochroa*), Peron's Tree Frog (*Litoria peronii*), Striped Marsh Frog (*Limnodynates peronii*) and Common Eastern Froglet (*Crinia signifera*).

The threatened Red-crowned Toadlet (*Pseudophryne australis*) usually lives close to non-perennial streams but previous ecological assessments conducted have recorded the Red-crowned Toadlet between Wicks Road and Epping Road, North Ryde, adjacent to the M2 corridor (Eco Logical Australia, 2009; Biosphere, 2007), and also at Nile Close, Marsfield. The North Ryde area is occupied by Transport Infrastructure Development Corporation (TIDC) and is currently proposed as a compound site for the M2 Upgrade.

The other creeks of the study area are more disturbed and are likely to contain a lower diversity and abundance of fish and frog species with the Plague Minnow becoming increasingly dominant in more disturbed areas.

Due to the low abundance of emergent aquatic vegetation along these creeks, little habitat for aquatic birds exists here.

A number of fish species likely to be found within the creeks of the study area are catadromous, meaning they spend their lives in freshwater and return to the ocean to spawn. Catadromous species likely to found in the creeks of the study area include:

- Shortfinned Eel (*Anguilla australis*).
- Longfinned Eel (*Anguilla reinhardtii*).
- Common Jollytail (*Galaxias maculatus*).

These species need to be able to move between freshwater and marine environments and thus may be susceptible to the obstruction of waterways. Other fish species which move into the smaller tributaries of river systems during the juvenile phase of their life cycles may also be susceptible. Fish species that have been previously recorded or considered likely to occur within the study area are listed below in Table 18.

Table 18 Fish species considered likely to occur within the study area

Scientific name	Common name	Conservation status (NSW)
Anguilla australis	Short-finned Eel	P
Anguilla reinhardtii	Long-finned Eel	P
Carassius auratus	Goldfish	U
Cyprinus carpio	Common carp	U
Gobiomorphus australis	Striped Gudgeon	-
Gobiomorphus coxii	Cox Gudgeon	-
Hypseleotris compressus	Empire Gudgeon	-
Hypseleotris galii	Firetail Gudgeon	-
Philypnodon grandiceps	Flathead Gudgeon	-
Galaxias maculatus	Common Jollytail	-
Gambusia affinis	Mosquito fish	U
Retropinna semoni	Australian Smelt	-
Anguilla australis	Short-finned Eel	P
Anguilla reinhardtii	Long-finned Eel	P

Note: P: Protected; U: Unprotected; –: Not classified.

Obstructions to fish movement within the M2 corridor exist where waterways pass beneath the Motorway via culverts. During low flow conditions, the streams of water flowing through the culverts are broad but very shallow and may limit the passage of some fish species. Higher water velocity and turbulence during rainfall events and a lack of pooled areas for fish to rest between bouts of swimming may also limit fish movement through the culverts. The extremely low light level within culverts may also create a nonphysical barrier for some fish species that may avoid dark areas during daylight hours (Fairfull and Witheridge, 2003).

Larger in stream structures (e.g. the retarding basin wall near Loyalty Road, North Rocks and weirs on the Lane Cove River) lower in the catchments of these creeks are also potential barriers to fish passage.

Prior to the 1980's 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 been previously been recorded and may still occur in the waterways of the study area.

4.7.2 Constructed water bodies (detention basins)

When constructed, the detention basins of the M2 corridor were planted with emergent aquatic native plants with the intention of providing wildlife habitat. This was in addition to the primary purpose of slowing stormwater flows to minimise water pollution and impacts to the hydrology of adjacent waterways.

Emergent aquatic 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*.

The detention basins vary somewhat in the characteristics of the aquatic vegetation found within them, some having an almost complete cover of emergent vegetation whilst others have larger areas of open water. The height and structure of the vegetation surrounding the basins also varies with some overshadowed by tree regrowth and others in relatively open sunlit conditions. Water levels within these basins are likely to increase after rainfall and decrease during extended dry periods though it is likely that water is continually present in most if not all of these basins.

Water quality in the basins is likely to be relatively poor due to the influx of pollutants from the road surface. Basins that are isolated from other water bodies are unlikely to be inhabited by fish though other aquatic fauna such as tortoises, snakes and wading birds may be found in these locations. It is unknown whether or not the

Amphibian Chytrid Fungus is found in any of these basins but it is possible that it may have been introduced there by colonising frogs.

4.7.3 Aquatic fauna species of conservation significance

No threatened or protected aquatic invertebrate or fish species have been recorded in the waterways of the M2 corridor. In their pre-development condition, the creeks of the study area may have provided potential habitat for the Australian Grayling (*Prototroctes maraena*) but this species has not been recorded in either of the river systems of the study area and is considered unlikely to exist there due to historical and ongoing pressures on these waterways.

4.7.4 Introduced aquatic animals

Introduced fish species recorded in the locality include Goldfish (*Carassius auratus*), Common Carp (*Cyprinus carpio*) and Plague Minnow (*Gambusia holbrooki*). Goldfish and Common Carp are not likely to be abundant in the small rocky streams of the study area however the Plague Minnow is found in all of the creeks, especially in disturbed areas. This species is listed as a Key Threatening Process due to its detrimental impacts upon tadpoles and frog eggs.

5.0 Impact Assessment

5.1 Impacts on Flora

5.1.1 Vegetation removal

Vegetation removal for the M2 Upgrade would be required for:

- Areas occupied by the widened M2 Motorway and fill batters.
- Construction access roads.
- Site compounds.
- Materials storage areas.
- New detention basins.
- Access to detention basins.

The nature of these impacts is summarised in Table 19.

