



Australian Government

**BUILDING OUR FUTURE**



# M4 Smart Motorway Submissions Report

October 2015



(blank page)

# Roads and Maritime Services

---

## M4 Smart Motorway

Submissions report  
October 2015

Prepared by

Jacobs Group (Australia) Pty Limited  
ABN 37 001 024 095

100 Christie Street  
St Leonards NSW 2065 Australia

PO Box 164 St Leonards NSW 2065 Australia

T +61 2 9928 2100  
F +61 2 9928 2500  
[www.jacobs.com](http://www.jacobs.com)

# Executive summary

---

Roads and Maritime Services (Roads and Maritime) proposes to introduce intelligent technology, known as a Smart (or managed) Motorway system, to the existing M4 Motorway between the Pitt Street overpass at Parramatta (just west of the Church Street interchange) and the Great Western Highway at Lapstone. The proposal is referred to as the M4 Smart Motorway project

The assessment of the proposal is documented in the review of environmental factors (REF) prepared for the M4 Smart Motorway (Roads and Maritime, 2015). The REF was placed on public display between 12 March and 10 April 2015 so that the community and stakeholders could understand the proposal, and provide their feedback. The REF was displayed at nine locations and was also placed on the Roads and Maritime website and made available for download.

Roads and Maritime accepted submissions until 18 May 2015. Thirty-six submissions were received, including 27 submissions from the community, seven submissions from government agencies, one submission from the operator of Westlink M7, and one submission from the NRMA.

## Issues raised by the community and stakeholders

Submissions received raised the following issues:

- Suggestions for alternative designs or additional works for the proposal
- Operation of the proposal
- Traffic performance of the proposal
- Operational noise impacts of the proposal
- Operational air quality impacts of the proposal
- Impacts of the proposal on biodiversity
- Clarifications regarding the Biodiversity Assessment
- Impacts of the proposal on flooding and groundwater
- Visual impacts of the proposal
- Impacts of the proposal on heritage items, including St Bartholomew's Church and Cemetery
- Roads and Maritime's community consultation process
- Locations and impacts of construction compounds
- Traffic management during construction
- Construction noise impacts of the proposal
- Construction impacts of the proposal on waterways.

## Refinements to the proposal

Since the display of the REF, Roads and Maritime have made further refinements to the proposal. These refinements include adjustments to the number and location of noise walls, modifications to ITS infrastructure locations and other minor design changes.

## Additional assessment

The impacts of the proposal on biodiversity were assessed in the Biodiversity Assessment. Since the display of the REF, the Biodiversity Assessment has been revised to consider the submission received from OEHL and to consider also minor design changes such as the ITS locations and additional noise walls. The revised

assessment also includes an updated study area boundary which encompasses design refinements and the location of potential ancillary facilities. The impacts of the proposal on Aboriginal heritage are assessed in the Cultural Heritage Assessment Report (CHAR). Since the display of the REF, the CHAR has been revised to include the assessment of a larger study area, which encompasses design refinements and the location of potential ancillary facilities.

### **Conclusion of this report**

The impacts of the proposal are not considered to be significant and the identified impacts will be appropriately managed and mitigated with implementation of the identified management measures.

The proposal meets the project objectives, while effectively minimising environmental impacts and considering community comments.

# Contents

---

Executive summary .....	i
1 Introduction and background .....	1
1.1 Purpose .....	1
1.2 The proposal.....	1
1.3 REF display .....	3
2 Response to issues .....	6
2.1 Overview of issues raised .....	7
2.2 Support for the proposal .....	8
2.3 Design of proposal.....	8
2.4 Operation of proposal .....	15
2.5 Traffic .....	16
2.6 Operational noise.....	22
2.7 Operational air quality .....	29
2.8 Biodiversity .....	30
2.9 Flooding.....	38
2.10 Groundwater.....	39
2.11 Visual impacts.....	39
2.12 Heritage .....	40
2.13 Consultation.....	44
2.14 Construction impacts .....	45
3 Changes to the proposal.....	52
3.1 Modifications to noise walls.....	52
3.2 Minor changes to the location of ITS infrastructure .....	52
3.3 Other design refinements.....	52
4 Additional assessment.....	83
4.1 Biodiversity .....	83
4.2 Aboriginal heritage .....	90
4.3 Visual impacts of additional noise walls .....	92
5 Environmental management.....	94
5.1 Environmental management plans (or system) .....	94
5.2 Summary of safeguards and management measures .....	94
5.3 Licensing and approvals .....	115
6 References.....	116

## Appendices

Appendix A	Community updates
Appendix B	Revised Biodiversity Assessment
Appendix C	Revised Cultural Heritage Assessment Report

# 1 Introduction and background

---

## 1.1 Purpose

This submissions report relates to the Review of Environmental Factors (REF) prepared for the M4 Smart Motorway proposal, and should be read in conjunction with that document.

The REF was placed on public display and submissions relating to the proposal and the REF were received by Roads and Maritime Services (Roads and Maritime). This submissions report summarises the issues raised and provides responses to each issue (Chapter 2), details investigations carried out since finalisation of the REF (Chapter 3), describes and assesses the environmental impact of changes to the proposal (Chapter 4), and identifies new or revised environmental management measures (Chapter 5).

## 1.2 The proposal

Roads and Maritime proposes to introduce intelligent technology, known as a Smart (or managed) Motorway system, to the existing M4 Motorway between the Pitt Street overpass at Parramatta (just west of the Church Street interchange) and the Great Western Highway at Lapstone. The proposal is referred to as the M4 Smart Motorway. The main features of the M4 Smart Motorway include:

### **Intelligent Traffic System (ITS) motorway works**

- Vehicle Detection Systems – Generally in-pavement vehicle detectors would be located at 500 metre intervals along the mainline motorway. At known incident and bottleneck locations such as downstream of a merge location (at an entry ramp or lane drop) the distance between in-pavement vehicle detectors would be less than 500 metres. The proposal currently includes 703 additional in-pavement vehicle detectors along the motorway, on the ramps and on the major/arterial roads
- Lane Use Management System (LUMS) – A typical LUMS would consist of multiple overhead gantries holding lane use signs (LUS) above each lane. Associated with each gantry would be a combined maintenance bay/breakdown bay with emergency telephone to allow for safe access and parking for maintenance or breakdowns/emergencies. These gantries would be located at frequent intervals along both the eastbound and westbound carriageways of the M4 Motorway. The proposal currently includes 88 gantries along the motorway. Just over 300 LUS/Variable Speed Limit Signs would be located on the gantries. The proposal also includes an additional 95 emergency telephones at the new maintenance/emergency bays for the gantries
- Variable Speed Limit Signs (VSLS) – On the mainline M4 Motorway, the VSLS would be installed on the LUMS gantries
- Closed Circuit Television (CCTV) – The existing CCTV system would be augmented to provide enhanced coverage of the M4 Motorway. The objective would be to provide vision from at least two CCTV cameras for all locations along the M4 Motorway including the interchanges and ramps. The proposal currently includes 111 CCTV cameras along the motorway and at the interchanges
- Variable Message Signage (VMS) – Additional VMS would be installed to complement the existing VMS system. A number of different sizes of VMS would be installed ranging from the large six metre wide, which is relatively

common in NSW, to smaller VMS. The proposal currently includes 11 additional large VMS along the motorway

- Communications and power – All of the ITS infrastructure would require cabling to provide power and communications. A “backbone” ITS cable network would be required along the whole length of the M4 Motorway and the new and existing ITS infrastructure would all be connected to the “backbone”. Connections along arterial or approach roads would also be required for power and communications.

### **Interchange works**

- Widening, lengthening and re-alignment of the entry ramps from the arterial and major road interchanges to the M4 Motorway through construction of additional pavement. This would allow for ramp signals to be installed to control the entry of vehicles onto the motorway. Entry ramps would be widened to a minimum of two lanes at the ramp signal stop line, however in most cases would be widened to accommodate three or more lanes. Past the stop line, the ramps would generally also require widening and lengthening to allow the safe merge of vehicles. The entry ramps to the M4 Motorway from the following interchanges would require modification: Burnett Street, Coleman Street, Cumberland Highway, Prospect Highway, Reservoir Road, Westlink M7, Wallgrove Road, Roper Road, Mamre Road, The Northern Road, Mulgoa Road and Russell Street
- Widening, lengthening and re-alignment of seven exit ramps through construction of additional pavement. Exit ramps that would be modified include: Cumberland Highway eastbound and westbound, Mamre Road eastbound, The Northern Road eastbound and westbound, and Mulgoa Road eastbound and westbound. Three intersections<sup>1</sup> would also be signalised, these include Coleman Street westbound and Reservoir Road eastbound and westbound
- Installing Intelligent Traffic System (ITS) infrastructure on the ramps including coordinated ramp signals, vehicle detection devices, electronic signage, variable speed limit signs, cabling and fixed signage. The proposal currently includes 39 new sets of ramp and traffic signals and 59 post-mounted VSLs on the entry ramps
- Installing ITS infrastructure in the road reserve of arterial and major roads including traffic signals, vehicle detection devices, electronic signage, cabling and fixed signage. The proposal currently includes 95 new electronic signs on arterial and major roads
- Minor modifications to the arterial and major road intersections with exit and entry ramps. This may include realigning kerbs, modifying or providing slip lanes to ramps and changing the traffic control at an intersection (eg removing a roundabout and replacing it with traffic signals)
- At the Reservoir Road interchange, the westbound M4 Motorway bridge which extends over Reservoir Road would need to be widened to provide additional road pavement.

### **Motorway widening**

- Between the Roper Road and the Westlink M7 interchanges an additional lane would be provided for both eastbound and westbound traffic by constructing the additional lanes in the median. The distance between the two interchanges is about 4.3 kilometres.

---

<sup>1</sup> The roundabout on the northern side of the Prospect Highway interchange will be upgraded to traffic signals as part of the Prospect Highway upgrade.

## Auxiliary infrastructure and works

- Temporary construction compounds would be required at each interchange and other locations to support the construction activities
- Public utilities such as power, wastewater, water, street lighting, and communications would require relocation or protection
- Motorway utilities such as communications, stormwater, water management basins and noise walls would require relocation and/or modification.

### 1.3 REF display

Roads and Maritime prepared a REF to assess the environmental impacts of the proposed works. The REF was publically displayed between 12 March and 10 April 2015 at nine locations, as detailed in Table 1-1. The REF was also published on the Roads and Maritime website and made available for download. The display locations and website link were advertised in the following newspapers:

- Daily Telegraph, 13 March 2015
- Penrith Press, 13 March 2015
- Blacktown Advocate, 18 March 2015
- Mt Druitt-St Marys Standard, 18 March 2015
- Mt Druitt-St Marys Standard, 25 March 2015
- Parramatta Advertiser, 25 March 2015.

While the REF was advertised as being on display for community and stakeholder comment until 10 April 2015, all submissions received up to 18 May 2015 have been considered in this report. No submissions were received after 18 May 2015.

**Table 1-1 Display locations**

Location	Address
Roads and Maritime Services	Level 9, 101 Miller Street, North Sydney
Holroyd City Council	16 Memorial Avenue, Merrylands
Parramatta City Council	30 Darcy Street, Parramatta
Wentworthville Branch Library	2 Lane Street, Wentworthville
Blacktown City Council	62 Flushcombe Road, Blacktown
Service NSW – Mount Druitt Registry	23-27 Luxford Road, Mount Druitt
Service NSW – St Marys Registry	33-43 Phillip Street, Shop M04, Station Plaza, St Marys
Penrith City Council	601 High Street, Penrith
Blue Mountains City Council (Springwood)	104 Macquarie Road, Springwood

The community was also informed of the REF display and invitation to comment through distribution of a community update (refer to Appendix A) to around 52,500 properties along the proposal corridor between 13 and 20 March 2015. The community update provided information on the proposal, the REF public display, details of community drop-in sessions and public display locations and invited written submissions. The community update was also published on the project website with email notifications sent to more than 100 registered stakeholders.

An email advising of the start of the REF display period was sent to each of the State and Federal members of parliament along the corridor. The email included a copy of the community update and provided contact details for the project team.

Additional tools and materials used to inform and engage the community and stakeholders during the REF display are detailed in Table 1-2.

**Table 1-2 Engagement tools and activities**

Engagement tool	Purpose and activity to date
Community drop-in sessions	<p>Five community drop-in sessions were held during the display period to allow the public to view project information and speak with the project team. Community drop-in sessions were held at the following locations:</p> <ul style="list-style-type: none"> <li>• Wednesday 18 March 2015 6pm to 9pm St Marys Memorial Hall – meeting room 29 Swanston Street (Corner Great Western Highway and Mamre Road), St Marys</li> <li>• Saturday 21 March 2015 1pm to 4pm Penrith Library Theatre 601 High Street, Penrith</li> <li>• Tuesday 24 March 2015 6pm to 9pm Max Webber Library Function Centre Level 1, Corner Flushcombe Road and Alpha Street, Blacktown</li> <li>• Wednesday 25 March 2015 6pm to 9pm Minchinbury Neighbourhood Centre 46 Minchin Drive, Minchinbury</li> <li>• Tuesday 31 March 2015 6pm to 9pm Merrylands Community Centre – Prospect Room 17 Miller Street, Merrylands</li> </ul>
Doorknocking	<p>Project team members doorknocked around 215 properties located next to areas of proposed construction activity to discuss the proposal, outline proposed changes to interchanges and potential future construction activity near their property and answer any other questions.</p>
Fact sheets	<p>Fact sheets on how to make a submission, construction impacts, visual amenity, noise and entry ramp signalling were prepared to provide project-specific information to the community. The fact sheets were published on the project website and made available for download. Copies were also made available at the community drop-in sessions.</p>
Interchange maps	<p>Maps of the 12 interchanges along the proposal area were prepared to inform the community and stakeholders of the proposed concept design at each interchange. These maps were available for download from the project website and for viewing at community drop-in sessions.</p>
Display posters	<p>Posters showing the key features of the concept design at each interchange and describing impacts and mitigation measures of the proposal were displayed at community drop-in sessions.</p>
Animation video	<p>An updated animation video was made available on the project website and at community drop-in sessions to highlight the benefits of a Smart Motorway for customers, describe key features and provide a driver's view of what the proposed M4 Smart Motorway would look like.</p>
Facebook	<p>An M4 Smart Motorway Facebook page (<a href="https://facebook.com/m4smartmotorway">facebook.com/m4smartmotorway</a>) was established to engage the community online, raise awareness of the proposal and Smart Motorway technology and seek community views. The REF public display was promoted on Facebook and the community invited to make a submission. Details of community drop-in sessions and public display locations were provided.</p>

Engagement tool	Purpose and activity to date
Letters	Letters were sent to around 300 properties that were identified as experiencing potential noise impact in excess of the relevant guidelines for the operation of the M4 Smart Motorway. Property owners and residents were invited to meet with Roads and Maritime staff and noise specialists at the community drop-in sessions to discuss the proposal and potential impacts.
Meetings	Meetings were held with 11 key stakeholders including local councils, motorway operators, emergency services, schools, child care centres and churches to discuss the proposal, potential impacts and mitigation measures.
Contact mechanisms	All communication material encouraged stakeholders to seek information about the proposal via the project website, information line (1800 989 929), email address (m4smartmotorway@rms.nsw.gov.au) and Facebook page (facebook.com/m4smartmotorway).
Project website	Updated information about the proposal was made available on the Roads and Maritime website (rms.nsw.gov.au/m4sm), including the REF, community update, fact sheets, interchange maps, animation video, times and locations for community drop-in sessions, public display locations and how to make a submission on the REF.

## 2 Response to issues

Roads and Maritime received 36 submissions, accepted up until the 18 May 2015. Table 2-1 lists the respondents and each respondent's allocated submission number. The table also indicates where the issues from each submission have been addressed in Chapter 3 of this report.

**Table 2-1 Respondents**

Respondent	Submission No.	Section number where issues are addressed
Individual	1	Section 2.2, Section 2.3.5, Section 2.4.1, Section 2.6.5
Individual	2	Section 2.2, Section 2.13.1, Section 2.14.6
Individual	3	Section 2.2, Section 2.3.1, Section 2.3.4
Individual	4	Section 2.2, Section 2.6.5
Individual	5	Section 2.2, Section 2.3.1, Section 2.3.2, Section 2.3.4
Individual	6	Section 2.2, Section 2.6.5
Individual	7	Section 2.2, Section 2.3.3, Section 2.5.4, Section 2.6.4
Individual	8	Section 2.3.1, Section 2.3.2, Section 2.5.1, Section 2.5.2, Section 2.5.6
Individual	9	Section 2.2, Section 2.6.5, Section 2.6.6, Section 2.6.9, Section 2.8.1
Individual	10	Section 2.5.3
Individual	11	Section 2.6.5, Section 2.11.1
Business	12	Section 2.2, Section 2.14.1
Department of Primary Industries (Fisheries)	13	Section 2.8.2
Individual	14	Section 2.3.7
Sydney Water	15	Section 2.3.8
Individual	16	Section 2.6.5
Individual	17	Section 2.6.5
Individual	18	Section 2.2
Individual	19	Section 2.6.6, Section 2.14.1
Individual	20	Section 2.3.1, Section 2.3.9, Section 2.5.1
Individual	21	Section 2.6.1, Section 2.6.7, Section 2.14.1, Section 2.14.3
Individual	22	Section 2.13.4, Section 2.14.1
Individual	23	Section 2.6.2, Section 2.6.3
Individual	24	Section 2.6.5, Section 2.13.4, Section 2.14.1
Individual	25	Section 2.14.1
Westlink M7 Operator	26	Section 2.2, Section 2.13.2
OEH	27	Section 2.8.4, Section 2.8.5, Section 2.8.6, Section 2.8.7, Section 2.8.8, Section 2.8.9, Section 2.8.10, Section 2.8.11, Section 2.8.12, Section 2.8.13, Section 2.8.14, Section 2.8.15, Section 2.8.16, Section 2.8.17
Individual	28	Section 2.3.11, Section 2.6.5, Section 2.7.1
Holroyd Council	29	Section 2.2, Section 2.3.4, Section 2.3.6, Section 2.3.11, Section 2.3.12, Section 2.5.5, Section 2.5.6, Section 2.13.3, Section 2.14.2, Section 2.14.5
Individual	30	Section 2.6.8, Section 2.8.1, Section 2.13.4
School	31	Section 2.3.4, Section 2.3.10, Section 2.6.5, Section 2.14.1, Section 2.14.2, Section 2.14.3
NSW Office of Water	32	Section 2.8.3, Section 2.10, Section 2.14.4
NRMA	33	Section 2.2, Section 2.4.2, Section 2.5.7, Section 2.5.8, Section 2.9
Religious organisation	34	Section 2.6.5
Blacktown City Council	35	Section 2.12.1, Section 2.12.2, Section 2.12.3
OEH – Heritage Division	36	Section 2.12.4

## 2.1 Overview of issues raised

A total of 36 submissions were received in response to the display of the environmental assessment, comprising seven from government agencies, one from the operator of Westlink M7, one from the NRMA and 27 from the community.

Each submission has been examined individually to understand the issues being raised. The issues raised have been extracted and collated, and corresponding responses to the issues have been provided. Where similar issues have been raised in different submissions, only one response has been provided. The issues raised and Roads and Maritimes' response to these issues form the basis of this chapter.

Thirteen of the submissions explicitly supported the proposal. Three submissions objected to the proposal as they did not believe that the proposal was the best solution for solving congestion on the M4 Motorway. Other submissions objected to certain aspects of the proposal (eg the location of construction compounds) however did not explicitly object to or support the concept of a Smart Motorway system for the M4 Motorway.

Sydney Water identified that some of their wastewater and water pipelines would be impacted by the proposal and detailed the consultation, design and approval processes for any works that impact their assets.

The Office of Environment and Heritage (OEH) requested additional information on the potential biodiversity impacts of the proposal and suggested that the impacts presented in the biodiversity report may have underestimated the impacts of the proposal on threatened species and communities. They also suggested that the proposal may trigger the requirement for biodiversity offsets.

Holroyd Council was concerned about traffic impacts on local and arterial roads from the proposal and requested further information on the design of specific elements of the proposal.

The NSW Office of Water recognised that the proposal was unlikely to have significant impacts on waterways. However, they identified that further assessment and mitigation of impacts from sedimentation and erosion during construction and stormwater detention during operation was required.

OEH-Heritage Division and Blacktown City Council were concerned about potential impacts to heritage listed items.

The NRMA supported the proposal, however requested further information on the motorway management system to be used, the use of freight bypass lanes by emergency service vehicles and the management of cyclists.

The key issues raised by members of the public were:

- Operational noise impacts and noise mitigation – Sixteen submissions were concerned about current and future operational noise impacts – and requested noise barriers to mitigate impacts
- Construction compound locations and impacts – Eight submissions raised concern about the location of a potential construction compound in Hollier Reserve. Concerns about potential construction compounds in other locations were also raised

- Alternatives or additional works – Seven submissions suggested alternatives to the proposal such as additional widening of the M4 Motorway – while others suggested complementary upgrades of the connecting arterial roads.

## 2.2 Support for the proposal

As noted in the previous section there was support for the proposal, with thirteen submissions stating that the proposal was a good approach to reducing congestion on the M4 Motorway.

### *Submission number(s)*

1, 2, 3, 4, 5, 6, 7, 9, 12, 18, 26, 29, 33

### *Issue description*

The respondents generally supported the proposal and its objectives.

### *Response*

Roads and Maritime is appreciative of the support shown for the proposal and looks forward to delivering the benefits that the proposal would provide.

## 2.3 Design of proposal

Many submissions suggested alternative designs for the proposal or proposed additional works especially on the intersecting arterial roads. While some of these may have some merit, the scope of the proposal is confined to works to enable the operation of a Smart Motorway system.

### 2.3.1 Widening of the M4 Motorway

#### *Submission number(s)*

3, 5, 8, 20

#### *Issue description*

The respondents suggested that the M4 Motorway be widened to four lanes in each direction or that full length dedicated merge lanes be provided between adjacent interchanges.

#### *Response*

The proposal involves widening the M4 Motorway to four lanes in each direction between the Roper Road and Westlink M7 interchanges. Widening of the M4 Motorway is not proposed in any other location as part of the M4 Smart Motorway proposal. However as part of the separate WestConnex project, the M4 Motorway would be widened to four lanes in each direction between Church Street and Homebush Bay Drive.

Widening of the M4 Motorway between the Roper Road and Westlink M7 interchanges is required as traffic monitoring and modelling undertaken for the proposal indicated that Smart Motorway technology alone would not result in the desired reduction in congestion on this section of the motorway. This is because the section of the M4 Motorway between these two interchanges is one of the busiest

and heavy vehicle numbers are particularly high. While widening of the other sections of the M4 Motorway or providing full length dedicated merge lanes between adjacent interchanges may improve capacity and safety and decrease congestion, the implementation of Smart Motorway technology and WestConnex would result in similar decreases in congestion. The costs of widening the M4 Motorway would be substantial and the widening of the motorway is not currently part of any of the NSW Government's transport or roads strategies.