Table 19 Direct impacts on vegetation

Element of proposal	Nature of impact
Widened M2 Motorway including fill batters	Permanent removal of vegetation would occur in areas occupied by the widened M2 Motorway. Permanent alteration of the soils of the batter slopes would occur.
Construction access roads and materials storage areas	Partial clearing of vegetation would occur in the areas identified for construction access roads. Construction access areas are largely located within areas dominated by native vegetation. Vegetation removal would be limited to that necessary for access. Mature trees and other fauna habitat features such as waterways and rock outcrops would be avoided where practicable. Access roads to compound sites and work locations associated with bridges over Darling Mills Creek, Devlins Creek and Terrys Creeks will be required. • Darling Mills Creek will be accessed via access tracks off the M2 Motorway. Entry to the site compound will be via eastbound lanes and exits will be via westbound lanes. • Devlins Creek will be accessed via Allerton Road (entry and exit) • Terrys Creek will be accessed via access tracks provided off Somerset Street (entry and exit) • Areas under the bridges will be utilised for access. Construction methodology will determined during the detailed design phase. Cleared areas would be rehabilitated post construction as described in Section 6.0.
Site compounds	Clearing of vegetation would occur in the areas identified for site compounds. The larger site compounds are located on filled areas. Vegetation in these areas is composed of trees and shrubs planted after the construction of the M2 Motorway with the ground layer consisting almost entirely of introduced species. Cleared areas would be rehabilitated post construction as described in Section 6.0.
New detention basins including access roads	Permanent removal of vegetation in areas occupied by the new detention basins and access roads. Detention basins would be planted with emergent native aquatic plant species.
Access to existing detention basins	Permanent removal of vegetation for permanent access roads to access new and existing detention basins. Works will involve permanent removal of vegetation, much of which is weedy regrowth from the original construction of the basins.

The amount of vegetation (native and exotic) estimated to be cleared is approximately 21 ha in total. A conservative estimate of the amount of vegetation considered to be in good condition within the study area is approximately 10 ha. These areas are characterised by having a relative intact understorey, shrub and canopy layer and are consistent with the floristic composition of the vegetation community as defined by the relevant native vegetation classification for each community.

Approximately 11 ha of this total are considered to be in poor condition as these areas are highly modified and characterised by high levels of weed invasion. Although dominated by exotic species, these areas are still considered to be part of the vegetation communities as identified in Table 20.

Table 20 shows the breakdown of clearing required in each vegetation community (as described by the predictive vegetation mapping datasets) within the M2 corridor. The local occurrence of the vegetation communities is defined as the ecological community that occurs within and adjacent to the study area.

Table 20 Vegetation clearing within the M2 corridor

Vegetation Community	Approximate local occurrence (ha)	Approximate amount of vegetation removal (ha)	Approximate amount of disturbed /exotic vegetation (ha)
Coastal Sandstone Ridgetop Woodland	25.2	0.4	0.16
Hinterland Sandstone Gully Forest	379.6	17.5	9.3
Sydney Hinterland Transition Woodland	24.4	0.1	0.08
Sandstone Riparian Scrub	64.5	3	1.3
Total		21	10.84

Potential impacts to threatened flora species considered to have a moderate to high likelihood of occurrence are summarised below.

Acacia bynoeana

Acacia bynoeana occurs in heath or dry sclerophyll forest on sandy soils and seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leafed Apple. The total population is estimated to be only a few hundred plants. The closest records of the species to the M2 corridor are within 2 km in Gordon and near the northern boundary of Bidjigal Reserve. No individuals of this species were recorded within the M2 corridor during recent flora surveys.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Acacia bynoeana.* As the potential habitat here is isolated from habitat containing known populations in the region as a result of urban development it is considered unlikely that any population here would be considered a key source population either for breeding or dispersal.

Callistemon linearifolius

Callistemon linearifolius has been recorded within the M2 corridor at Marsfield (DECCW, 2001). The species was not detected during the flora survey of the M2 corridor. An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Callistemon linearifolius* and with the implementation of the mitigation measures provided in section 5 (such as pre-clearance surveys prior to construction), potential impacts to this species will be minimised.

Darwinia biflora

There are 20 populations of *Darwinia biflora* within the Sydney Region that are not currently covered by the reserve system and have been identified as important and suitable to be targeted for conservation. The bushland

of the M2 corridor and adjacent bushland (e.g. Bidjigal Reserve, Lane Cove National Park) are not included in these lists of important populations.

The species was not recorded during flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a large population exists here.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Darwinia biflora* as it is considered unlikely that a large population exists here.

Epacris purpurascens var.purpurascens

Epacris purpurascens var. *purpurascens* habitats which remain (particularly on ridgetops) are under increasing threat of clearance or habitat modification (DECCW, 2009).

A conservative estimate of potential habitat for *Epacris purpurascens* var. *purpurascens* within the M2 corridor is approximately 30 ha. Approximately 20 individuals of this species (observed in flora plots during flora surveys) are likely to be removed (refer to Figure 4). As these individuals of the species are located in translocated soils and earth mounds within the M2 corridor, further regeneration of the species from soils translocated during the proposed project is considered likely.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. Based on the above considerations and assessment conducted the M2 Upgrade is unlikely to have a significant impact on a local population of *Epacris purpurascens* var. *purpurascens.*

Persoonia hirsuta

Persoonia hirsuta was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, the closest recent (post 1980) record of the species is approximately 5 km from the M2 corridor and the species has not been detected within the adjacent bushland reserves.

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The proposed works are unlikely to have a significant impact on this species as a potentially important population is not considered likely to exist within the M2 corridor.

Pimelea curviflora var. curviflora

Pimelea curviflora var. *curviflora* was recorded during the EIS for the western section of the M2 Motorway (Mount King 1992) however the specific location and the population size of this species were not reported. It is found in two fairly small populations in Lane Cove National Park, North Ryde and a few plants were recorded in the Pages Creek area. The Field of Mars Reserve population was estimated to be greater than 300 plants. The species is known to also occur at Epping Oval (DECCW, 2001).

An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Pimelea curviflora* var. *curviflora.*

Tetratheca glandulosa

Tetratheca glandulosa is associated with areas of shale-sandstone transition habitat. The vegetation varies from heaths and scrub to woodlands/open woodlands, and open forest. The species was not recorded during recent flora surveys within the M2 corridor. Whilst it is considered possible that this species may exist within the M2 corridor, it is considered unlikely that a potentially important population exists within the development footprint due to the level of disturbance occurring in these areas.

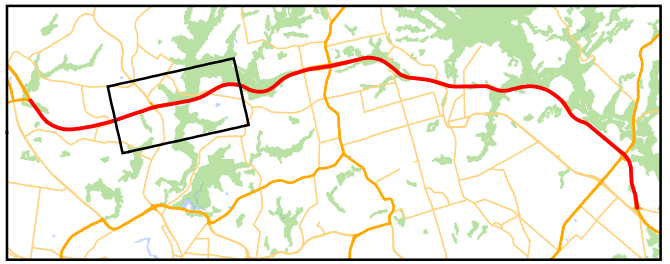
An assessment of significance for the potential impact on this species has been undertaken and is presented in **Appendix F**. The M2 Upgrade is unlikely to have a significant impact on a local population of *Tetratheca glandulosa.*

Figure 4 – Approximate locations of *Epacris purpurascens* var. *purpurascens* found within the study area

Lease boundary

Proposed Design

Epacris purpurascens var. *purpurascens*



Source: RTA (2009)

5.1.2 Ecological communities

The project is not considered to have any impact on the EPBC Act and TSC Act listed threatened ecological communities. Sydney Turpentine–Ironbark Forest is listed as a CEEC under the TSC Act and the EPBC Act. Site surveys conducted reveal that vegetation mapped as Sydney Turpentine-Ironbark Forest is not consistent with either the EPBC Act or TSC Act definitions of this community. This vegetation is consistent with the floristic composition of the larger patches of adjacent Hinterland Sandstone Gully Forest vegetation community.

No other EECs are considered in the impact assessment.

5.1.3 Indirect impacts

The Blue Gum High Forest community is listed as a CEEC under the TSC Act and the EPBC Act. The extent and condition of this community has been verified through on ground inspection and the present distribution within the M2 corridor is restricted to a narrow band between the M2 Motorway and Pennant Hills Golf Course to the north. This area is approximately 1.36 hectares in area and in moderate to poor condition.

The design option for the proposed widening of the M2 Motorway was specifically chosen to avoid vegetation clearing or modification to this ecological community, however indirect impacts are possible.

The earthworks required for the construction of the M2 Upgrade have the potential to spread weed seeds between locations along the length of the M2 corridor in soil adhered to vehicles and construction equipment and on the clothing of construction workers. Soil disturbance as a result of earthworks activities may also create a favourable environment for the proliferation of weed species already present.

Shading and the reduction in soil moisture due to the interception of rainfall by overbridges may result in alteration to or loss of native vegetation underneath these structures.

An assessment of significance for the potential impact on Blue Gum High Forest has been undertaken and is presented in **Appendix F**.

5.1.4 Threatening processes

The Key Threatening Processes (KTPs) listed under the TSC Act that are known or considered likely to affect the biodiversity of the study area and the interaction of the proposed works with these processes is summarised in Table 21.

Table 21 KTPs and potential impacts on flora and fauna within the M2 corridor

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands (TSC)	The flow regime of Darling Mills Creek is altered due to the presence of the flood retarding basin upstream of the study area. The presence of impervious surfaces such as roads within the catchments of the study area has resulted in alteration of the flow regime of these creeks. Altered moisture levels in the soils of riparian areas, erosion and sediment deposition affect the health of native vegetation and may promote weed invasion. The alteration to riparian habitat, increased turbidity and barriers to fish passage affect aquatic and terrestrial fauna species.	The increased road surface as a result of the works could further alter the natural flow regime of the creeks of the study area however the detention basin works proposed are being designed with capacity for the additional stormwater from the Motorway. The flow patterns within the waterways may be altered by the construction of piers in or adjacent to the waterway. It may be necessary to build one or two piers in or adjacent to Darling Mills Creek or its tributary (chainage 4750) and a tributary of Devlins Creek (chainage 9770).