While the dedicated merge lanes between interchanges would avoid high cost modifications to interchange bridges to provide an additional lane, there are a number of other bridges, including local road bridges, across the M4 Motorway between the interchanges which would require modification to provide the additional lane. The modification to these bridges would also increase the cost of providing additional merging lanes.

### 2.3.2 Upgraded ramps to improve merging and reduce queuing

#### *Submission number(s)*

5, 8

#### *Issue description*

The respondents suggested that the entry ramps need to be longer to improve merging of vehicles entering the motorway – and some exit ramps needed to be widened reduce queuing on the mainline M4 Motorway.

#### *Response*

As part of the Smart Motorway proposal, all entry ramps would be modified to improve the safety of traffic merging on to the mainline motorway. Most entry ramps would be lengthened to allow vehicles stopped at the ramp signals to accelerate to a safe merging speed before merging with the mainline motorway. Other minor historical design issues which affect safe merging would also be addressed.

To reduce the risk of exiting vehicles queuing on the mainline M4 Motorway, seven exit ramps would be widened, lengthened and/or re-aligned through construction of additional pavement. Exit ramps that would be modified include: Cumberland Highway eastbound and westbound; Mamre Road eastbound, The Northern Road eastbound and westbound and; Mulgoa Road eastbound and westbound. Three intersections<sup>2</sup> would also be signalised, these include Coleman Street westbound and Reservoir Road eastbound and westbound.

### 2.3.3 Roper Road interchange

#### *Submission number(s)*

7

#### *Issue description*

The respondent suggested a new eastbound entry ramp be constructed from Roper Road to avoid traffic from the north having to cross Roper Road to access the entry ramp.

---

<sup>2</sup> The roundabout on the northern side of the Prospect Highway interchange will be upgraded to traffic signals as part of the Prospect Highway upgrade.

## *Response*

While it is recognised that there are existing congestion issues with some of the connecting interchanges, the scope of the proposal is confined to ensuring the M4 Smart Motorway proposal is successfully implemented and that there is no deterioration in interchange performance due to the proposal. Any other works on the interchanges, such as the proposal for a new east facing Roper Road on ramp, are outside the scope of the proposal. There is currently no proposal for an additional ramp connection between Roper Road and the M4 Motorway. However, should a proposal be developed, this would be a separate project. Roads and Maritime would integrate its requirements for Smart Motorways into any such adjoining projects. The Werrington Arterial project is an example of this integration, whereby following completion of the new ramp connections to the motorway, Roads and Maritime will be able to easily install the additional ITS equipment to the site to enable Smart Motorway operations.

### 2.3.4 Arterial road and interchange works

#### *Submission number(s)*

3, 5, 29, 31

#### *Issue description*

The respondents suggested that additional works be undertaken on the interchanges and arterial roads to improve the operation of the M4 Motorway and surrounding arterial road network. The Cumberland Highway, Prospect Highway, Reservoir Road and Frogmore Road/The Northern Road intersection were locations where additional works were suggested.

#### *Response*

While it is recognised that there are existing congestion and safety issues with some of the connecting arterial roads and interchanges (including between the Great Western Highway and Cumberland Highway/M4 Motorway interchange – and at the Frogmore Road/The Northern Road intersection), the scope of the proposal is confined to ensuring the M4 Smart Motorway proposal is successfully implemented and that there is no deterioration in interchange and arterial road performance due to the proposal. Any other works on the arterial roads and interchanges are outside the scope of the proposal – and would be considered as separate projects to the proposal.

The Australian Government is funding a \$200 million Local Roads Package as part of the Western Sydney Infrastructure Plan linked to the development of the western Sydney airport, at Badgerys Creek. As part of this funding package, Penrith City Council was granted \$1.1 million to carry out a traffic, safety and scoping study for the section of The Northern Road between the M4 Motorway and the Great Western Highway. This section includes the intersection of The Northern Road and Frogmore Road.

Further, Roads and Maritime is separately planning for the upgrade of Prospect Highway between Reservoir Road at Prospect and St Martins Crescent at Blacktown. The planning for this section of Prospect Highway is being undertaken in close consultation with the project team for the M4 Smart Motorway to ensure compatibility between the projects. The section of Reconciliation Road south of Reservoir Road is

a local road under the care and control of Holroyd Council. No works are proposed on this section of the network.

### 2.3.5 Arterial road tunnels

#### *Submission number(s)*

1

#### *Issue description*

The respondent suggested that there should be a greater use of tunnels on arterial roads.

#### *Response*

The suggestion of more use of tunnels for arterial roads is beyond the scope of the current project. A Smart Motorway attempts to utilise the existing asset more efficiently through the application of active management to the motorway. Where appropriate, the NSW Government has adopted road tunnels as the appropriate solution, such as large sections of the WestConnex project.

### 2.3.6 Cumberland Highway works

#### *Submission number(s)*

29

#### *Issue description*

The respondent (Holroyd Council) requested further information on the Cumberland Highway westbound entry ramp works.

#### *Response*

During detailed design, all local councils potentially impacted by the proposed works would be further consulted and details of the proposed works would be provided for their comment.

### 2.3.7 Immediate work

#### *Submission number(s)*

14

#### *Issue description*

The respondent suggested that a suite of works be undertaken immediately to improve the safety and performance of the M4 Motorway.

#### *Response*

Subject to planning and funding approval, construction of the proposal is expected to occur between 2017 and 2020 based upon current programming. Construction of the proposal is unlikely to start before 2017 because of the need to complete detailed design of works and time required to tender and procure a construction contractor(s) to deliver the works.

A suite of immediate works has been identified by a respondent and these are discussed in greater detail in Table 2-2.

**Table 2-2 Immediate works identified by respondent and Roads and Maritime response**

<b>Works</b>	<b>Response</b>
Resurfacing Lapstone Hill in both directions	This section of the highway is outside the proposal area and the proposed works are not relevant to the Smart Motorway proposal. Roads and Maritimes' maintenance partners regularly reviews the condition of pavement on roads they are responsible for managing and initiate maintenance activities such as resurfacing where warranted. The resurfacing of this section of the Great Western is in the Forwards Works program. This area has been programmed for resurfacing in the Forward Works Program.
Remove vegetation on Russell Street exit ramps to improve sight lines	This issue has been noted and has been scheduled for action subject to funding.
Resurfacing Nepean River bridge and Mulgoa Road bridge	Roads and Maritimes' maintenance partners regularly reviews the condition of pavement on roads they are responsible for managing and initiate maintenance activities such as resurfacing where warranted. The westbound section at Mulgoa Road bridge has been resurfaced recently. Other areas identified for resurfacing have been noted and have been scheduled for action subject to funding.
Widen eastbound Mulgoa Road exit ramp	While the Smart Motorway proposal was primarily focussed on entry control to support the efficient operation of the motorway, a number of existing exit ramps experience queuing which at times can extend back onto the motorway. The exit ramps proposed for upgrade include the eastbound and westbound ramps at The Northern Road as well as the eastbound exit ramp to Mulgoa Road. These changes would minimise queuing of exiting vehicles on the mainline motorway.
Widen westbound The Northern Road exit ramp	While the Smart Motorway proposal was primarily focussed on entry control to support the efficient operation of the motorway, a number of existing exit ramps experience queuing which at times can extend back onto the motorway. The exit ramps proposed for upgrade include the eastbound and westbound ramps at The Northern Road as well as the eastbound exit ramp to Mulgoa Road. These changes would minimise queuing of exiting vehicles on the mainline motorway.
Repair eastbound and westbound approaches to Byrnes Creek, South Creek, Ropes Creek and Eastern Creek bridges	Roads and Maritimes' maintenance partners regularly reviews the condition of pavement on roads they are responsible for managing and initiate maintenance activities such as resurfacing where warranted. The eastbound and westbound departures at the Ropes Creek Bridge have been repaired. The eastbound and westbound approaches to the Byrnes Creek, South Creek and Ropes Creek bridges are monitored twice weekly and will be resurfaced when required.
Additional signage for The Northern Road exits	Road and Maritime would ensure the signage provided along the motorway complies with the required standards.
Barriers between the entry ramp and motorway to stop illegal merging	As part of the ramp upgrades for the proposal, concrete safety barriers would be installed or extended on most ramps to prevent illegal merging.
Resurface areas of the motorway that have been damaged by heavy vehicles and are a risk to motorcyclists	Roads and Maritimes' maintenance partner regularly reviews the condition of pavement on roads they are responsible for managing and initiate maintenance activities such as resurfacing where warranted. Details of proposed resurfacing activities have been provided in this table.
Resurface during daylight hours to ensure high quality of works	Roads and Maritime has quality and testing procedures that ensure that any maintenance activities are performed to the required standard – whether it be in day light hours or night. Decisions around

Works	Response
	maintenance activities and their timing are made in consideration of the type of activity, the location of the activity, prevailing speed limits and traffic volumes and the consideration of worker and motorist safety. Given the prevailing traffic volumes and travel speeds on Sydney motorways, many of the maintenance activities are scheduled outside of peak hours, with activities such as paving often scheduled at night due to the time involved in completing these activities and lower prevailing traffic volumes.

### 2.3.8 Impacts on Sydney Water assets

*Submission number(s)*

15

*Issue description*

Sydney Water noted that the proposal would impact on a number of its water and wastewater assets (ie pipelines) and requested further consultation and design approval of any proposed modifications to its assets.

*Response*

Based upon the concept design supporting the REF, a number of Sydney Water assets would be impacted by the proposal. Table 3-8 in the REF provide a preliminary list of Sydney Water and other utility assets that would be impacted by the proposal. These assets are predominately water and wastewater pipelines either within the motorway corridor or at the interchanges.

During detailed design, further consultation would be undertaken with Sydney Water (and other service providers) to identify the assets that would be impacted; design solutions for their modification or protection; access requirements during construction and operations; approval processes for final designs; and additional environmental impact assessments if required.

### 2.3.9 Design and implementation of Smart Motorways

*Submission number(s)*

20

*Issue description*

The respondent suggested that USA guidelines and designers should be used to plan and design motorways in NSW. They also suggested that a Smart Motorway system would not be implemented in the USA.

*Response*

As noted in Section 1 of the REF, Smart Motorway systems have been installed and operated successfully in many countries and cities in the United States including Minneapolis, Seattle and Los Angeles.

The California Transport Agency (CALTRANS) have a program which installs entry ramp signals ([http://www.dot.ca.gov/hq/traffops/systemops/ramp\\_meter/](http://www.dot.ca.gov/hq/traffops/systemops/ramp_meter/)) with the Ramp Metering Development Program (2013) noting that "Caltrans has found that

the traffic management strategy of metering freeway entrance ramps (ramp metering) has been effective at reducing congestion and travel time in locations where deployed".

The design of motorways and other roads in NSW (including the Smart Motorway) would be undertaken in compliance with relevant NSW, Australian and international guidelines. The use of designers and guidelines from the USA is not justified.

### 2.3.10 Unsafe access to M4 Motorway

*Submission number(s)*

31

*Issue description*

The respondent identified that people are accessing the M4 Motorway through the existing motorway fence to obtain pre-arranged lifts with vehicles stopped in the breakdown lane. They suggested that fencing in this area needs to be upgraded.

*Response*

This activity is a safety risk to M4 Motorway users and is not permitted. This matter has been referred to Roads and Maritimes' maintenance provider for consideration and response.

### 2.3.11 Storage and queuing on ramps

*Submission number(s)*

28, 29

*Issue description*

The respondents requested clarification on how the vehicle queue and storage requirements behind the ramps signal stop lines have been determined. They also suggested that the ramp signalling would result in queuing back on to arterial/major roads and that intersection modelling should be included in the REF.

*Response*

Page 22 of the REF details the design criteria used to determine the amount of vehicle storage required behind the ramp signal stop lines. For the M4 Smart Motorway, a storage capacity of four minutes of the peak hour ramp traffic volume (including consideration of the proportion of longer heavy vehicles) was adopted as the design criteria. This is the design criteria recommended by the Austroads guidelines for Smart Motorways. The queue length is determined by the length and number of lanes that can be constructed behind the ramp signals stop lane.

For most entry ramps the maximum queue of vehicles at the ramp signals would be able to be contained on the upgraded ramp. However there are three ramps where there is insufficient land available within the motorway corridor to provide an upgraded ramp capable of storing all vehicles. At these entry ramps, there may be some minor queuing in peak periods on to the arterial/ major roads. Modifications to these arterial/major roads have been included to provide dedicated lanes for vehicles wanting to access the entry ramps.

SIDRA (intersection modelling) results for each of the interchanges were included in Volume 2 of the REF. Roads and Maritime will continue to liaise with councils and stakeholders to advise of any changes to potential operational impacts as the projects planning progresses.

### 2.3.12 Impacts on pedestrian crossings

#### *Submission number(s)*

29

#### *Issue description*

The respondent requested further information on the impact of the proposal on signalised pedestrian crossings.

#### *Response*

Existing signalised pedestrian crossings of entry and exit ramps would be maintained. At some crossings traffic lights may need to be relocated, additional refuges provided and crossing locations adjusted slightly to accommodate the revised ramp design. However, overall the changes would be relatively minor. Further consultation would be undertaken with relevant councils during detailed design on potential modifications to existing signalised pedestrian crossings.

## 2.4 Operation of proposal

There were two submissions that raised issues about the operation of the proposal.

### 2.4.1 Closure of ramps during peak periods

#### *Submission number(s)*

1

#### *Issue description*

The respondent suggested that some entry ramps should be closed down in peak periods to limit vehicles entering the M4 Motorway, which would maintain free flowing traffic on the motorway.

#### *Response*

The operation of ramp signals on entry ramps to the M4 Smart Motorway would allow for the controlled release of the vehicles from the entry ramps to the M4 Motorway. The timing (or phasing) of the entry ramp signals would be adjusted to allow vehicles to safely merge with the M4 Motorway traffic with only minimal impacts on the free flow of traffic on the motorway. Ramps would not be closed during the normal operation of the Smart Motorway system in peak periods.

However entry ramps may be closed if an incident (such as an accident) occurs on the motorway. Entry ramps immediately before the location of an incident may be closed temporarily to ensure that general traffic is diverted around the incident site. The closure of the entry ramps to general traffic would also allow emergency services vehicles to use the closed entry ramps to rapidly access the incident location.

## 2.4.2 Motorway control system

### *Submission number(s)*

33

### *Issue description*

The NRMA has requested more information on the performance and type of motorway control system to be used for the proposal. They have also requested additional information on how the control system would integrate with WestConnex and the Traffic Management Centre.

### *Response*

The REF identifies improvements of up to 25 per cent in peak period travel times. This improvement is as a direct result of the control system as part of the Smart Motorway proposal, of which the Managed Motorway System (MMS) is a key component.

Roads and Maritime has recently released an Expression of Interest to industry for the development of the MMS. The development of this system will consider the way it is integrated into existing network operation practices by Roads and Maritime and Transport for NSW.

The MMS would be developed to enable it to operate multiple sections of the one motorway (such as the M4 Motorway) or multiple motorways.

## 2.5 Traffic

There were many submissions that raised issues regarding the traffic performance and impacts of the proposal. Some submissions doubted that the proposal would result in improvements in traffic performance, while a number of other submissions were concerned about potential impacts on local roads and intersections. Other submissions requested more information on the traffic modelling and the assumptions used.

### 2.5.1 Increase in crashes and congestion due to proposal

#### *Submission number(s)*

8, 20

#### *Issue description*

The respondents suggested the proposal would result in increased crashes and congestion at the entry ramp merges and other locations.

#### *Response*

As discussed in the REF, Smart Motorway systems have been implemented both in Australia and internationally. While these systems may vary slightly from what is proposed for the M4 Motorway, most of the systems include ramp signals, lane use management systems and/or variable speed limits. Table 2-3 summarises the reported benefits of implementing Smart Motorway systems on other motorways. The

results indicate the implementation of Smart Motorway systems both reduce crashes and reduce congestion.

**Table 2-3 Observed benefits of Smart Motorways**

Scheme	Benefits
Highways Agency Studies across the UK	Average journey time savings between 5 per cent and 30 per cent Average increase in volume between 1 per cent and 5 per cent Average increase in average speeds 4 per cent to 35 per cent
M1, Coordinated Ramp Metering, Victoria, Australia	Volume increased 30 per cent Average speed increased by 25 km/h
A40 Ramp Metering pilot, Germany	50 per cent congestion reduction during peaks 40 per cent reduction in crashes on ramps 10 km/h increase in motorway average speeds
Variable Speed Limits, The Netherlands	Crashes reduced 16 per cent Throughput increased by 3 to 5 per cent
Ramp Metering, The Netherlands	Increased speeds Reduced shockwaves Reduced short trips (rat running) 5 per cent capacity increase
Auckland, New Zealand	9 per cent gain in peak motorway throughput Reduction in peak period crashes of 15 to 20 per cent Onset of severe congestion deferred by up to an hour, and normal flows resume up to 30 minutes earlier than in the past Peak period ramp flows increased by 150 to 250 vehicles per hour
Minneapolis, USA	35 per cent freeway speed increase after 10 years, while peak period traffic volume increased by 32 per cent over the same period
Seattle, USA	Travel time reduction of around 50 per cent, while peak traffic volumes increased by 86 per cent (northbound) and 62 per cent (southbound) over the same period
Los Angeles, USA	Achieved 18 per cent travel time reduction, 44 per cent delay reduction, 16 per cent average travel speed increase and an estimated Benefit Cost Ratio of 9.8

## 2.5.2 Education of drivers

*Submission number(s)*

8

*Issue description*

The respondent suggested drivers need more education on how to merge safely.

*Response*

While it is beyond the scope of the proposal to provide all drivers with education of how to merge correctly, there would be a public education campaign associated with the Smart Motorway system. This public education campaign would occur before and during the commissioning of the Smart Motorway system and would aim to educate drivers on ramp signalling, safe merging and the lane use management system.

### 2.5.3 Modification of permanent red turning arrows

#### *Submission number(s)*

10

#### *Issue description*

The respondent suggested that permanent red turning arrows at ramp intersections should be removed to allow continual traffic movement and avoiding delay.

#### *Response*

Roads and Maritime has guidelines to assess the suitability of allowing right turn filtering across opposing through traffic. The guidelines prohibit filtering based on factors that include lack of sight distance, more than one lane turning right, speed zones over 70 km/h and the number of lanes the right turn vehicle must cross. If a site meets the guidelines then right turn filtering is allowed, unless there is a high right turn to through crash history. If the site has a high right turn to through crash history, then the crash history is assessed to see if the crashes are occurring at a particular time. If they are then the right turn red arrow is displayed for that time. If the crash profile shows that they are occurring at various times then the red arrow is displayed at all times. The major interchanges at the western end of the M4 Motorway (such as The Northern Road and Mulgoa Road) have had a right turn to through vehicle crash history that would not support the introduction of right turn filtering at any time.

### 2.5.4 Local and other road impacts

#### *Submission number(s)*

7

#### *Issue description*

The respondent suggested that there would be traffic and resulting noise impacts on local and other roads around the interchanges due to the ramp signalling. Further modelling and assessment of the impacts of the proposal on local and other roads was also requested.

#### *Response*

The Traffic and Transport working paper included an assessment of the proposal on the road network surrounding the M4 Motorway. Figure 38 and Figure 39 in the Traffic and Transport working paper detail predicted impacts on the surrounding road network in the AM and PM and peak traffic periods.

For most roads in the surrounding road network, there would be no change in the traffic volumes. For some of the arterial and major roads connecting to M4 Motorway, there would be increases in the number of vehicles in peak periods. However generally these increases would be small (<500 vehicles per hour) and within the roads current capacity.

Also for some arterial and major roads connecting to M4 Motorway, it is predicted that there would be a decrease in traffic volumes as the M4 Motorway becomes the preferred route, rather than the surrounding road network. A substantial decrease in

traffic on the Great Western Highway was predicted in the both the AM and PM peaks, as the M4 Smart Motorway becomes a more attractive route for motorists.

Overall, the traffic modelling for the REF indicates that traffic volumes on local roads would be largely unaffected by the proposal.

Roads and Maritime intends to undertake additional traffic modelling using a hybrid network and local traffic model to further investigate any changes in traffic volumes on local and other roads due to the proposal. If unacceptable impacts are identified, Roads and Maritime would work with the relevant local councils to identify measures to minimise any impacts.

### 2.5.5 Heavy vehicle management on the motorway

#### *Submission number(s)*

29

#### *Issue description*

The respondent suggested that Roads and Maritime should investigate the management of heavy vehicles on the motorway including reduced speed limits for heavy vehicles or restricting their movement to outside peak traffic hours.

#### *Response*

Roads and Maritime does not intend to have alternative reduced speed limits for heavy vehicles or to restrict access to the M4 Motorway for heavy vehicles during peak traffic periods. Both of these measures would be difficult to enforce and are likely to result in greater heavy vehicles numbers on local and arterial roads. This in turn would cause more arterial road congestion and higher noise and air quality impacts. Decreasing congestion of the M4 Motorway through the proposal would reduce heavy vehicle impacts on the congestion, noise and air quality.

### 2.5.6 Traffic modelling

#### *Submission number(s)*

8, 29

#### *Issue description*

One respondent (Holroyd Council) requested that all road widening and intersection design be based upon traffic modelling that considers all future growth including new employment lands, residential land releases, major traffic generators/attractors and transport infrastructure upgrades. The respondent also raised concerns that the traffic studies undertaken now may not be relevant by 2020. Another respondent was concerned that traffic increases due to population and employment growth would not result in any congestion reduction from the proposal.

#### *Response*

Traffic modelling used for the design and assessment of the proposal was based upon 2031 traffic estimates. The Traffic and Transport Working Paper for the proposal presented details on the assumptions on future population and employment growth and future infrastructure likely to be built between the 2012 (base year) and 2031 used in generating future traffic estimates for the modelling. This includes

allowance for future network enhancements such as WestConnex and major land use changes including the Badgerys Creek Airport. Relevant section of the report are summarised below.

A Strategic Traffic Assignment Model (STAM) for the whole of Sydney has been built by Roads and Maritime. This model was refined and used for assessment of traffic impacts of the proposal. STAM is a link based model, reflecting all-vehicle traffic demand for the average AM and PM peak two hour periods, for a typical weekday on the Greater Metropolitan Area (GMA) roads. Variants of the model have been established to account for future land use, population and travel patterns.

The REF considered numerous scenarios, including:

- 2012 Base scenario – represent existing conditions
- 2021 future years with and without Smart Motorways; and
- 2031 future years with and without Smart Motorways.

All models were assessed for performance in each of the AM and PM peak periods.

The inputs to STAM are based on the NSW Government plans, policies and population/employment projections and “most likely” infrastructure assumptions.

In general, Sydney is forecast to experience continuing growth in population and employment. Alongside this growth is a commensurate forecast growth in the number of dwellings. The main source of forecasts for future population, employment and dwellings for the purposes of this study is the *Draft Metropolitan Strategy for Sydney to 2031* but other similar strategies in place for surrounding regions have also been used as inputs.

In particular, land use forecasts are in line with the most recent forecasts produced by Transport for New South Wales (September 2014) and show the expected changes in land use between 2011 and 2031 for employment and population respectively.

Table 2-4 (reproduced from Table 13 in the Traffic and Transport working paper) shows the infrastructure included in the strategic traffic model in the future model years 2021 and 2031.

**Table 2-4 Infrastructure assumptions for future years 2021 and 2031**

Project	2021	2031
NorthConnex	✓	✓
WestConnex Stage 1 & 2	✓	✓
WestConnex Stage 3		✓
The Northern Road <ul style="list-style-type: none"> <li>- Widening north of Penrith</li> <li>- Capacity increases north of Narellan</li> <li>- Capacity increases south of the M4</li> </ul> (Western Sydney Infrastructure Plan)	✓	✓
Eastern Creek- Old Wallgrove Road	✓	✓
M2 Widening (completed 2013)	✓	✓

Project	2021	2031
M5 west widening (complete 2014)	✓	✓
Erskine Park Link Road and associated improvements (BWSEA)	✓	✓
New Southern Link Road (BWSEA)		✓
Widening of Mamre Road and Elizabeth Drive (BWSEA)		✓
Werrington Arterial Road – Stage 1	✓	✓
Hume Highway widening (north of Campbelltown) (completed 2012)	✓	✓
Prospect Highway upgrade	✓	✓
Richmond Road widening north of M7	✓	✓
Windsor Road widening (north of M2)	✓	✓
Widening of Castlereagh Road north of Penrith		✓
Planned widening on the Northern Road, Camden Valley Way, Narellan Road (STAM model assumptions beyond current proposals in order to support South West Growth Centre)		✓
Widening of Richmond Road and Garfield Road East (to support North West Growth Centre)		✓

The assumptions on future population and employment growth and future infrastructure were comprehensive and relatively conservative. Therefore the estimates of future traffic numbers are considered robust and suitable for design of the proposal. To ensure confidence in the traffic numbers, the modelling would be reviewed and potentially supplemented as part of the detailed design.

#### 2.5.7 Use of priority freight bypass lanes by emergency response vehicles

##### *Submission number(s)*

33

##### *Issue description*

The NRMA has requested that emergency response vehicles and NRMA patrols be permitted to use the freight bypass lanes.

##### *Response*

Roads and Maritime is planning to designate the priority access lanes as truck and/or bus lanes depending on transport needs. Emergency vehicles would be exempt from the restrictions placed on these facilities to ensure a rapid response to any incidents on the motorway. It should be noted that the priority access lanes are only proposed on the Westlink M7 westbound entry ramp, Prospect Highway westbound entry ramp and at the Roper Road eastbound entry ramp. However trafficable road shoulders would be provided on all entry ramps, which would enable most emergency vehicles to bypass vehicles queued at the ramp signals.

At this stage, it is not proposed that this exemption be extend to NRMA patrols. Roads and Maritime considers the NRMA patrols as road customers. In the interests

of improving safety for all customers, Roads and Maritime would not support the continued practice whereby roadside assistance providers, such as NRMA patrols, attend to broken down vehicles in a live traffic, high speed motorway environment.

Roads and Maritime will review the operational practice for the clearing of 'broken down' vehicles within shoulders on Smart Motorways. The initiatives that Roads and Maritime will consider include the provision of a dedicated tow truck service to remove vehicles from the motorway, additional Traffic Emergency Patrols and the development of a response time service level agreement. The broken down vehicles can then be towed to a safer, lower speed environment to allow NRMA patrols to attend to the vehicles.

## 2.5.8 Management of cyclists

### *Submission number(s)*

33

### *Issue description*

The NRMA has requested further information on how cyclists on the M4 Motorway will be managed during incidents.

### *Response*

During incidents, cyclists would be managed in a similar manner to other vehicles, although they would not be required to immediately merge to centre lanes if the outside lanes were to be closed. Cyclists would also be required to exit the motorway with other vehicles if a section of the motorway is closed due to incident. At this stage no special signage or other traffic control measures are proposed to manage the motorway shoulder or to manage cyclists. If a ramp is closed in the event of an incident, this would include the shoulder and Roads and Maritime will consider the need for communication, consultation and education around this fact during the ongoing development of the project.

## 2.6 Operational noise

Many submissions identified the existing and future operational traffic noise impacts of the M4 Motorway and the proposal as an issue. The timing and process for the determination of noise mitigation measures such as noise wall locations was also a common issue identified.

### 2.6.1 Noise assessment and verification

#### *Submission number(s)*

21

#### *Issue description*

The respondent requested further information the operational noise assessment and verification process.

#### *Response*

The noise assessment process is described in Section 9.5 of the REF and is summarised below.

## Identification of noise and vibration sensitive receivers

The sensitivity of receivers to noise and vibration is dependent upon the occupancy type and the nature of the activities performed within the affected premises. Sensitivity to noise is a subjective response varying for different individuals and can depend on the existing noise environment. Land uses sensitive to construction noise are identified in the Interim Construction Noise Guidelines (ICNG) (DECC 2009). Receivers sensitive to operational road noise are identified in the NSW Road Noise Policy (RNP) (DECCW, 2011). For the purpose of this assessment, receivers potentially sensitive to noise and vibration have been categorised as:

- Residential
- Education institutions
- Child-care centres
- Hospitals (wards or other uses including medical centres)
- Places of worship
- Other (such as cinemas, theatres, recreation areas).

This assessment considers all residences to be sensitive receivers during both construction and operation. All educational institutions, child-care centres, recreation areas, medical facilities and places of worship are also considered to be sensitive to operational and construction noise and vibration impacts.

## Ambient noise surveys and monitoring locations

To quantify and characterise the existing ambient noise environment across the proposal both unattended and attended noise monitoring was carried out during February and March 2013. A supplementary survey was carried out at three additional locations next to the M4 Motorway in November 2014. Unattended noise monitoring involved deployment of the noise monitoring equipment with the consent of the relevant landowners. The noise loggers continuously measured noise levels in 15 minute sampling periods to determine the  $L_{Aeq}$ ,  $L_{A90}$  and other relevant statistical noise levels during the daytime, evening and night-time noise periods.

Attended ambient noise monitoring was completed at the same time to determine the various noise sources that influence the existing noise environment. During each measurement the observer noted the various noise sources and the contributing noise level.

The results of the noise monitoring were processed to exclude noise identified as extraneous and/or affected by adverse weather conditions (ie strong wind or rain) so as to establish representative noise levels in each area.

The measured noise levels were used to establish existing road traffic noise levels to allow for validation of the operational noise model and as a basis for assessing potential noise impacts during construction. The noise monitoring locations were selected to be representative of receivers and communities potentially affected by the construction and operation of the proposal.

## Operational noise modelling

To assess road traffic noise impacts, noise modelling of the areas impacted by the proposal was carried out. The modelling allows consideration of traffic volume and mix of vehicles, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers. Noise modelling was carried out using traffic modelling

outputs for each of the forecast future traffic years and road network configurations. Predicted noise levels were considered against the Noise Criteria Guideline. The assessed noise modelling scenarios were:

- 2021 No Build - the forecast road traffic volumes without the proposal
- 2021 Build - the forecast 'at opening' road traffic volumes including the proposal
- 2031 No Build - the forecast road traffic volumes 10 years after the opening year due to general traffic growth that would have occurred without the proposal
- 2031 Build - the forecast '10 year after opening' road traffic volumes including the proposal.

The comparison for 2021 indicates the potential for any noise issues at the commencement of the proposal. The comparison for 2031 indicates the potential for noise impacts in the longer term once the proposal is well established and the surrounding road network has stabilised.

The assessment of impacts was limited to areas immediately adjacent to the components of the proposal that had the potential to generate additional road noise impacts, namely the modifications to the ramps at the interchanges and the widening of the M4 Motorway between the Westlink M7 and the Roper Road interchanges.

Where relevant noise guidelines are exceeded at sensitive receivers, Roads and Maritime is required to consider noise mitigation for affected properties to reduce noise levels below relevant guidelines where reasonable and feasible.

As discussed in Section 6.5.6 of the REF, the selection of appropriate noise mitigation measures are considered in following order of priority, namely:

- a) Road design and traffic management
- b) Low noise pavement surfaces
- c) In-corridor noise barriers/mounds
- d) At-property treatments or localised barriers/mounds.

During detailed design of the proposal, the noise modelling would be repeated on the final design and noise mitigation measures above would be considered, with the most reasonable and feasible method(s) of mitigation selected. The first mitigation measure is most applicable to new roads, where the road design (location and height) of the road relative to adjacent properties can be modified. This is not really applicable to the M4 Smart Motorway project. Mitigation options b (which could include resealing existing surfaces) and c would be unlikely to achieve the required noise mitigation at all affected properties and consequently a combination of noise barriers and at-property treatments would be the most likely outcome at some locations.

After construction has been completed and generally within a year of commencement of full operations, noise monitoring and modelling would be undertaken to confirm that the initial noise predictions (including consideration of noise mitigation measures) have been achieved. Where the actual operational noise levels exceed the predictions made during detailed design, further investigation of additional noise measures would be undertaken.

## 2.6.2 Extent of noise assessment and mitigation

### *Submission number(s)*

23

### *Issue description*

The respondent queried the extent of the noise assessment area for The Northern Road westbound entry ramp, suggesting that it does not comply with Road Noise Policy and should be larger to include Aberdeen Circuit Glenmore Park.

### *Response*

Notwithstanding the recommendations for further analysis during detailed design (refer to Section 19.3 of the REF noise and vibration technical paper), the assessment within each interchange area has been carried out in accordance with the requirements of the Road Noise Policy (RNP) (DECCW, 2011) using the procedures specified in the Noise Mitigation Guideline (NMG) (Roads and Maritime, 2015) and Noise Criteria Guideline (NCG) (Roads and Maritime, 2015). The project area for each interchange includes the roads where physical works occur and may be extended to close-by landmarks such as cross streets, parks and reserves or utility corridors to provide a logical endpoint.

The RNP and NCG defines the urban study area width as up to '600 metres from the centre line of the outermost traffic lane on each side of the subject road'. The extent of works for the westbound on-ramp for The Northern Road are from the beginning of the existing on-ramp to around Castlerock Avenue. The respondent's residence in Aberdeen Circuit Glenmore Park is outside the study area and therefore was not considered in the assessment. It is noted that the M4 Motorway traffic volumes associated with the proposal in this area are predicted to result in a noise increase of less than 2 dB compared to the No Build scenario. As noted in the RNP, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

## 2.6.3 Noise assessment

### *Submission number(s)*

23

### *Issue description*

The respondent queried why only night time noise levels appeared to be assessed for The Northern Road westbound entry ramp and that the noise levels were high enough to warrant a noise wall.

### *Response*

As noted in Section 3.3 of the REF, noise and vibration technical paper, the assessment considered noise surveys conducted at 29 locations across the interchange areas to enable assessment for both day and night time impacts. The results of the noise monitoring have been used to establish representative noise levels in each area. Logger A11.3 was within NCA27 at a location representative of the affected sensitive receivers (20 South St, Glenmore Park) – please refer to Table 5 and Appendix C-A11 in the REF noise and vibration technical paper for a more

detailed site description and results of the noise monitoring survey. The results of the noise survey were used to establish Noise Management Levels for the assessment of noise impacts during construction and to validate the noise model used to predict future operational noise levels at all assessed noise sensitive receivers.

In accordance with the RNP assessment requirements, and with reference to Section 16 and Appendix L4 of the REF noise and vibration technical paper, noise predictions were assessed for both daytime (7.00am until 10.00pm) and night-time (10.00pm until 7.00am) periods. In addition to considering both daytime and night-time impacts, the assessment also considers both the 2021 (year of opening) and 2031 (10 years after opening) scenarios. The comparison for 2021 will indicate the potential for any noise issues at the commencement of the project, such as community reaction to significant changes in noise levels. The comparison for 2031 will indicate the potential for noise impacts in the longer term.

The noise report identified the controlling criterion as the night time criterion for the majority of the residences assessed for the project ie the night time exceedances were generally higher above the night time criterion than the daytime exceedances above the daytime criterion. Although the summary sections for each interchange reflect the night time impacts, noise predictions for both day and night time periods are provided in Appendices E to N of the noise report. As discussed in Section 16.2 of the REF, noise and vibration technical paper, there are not more than three closely grouped receivers identified for consideration of additional noise mitigation in this area. Therefore, there is no requirement for consideration of noise barriers in this interchange area.

#### 2.6.4 Increase in noise from traffic on local roads due to the proposal

*Submission number(s)*

7

*Issue description*

The respondent was concerned that the proposal would result in additional traffic congestion on surrounding streets which in turn would cause higher noise impacts.

*Response*

The ramp signals installed on all the entry ramps, while similar in appearance to traffic signals controlling intersections, would operate differently than typical traffic signals. Firstly they would only operate during peak or congested periods – at other times they would be turned off. Secondly the ramp signals would change to green typically every 7 to 14 seconds, unlike normal traffic signals which may have phases between green lights of over two minutes. As well as the installation of ramp signalling, the ramps would also be widened and lengthened to increase the amount of vehicle storage behind the ramps signal stop lines. This combination of rapid changes in the ramps signals and increased storage on the ramps would not result in any additional queuing on arterial roads and surrounding streets – and therefore there would be no additional noise impacts.

#### 2.6.5 Noise mitigation

*Submission number(s)*

1, 4, 6, 9, 11, 16, 17, 24, 28, 31, 34

### *Issue description*

A number of respondents requested that noise walls be installed near or adjacent to their properties. They were also concerned that the proposal would result in additional traffic noise and that noise mitigation measures would not address excessive noise levels.

### *Response*

The process for assessing operational noise and mitigation measures is described in Section 2.6.1 of this report, Section 6.5 of the REF and in detail in the Noise and Vibration Working Paper accompanying the REF (Volumes 4 and 5).

The number and location of properties which exceed operational noise guidelines and qualify for consideration of additional noise mitigation is presented in Table 6.44 of the REF and in Figure 6-14 of the REF. At most locations assessed, the implementation of the proposal would not result in a substantial increase in the number of properties exceeding noise guidelines, suggesting that noise from existing traffic (and natural growth in traffic due to population and land use changes) is the main cause of current exceedances. At a few locations, such as the widening of M4 Motorway between the Roper Road and Westlink M7 interchanges, the proposal would result in an increase in the number of properties exceeding the relevant noise guidelines.

Where noise guidelines at properties are exceeded, Roads and Maritime is required to consider feasible and reasonable noise mitigation for affected properties.

As discussed in Section 6.5.6 of the REF, the selection of appropriate noise mitigation measures are considered in the following order of priority, namely:

- a) Road design and traffic management
- b) Low noise pavement surfaces
- c) In-corridor noise barriers/mounds
- d) At-property treatments or localised barriers/mounds.

The noise and vibration assessment in the REF identified potential noise mitigation measures based upon the concept design and the traffic assessment in the REF. This included identifying potential locations where new noise barriers may be installed. Details of the potential noise wall locations for the proposal are provided in Figure 3-1 and Figure 3-2 of this report. These locations would be subject to further investigation during detailed design as the noise assessment would be repeated using the final design of the proposal and any new traffic information would be considered.

Noise mitigation measures above would again be considered and the most reasonable and feasible method(s) of mitigation selected. A combination of noise mitigation measures above may be required to reduce noise at all affected premises. The first mitigation measure is most applicable to new roads, where the road design (location and height) of the road relative to adjacent properties can be modified. This is not readily applicable to the M4 Smart Motorway proposal. Mitigation options b (which could include resealing existing surfaces) and c would be unlikely to achieve the required noise mitigation at all affected properties and consequently a combination of noise barriers and at-property treatments would be the most likely outcome at some locations. Roads and Maritime would carry out noise mitigation measures as early as is reasonably practicable.

Further noise impact assessment and consultation with affected property owners on noise mitigation measures would also be undertaken during detailed design. Roads and Maritime would endeavour to install noise mitigation measures (new or relocated noise walls) and/or the provision of at property architectural treatments as early as reasonably practicable during the construction phase.

#### 2.6.6 Noise wall at Russell Street eastbound entry ramp

##### *Submission number(s)*

19

##### *Issue description*

The respondent requested that the existing timber noise wall along the Russell Street eastbound entry ramp be upgraded and extended.

##### *Response*

The noise wall along the Russell Street eastbound entry ramp would be relocated as part of the upgrade of the entry ramp. As generally it is not feasible to relocate timber noise walls, the existing timber wall would be demolished and a new noise wall constructed. Typically a new noise wall would be constructed of light weight concrete panels which are more effective at mitigating noise than timber.

The length and height of the relocated noise wall would be determined during the detailed design.

#### 2.6.7 Noise wall at Mulgoa Road eastbound entry ramp

##### *Submission number(s)*

21

##### *Issue description*

The respondent requested further information on the re-location of noise walls at Mulgoa Road eastbound entry ramp.

##### *Response*

Based on the level of investigation and design completed to date, the noise wall along the Mulgoa Road eastbound entry ramp would be relocated approximately 10 metres closer to Clynburn Avenue Jamisontown. Noise modelling undertaken for the REF indicates that the noise wall would not need to be heightened to achieve the same noise mitigation as the current situation. It should be noted that height refers to the AHD (Australian Height Datum) of the top of the noise wall. A larger noise wall may be required if the base of the relocated noise wall is at a lower level than its current level. The exact location and size of the relocated noise wall would be determined during detailed design.

#### 2.6.8 Heavy vehicle noise at Mulgoa Road eastbound entry ramp

##### *Submission number(s)*

9, 30

### *Issue description*

The respondent stated that heavy vehicle air brakes at Mulgoa Road eastbound entry ramp was excessive and request signage be placed to encourage heavy vehicles to reduce their use of air brakes.

### *Response*

Roads and Maritime are mindful of the problems associated with excessively noisy heavy vehicle compression brakes in the vicinity of residential areas. Roads and Maritime do not however, have any regulatory powers to prosecute in relation to exhaust brake noise. The issues relating to exhaust brake noise are being addressed as follows:

#### **Inspections**

Roads and Maritime check heavy vehicles for faulty noise emission control equipment at periodic inspections or following complaint and issues defect notices where warranted.

#### **Compression brake sign education strategy**

This strategy comprises:

- An education program providing information to encourage long-term behavioural changes among heavy vehicle operators travelling along the entire Roads and Maritime road network to encourage the appropriate use of compression brakes.
- Installing signs on all major truck routes at strategic locations around Sydney advising truck drivers to limit the use of compression brakes in the vicinity of residential areas. The vast majority of heavy vehicle operators now see at least one sign on any given journey.

Roads and Maritime has found that installing additional compression brake signs in response to individual complaints has not provided long-term benefits in reducing the incidence of compression braking. Installing signs along every section of arterial road where compression braking is an issue could also detract from other road safety sign messages.

## **2.7 Operational air quality**

### **2.7.1 Operational air quality impacts**

#### *Submission number(s)*

28

#### *Issue description*

The respondent suggested that there would be increased air quality impacts associated with the proposal from vehicle emissions. They also suggested that the recent removal of vegetation between their residence and the M4 Motorway had made air quality impacts worse.

#### *Response*

Operational impacts on air quality are largely dependent on the volume of traffic, its average speed, composition (eg heavy vehicle proportions), road gradient and driving conditions (eg congestion).

Air pollutant source emission rates can be reduced by optimising vehicle operating speeds. The proposal supports this by implementing technologies to maintain free flowing traffic, reducing congestion and limiting the requirement for idling and acceleration/deceleration.

One of the primary objectives of the proposal is to ease congestion rather than increase capacity of the M4 Motorway, with the exception of the section between the Westlink M7 and Roper Road interchanges where widening would result in an increase in capacity. Traffic flows should be improved and air emissions reduced accordingly.

Many of the ramps would be widened and lengthened. In some cases this may bring the road closer to existing residences; however, would not directly result in an increase in traffic using the ramps or alter the current ramp gradient, hence associated air quality impacts would be negligible.

For those residences within close proximity (less than around 30 metres from the existing road) or those residences which would be brought closer to the interchange as a result of the proposal, air quality impacts from vehicle emissions may already exist.

Experience from Smart Motorways schemes currently in operation in Melbourne, New Zealand, the United Kingdom and the United States has shown the benefits during peak periods include travel time reduction, increased flow on the ramps and a reduction in delays, which has an associated reduction in vehicle emissions. It is expected that there would be positive air quality impacts for residents in the vicinity of the ramps through improving the flow of traffic through these interchanges.

## 2.8 Biodiversity

### 2.8.1 Vegetation at Mulgoa Road eastbound entry ramp

#### *Submission number(s)*

9, 30

#### *Issue description*

The respondents stated that roadside vegetation along Mulgoa Road eastbound entry ramp was overgrown and weed infested - and requested it be removed and replaced with either more appropriate vegetation or a noise wall.

#### *Response*

A Roads and Maritime maintenance contractor has inspected the vegetation in this area and has concluded that currently no trimming or maintenance of this vegetation is required.

As part of construction of the proposal, road side vegetation may be cleared in some locations. Where the land cleared is not used for new road infrastructure, the cleared land would be replanted with appropriate native vegetation. At this stage it has not been determined whether the road side vegetation along Mulgoa Road eastbound entry ramp would require clearing. The assessment for the REF has suggested the likely need for a noise wall in the vicinity. This will be further assessed in detailed design, though would likely result in the clearing of an amount of vegetation to enable

construction to occur. Once detailed design and construction planning is complete details of vegetation clearing and replanting in specific locations would be available.

### 2.8.2 Key fish habitats

#### *Submission number(s)*

13

#### *Issue description*

The Department of Primary (Fisheries) noted that the Nepean River, South Creek, Eastern Creek, Ropes Creek and Surveyors Creek are key fish habitat. It also noted that no instream works are proposed at these locations and the only potential impact is from sedimentation and erosion from construction areas.

#### *Response*

It is noted that the Nepean River, South Creek, Eastern Creek, Ropes Creek and Surveyors Creek are key fish habitat. As discussed in Section 6.6.4 of the REF, a Soil and Water Management Plan and Erosion and Sedimentation Control Plan would be prepared and implemented during construction.

### 2.8.3 Impacts on freshwater wetlands

#### *Submission number(s)*

32

#### *Issue description*

The NSW Office of Water noted that a number of freshwater wetlands would be impacted by the proposal and requested that further consideration be given to protecting these wetlands due to their environmental value and water treatment function.