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
	The vegetation underneath existing bridge structures is degraded due to previous earthworks, the impacts of shading and the interception of rainfall by the roadway overhead. Around existing abutments, the soil is loose and dry. A lack of suitable soil cover post-construction and low water availability has resulted in a lack of vegetation cover.	The potential impact of the piers includes localised increases in flow velocities around the piers however these are not considered significant for flood flows (see Surface Water Assessment, AECOM 2010). Construction of additional piers may also result in localised changes to flow patterns and localised scour. Due to the sandy nature of soil under bridges, the construction of piers may result in increased erosion and sedimentation during the construction phase however erosion control plans will be implemented and these areas will be remediated (revegetated) or stabilised post-construction. The lack of vegetation cover under bridges is likely to limit the use of these areas as movement corridors by fauna species which require cover from predators or moist conditions (e.g. frogs).
Bushrock Removal (TSC)	Rock outcropping exists in within the sandstone valleys and ridgetops of the study area. Bushrock removal can be detrimental to the habitat of some fauna species, particularly reptiles and frogs (e.g. Red-crowned Toadlet (*Pseudophryne australis*)).	Some areas of bushrock would be removed during construction. The area of forest with abundant rock outcropping that would be removed is approximately 0.5 ha.
Clearing of native vegetation (TSC) Land clearance (EPBC)	Much of the original vegetation of the study area has been cleared for residential development and road construction. This has also resulted in fragmentation of the remaining vegetation. Clearing reduces the habitat available to fauna species, affects ecosystem function through the loss of pollinators and seed dispersal vectors in isolated remnants and creates opportunities for weed invasion and feral animals.	The proposal would result in additional vegetation removal and disturbance as described in section 5.1.1. As the widening is alongside the existing Motorway vegetation fragmentation is not likely to be significantly increased.
Competition and grazing by the feral European rabbit (TSC) Competition and land degradation by rabbits (EPBC)	The feral European rabbit have been recorded within the study area but do not appear to be present in large numbers at present or to have had significant impact on vegetation. Grazing by feral rabbits can inhibit seedling recruitment thereby degrading native vegetation and fauna habitat.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that rabbits would be likely to increase in abundance or in their impact on native species.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Competition from feral honeybees (TSC)	Feral honeybees are likely to form hives in hollow trees within the study area. Competition from feral honeybees reduces the availability of nesting and roosting resources for hollow-dependent fauna such as species of owls, parrots, possums and microbats. Feral honeybees also compete with native fauna for nectar and pollen resources.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral honeybees would be likely to increase in abundance or in their impact on native species. Any nest boxes installed for native fauna may become inhabited by feral honeybees. Regular monitoring of nest boxes should be conducted to ensure that any bees that infest the boxes are removed.
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (TSC) Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC)	Chytridiomycosis caused by Amphibian Chytrid Fungus has been implicated in severe population declines and species extinctions of frogs in the past 20 years (DEH 2006). Chytridiomycosis is a threat to populations of threatened frog species such as the Green and Golden Bell Frog *Litoria aurea*. Amphibian chytrid fungus *Batrachochytrium dendrobatidis* is widespread in the Sydney region and it is considered likely to occur in the waterways of the M2 corridor. It is also possible that the fungus may have been introduced to some or all of the detention basins of the M2 corridor by frog species that inhabit both still and flowing water bodies.	With the use of equipment in wet environments in several locations within the M2 Corridor, there is a risk that amphibian chytrid fungus could be spread in wet mud. With the implementation of the proposed mitigation measures, this risk of spreading this disease to uninfected water bodies is considered to be low.
Infection of native plants by *Phytophthora cinnamomi* (TSC)	The pathogen (*Phytophthora cinnamomi*) appears to be widespread in coastal forests. The pathogen has been recorded in the nearby Lane Cove National Park and Garigal National Park (DECCW 2008). The presence or absence of this pathogen within the study area is unknown. This pathogen can result in the loss of susceptible plant species from affected areas, causing an alteration to vegetation composition and structure thereby altering habitat characteristics for fauna species.	The proposed works have some potential to introduce this pathogen in soil or water on equipment and footwear and in soils and plant material brought into the corridor during the works. Mitigation measures are proposed that would minimise the likelihood of the introduction of plant pathogens. The importation of soil and mulch into bushland areas would be minimized through the use of in situ materials wherever feasible.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Invasion and establishment of exotic vines and scramblers (TSC)	Several species of exotic vines and scramblers are found in the M2 corridor, chiefly along the creeks and in moist environments. Affected vegetation has a decreased ability to regenerate and is of lower value to fauna due to reductions in vegetation structural complexity and food resources.	Some of the areas affected by the proposal (chiefly areas near waterways) are currently infested with exotic vines and scramblers. Earthworks have the potential to spread these species. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of exotic vines and scramblers is not likely to be increased significantly.
Invasion, establishment and spread of *Lantana camara* (TSC)	*Lantana camara* (Lantana) is abundant in several locations within the M2 corridor where vegetation has been disturbed by earthworks. Affected vegetation is reduced in its ability to regenerate and has lower value to fauna due to reductions in vegetation structural complexity and food resources.	Some of the areas affected by the proposal are currently infested with Lantana. Earthworks have the potential to spread this species and to create opportunities for existing infestations to expand. Proposed mitigation measures have been designed to minimise the likelihood of the introduction, spread and proliferation of weeds and to encourage the regeneration of native vegetation. With the implementation of these measures, the impact of Lantana is not likely to be increased significantly.
Loss of Hollow-bearing Trees - key threatening process (TSC)	Hollow-dependent fauna such as species of owls, parrots, possums and microbats are known or considered likely to occupy the M2 corridor. The density of mature, potentially hollow-bearing, trees within the M2 corridor is lower than would be expected to occur in undisturbed forest. Previous land use activities such as timber-getting and forestry (e.g. in the former Darling Mills State Forest) and clearing for infrastructure and residential development are likely to have reduced the local abundance of tree hollows.	The proposed works would require the permanent removal of approximately 7 ha of eucalypt forest and woodland. A further 3 ha would need to be removed for access and compound sites though this area would be rehabilitated post-construction and mature trees would be avoided where practicable. No tree hollows of sufficient size to provide nesting opportunities for larger species, such as the Powerful Owl, were observed within the areas potentially affected by clearing activities. Most of the trees removed are immature or semi-mature and are likely to contain chiefly small to medium-sized hollows that are potential habitat for smaller species of birds and mammals. These trees also have the potential to develop hollows as they mature, providing opportunities for populations of hollow-dependent fauna to recover. The loss of hollow-bearing trees would be offset by the proposed installation of nest boxes of a variety of designs.

Key Threatening Processes	Relevance to Study Area	Potential Impact of Proposed Works
Predation by feral cats (TSC) Predation by feral cats (EPBC)	Predation by feral and domestic cats, in association with predation by the feral cats and other factors, is likely to have caused the local extinction of a number of native ground-dwelling mammals, birds and reptiles.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that feral cats would be likely to increase in abundance or in their impact on native species.
Predation by the European Red Fox (TSC) Predation by European red fox (EPBC)	Predation by the European Red Fox, in association with predation by feral and domestic cats and other factors, is likely to have caused the local extinction of a number of native ground-dwelling mammals, birds and reptiles.	The proposal is unlikely to affect the vegetation or otherwise affect habitat such that the European Red Fox would be likely to increase in abundance or in its impact on native species.
Predation by the Plague Minnow (*Gambusia holbrooki*) (TSC)	The Plague Minnow is a small introduced fish that preys on and competes with native fish, aquatic invertebrates and the tadpoles of frogs. This species has been implicated in the decline of populations of the Green and Golden Bell Frog (*Litoria aurea)*. The Plague Minnow is present in all of the creeks of the study area.	With the use of equipment in wet environments in several locations within the M2 corridor, there is a risk that juvenile Plague Minnow could be spread in wet mud. With the implementation of the proposed mitigation measures, the spread of this species is however unlikely. The proposed works are not considered likely to modify the waterways of the study area in such a way as to encourage the proliferation of the Plague Minnow.