#### *Response*

The vast majority of areas identified as freshwater wetlands within the M4 Motorway corridor are water management basins that have been either colonised by or planted with wetlands species that met the Threatened Ecological Community definition under the TSC Act. There are very few “natural” remnant wetland areas within the M4 Motorway corridor. Nevertheless Roads and Maritime recognise the environmental and water treatment values of all freshwater wetland areas and would aim to minimise their disturbance during the detailed design and construction of the proposal. Also it should be recognised that placing infrastructure in wetland areas would increase the engineering and construction complexity as well as the cost of the proposal – which is undesirable.

The majority of the freshwater wetland areas impacted would be from the installation of the ITS infrastructure including the ITS backbone and cable spurs. In many locations the ITS backbone and connecting cable spurs could be rerouted to avoid direct impacts.

Generally where ramp upgrades impact upon freshwater wetlands, these wetlands are water management basins. These impacts would be unable to be avoided, however

where possible area of the basin/wetlands that are not directly impacted would be retained.

Where water management basins/freshwater wetlands have been identified for augmentation due to the increased impervious area draining to them, alternative designs would be investigated to avoid direct disturbance of the areas.

#### 2.8.4 Impacts on biodiversity

*Submission number(s)*

27

*Issue description*

OEH suggested that the impacts of clearing associated with the proposal were not negligible given the high condition of some patches of Threatened Ecological Communities (TECs) and biodiversity within the corridor.

*Response*

While some patches of vegetation with high site value scores are present in the study area (ie near Roper Road) these areas will largely be avoided by the project. Plot assessments were undertaken generally in the core area of each patch rather than the edges where impacts would generally be limited to, and therefore site value scores are likely to be inflated when considering the level of edge effects and weed invasion along the edges of these patches.

The high flora diversity is due to the relatively large linear study area that spans multiple vegetation types, microhabitats, climatic conditions and areas of planting. The high flora species diversity is not a result of the presence of large areas of high quality native vegetation, but rather a series of small to medium sized patches with low-moderate levels of flora diversity. A highly precautionary approach has been taken for assessing the predicted impact to threatened species which has included the total area of potential habitat. Much of the habitat along the M4 Motorway is not suitable or would provide only marginal habitat for threatened species. The project design has generally avoided known locations of conservation significant biota such as threatened flora at the Roper Road interchange.

Predicted impacts to TECs are based on a worst case scenario, the project design has generally avoided high quality areas of remnant TECs. Detailed design is likely to result in ecological impacts being further reduced.

The mitigation measures discussed in the Biodiversity Assessment (refer to Chapter 5 of Appendix B) and within the REF ensure that important areas containing TECs, threatened species, or threatened species habitats would be avoided where possible during the construction phase. For example, the ITS infrastructure near Roper Road has been designed to avoid the higher quality patches of TECs and threatened flora populations in this area, however some individuals/areas of habitat fall within the two to three metre buffer around the ITS, whereas during construction it is likely that these areas/individuals will be retained. A large proportion of the impacts reported are likely to be limited to indirect impacts such as edge effects (which would be minimal when considering much of the existing habitat in the study area is edge affected) which are to be mitigated.

These factors have been expanded in the revised Biodiversity Assessment (refer to Chapter 4 in Appendix B).

#### 2.8.5 Inconsistencies in clearing estimates

##### *Submission number(s)*

27

##### *Issue description*

OEH queried minor inconsistencies in clearing estimates between different sections of the Biodiversity Assessment. They also requested further clarification regarding potential impacts on the Freshwater wetlands TEC.

##### *Response*

There are some inconsistencies in clearing estimates between different sections of the report and changes have been made to the revised Biodiversity Assessment to ensure consistency (refer to Appendix B). In regards to the TEC freshwater wetlands, much of these areas are not completely remnant but rather modified in an urban landscape comprising disturbed drainage lines and water management basins with macrophytes. These areas have affinities to the TEC listing, but are not extensive naturally occurring wetlands. Remnant vegetation has been identified as map units 1, 2 and 3 only excluding the highly modified/derived wetlands.

Calculations have been altered to consider the latest infrastructure design and proposed construction buffers have been modified slightly to provide a realistic indication of the extent of ecological impacts.

#### 2.8.6 ITS backbone outside proposal area

##### *Submission number(s)*

27

##### *Issue description*

OEH queried whether the clearing impacts of the ITS backbone at approximately chainage 27400 had been assessed as there was no vegetation mapping and the ITS backbone extended outside the proposal area.

##### *Response*

The ITS backbone in this location was placed on the exit and entry ramps for the proposed Archbold Road interchange. This new interchange is proposed to service the development of the Western Sydney Employment Area. However, it is recognised that full project approval has not yet been received for the Archbold Road interchange. The ITS backbone has been moved back into the project corridor and its clearing impacts have been assessed.

## 2.8.7 Indirect impact assessment

### *Submission number(s)*

27

### *Issue description*

OEH suggested that the indirect impacts of the proposal on biodiversity were not addressed adequately including issues such as weed management.

### *Response*

The Biodiversity Assessment report considers direct and indirect impacts (refer to Chapter 4 in Appendix B). The report states that weed management measures would limit the establishment and spread of weed species during construction and operation and that weed invasion would remain as a potential impact of the project.

Most patches of vegetation along the M4 Motorway have substantial weed infestations and are currently impacted by edge effects. Although these patches are not in a high ecological condition some level of ecological function is maintained particularly where there has been no/limited soil disturbance. Following construction, the remaining patches are likely to maintain a similar level of ecological function. Larger patches are considered to have a greater viability, and the direct and indirect impacts to the proportion of each of these has been investigated and provided in the revised Biodiversity Assessment (refer to Table 3-3 and Table 4-2 in Appendix B). Section 4.1.2 of the Biodiversity Assessment addresses indirect impacts (refer to Appendix B).

Roads and Maritime has significantly improved their weed management protocols since the original construction of the M4 Motorway. Considering the existing levels of weed infestation and the proposed strict weed control protocols during construction, any further impacts from weeds as a result of the proposal would be unlikely to be substantial.

## 2.8.8 No vegetation mapping or assessment west of Jamison Creek

### *Submission number(s)*

27

### *Issue description*

OEH noted that there was no vegetation mapping or biodiversity assessment for proposed ITS infrastructure west of Jamison Creek.

### *Response*

The revised Biodiversity Assessment assesses the ITS infrastructure proposed west of Jamison Creek. It should be noted that the ITS cabling and infrastructure would be located immediately adjacent to the road shoulder or in cleared areas to allow maintenance access. Unlike other areas of the M4 Motorway corridor, there are no alternative access locations for ITS infrastructure and cabling in this area.

### 2.8.9 Survey effort

#### *Submission number(s)*

27

#### *Issue description*

OEH noted that the survey effort for threatened plant species was not reported.

#### *Response*

These details have been added to the revised Biodiversity Assessment (refer to Table 2-6 in Appendix B). The total survey effort for threatened plant species searches was 176 person hours.

### 2.8.10 Hollow bearing trees

#### *Submission number(s)*

27

#### *Issue description*

OEH suggested that the number of hollow bearing trees in the study area has been underestimated and the potential number should be revised.

#### *Response*

The Biodiversity Assessment discusses the absence of structural maturity and tree hollows as a result of historic land clearing and disturbances (refer to Appendix B). Traverses and searches for Hollow Bearing Trees were thoroughly undertaken across the study area. The majority of vegetation in the study area is planted and at a premature age for hollow development. Only remnant patches are likely to have hollow-bearing trees and these areas were searched.

It is believed that all hollow-bearing trees within the study area were located and that extrapolation of the result to the entire study area would overestimate the actual number of hollow bearing trees that are present.

### 2.8.11 Assessment of impact on Priority Conservation Lands

#### *Submission number(s)*

27

#### *Issue description*

OEH noted that there was no discussion on the Priority Conservation Lands around Ropes Creek – and that impacts on vegetation in this area should be avoided.

#### *Response*

Additional discussion around Cumberland Plain Priority Conservation Lands (PCL) near Ropes Creek has been included in the Biodiversity Assessment (refer to Section 3.4.2 in Appendix B). Three hectares of vegetation in the PCL have been identified in the study area located to the south of the M4 Motorway on the east and west of the

Roper Road interchange. Based upon the current concept design only the edge of patches of vegetation in the PCL would be impacted – which is a minimal impact. During detailed design, further options to avoid impacting any vegetation in the PCL would be investigated.

#### 2.8.12 Definition of local occurrences of EECs

##### *Submission number(s)*

27

##### *Issue description*

OEH suggested the biodiversity assessment used an incorrect approach to define local populations of C/EECs which led to an underestimation of the impacts of clearing of C/EECs.

##### *Response*

The revised Biodiversity Assessment contains additional assessment on the impacts of clearing on local occurrence of C/EECs. In the original Biodiversity Assessment, two definitions of local occurrences were used - the occurrences of the C/EEC type within the study area and within 10 kilometres of the study area. An additional definition was included in the revised Biodiversity Assessment namely, the remnant C/EEC patch within the study area and any adjacent contiguous vegetation outside the study area.

Of the 21 remnant patches of C/EEC impacted, the direct impacts of proposal would result in a loss of less two per cent of the local occurrence of the C/EEC. For a further two remnant patches, the direct losses would be 3.2 and 3.7 per cent of high and moderate condition patches, respectively. The direct impacts on these local occurrences of C/EECs would be minor.

One local occurrence of a high quality remnant C/EEC near the Roper Road interchange would experience of a loss of about 17 per cent of its area due to direct impacts. While this is a relatively high percentage, the size of the remnant patch is small (about one hectare) and only 0.17 hectares of high quality condition C/EEC would be directly impacted. There would be no local extinction of any patches of C/EEC.

#### 2.8.13 Impacts on remnant Shale-Gravel Transition Forest

##### *Submission number(s)*

27

##### *Issue description*

OEH suggested the biodiversity assessment does not address impacts to remnant Shale-Gravel Transition Forest and only the planted occurrence is assessed.

##### *Response*

The impacts on remnant Shale-Gravel Transition Forest were assessed. However, in some locations in the Biodiversity Assessment report, the areas of remnant and planted Shale-Gravel Transition Forest directly impacted were not presented separately. This has been remedied in the revised Biodiversity Assessment report.

About 0.32 hectares of remnant Shale-Gravel Transition Forest were assessed as being directly impacted by the proposal (refer to Appendix B).

#### 2.8.14 Impacts on threatened flora location populations

##### *Submission number(s)*

27

##### *Issue description*

OEH requested further information on the impact of the proposal on local populations of threatened flora species.

##### *Response*

Additional assessment in the revised Biodiversity Assessment has been provided on the proportion of each local population of each threatened flora species impacted. The additional assessment concludes that a small proportion relative to population size of each population is being impacted (ie three to five per cent) (refer to Appendix B).

The local populations of each threatened flora species are considered to be currently viable and are considered to remain viable after the project has been constructed. Further reducing the direct impacts of the proposal on local populations of threatened flora species would be investigated during detailed design.

#### 2.8.15 Translocation of threatened flora

##### *Submission number(s)*

27

##### *Issue description*

OEH does not support translocation as a mitigation measure for threatened flora species.

##### *Response*

It is recognised that OEH does not support translocation as a mitigation measure and that translocation cannot be used to lessen the significance of an impact. Translocation of threatened flora species has not been used as a mitigation measure to lessen the significance of an impact to an acceptable (or not significant) threshold (refer to revised Biodiversity Assessment in Appendix B).

In planning for projects, Roads and Maritime follows the avoid, minimise, mitigate, and offset hierarchy and is seeking to avoid removal of threatened flora species during construction, as well as through minor modifications to the alignment of ancillary infrastructure in the first instance. Secondly, mitigation measures such as exclusion zones would be implemented so the removal or damage of threatened flora species is minimised during construction.

However, when all other measures have been taken to avoid impacts and impacts exist that cannot be fully avoided, translocation of some threatened flora individuals may be considered by Roads and Maritime. If supported by OEH, Roads and Maritime, may consider propagation trials and translocation as an option to retain

genetic material of these species. This process would be properly planned and managed so as to contribute to the recovery of the species.

#### 2.8.16 Biodiversity offsets

*Submission number(s)*

27

*Issue description*

OEH suggested that direct impacts on C/EECs from the proposal require that biodiversity offsets be considered both under OEH and Roads and Maritime biodiversity guidelines.

*Response*

The need to provide secure biodiversity offsets is recognised and an offset strategy would be prepared once detailed design has been completed. Due to the potential changes in the route of the ITS backbone (which is responsible for a large proportion of the direct impacts), a biodiversity offset strategy cannot be prepared currently. A commitment to prepare a biodiversity offset has been included in the revised Biodiversity Assessment (refer to Chapter 5 in Appendix B) and Section 5.2.

The most likely form of offset for the project would be the retirement of BioBanking credits at a BioBanking site.

#### 2.8.17 Existing biodiversity offsets

*Submission number(s)*

27

*Issue description*

OEH requested further information on whether any of the planted vegetation within the M4 Motorway corridor was a biodiversity offset or compensatory habitat.

*Response*

The M4 Motorway has been successively constructed and upgraded over the past fifty years, with most of the construction completed or commenced before 1979, with the section between Parramatta and Mays Hill completed in 1982. The final stage to complete the 46 kilometre motorway between Concord and Lapstone, the section between Mays Hill and Prospect was completed as in 1992.

Roads and Maritime are responsible for the operation and maintenance of the motorway, including maintenance within the motorway corridor. While there are sections of both remnant and planted vegetation within the motorway corridor, these areas were never considered or adopted as a biodiversity offset or compensatory habitat for the M4 Motorway or any other projects.

## 2.9 Flooding

*Submission number(s)*

33

### *Issue description*

The NSW Office of Water has requested that additional hydrological modelling be undertaken to assess the impacts of the proposal on flooding and the performance of any proposed flood mitigation measures.

### *Response*

Apart from the widening of the M4 Motorway between Ropers Road and M7 Westlink interchanges, the increase in impervious area associated with the proposal would be relatively minor in comparison to existing M4 Motorway pavement and the urban development outside the motorway corridor. Also the proposal would not modify current overland flow paths as the ramp upgrades would involve the extension and widening of existing ramps, rather than creating new earthwork formations that could potentially affect overland flows. However there may be some localised impacts on flooding from the proposal. In recognition of these impacts, as part of the proposal the existing water management basins have been increased in capacity to mitigate potential flooding impacts. Also new water detention basins would be provided for the widening of M4 Motorway between the Roper Road and Westlink M7 interchanges. During detailed design further assessment of potential flooding impacts would be undertaken including hydrological modelling where potential flooding risks from the proposal could occur. This would be predominately where the increase in impervious area due to the proposal within a local catchment is substantial – or where the proposal drains directly to a local council stormwater system. Flood mitigation measures such as increasing the volumes of existing water management basins would also be assessed for effectiveness.

## 2.10 Groundwater

### *Submission number(s)*

32

### *Issue description*

The NSW Office of Water concurs with the assessment the proposal is unlikely to have any impact on groundwater resources. It requests that they be consulted if any design changes result in potential risks to groundwater or the excessive inflow of groundwater is encountered during or post construction.

### *Response*

If during detailed design, any changes in the design of the proposal result in potential impacts on groundwater resources, the NSW Office of Water would be consulted. The Construction Environmental Management prepared for the proposal would include a requirement to consult with the NSW Office of Water if excessive groundwater inflow is encountered during or post construction.

## 2.11 Visual impacts

### 2.11.1 Impacts from increased illumination of ramps and lane use management systems

### *Submission number(s)*

11

### *Issue description*

The respondent was concerned about increased lighting impacts from the modified ramps and land use management systems.

### *Response*

There would be new sources of lighting due to the implementation of the proposal. These include the ramp signalling infrastructure (traffic signals and electronic signage), new Variable Message Signs and the lane use management system mounted on overhead gantries at regular intervals along the mainline M4 Motorway. It is recognised that new sources of lighting have the potential to cause visual impacts on sensitive receivers especially those in close proximity to ramps and interchanges.

To minimise these impacts the following measures would be implemented:

- Where possible new ITS infrastructure would be located to minimise lighting impacts
- ITS infrastructure would be designed to minimise light spill (eg the lane use signs would be hooded and only visible 15 degrees either side of the sign)
- Screening vegetation or noise walls would be located between light sources and sensitive receivers where possible.

It should also be noted that the ramp signalling would generally only be operational during peak periods. Peak periods occur during daylight hours or in the early evening. At other times the ramp signalling would be turned off, reducing lighting impacts.

Existing street lighting on or near the ramps would be re-located with some additional lighting proposed at locations where the entry ramps are being lengthened to comply with current standards. Similar mitigation measures to those described above would be implemented to minimise any street lighting impacts.

## 2.12 Heritage

### 2.12.1 Vibration and stability impacts on St Bartholomew's Church and Cemetery

#### *Submission number(s)*

35

#### *Issue description*

Blacktown City Council was concerned about vibration and stability impacts on the St Bartholomew's Church and Cemetery – and especially on graves along Ponds Road which have been impacted by previous works.

#### *Response*

The proposal would not involve any major construction works in the close proximity to St Bartholomew's Church and Cemetery. The only works planned for Ponds Road would be the installation of cable conduits for ITS infrastructure across Ponds Road at its intersection with Prospect Highway. This would involve the excavation of a 600mm wide and one metre deep trench across the road, the placement of cable

conduits and restoration of the road. These activities would not cause significant vibration or stability impacts – especially to graves along Ponds Road already affected by previous works.

The upgrade of the Prospect Highway eastbound entry ramp would involve earthworks and road construction and near the top of the ramp would be with 20 metres of the curtilage of St Bartholomew's Church and Cemetery. While the works would be further than 20 metres from the church itself and any graves, there is the potential for impact from vibration if the works are not managed appropriately.

To ensure that there are no impacts St Bartholomew's Church and Cemetery a number of mitigation measures are proposed. This includes the preparation and implementation of Non-Aboriginal Heritage Management Plan and a Construction Noise and Vibration Management Plan.

The Non-Aboriginal Heritage Management Plan will include but not be limited to the following:

- A map identifying locations of items or sites (including curtilages) which are to be protected and those which are to be destroyed/impacted and no-go zones
- Identification of potential environmental risks/impacts due to the works/activities
- Management measures to minimise the potential risk
- Mitigation measures to avoid risk of harm and the interface with work activities on site
- Implementation of mitigation measures to protect identified heritage items or areas
- Identify in toolbox talks where management of non-aboriginal heritage is required such as identification of no go zones and responsibilities under the *Heritage Act 1977* and any obtained permits or exemptions
- A stop works procedure in the event of actual or suspected potential harm to a heritage feature/place
- Requirement to comply with the Standard Management Procedure – Unexpected Archaeological Finds (Roads and Maritime, 2012).

The Construction Noise and Vibration Management Plan will include but not be limited to:

- A map indicating the locations of sensitive receivers including residential properties
- Mitigation measures to avoid noise and vibration impacts during construction activities including those associated with truck movements
- A process for assessing the performance of the implemented mitigation measures
- A process for documenting and resolving issues and complaints
- A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers
- A process for updating the plan when activities affecting construction noise and vibration change
- Identify in toolbox talks where noise and vibration management is required.

Further consultation would be undertaken with Blacktown City Council regarding the design and construction of works in the vicinity of St Bartholomew's Church and Cemetery.

## 2.12.2 Visual impacts on St Bartholomew's Church and Cemetery

### *Submission number(s)*

35

### *Issue description*

Blacktown City Council was concerned about visual impacts from ITS infrastructure on St Bartholomew's Church and Cemetery.

### *Response*

Based upon the concept design of the ITS infrastructure, some elements may be visible from the church and cemetery. This is likely to include one electronic sign on Prospect Highway, a LUMS gantry on the M4 Motorway and possibly the ramp signalling infrastructure on the Prospect Highway eastbound entry ramp. While the visual impact on the heritage significance of the St Bartholomew's Church and Cemetery has been assessed as minor, Roads and Maritime is committed to further minimising any visual impacts. This may include relocation of ITS infrastructure and/or planting of screening vegetation.

Further consultation would be undertaken during detailed design with Blacktown City Council regarding the location of ITS infrastructure and associated mitigation measures to minimise visual impacts on St Bartholomew's Church and Cemetery.

## 2.12.3 Noise mitigation at St Bartholomew's Church

### *Submission number(s)*

35

### *Issue description*

Blacktown City Council was concerned about the impacts of property treatments on St Bartholomew's Church to minimise noise.

### *Response*

The noise impact assessment in the REF identified that current and future noise from the M4 Motorway exceeds noise guidelines and St Bartholomew's Church qualifies for consideration of noise mitigation. While possible noise mitigation measures generally include noise walls, as St Bartholomew's Church is an isolated building on a hill it is unlikely that noise walls would be cost effective or would deliver the required noise mitigation. Therefore architectural treatment of the church would be required to meet noise mitigation guidelines. As St Bartholomew's Church is a State and locally listed heritage item, any architectural treatments would need to be undertaken to ensure that the heritage values and status of the church is not impacted. To ensure that the architectural treatment of St Bartholomew's Church is undertaken sympathetically and without heritage impact, a heritage architect would be engaged by Roads and Maritime to develop appropriate architectural treatments. This would also include consulting with Blacktown City Council, the church trust and the Heritage Branch. Once architectural treatments have been agreed upon, a revised Statement of Heritage Impact would be prepared – and if required, appropriate approvals under the Heritage Act would be obtained.

## 2.12.4 Impacts on heritage items

### *Submission number(s)*

36

### *Issue description*

OEH-Heritage Division recognised that the proposal would not directly impact State heritage listed items, however recommended that mitigation measures be developed for potential indirect impacts such as construction vibration, ground settlement, slump and visual impacts. They also recommended that a Construction Heritage Management Plan be prepared.

### *Response*

As presented in the REF, a number of management plans would be prepared that would address OEH's concerns. This includes the preparation and implementation of Non-Aboriginal Heritage Management Plan and a Construction Noise and Vibration Management Plan. The Non-Aboriginal Heritage Management Plan will include but not be limited to the following:

- A map identifying locations of items or sites (including curtilages) which are to be protected and those which are to be destroyed/impacted and no-go zones
- Identification of potential environmental risks/impacts due to the works/activities
- Management measures to minimise the potential risk
- Mitigation measures to avoid risk of harm and the interface with work activities on site
- Implementation of mitigation measures to protect identified heritage items or areas
- Identify in toolbox talks where management of non-aboriginal heritage is required such as identification of no go zones and responsibilities under the *Heritage Act 1977* and any obtained permits or exemptions
- A stop works procedure in the event of actual or suspected potential harm to a heritage feature/place
- Requirement to comply with the Standard Management Procedure - Unexpected Archaeological Finds (Roads and Maritime, 2012).

The Construction Noise and Vibration Management Plan will include but not be limited to:

- A map indicating the locations of sensitive receivers including residential properties
- Mitigation measures to avoid noise and vibration impacts during construction activities including those associated with truck movements
- A process for assessing the performance of the implemented mitigation measures
- A process for documenting and resolving issues and complaints
- A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers
- A process for updating the plan when activities affecting construction noise and vibration change
- Identify in toolbox talks where noise and vibration management is required.

## 2.13 Consultation

Numerous submissions received by Roads and Maritime requested additional and/or ongoing community consultation. Issues raised in these submissions and corresponding responses from Roads and Maritime, are provided below.

### 2.13.1 Community input into final design

#### *Submission number(s)*

2

#### *Issue description*

The respondent suggested that the community should be given the opportunity to provide input into the final design of the proposal.

#### *Response*

The display of the M4 Smart Motorway REF provide the community with the opportunity to provide input on the design of the proposal. As the proposal has been designed in consideration of relevant road design guidelines, the final design of the proposal is not likely to change substantially from what is proposed – and therefore it is not planned to have a further stage of community input into the design. However if there are substantial changes to the design, a supplementary REF would be prepared and exhibited and the community would have the opportunity to comment on the changes.

During the detailed design and construction, further input may be sought from the local community and property owners on specific design aspects of the proposal such as landscaping, noise barriers design and property treatments for noise.

### 2.13.2 Further consultation with other motorway operators

#### *Submission number(s)*

26

#### *Issue description*

Westlink M7 operators requested further consultation and communication during the detailed design, construction tendering, construction and operational phases.

#### *Response*

Roads and Maritime intends to undertake further consultation with the operators of Westlink M7 during the detailed design, construction tendering, construction and operational phases. This would be required as some of Westlink M7's assets would be directly impacted by the proposal and there may be additional traffic impacts during the construction of upgraded entry ramps. In addition, consultation would occur during the development of the operational procedures for the M4 Smart Motorway.

As part of the operational procedures, the Transport Management Centre (TMC) would provide real-time information to the Westlink M7 to ensure that the operations of both are effectively coordinated.

### 2.13.3 Further consultation with Councils

#### *Submission number(s)*

29

#### *Issue description*

Holroyd Council operators requested further details on the design of specific elements of the proposal (eg Cumberland Highway).

#### *Response*

During detailed design, further consultation would be undertaken with councils on the works proposed in their local government area. This would include intersections, footpaths, traffic signals, noise walls, signage and other infrastructure.

### 2.13.4 Lack of consultation

#### *Submission number(s)*

22, 24, 30

#### *Issue description*

A number of respondents complained that they were not sufficiently consulted about the proposal.

#### *Response*

A comprehensive consultation program was carried out to inform interested and affected stakeholders, residents, business, councils and others about the proposal, its impacts and benefits. This included doorknocking of residents and businesses adjacent to entry and exit ramp works as well as those adjacent to proposed construction compound locations, advertisements in local papers, a community update distributed to more than 50,000 properties along the proposal length, Roads and Maritime website, M4 Smart Motorway Facebook page, five community information sessions, dedicated briefings, 1800 number and dedicated email address. A detailed breakdown of the consultation activities carried out for the proposal is contained in Chapter 5 of the REF and in Section 1.3 of this report.

## 2.14 Construction impacts

### 2.14.1 Construction compound locations and impacts

#### *Submission number(s)*

12, 19, 21, 22, 24, 25, 31

#### *Issue description*

The respondents were concerned about potential construction impacts and risks from construction compounds near or adjacent to sensitive receivers and sensitive environments. This includes concerns about traffic, noise, dust, dangerous goods, clearing of vegetation and security. Concerns were raised about the potential construction compounds at Hollier Reserve, Simeon Road, Factory Road and Clyburn Avenue.

## *Response*

The REF has identified potential sites that may be used as compounds during construction of the proposal. Before construction commences, the contractor(s) selected by Roads and Maritime to construct the proposal would review the suitability of potential sites identified in the REF. Some of these potential sites may not be considered suitable for a compound and alternative sites may be selected and investigated. Further communication would be undertaken with potential nearby receivers during the selection and assessment of construction compounds to ensure that any issues are identified and appropriate mitigation measures can be developed.

Generally construction compounds would contain offices, amenities for workers, storage areas for materials (eg pipes, concrete barriers) and equipment and possibly a small store for dangerous goods. The bulk handling and processing of construction materials would not occur at construction compound sites. However, the size and potential uses of the construction compound site cannot be conclusively determined until a construction contractor is engaged.

The construction compounds would be located within the identified area and designed to minimise any clearing of vegetation and to minimise impact on nearby sensitive receivers. If an area has been identified as a green corridor or important for the movement of fauna, any clearing would be undertaken to minimise the width of clearing – and to provide opportunities for fauna to safely cross any accesses between construction sites and compounds.

Typically there would be up to 10 heavy vehicle movements a day to a construction compound, mainly delivering equipment and some construction materials (eg pipes, concrete barriers). The vast majority of heavy vehicle movements associated with the upgrade works would deliver materials directly to the construction site on the ramp, rather than to the compound. Generally, parking would be provided in the construction compound for workers and plant, however it is recognised that in some locations that there would be insufficient areas to provide parking. In some locations parking on local roads may be required. A Construction Traffic Management Plan would be prepared to minimise the impacts of construction traffic on local roads, arterial roads and the motorway.

Most works associated with the upgrade of the ramps would be undertaken during standard construction hours (7am to 6pm Monday to Friday and 8am to 1pm on Saturday). However some works would be required outside these hours during low traffic periods. Access to the construction compound would be required when works are occurring. Project specific noise monitoring was undertaken for the preparation of the noise assessment of the REF (refer to the Noise and Vibration Working Paper for locations) and this may be supplemented by further noise monitoring before construction commences. The noise monitoring would be used in the further assessment of the construction work impacts in the Construction Noise and Vibration Monitoring Plan and to develop appropriate site specific mitigation measures to minimise impacts on sensitive receivers.

Any existing security arrangements (eg fencing) would be modified to maintain the security of the area and construction compound.

Dust generation from the construction compounds would be minimised through the provision of hard stand surfaces.

The suite of construction environmental management plans would be prepared and implemented covering environmental aspects such as biodiversity, traffic, noise, dust,

and soil and water management. These plans would include consideration of construction compounds and site specific mitigation measures to minimise the impacts of construction compounds.

## 2.14.2 Construction traffic management plans

### *Submission number(s)*

29, 31

### *Issue description*

One respondent (Holroyd Council) requested that they be consulted on construction traffic management plans and local road closures. Another respondent expressed concerns that the intersection of Frogmore Road and The Northern Road would be impacted during construction.

### *Response*

The Australian Government is funding a \$200 million Local Roads Package as part of the Western Sydney Infrastructure Plan linked to the development of the western Sydney airport, at Badgerys Creek. As part of this funding package, Penrith City Council was granted \$1.1 million to carry out a traffic, safety and scoping study for the section of The Northern Road between the M4 Motorway and the Great Western Highway. This section includes the intersection of The Northern Road and Frogmore Road.

A Construction Traffic Management Plan (CTMP) would be prepared before construction commences. The CTMP will be prepared in accordance with the Roads and Maritime Traffic Control at Work Sites (Roads and Maritime, 2010a) and Roads and Maritime Specification G10 - Control of Traffic, to provide a comprehensive and objective approach to minimise any potential impacts on-road network operations during construction. The CTMP will include (as a minimum):

- Measures to minimise heavy vehicle usage on local roads. Where practicable, deliveries of construction plant and materials will be carried out outside of peak traffic periods
- Consultation with emergency services and maintenance of access for emergency vehicles
- Traffic control provided to manage and regulate traffic movements during construction, including minimising traffic switching
- Maintain the continuous, safe and efficient movement of traffic for both the public and construction workers
- Entry and exit ramps to/from the M4 Motorway to generally remain open throughout the construction period with suitable alternative access arrangement provided where this is not achievable
- Haulage routes/access arrangements to minimise impacts on local routes
- Access to local roads and properties will be considered when determining the final location of construction compounds
- Construction and delivery vehicles entering/leaving site compounds, and/or stockpile sites to be limited in peak periods
- Access to local roads and properties will be maintained, where practicable
- Maintain pedestrian and cyclists access throughout construction, with adequate planning and consultation undertaken relating to any temporary detours
- Provision of appropriate warning and advisory signposting

- Include requirements and methods to consult and inform local community of impacts on local road network and traffic
- Consider other developments that may also be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic.

As there would be a large number of construction areas along the length of the M4 Motorway it is likely that an overarching CTMP would be prepared, with individual CTMPs prepared for each construction area.

Where appropriate these plans would be prepared in consultation with the relevant council to ensure that any local issues are identified and considered – and also to provide council's with information on the proposed traffic management measures. Where a temporary local road closure is required, council would generally be required to provide approval for closure as it the road authority responsible for local roads.

### 2.14.3 Construction noise impacts

#### *Submission number(s)*

21, 31

#### *Issue description*

The respondents were concerned about potential construction noise impacts from the proposal.

#### *Response*

During construction of the proposal some sensitive receivers would experience increased noise from construction activities. The most affected sensitive receivers would be near the ramp upgrade construction sites and the widening of the motorway between the Roper Road and Westlink M7 interchanges. Some construction activities would exceed the noise goals specified in the Interim Construction Noise Guidelines (DECC, 2009) at some sensitive receivers. Section 6.5.2 of the REF details potential exceedances at specific locations and for specific construction activities. It should be recognised that these exceedances are worst case predictions and may only occur for short periods.

To minimise construction and noise impacts a Construction Noise and Vibration Management Plan (CNVMP) will be prepared as part of the CEMP. This plan will include but not be limited to:

- A map indicating the locations of sensitive receivers including residential properties
- A quantitative noise assessment in accordance with the Interim Construction Noise Guidelines (DECCW, 2009)
- Management measures to minimise the potential noise impacts from the quantitative noise assessment and for potential works outside of standard working hours (including implementation of Interim Construction Noise Guidelines (DECCW, 2009)
- A risk assessment to determine potential risk for activities likely to affect receivers (for activities undertaken during and outside of standard working hours)

- Mitigation measures to avoid noise and vibration impacts during construction activities including those associated with truck movements
- A process for assessing the performance of the implemented mitigation measures
- A process for documenting and resolving issues and complaints
- A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers
- A process for updating the plan when activities affecting construction noise and vibration change
- Identify in toolbox talks where noise and vibration management is required.

#### 2.14.4 Impacts on waterways during construction

##### *Submission number(s)*

32

##### *Issue description*

The respondent (NSW Office of Water) identified that there may be impacts on waterways during construction including sediment and erosion impacts and impacts on the bank stability of waterways.

##### *Response*

While identifying there may be impacts on waterways from the proposal, NSW Office of Water also recognises that major civil works associated with the proposal largely avoid direct impacts on waterways. All of the interchanges and associated ramp upgrades are located away from waterways and therefore no major works are required in waterways. However as identified in the REF some of the ramp upgrade works would be near waterways. The other two components of the proposal that present the greatest risk to waterways are the M4 Motorway widening between Roper Road and M7 Westlink and the installation of the ITS infrastructure.

To minimise risks to waterways from sediment and erosion impacts a Soil and Water Management Plan (SWMP) will be prepared as part of the CEMP in accordance with the requirements of the Roads and Maritime contract specification G38 prior to the commencement of construction. The SWMP will also address the following:

- Code of Practice for Water Management (Roads and Maritime, 1999)
- , the Roads and Maritime Erosion and Sedimentation Procedure
- The NSW Soils and Construction – Managing Urban Stormwater Volume 1 “the Blue Book” (Landcom, 2004) and Volume 2 (DECC, 2008)
- Technical Guideline: Temporary Stormwater Drainage for Road Construction (Roads and Maritime, 2011)
- Technical Guideline: Environmental Management of Construction Site Dewatering (Roads and Maritime, 2011).

The SWMP will detail the following as a minimum:

- Identification of catchment and sub-catchment areas, high risk areas and sensitive areas
- Sizing of each of the above areas and catchment
- The likely volume of run-off from each road sub-catchment
- Direction of flow of on-site and off-site water

- Separation of on-site and off-site water
- The direction of run-off and drainage points during each stage of construction
- The locations and sizing of sediment traps such as sump or basin as well as associated drainage
- Dewatering plan which includes process for monitoring, flocculating and dewatering water from site (ie sediment basin and sumps)
- The staging plans, location, sizing and details of creek alignment and realignment controls for scour protection and bank and bed stabilisation including those used during construction and long term.
- A mapped plan identifying the above
- Include progressive site specific Erosion and Sedimentation Control Plans (ESCPs). The ESCP is to be updated at least fortnightly.
- A process to routinely monitor the BOM weather forecast
- Preparation of a wet weather (rain event) plan which includes a process for monitoring potential wet weather and identification of controls to be implemented in the event of wet weather. These controls are to be shown on the ESCPs
- Provision of an inspection and maintenance schedule for ongoing maintenance of temporary and permanent erosion.

At this stage there are no works planned directly within a waterway and it is not expected that bank and bed stability of waterways would be impacted. The current proposal provides for ITS infrastructure, including conduits and cabling to be attached to existing bridge structures. However if during detailed design, works within a waterway or in a riparian zone are required, appropriate measures would be included to minimise disturbance to the riparian waterway environments including soft engineering solutions to maintain bed and bank stability. Rehabilitation work on the riparian vegetation communities would also be undertaken to maintain the condition of the existing riparian creek environment.

Any works for pipes and the ITS infrastructure cable would be carried out in consideration with the *Guidelines for Controlled Activities - guidelines for laying pipes and cables on waterfront land*.

#### 2.14.5 Consultation during construction

*Submission number(s)*

29

*Issue description*

The respondent (Holroyd Council) requested that consultation with residents, business owners and other stakeholders continue during the construction period.

*Response*

As noted in the REF, a Communication Plan will be prepared and included in the CEMP. The Communication Plan will include (as a minimum):

- Requirements to provide details and timing of proposed activities to affected residents, business and other stakeholders
- A complaint handling procedure including a contact name and number
- A procedure to notify adjacent land users for changed conditions during the construction period such as traffic, pedestrian or driveway access.

The communication plan will be prepared in accordance with G36 requirements and Community Engagement and Communications Manual (Roads and Maritime, 2012).

Further consultation would also be undertaken if there are any substantial changes to the design of the proposal.

Also, as part the development of noise mitigation measures, further consultation would be undertaken with affected sensitive receivers to inform them of the outcomes of final noise assessment and mitigation options. Where a property has been identified as requiring treatment for noise mitigation, property owners and/or residents would be consulted on the type and timing for property treatments.

#### 2.14.6 Community input into funding of proposal

##### *Submission number(s)*

2

##### *Issue description*

The respondent suggested that the community should be given the opportunity to comment on the proposed funding of the proposal, namely whether it should be funded by reintroduced tolls or from existing taxes.

##### *Response*

The current concept design and environmental assessment phase of the M4 Smart Motorway project is jointly funded by the Australian and NSW governments. There would be no toll introduced to the M4 Motorway as part of this proposal, though there would be a toll introduced on the M4 Motorway east of Church Street as part of the WestConnex project.

The NSW Government has made a \$395 million Rebuilding NSW funding allocation towards the M4 Smart Motorway project. No further community input into the funding of the proposal is proposed.

## 3 Changes to the proposal

---

Since the display of the REF, Roads and Maritime have made refinements to the proposal. These refinements are shown in Figure 3-1 and Figure 3-2 and are discussed in further detail below.

### 3.1 Modifications to noise walls

#### 3.1.1 Description

The location and extent of noise walls included as part of the proposal has been modified based upon the outcomes of the Construction and Operational Road Traffic Noise and Vibration Impact Assessment (SLR, 2015). This includes potential new noise walls identified in the noise assessment. Details of the potential noise wall locations are provided in Figure 3-1 and Figure 3-2. As discussed in Section 2, the operational noise assessment and identification of noise mitigation measures (including the location and height of new noise walls) would be repeated during the detailed design using the final detailed design and any changes in traffic numbers. Based upon this final noise assessment, the final location and height of new and existing noise walls would be determined.

To ensure that the impacts of new noise walls are assessed, the clearing estimates in the Biodiversity Assessment have been updated to include the new noise walls (refer to Section 4). The visual impact of the new noise walls have also been assessed in Section 4.

### 3.2 Minor changes to the location of ITS infrastructure

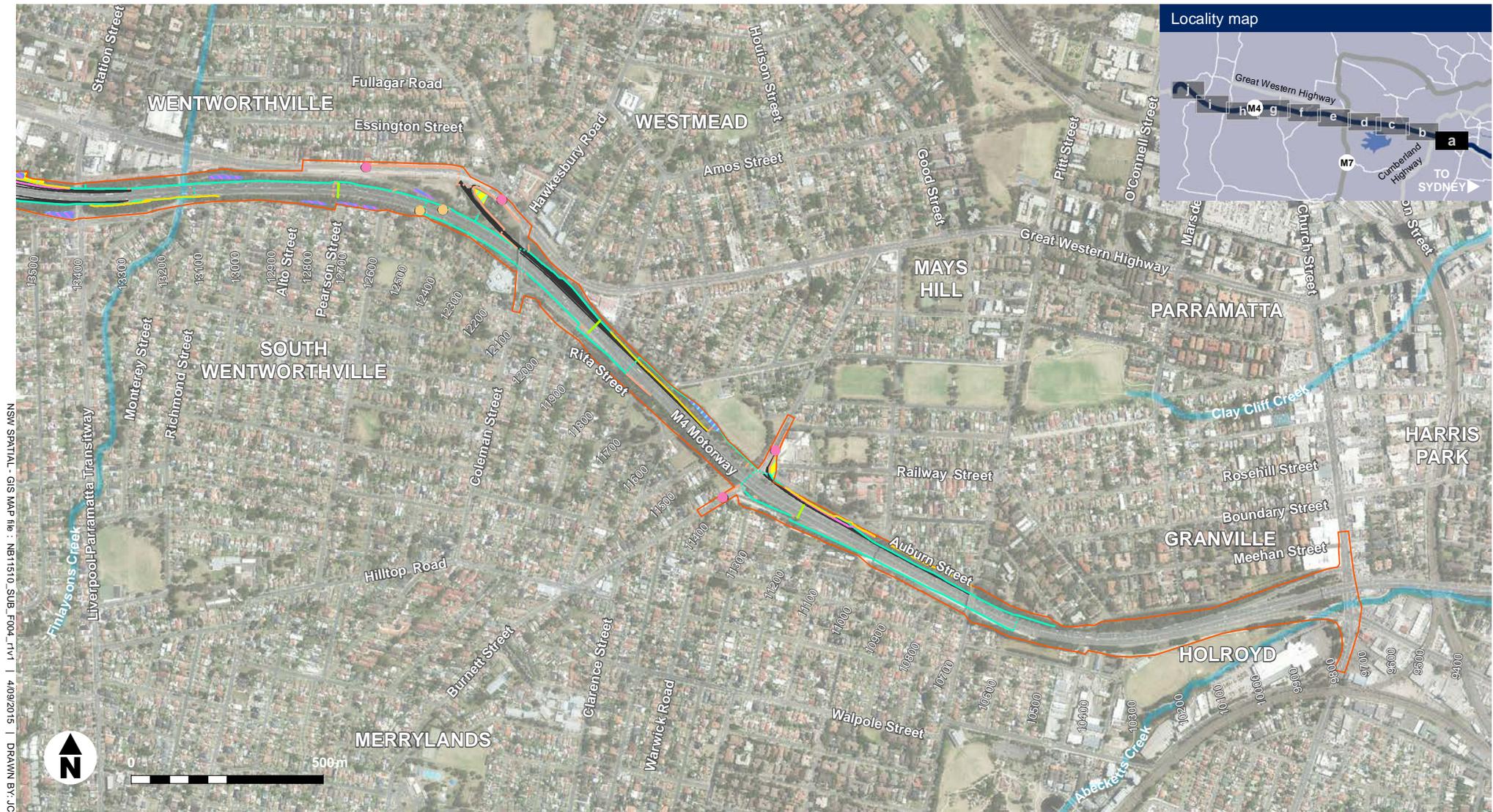
#### 3.2.1 Description

Details of ITS infrastructure included as part of the proposal is provided in Section 3.2 of the REF. The location of some of the ITS infrastructure within the M4 Motorway corridor has been modified as a result of the review of the concept design. Changes to the location of ITS infrastructure are minor and are confined to within the existing M4 Motorway corridor. Generally the changes include the relocation of the ITS primary and secondary backbones to minimise impacts, improve accessibility, and integrate with the civil works.

As a result of the modified ITS locations, the revised Biodiversity Assessment includes a recalculation of clearing estimates (refer to Appendix B).

### 3.3 Other design refinements

A number of other minor refinements to the design of the proposal have been made since the display of the REF (refer to Figure 3-1 and Figure 3-2). These generally include changes to drainage design, changes to road design and minor adjustments to the height and extent of retaining walls.