5.2 Impacts on Fauna

Measures would be implemented to minimise the risk of harm to native fauna during construction activities. Detailed consideration of the impacts of the project on threatened species is provided in the Assessments of Significance in **Appendix F**. Species assessed include:

- Green and Golden Bell Frog
- Red-crowned Toadlet
- Swift Parrot
- Regent Honeyeater
- Gang-gang Cockatoo
- Glossy Black Cockatoo
- Powerful Owl
- Grey-headed Flying-Fox
- Eastern Freetail-bat
- Yellow-bellied Sheathtail-bat
- Greater Broad-nosed Bat
- Eastern Bentwing-bat
- Large-footed Myotis
- Large-eared Pied Bat.

Migratory species assessed include:

- Black-faced Monarch *Monarcha melanopsis*
- Rainbow Bee-eater *Merops ornatus*

- Rufous Fantail *Rhipidura rufifrons*
- Satin Flycatcher *Myiagra cyanoleuca*
- White-throated Needletail *Hirundapus caudacutus*

The conclusions of the assessments are that a significant adverse impact on the above species is unlikely.

Green and Golden Bell Frog

While some of this area is considered to be potential foraging habitat for this species, most of this area is considered to be marginal or unsuitable as habitat due to a lack of suitable vegetation cover, dry surface conditions and distance from potential breeding habitat. Modification to these areas as a result of clearing may result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term.

Assessments of significance concluded that a significant impact on the Green and Golden Bell Frog is unlikely.

Red-crowned Toadlet

Although the Red-crowned Toadlet was not recorded during current surveys within the M2 corridor, this species has been recorded between Wicks Road and Epping Road, North Ryde, adjacent to the M2 corridor (Eco Logical Australia, 2009 and Biosphere, 2007), and also at Nile Close, Marsfield. The North Ryde area is occupied by Transport Infrastructure Development Corporation (TIDC) and is currently proposed as a compound site for the M2 Upgrade project.

Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat. Much of the widening works are not are not in close proximity to breeding areas of the Red-crowned Toadlet and are considered to be at best, marginal as habitat for the species.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on this species is unlikely.

Swift Parrot

Favoured feed trees of the Swift Parrot are wintering flowering eucalypts. Little of this vegetation remains however revegetation along the edges of the M2 Motorway has involved in the planting of some individuals of these species. This revegetation consists of narrow bands of immature trees between the edge of the M2 Motorway and adjacent residential lands.

Given the lack of breeding habitat and the relatively small amount of marginal potential foraging habitat that would be affected, the M2 Upgrade project is not considered likely to significantly disrupt the breeding cycle of any subset of the population of the Swift Parrot.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Swift Parrot is unlikely.

Regent Honeyeater

The Regent Honeyeater generally inhabits dry, temperate woodlands and open forests of the inland slopes of south-eastern Australia (DECCW, 2009). There are only three known major breeding locations and two of these occur in NSW.

Breeding of the species has not been recorded in the Sydney area and breeding of the species in the vicinity of the M2 corridor is considered highly unlikely. A reduction in available foraging habitat in the short-term would occur but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation would be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Regent Honeyeater is unlikely.

Gang-Gang Cockatoo

The Gang-gang Cockatoo was recorded during the current study flying overhead in the vicinity of the Terry Creek overpass near Crimea Road on the border of Epping and Marsfield.

A population of Gang-gang Cockatoos persists in the Hornsby and Kur-ing-gai Local Government Areas and is largely believed to be confined to an area bounded by Thornleigh and Wahroonga in the north, Epping and North

Epping in the south, Beecroft and Cheltenham in the west and Turramurra/South Turramurra to the east (DECCW, 2009). The population encompasses, but is not restricted to, Pennant Hills Park and parts of Lane Cove National Park.

Given the proximity of the existing M2 Motorway to the vegetation that would be affected, it is considered unlikely that sites used for breeding by this species would be affected. Potential nesting hollows for the species are not known or considered likely to be abundant in the area affected by the proposed M2 Upgrade. No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed.

Assessments of significance (provided in **Appendix F**) concluded the proposed M2 Upgrade is unlikely to have a significant adverse impact on the Gang-gang Cockatoo.

Glossy Black Cockatoo

This species depends on large hollow-bearing eucalypts for nest sites and feeds exclusively on the seeds of several species of She-oak (Casuarina and Allocasuarina species). No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed as a result of the M2 Upgrade project.

These birds are all highly mobile species with large home ranges and the small linear patch of vegetation removal that is proposed would not significantly increase habitat fragmentation for these species.

Due to their ability to fly, the bird species may forage within the vegetation along the M2 corridor but most are likely only as occasional visitors to these areas with their core habitat being within larger more intact areas of vegetation in the locality.

Assessments of significance (provided in **Appendix F**) concluded a significant impact on a local population of the Glossy Black Cockatoo is unlikely.

Powerful Owl

The Powerful Owl requires large tracts of forest or woodland habitat but can also occur in fragmented landscapes (DEC, 2006). This species is known to nest in large tree hollows (at least 0.5 m deep), in large eucalypts that are at least 150 years old (DECCW, 2009) and some of their prey also rely on tree hollows for refuge.

No hollows of sufficient size to accommodate the species were observed in any of the trees that would be removed. The majority of the trees to be removed are relatively small due to low nutrient and moisture levels, previous clearing for the existing M2 Motorway and the logging history of the area.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on this species is unlikely.

Grey-headed Flying Fox

The Grey-headed Flying-fox was recorded flying overhead in several locations during field surveys. Individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon.

Foraging habitat for this species is considered to be present throughout the study area wherever fleshy-fruited and nectar-producing trees are present and forages throughout the Sydney Metropolitan area. No camp sites are present within or in the bushland adjacent to the M2 corridor.

Modification and vegetation clearing as a result of the M2 Upgrade project would result in a reduction in available foraging habitat in the short-term but is not considered likely to prevent the species from using these areas as foraging sites in the medium to long term. Although this vegetation would be removed, upon completion of works the vegetation would be allowed to regenerate naturally and would be supplemented by revegetation and bushland regeneration works.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on the Grey-headed Flying-fox is unlikely.

Insectivorous (microchiropteran) bats

The study area does not contain any caves, or mines near or above water and is consequently unlikely to provide preferred roosting or maternity sites for many of the threatened microbat species listed above. Preferred habitat for threatened microbat species is likely to be found lower within moister valleys of the locality rather than the upper slope areas in which the M2 Motorway is chiefly located. Species such as the Eastern False Pipistrelle are not considered to occur within the study area as they prefer moist habitats in vegetation characterised with tree species over 20 metres (DECCW, 2009).

The core likely foraging habitat for threatened microbats in the locality is concentrated in the larger areas of more mature vegetation that would not be substantially affected by the proposed works. The habitat affected by the proposed works is of marginal quality due to previous clearing, weed invasion and traffic noise. Due to the lack of suitable roosting habitat, and disturbance, this area is considered to be of relatively low value as potential habitat for the threatened microbat species listed above when compared to larger areas of vegetation at greater distance from the M2 Motorway.

Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on insectivorous (microchiropteran) bats is unlikely.

Migratory Species

Migratory species are considered unlikely to rely on the affected areas as breeding, foraging or roosting habitat due to the level of disturbance adjacent to the M2 Motorway. Breeding habitat is more likely to be located in core bushland areas beyond the study area. Suitable foraging habitat is only considered to be marginal at best with preferred habitat more likely to be located in areas of less-disturbed habitat in the locality. Assessments of significance (provided in **Appendix F**) concluded that a significant adverse impact on migratory species is unlikely.

5.2.1 Fauna habitat loss

The main direct impact on fauna is habitat removal. The works would cause a reduction in habitat available for native fauna species through the removal of native vegetation and habitat features such as rock outcrops and organic debris. The extent of habitat removal is likely to total approximately 21 hectares, of which approximately 10 ha is considered to be in relatively good condition (predominantly native). Of this total, 3 ha would be subsequently rehabilitated.

Vegetation removal (particularly native vegetation) has the potential to impact on fauna species through a reduction in the availability of feeding resources, shelter from environmental extremes, refuge from predators and breeding sites. Whilst removal of vegetation within the development footprint would be permanent, clearing for access and compound areas would be temporary as these areas would be rehabilitated post-construction.

No tree hollows of sufficient size to provide nesting opportunities for larger hollow-dependant species were observed within the areas potentially affected by clearing activities. Most of the trees removed are immature or semi-mature, but have the potential to develop hollows as they mature, providing opportunities for populations of hollow-dependent fauna to recover. The mitigation measures proposed include the installation of nest boxes to compensate for the loss of potential hollow-bearing trees.

5.2.2 Lighting

Following the upgrade, there will be additional lighting requirements at the new interchanges at Windsor Road, Christie Road and Herring Road only. Given that there is existing lighting along the Motorway and at these interchanges, the increase in lighting to fauna species will be negligible as a result of the M2 Upgrade.

Lighting during the construction period will be required for works carried out at night-time (ie pre-sunset and post-sunset), especially during the winter months. Lighting will be required at all compound sites however eight proposed compound sites may be operational 24 hours a day. These compounds are discussed in detail in the *M2 Motorway Upgrade Environmental Assessment Specialist Report Lighting Impact Assessment* (Heggies, 2009). It is assumed that the remaining compounds would be lit with localised security lighting during night time periods.

Light spill will occur at locations of the proposed compound sites. Potential impacts to fauna resulting from obtrusive light spill will be greatest adjacent to larger areas of bushland reserves, such as the proposed Terrys Creek Compound and the Darling Mills Creek Compound.

Nocturnal species are adapted to low light conditions to forage for food and could therefore be deterred from foraging areas as a result of excessive light spill. Nocturnal mammals and birds are also likely to be disturbed by artificial light at night-time as they are at an increased risk from predators.

The regular route of threatened bat species may also be affected as a result of light spill. The Grey-headed Flying-fox was recorded flying overhead in several locations and individuals feeding within the study area are considered most likely to roost in the Ku-ring-gai Flying-fox Reserve in Gordon. The study area does not contain any camp sites for the Grey-headed Flying-fox and although vegetation in parts of the M2 corridor may be suitable

for roosting, the presence of the M2 Motorway and walking trails with existing noise and light disturbances is considered likely to dissuade the species from roosting in these areas.

Potential impacts may occur to threatened insectivorous bat species, however species such as the Large-footed Myotis (*Myotis adversus*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) are more likely to be found lower within the moister valleys of the locality rather than the upper slope areas in which the Motorway and compound areas are chiefly located. Therefore, roosting and breeding habit for these species is considered unlikely to be affected by the increase in lighting as a result of the proposed project. The potential impacts to threatened bat species as a result of obtrusive light spill are considered to be less likely during the winter months when foraging activities decline.

The increase in some species of insects attracted to light sources (e.g. moths) may be beneficial to some threatened insectivorous bat species that are high speed aerial foragers such as the Eastern Bentwing-Bat and Yellow-bellied Sheathtail-Bat.

Light mitigation will be addressed during the detail design stage to develop appropriate light spill management strategies, including measures such as correctly positioned and aimed floodlights and screening of compound areas for the control of construction vehicle headlamp impacts. Careful design and selection of luminaries is considered likely to minimise the impacts on fauna.

5.2.3 Habitat Fragmentation

Alteration to fauna movement (wildlife) corridors through the permanent removal of approximately 21 ha of eucalypt forest and woodland may occur as a result of the works, of which 10 ha is considered to be in relatively good condition . Of this 10 ha, 3 ha is required to be removed for access and compound sites. This 3 ha area would be rehabilitated post-construction and mature trees would be avoided where practicable. The vegetation types that occur in the 3 ha area comprise Hinterland Sandstone Gully Forest and Sandstone Riparian Scrub. These communities are not listed as an EEC under the EPBC Act or TSC Act. The main wildlife corridors within the M2 Corridor include the bushland and disturbed vegetation surrounding Blue Gum Creek, Devlins Creek, Darling Mills Creek and Terrys Creek.