NSW SPATIAL - GIS MAP file : NB11510.SUB\_F004\_T1V1 | 4/09/2015 | DRAWN BY: JC

Figure 3-1a Revised preliminary layout of ITS infrastructure on the mainline

- |   |                                 |   |  |   |                          |   |                                     |
|---|---------------------------------|---|--|---|--------------------------|---|-------------------------------------|
|  | The proposal area               |  | Lane use signs mounted on gantry structure   |  | ITS backbone (trench)    |  | Relocated or modified noise wall    |
|  | New or resurfaced road          |  | Variable message signs   |  | ITS backbone (underbore) |  | Existing noise wall to be relocated |
|  | Potential construction compound |  | Approximate location of 3 x 1 metre electronic signs<br>Exact location to be determined during detailed design |  | ITS spur (trench)        |  | Proposed drainage basin             |
|   |                                 |   |  |  | ITS spur (underbore)     |  | Existing drainage basin             |

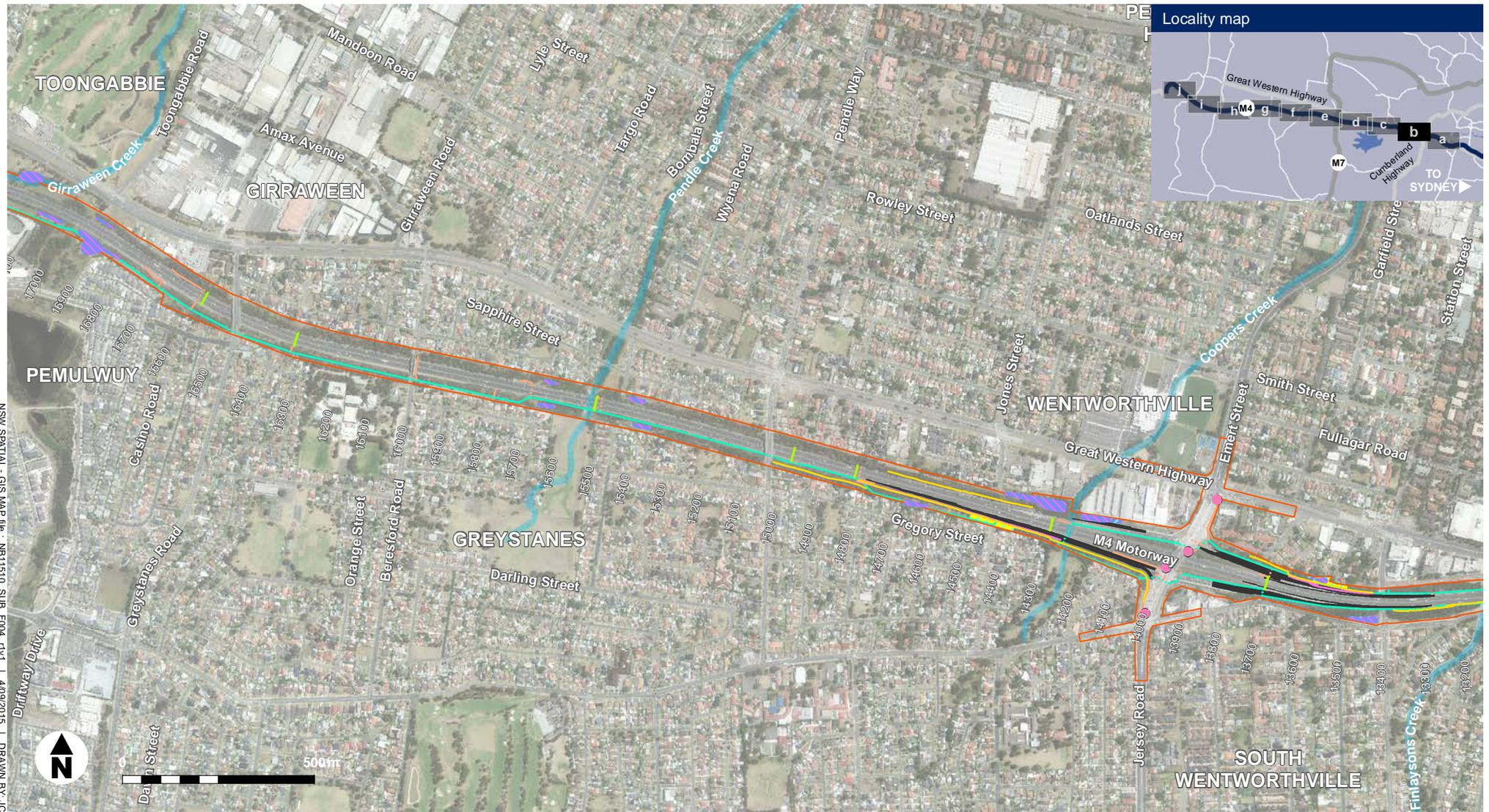


Figure 3-1b Revised preliminary layout of ITS infrastructure on the mainline

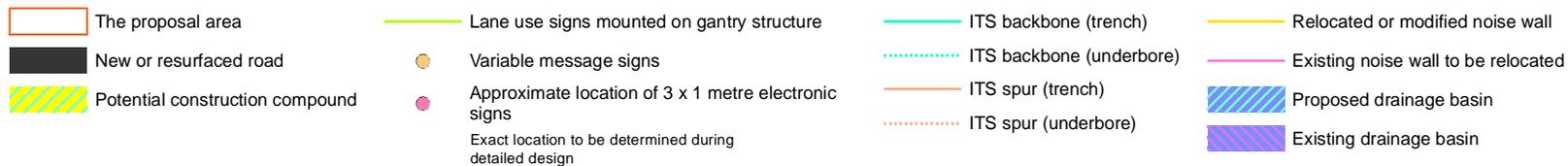
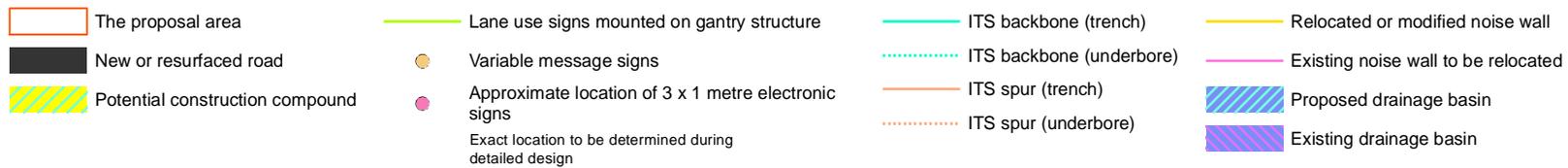
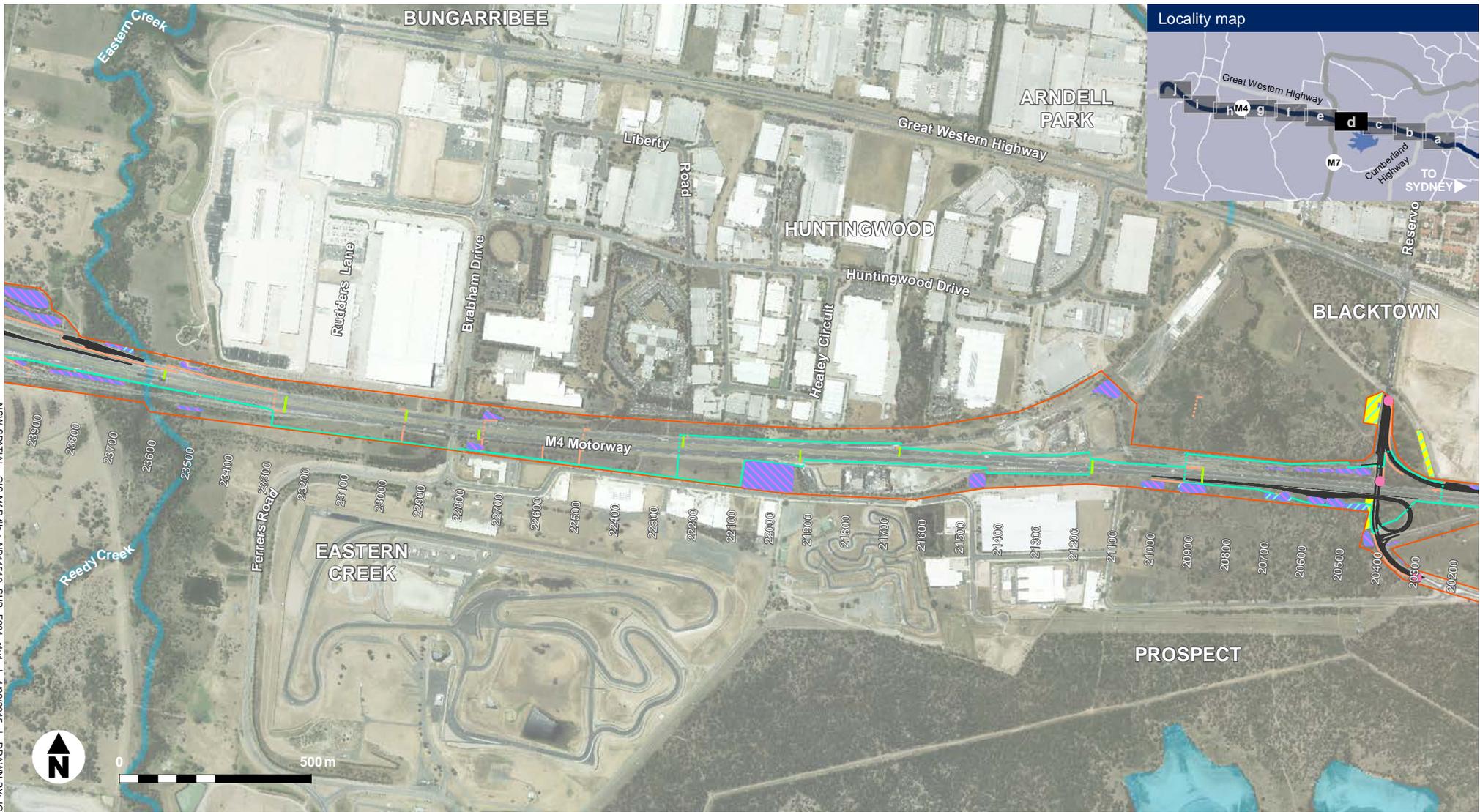




Figure 3-1c Revised preliminary layout of ITS infrastructure on the mainline





NSW SPATIAL - GIS MAP file : NB11510.SUB\_F004\_L1V1 | 4/09/2015 | DRAWN BY: JC

Figure 3-1d Revised preliminary layout of ITS infrastructure on the mainline

- |   |  |  |   |
|---|--|--|---|
|  The proposal area               |  Lane use signs mounted on gantry structure   |  ITS backbone (trench)    |  Relocated or modified noise wall    |
|  New or resurfaced road          |  Variable message signs   |  ITS backbone (underbore) |  Existing noise wall to be relocated |
|  Potential construction compound |  Approximate location of 3 x 1 metre electronic signs<br>Exact location to be determined during detailed design |  ITS spur (trench)        |  Proposed drainage basin             |
|   |  |  ITS spur (underbore)     |  Existing drainage basin             |

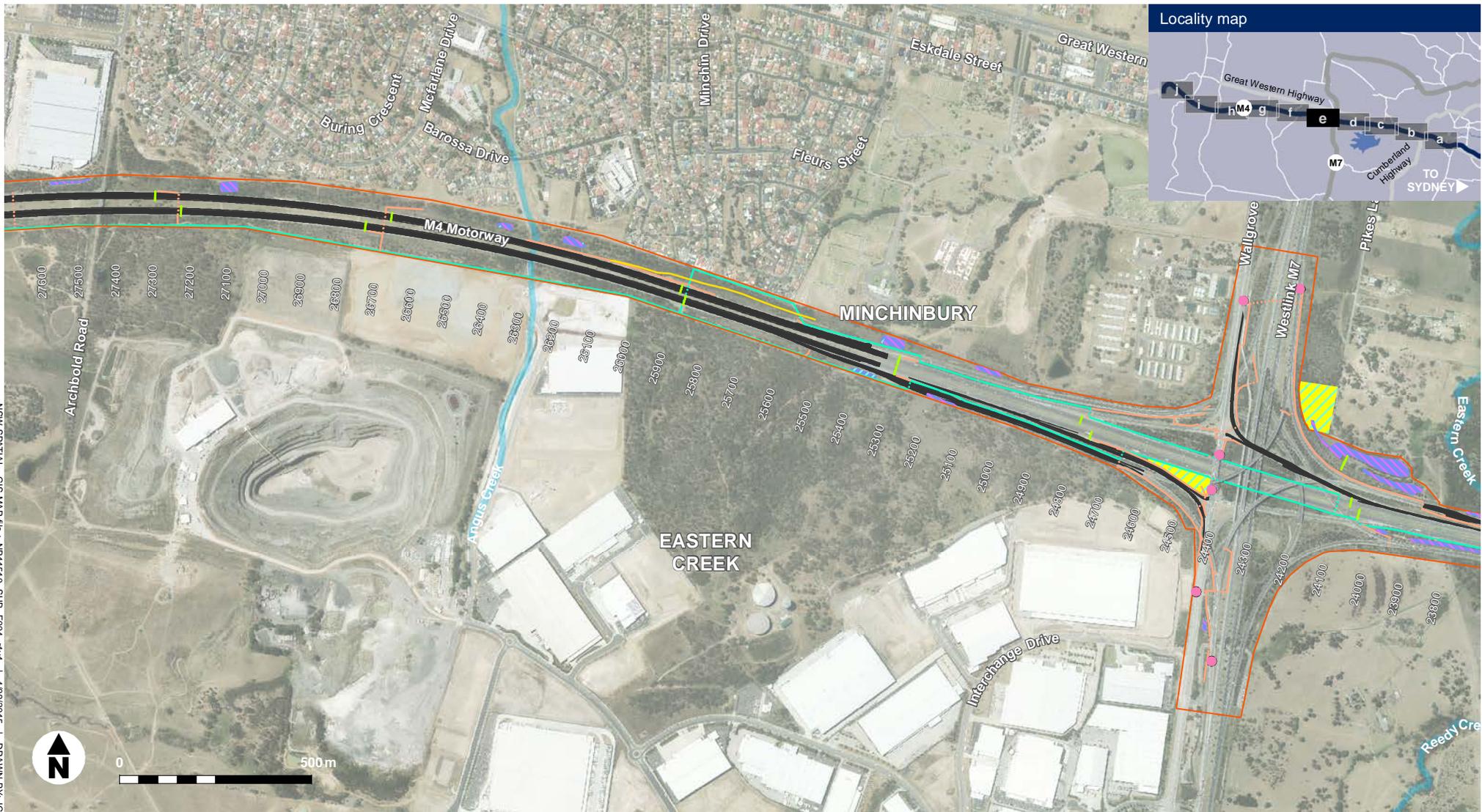


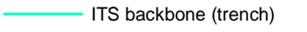
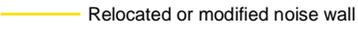
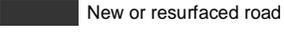
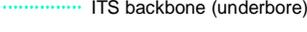
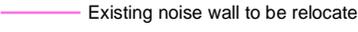
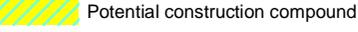
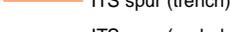
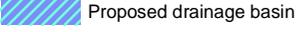
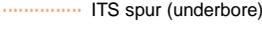
Figure 3-1e Revised preliminary layout of ITS infrastructure on the mainline

- |   |                                 |   |  |   |                          |   |                                     |
|---|---------------------------------|---|--|---|--------------------------|---|-------------------------------------|
|  | The proposal area               |  | Lane use signs mounted on gantry structure   |  | ITS backbone (trench)    |  | Relocated or modified noise wall    |
|  | New or resurfaced road          |  | Variable message signs   |  | ITS backbone (underbore) |  | Existing noise wall to be relocated |
|  | Potential construction compound |  | Approximate location of 3 x 1 metre electronic signs<br>Exact location to be determined during detailed design |  | ITS spur (trench)        |  | Proposed drainage basin             |
|   |                                 |   |  |  | ITS spur (underbore)     |  | Existing drainage basin             |



NSW SPATIAL - GIS MAP file : NB11510.SUB\_F004\_L1V1 | 4/09/2015 | DRAWN BY: JC

Figure 3-1f Revised preliminary layout of ITS infrastructure on the mainline

- |   |  |  |   |
|---|--|--|---|
|  The proposal area               |  Lane use signs mounted on gantry structure   |  ITS backbone (trench)    |  Relocated or modified noise wall    |
|  New or resurfaced road          |  Variable message signs   |  ITS backbone (underbore) |  Existing noise wall to be relocated |
|  Potential construction compound |  Approximate location of 3 x 1 metre electronic signs<br>Exact location to be determined during detailed design |  ITS spur (trench)        |  Proposed drainage basin             |
|   |  |  ITS spur (underbore)     |  Existing drainage basin             |



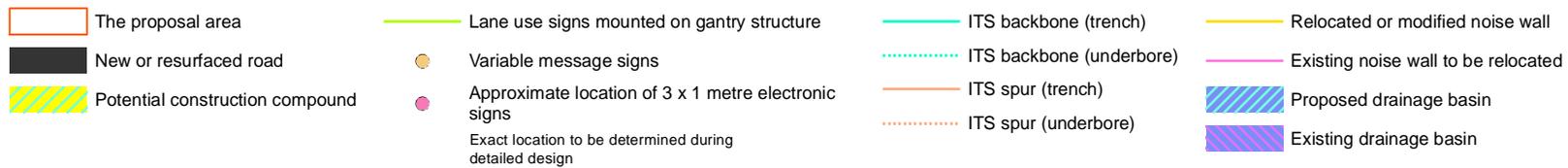
NSW SPATIAL - GIS MAP file : NB11510.SUB\_F004\_L1V1 | 4/09/2015 | DRAWN BY: JC

Figure 3-1g Revised preliminary layout of ITS infrastructure on the mainline

- |   |                                 |   |  |   |                          |   |                                     |
|---|---------------------------------|---|--|---|--------------------------|---|-------------------------------------|
|  | The proposal area               |  | Lane use signs mounted on gantry structure   |  | ITS backbone (trench)    |  | Relocated or modified noise wall    |
|  | New or resurfaced road          |  | Variable message signs   |  | ITS backbone (underbore) |  | Existing noise wall to be relocated |
|  | Potential construction compound |  | Approximate location of 3 x 1 metre electronic signs<br>Exact location to be determined during detailed design |  | ITS spur (trench)        |  | Proposed drainage basin             |
|   |                                 |   |  |  | ITS spur (underbore)     |  | Existing drainage basin             |



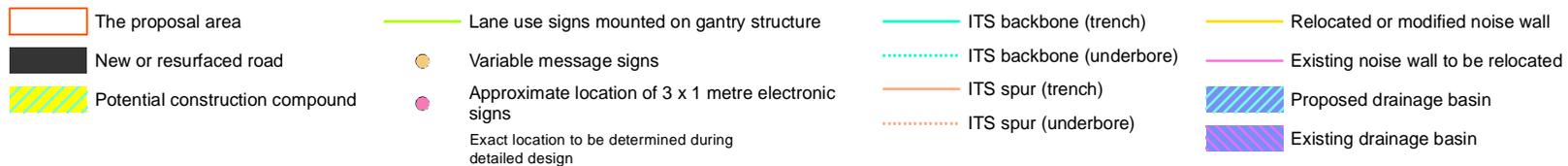
Figure 3-1h Revised preliminary layout of ITS infrastructure on the mainline





NSW SPATIAL - GIS MAP file : NB11510.SUB\_F004\_L1V1 | 4/09/2015 | DRAWN BY: JC

Figure 3-1i Revised preliminary layout of ITS infrastructure on the mainline



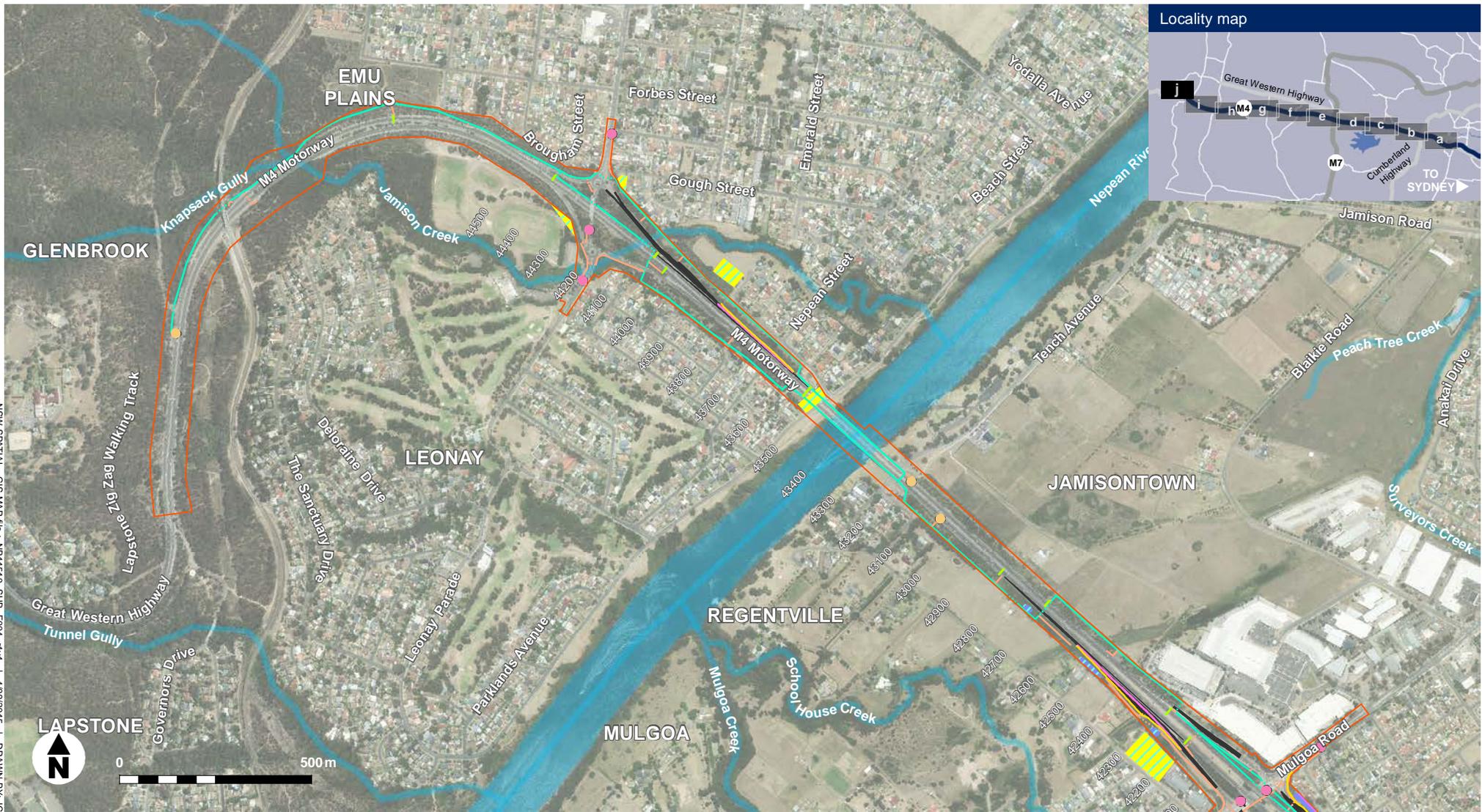


Figure 3-1j Revised preliminary layout of ITS infrastructure on the mainline

- |   |                                 |   |  |   |                          |   |                                     |
|---|---------------------------------|---|--|---|--------------------------|---|-------------------------------------|
|  | The proposal area               |  | Lane use signs mounted on gantry structure             |  | ITS backbone (trench)    |  | Relocated or modified noise wall    |
|  | New or resurfaced road          |  | Variable message signs                                 |  | ITS backbone (underbore) |  | Existing noise wall to be relocated |
|  | Potential construction compound |  | Approximate location of 3 x 1 metre electronic signs   |  | ITS spur (trench)        |  | Proposed drainage basin             |
|   |                                 |   | Exact location to be determined during detailed design |  | ITS spur (underbore)     |  | Existing drainage basin             |