Where bridge structures span Darling Mills Creek, Devlins Creek and Terrys Creek, the vegetation underneath forms the only habitat connection between bushland areas on opposite sides of the Motorway. These areas are considered to be of particular importance to fauna movement. The vegetation underneath these structures is somewhat degraded due to previous earthworks and the impacts of shading and interception of rainfall by the roadway overhead.

Closing the existing gap between the two bridge structures across Devlins Creek and widening to the south is the preferred option to minimise the potential impacts on the surrounding environment and avoid the need to construct two new culverts which would impact on the water quality of the Creek during construction.

Bridges and arch structures generally have the least impact on fish passage as they normally involve limited disturbance to the flow or the aquatic habitat of a waterway (Fairfull and Witheridge, 2003).

Possible impacts to fish passage movement include (Fairfull and Witheridge, 2003):

- large scale turbulence resulting from bridge piers
- changes to in-stream and bank vegetation affecting water shading
- habitat values
- water velocities and increased flood flow velocities
- limited light penetration under the bridge deck can create a non-physical barrier for some fish species that may avoid dark areas during daylight hours

The potential impact of the bridge piers may also result in localised changes to flow patterns and localised scour. Due to the sandy nature of soil under bridges, the construction of piers may result in increased erosion and sedimentation during the construction phase however erosion control plans will be implemented and these areas will be remediated (revegetated) or stabilised post-construction.

The proposed widening of the bridge structures over each of these creeks has the potential to result in further degradation of the riparian vegetation of these areas and hence limits their ability to act as movement corridors for terrestrial species due to shading and the reduction in soil moisture.

The extension of culverts may also affect the passage of fish and other aquatic fauna. The most common fish passage problems associated with culverts include: excessive flow velocities within the culvert, inadequate flow depth within the culvert and debris blockage of the culvert (Fairfull and Witheridge, 2003). As these culverts currently present a substantial constraint to fish movement, the extension of these barriers is unlikely to substantially alter the current situation. Design and construction considerations for bridges and arches have been included in the mitigation measures to avoid potential disturbance to fish passage during the construction phase.

With the implementation of the proposed habitat enhancement measures, such as the placement of woody debris, soil coverings and revegetation, the utility of these areas as wildlife corridors for land-based species is likely to be improved or maintained.

Degradation of fauna habitat as a result of weed invasion and proliferation is a potential impact of the works. Weed dominance may result in a reduction in plant species which are important as habitat for native wildlife. Weed thickets may harbour feral animals such as foxes and rabbits. With the implementation of the proposed weed management and vegetation rehabilitation measures the current weed situation is unlikely to be significantly exacerbated.

Impacts on water quality may occur as a result of the exposure of soils to erosion during construction and the flow of turbid water into local creeks.

5.2.4 Other Operational Impacts

Once constructed, there may be additional run-off from the upgraded motorway. As described in the Technical Paper 6, M2 Upgrade Environmental Assessment – Surface Water Assessment (AECOM, 2010), the existing water quality basins would be modified as required to account for any significant changes in contributing catchment area or to meet the target pollutant reduction criteria. Due to the constrained project corridor, and in an effort to minimise further disturbance of the established vegetation, wherever practical it is proposed to modify the inlet/outlet details of the existing basins to better utilise the storage volume already available by increasing the ponded (extended) depth.

There are not expected to be other significant additional impacts above and beyond the current motorway use.

6.0 Environmental Management

An Environmental Management Plan (EMP) will be developed which describes in detail the minimisation, mitigation and management measures which would be conducted during construction (CEMP) and operation (OEMP) of the works. The EMP would be developed in consultation with DECCW, I&INSW and other relevant stakeholders. Options for offsetting residual impacts on flora and fauna habitat are also proposed (Section 6.1).

The CEMP would include measures to **minimise removal of vegetation** in areas of construction throughout the extent and duration of the project, such as:

- Clearly marking and delineating the extents of required vegetation clearance in order to minimise the risk of over-clearing.
- Minimising clearing for construction compounds by retaining mature trees and other vegetation of conservation significance where feasible within compound sites.
- The demarcation of Blue Gum High Forest boundary to avoid potential indirect impacts to this CEEC.
- Prior to the commencement of construction, all specimens of *Epacris purpurascens* var. *purpurascens* within areas identified for temporary clearing would be marked by an ecologist. Wherever feasible, the temporary clearing extents would be slightly modified to avoid the need to remove individuals of this species. Pre-clearance surveys prior to construction will also be conducted by a suitably qualified ecologist to avoid the need to remove threatened flora species potentially occurring within the M2 corridor, as listed in Table 9.
- Potential hollow-bearing trees will be identified and marked, and targeted measures to minimise potential harm to fauna during clearing will be implemented.
- Stabilisation of the riparian zone against flow changes would be implemented as described in the Technical Paper 6, M2 Upgrade Environmental Assessment – Surface Water Assessment (AECOM, 2010). Riparian areas disturbed during the works would be reinstated and replanted as quickly as possible.

The CEMP would include measures to **minimise the indirect impacts on flora and fauna** as a result of vegetation removal in areas of construction throughout the extent and duration of the project, such as:

- All earth-working machinery will be received on-site free from excessive soil and vegetative matter to minimise the likelihood of introducing weed seeds and plant pathogens (e.g. Phytophthora root rot fungus) to project areas.
- Cleaning of equipment used for works within detention basins to minimise the likelihood of the transmission of any frog pathogens (e.g. Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)) will involve the use of a high pressure hose (or a suitable alternative method) to remove mud after use in a water body and allowing equipment to dry fully prior to use in the next water body.