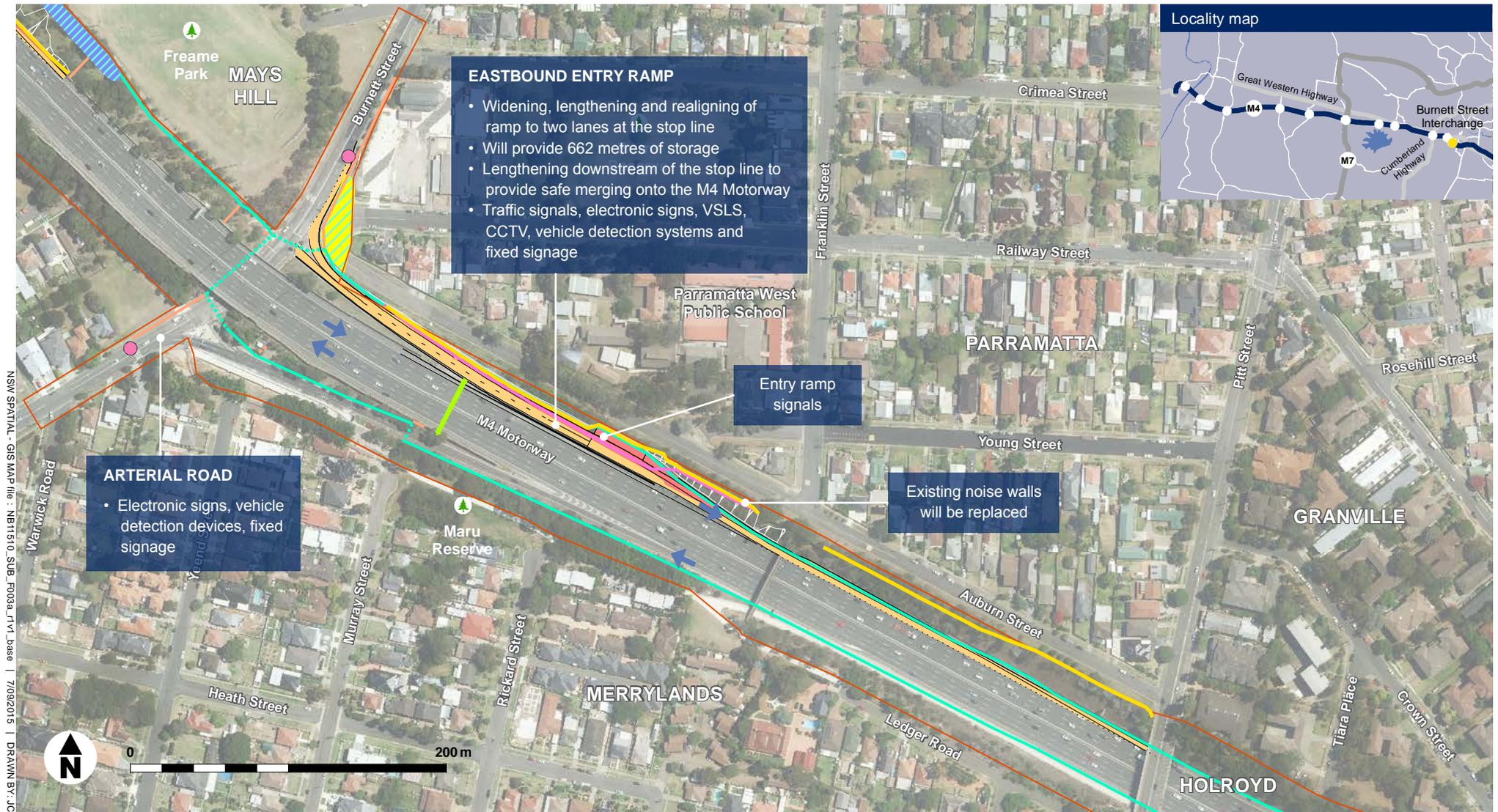
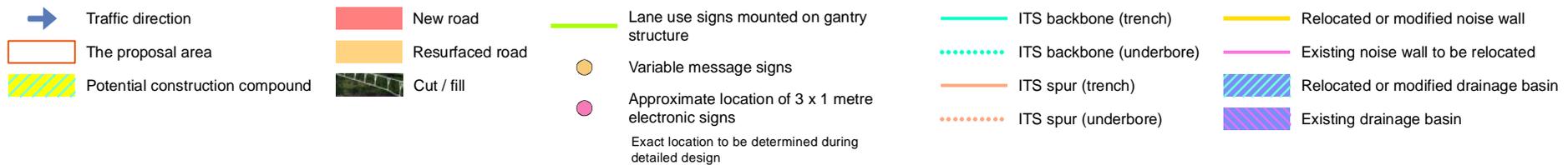


Figure 3-2a Burnett Street interchange upgrade



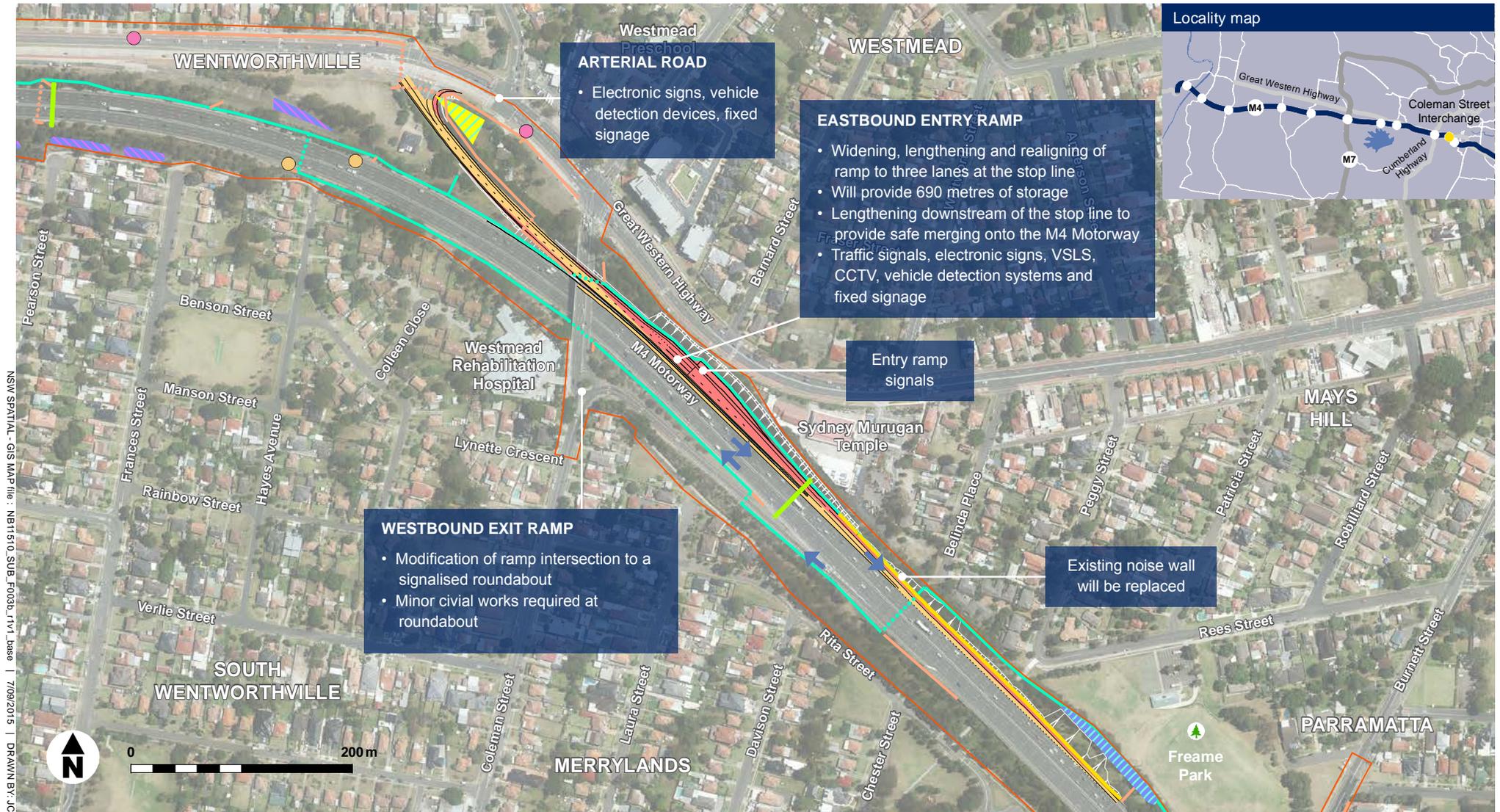


Figure 3-2b Coleman Street interchange upgrade



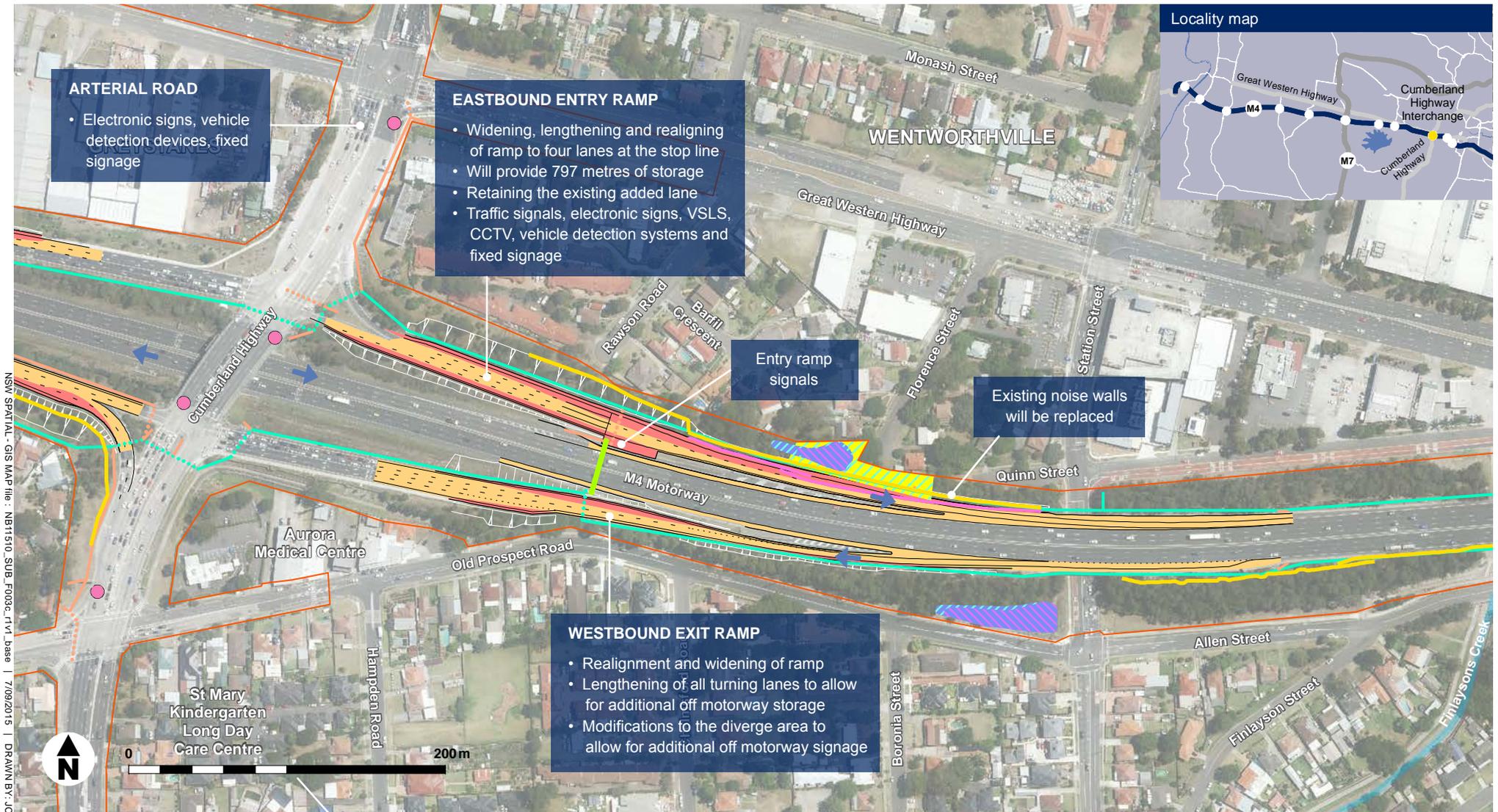
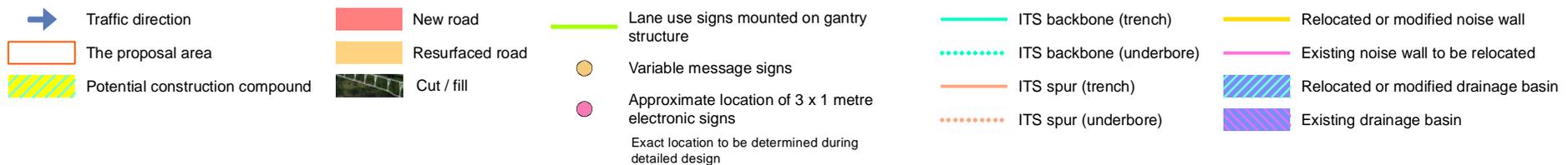


Figure 3-2c East of Cumberland Highway interchange upgrade



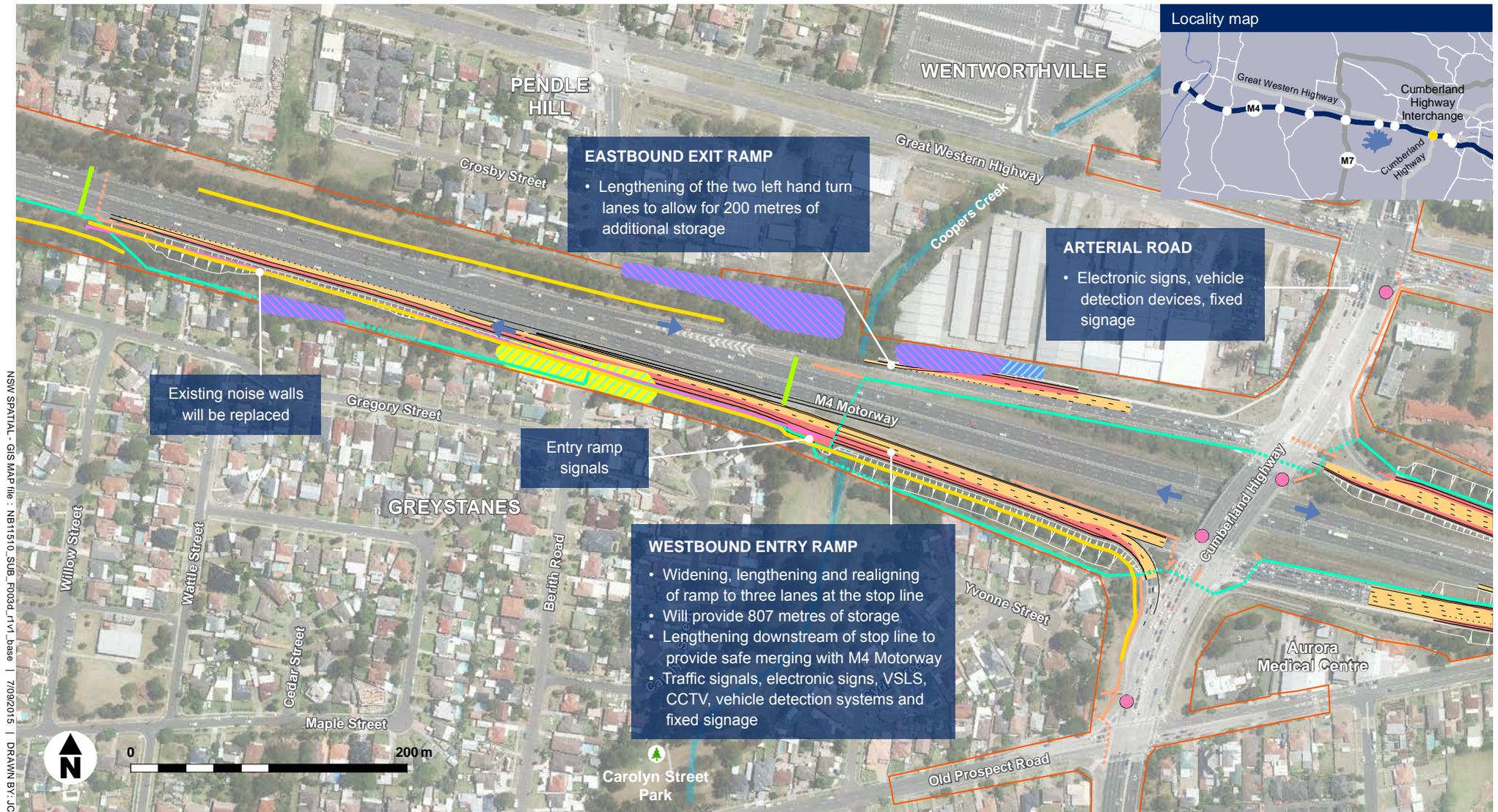
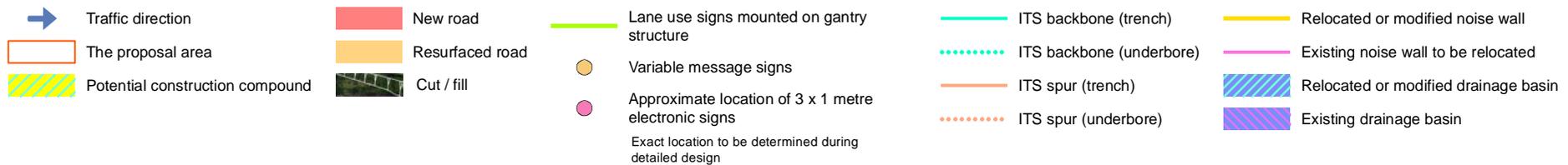


Figure 3-2d West of Cumberland Highway interchange upgrade



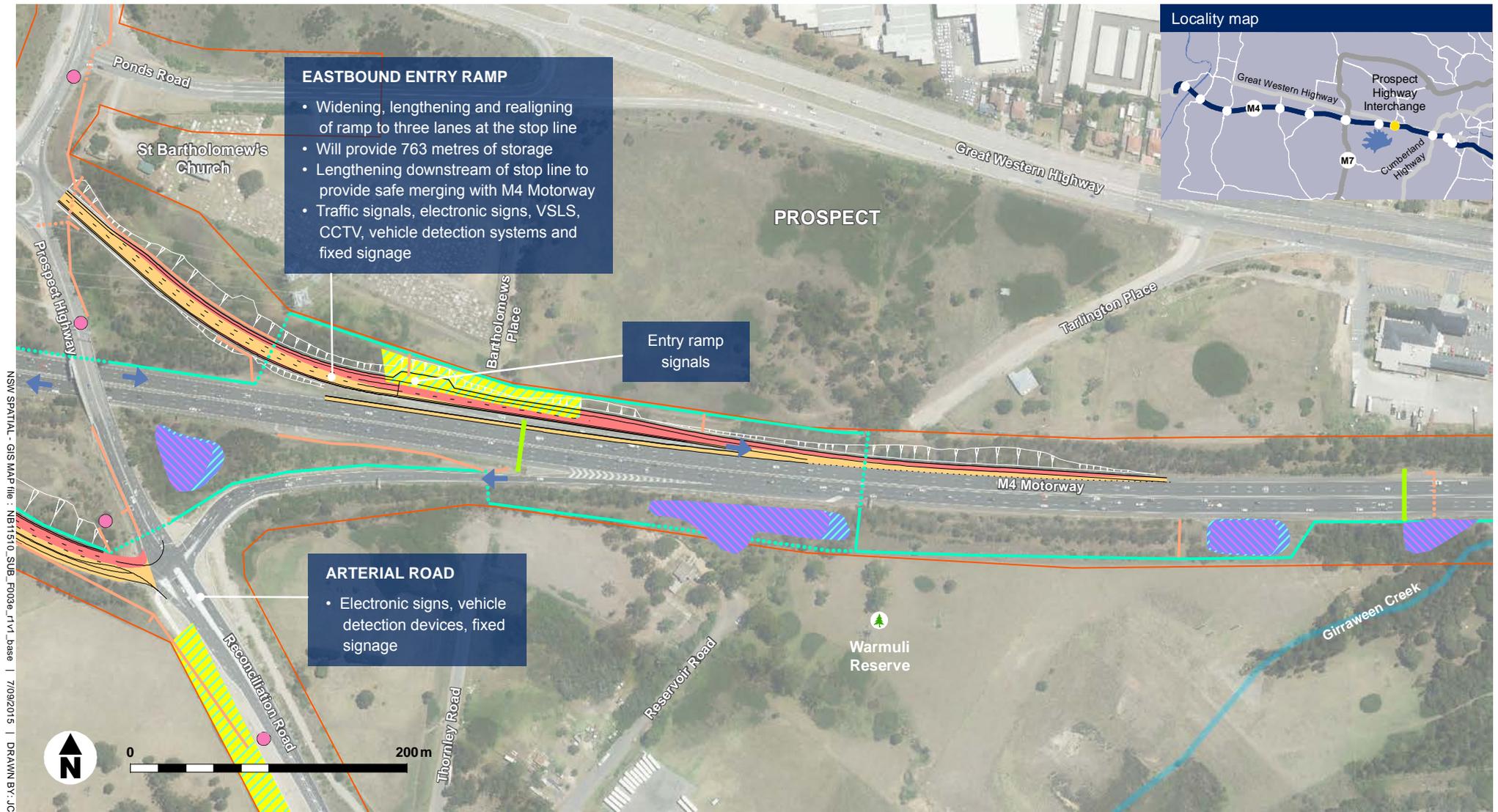
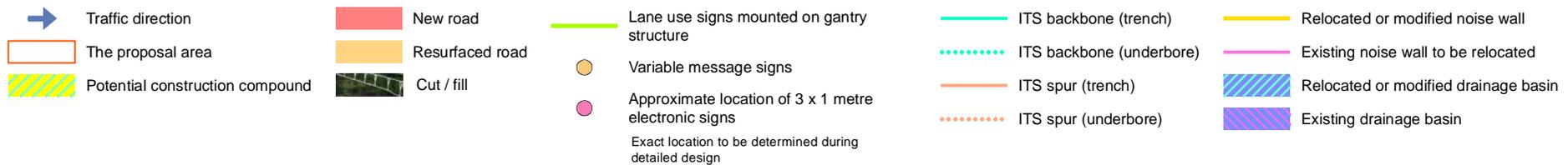