Measures to **minimise the direct impacts on flora and fauna** would include:

- Prior to works which involve the clearing of vegetation and debris within detention basins or drainage lines, a suitable and targeted survey will be undertaken by an ecologist in order to allow for the detection of any Green and Golden Bell Frogs or Red-crowned Toadlets. If Green and Golden Bell Frogs or Red-crowned Toadlets are detected, no clearing works within these areas would commence until the threatened frog species response provisions in the EMP have been implemented.
- Weed control measures in known Red-crowned Toadlet occupation sites (TIDC site) should be avoided.
- Construction compound lighting will be directed towards the ground so that the angle between the beam and the vertical is kept as small as possible. Glare will be kept to a minimum by keeping the main beam angle less than 70^{o} wherever practicable.
- Non-translucent barriers should be positioned to shield sensitive locations located directly opposite access points to minimise disturbances to native fauna from vehicle headlights entering and exiting the site.
- Where feasible, site lighting should be directed away from sensitive locations such as potential foraging areas and movement corridors within the larger more intact areas of bushland such as Bidjigal Reserve, Lane Cove National Park and Pennant Hills Park. Wherever possible, trees will not be directly illuminated.
- Accessories such as light shields mounted at the front or back of the light source should be used to direct light to the intended area only and minimise excessive light spill.
- Where feasible, the mounting height of the lighting column will be lowered to reduce horizontal light spill.

- The use of high power lamps used for security at compound sites should be avoided. Accessories such as glass protectors (glass glazing) are preferred due to their UV filtration characteristics will be considered during the design of light installations.

Measures to **mitigate the loss of vegetation** as a result of the project would include:

- Revegetation of disturbed areas as a result of construction activities, adjacent to the construction areas and bordering natural bushland will be conducted by suitably qualified and experienced persons using local provenance plant species representative of the relevant vegetation communities. This strategy would be documented in a Landscape Plan or bushland rehabilitation section of the CEMP.
- In areas bordering adjacent urban development, revegetation works would be undertaken in accordance with a Landscape Plan.
- Where available, seeds will be collected from local understorey and ground layer vegetation prior to clearing and from felled trees and branches following clearing where feasible for use in revegetation.
- A revegetation strategy would be developed that takes into account the availability of light, moisture and the most suitable plant species.
- Re-use of felled native trees in habitat augmentation within revegetated areas and mulching of other native vegetation cleared for use in soil stabilisation and vegetation rehabilitation.
- Weed management as required in areas affected by construction throughout the extent and duration of the project (in a staged manner and for a minimum period of two years following construction works).
- Re-use of the soil seedbank where practicable during revegetation works either within or outside the M2 corridor.

The CEMP would include measures to **minimise the impacts on aquatic environments** such as:

- All potential chemical pollutants (e.g. fuels, oils, lubricants, paints, etc.) will be stored in appropriate containers within bunded areas within construction compounds to minimise the risk of pollution of aquatic environments.
- Works around waterways will be managed to retain bank stability and prevent erosion.
- Water quality would be protected through the implementation of suitable sediment control measures in relevant work areas.
- Where practicable and feasible, bridge piers or foundations located within the main waterway channel would be avoided.
- Where practical, culverts would be aligned with the downstream channel to minimise bank erosion.
- Works would be sited and carried out to avoid the clearing of riparian vegetation where practicable.
- Riparian areas disturbed during the works would be reinstated and replanted as quickly as possible with the aim of providing a net long term biodiversity benefit.

6.1 Biodiversity Offset Strategy

Although the ecological assessment concludes that the project would not have a significant impact on threatened flora and fauna species or ecological communities, there would be some residual impacts after mitigation measures have been applied. In order to offset the residual impacts to native fauna habitat and the residual impacts to *Epacris purpurascens var. purpurascens,* a biodiversity offset strategy would be developed in consultation with DECCW.

The residual impacts to 7ha of native forest and woodland habitat that is proposed to be cleared permanently would be offset. The area of habitat to be offset includes the following vegetation types:

1) Coastal Sandstone Ridgetop Woodland;
2) Hinterland Sandstone Gully Forest;
3) Sydney Hinterland Transition Woodland; and
4) Sandstone Riparian Scrub.

The management measures that will be compiled for offsetting impacts to these communities will focus on conservation and enhancement of habitat in the M2 Motorway corridor that will not be impacted by the project.

The biodiversity offset strategy would outline the process for identifying priority areas for habitat enhancement within the M2 Motorway corridor and management measures that would be undertaken to enhance the value of

habitat. The areas to be included in the biodiversity offset strategy and the management measures would be determined in consultation with DECCW.

In terms of identifying priority areas for habitat enhancement, it is anticipated that priority would be given to habitat within the M2 Motorway corridor that adjoins major waterway crossings, is along the edges of high quality native vegetation in which weed invasion is apparent and the edges of waterways. In addition, factors such as the condition of habitat, its connectivity and proximity to remnant native vegetation would also be considered when identifying areas for enhancement.

Management measures to enhance native fauna habitat within the M2 Motorway corridor would include bush regeneration throughout the M2 Motorway corridor, installation of nest boxes for birds and bats, and the use of boulders and felled timber to enhance the structural complexity of fauna habitat. The following management actions could also be considered:

- Control of weeds
- Management of fire for conservation
- Management of human disturbance
- Retention of regrowth and remnant native vegetation
- Replanting or supplementary planting where natural regeneration will not be sufficient
- Retention of dead timber
- Control of erosion
- Retention of rocks

The following measures warrant further consideration for enhancement of habitat areas and rehabilitation of the degraded nature of existing vegetation communities:

- A system of gravity fed perforated stormwater pipes to be installed underneath bridges that will result in rainfall being distributed across all areas underneath bridges structures, thereby providing adequate moisture for plant growth; and
- The underside and inner surface of bridge structures over Terrys Creek and Darling Mills Creek will be constructed with a rough finish that would enable the bird species, Fairy Martins (*Hirundo ariel*), to create their bottle-shaped mud nests. A wide variety of native fauna species (including the threatened Large-eared Pied Bat (*Chalinolobus picatus*) have been recorded using the abandoned nests of Fairy Martins attached to artificial structures such as bridges and culverts.
- There is an opportunity to improve habitat connectivity between neighbouring areas through intensive treatment of environmental weeds within and immediately adjacent to the Blue Gum High Forest adjacent to Pennant Hills Golf Course.
- The Landscape Plan should seek opportunities to implement additional habitat creation (such as breeding areas) for threatened species within open space areas adjacent to the M2 Motorway.

7.0 References

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