Figure 3-2e East of Prospect Highway interchange upgrade



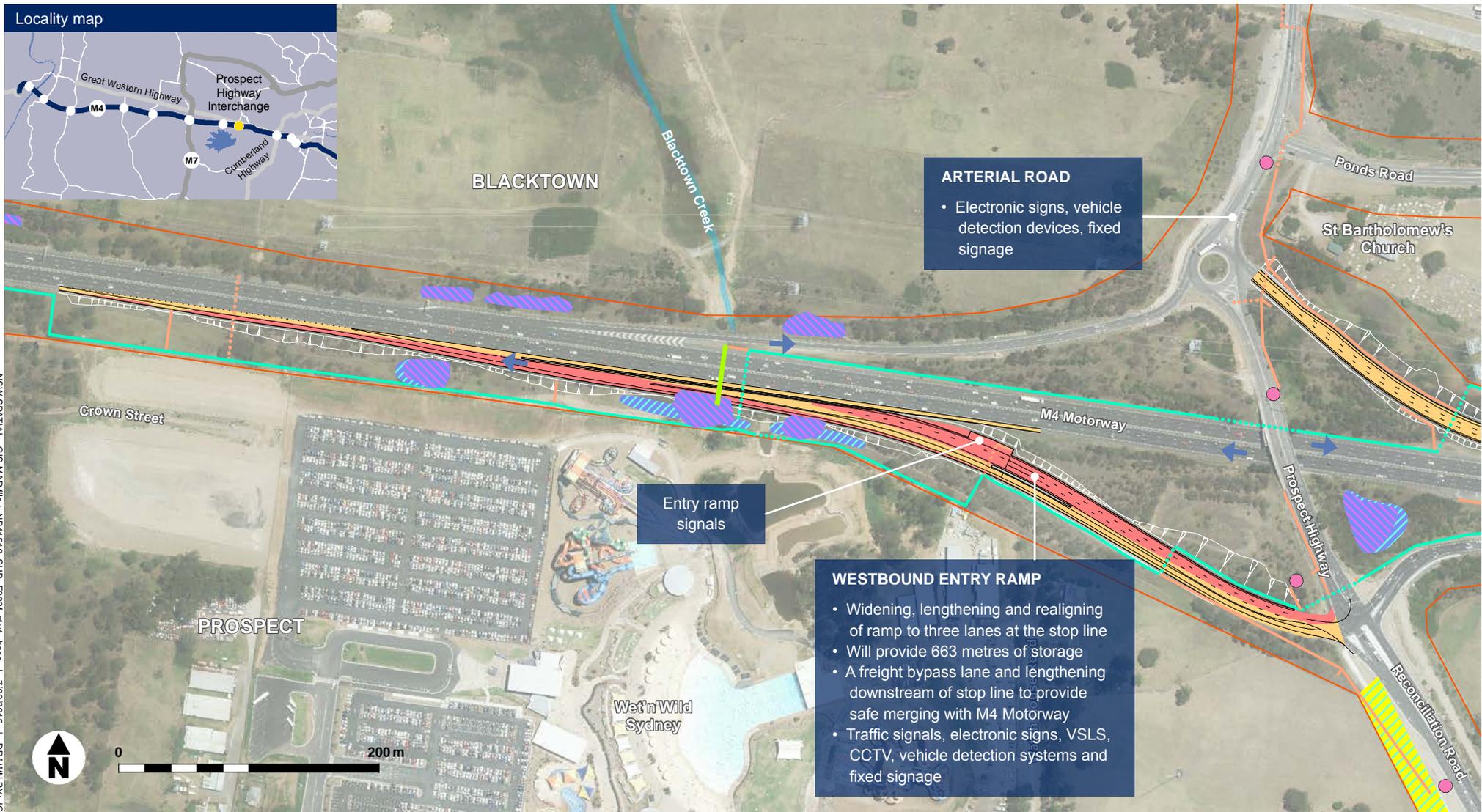
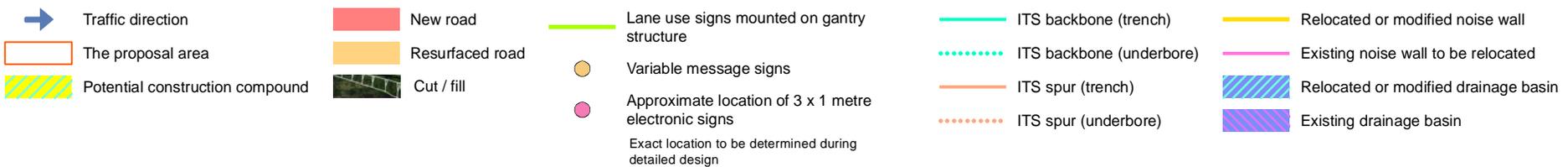


Figure 3-2f West of Prospect Highway interchange upgrade



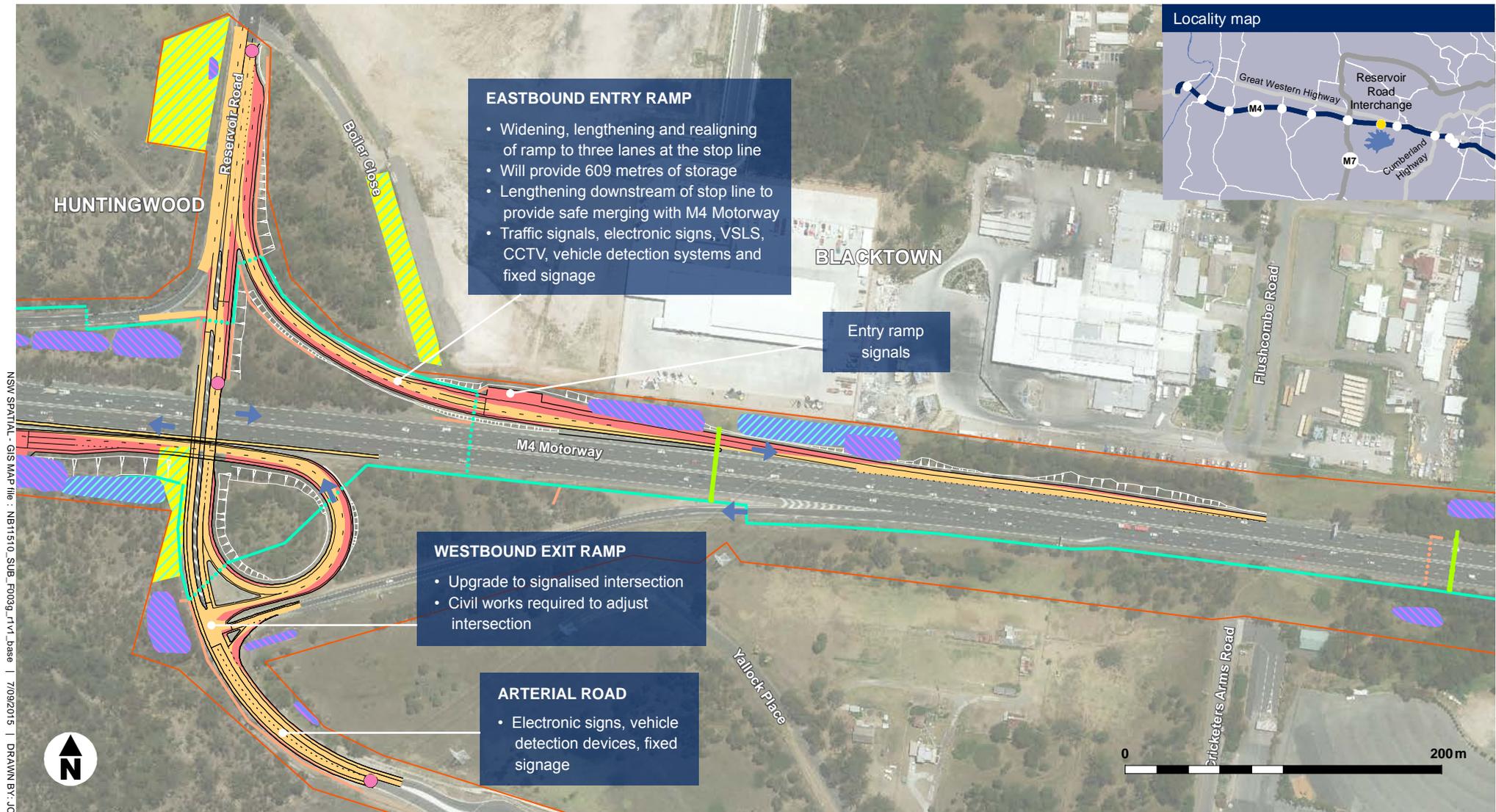
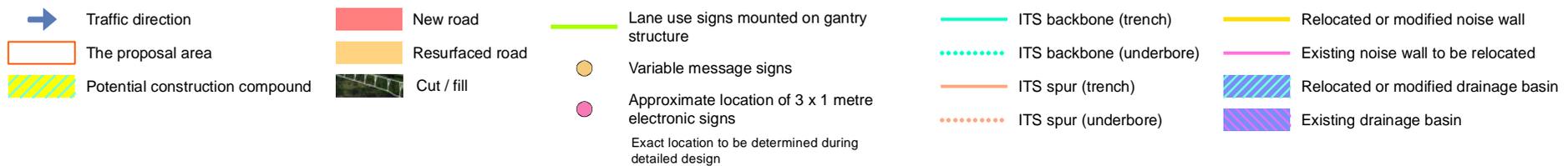


Figure 3-2g East of Reservoir Road interchange upgrade



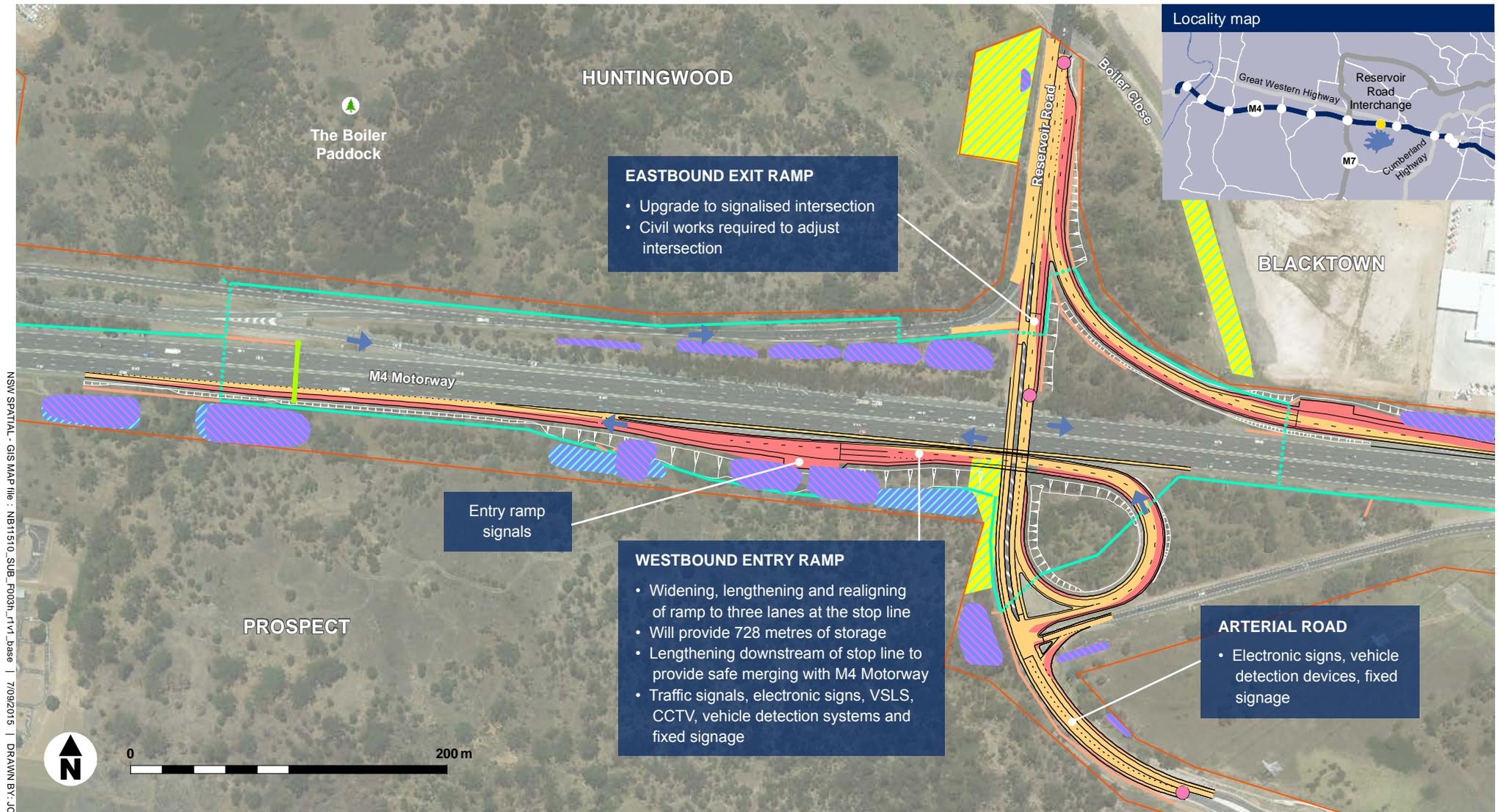
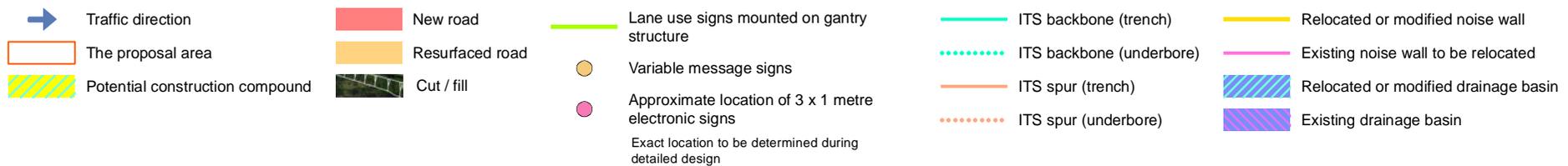


Figure 3-2h West of Reservoir Road interchange upgrade



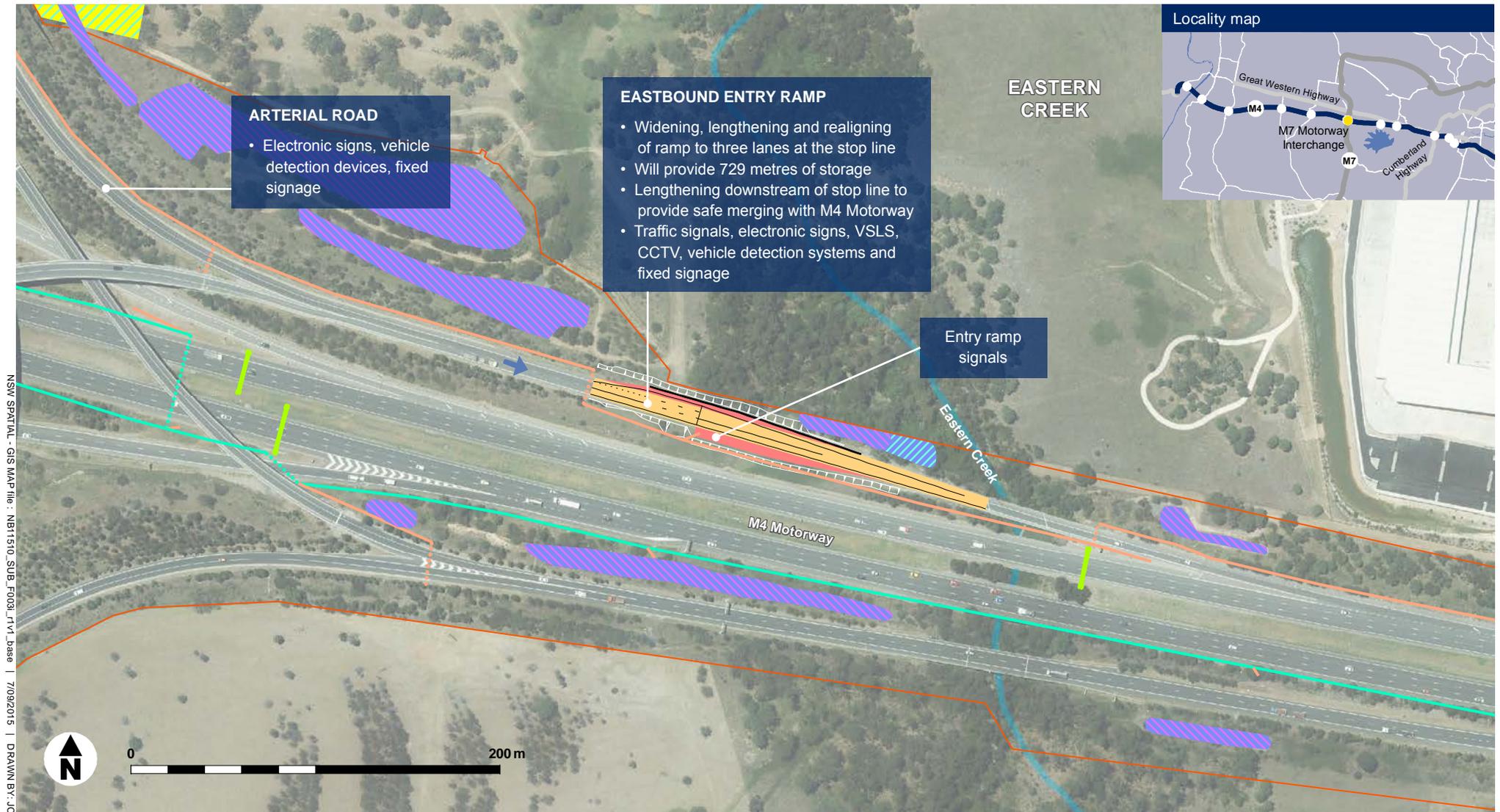
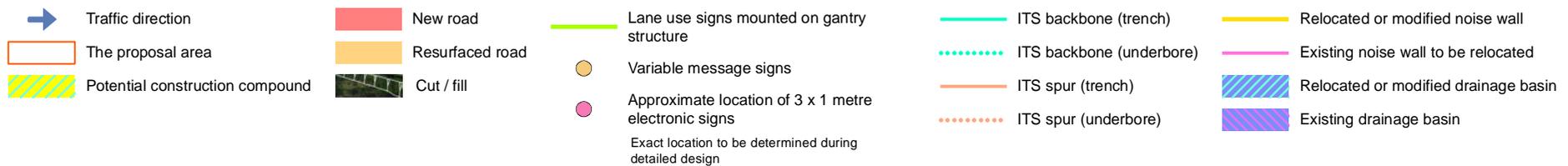
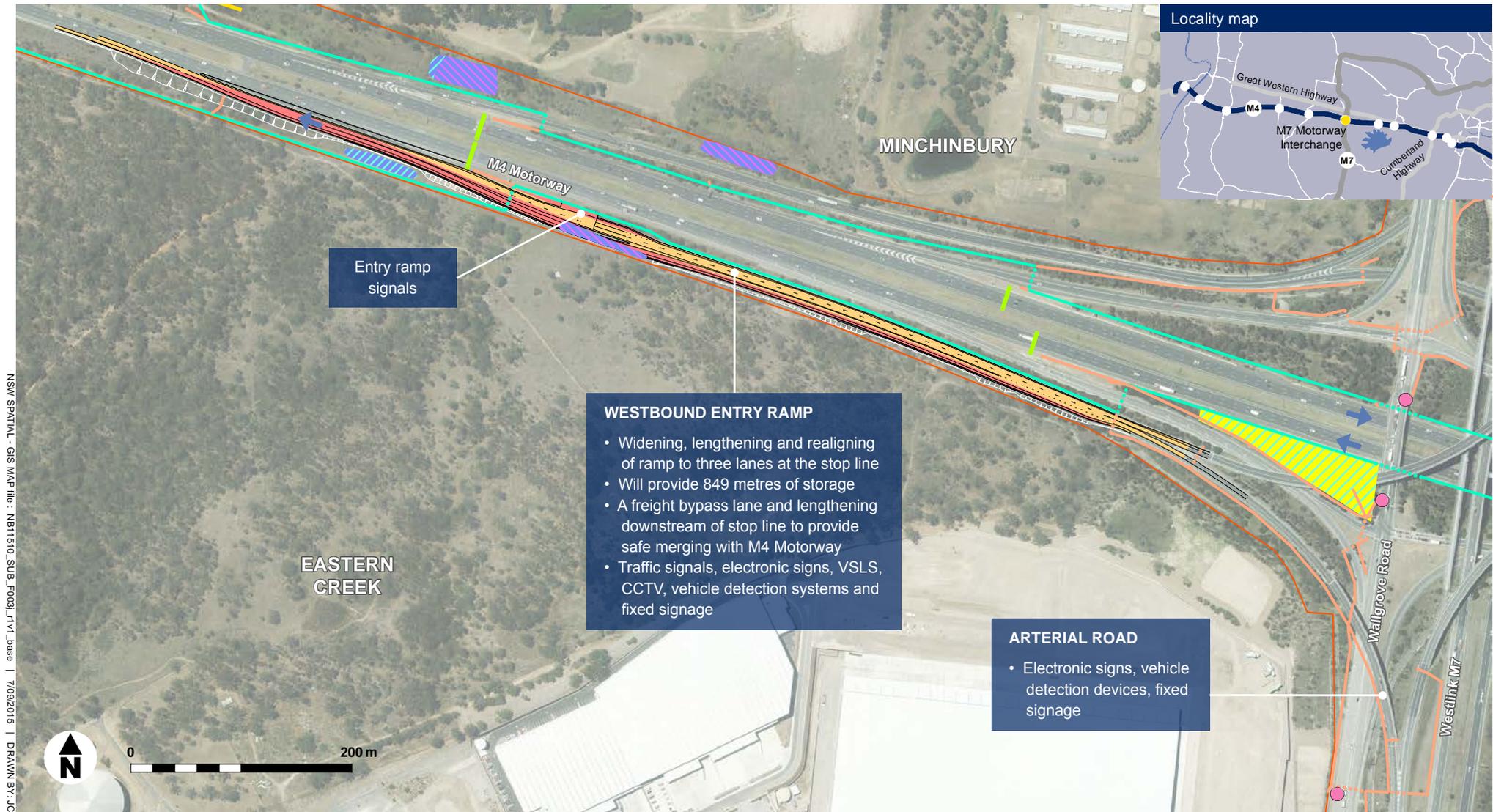


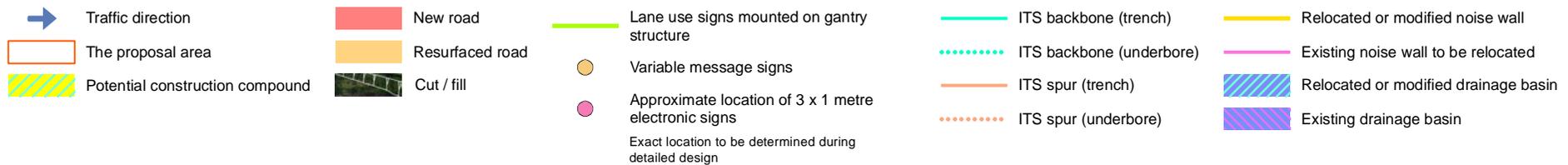
Figure 3-2i East of Westlink/M7 Motorway interchange upgrade





NSW SPATIAL - GIS MAP file : NB11510\_SUB\_F003\_L1\_V1\_base | 7/09/2015 | DRAWN BY: JC

Figure 3-2j West of Westlink/M7 Motorway interchange upgrade



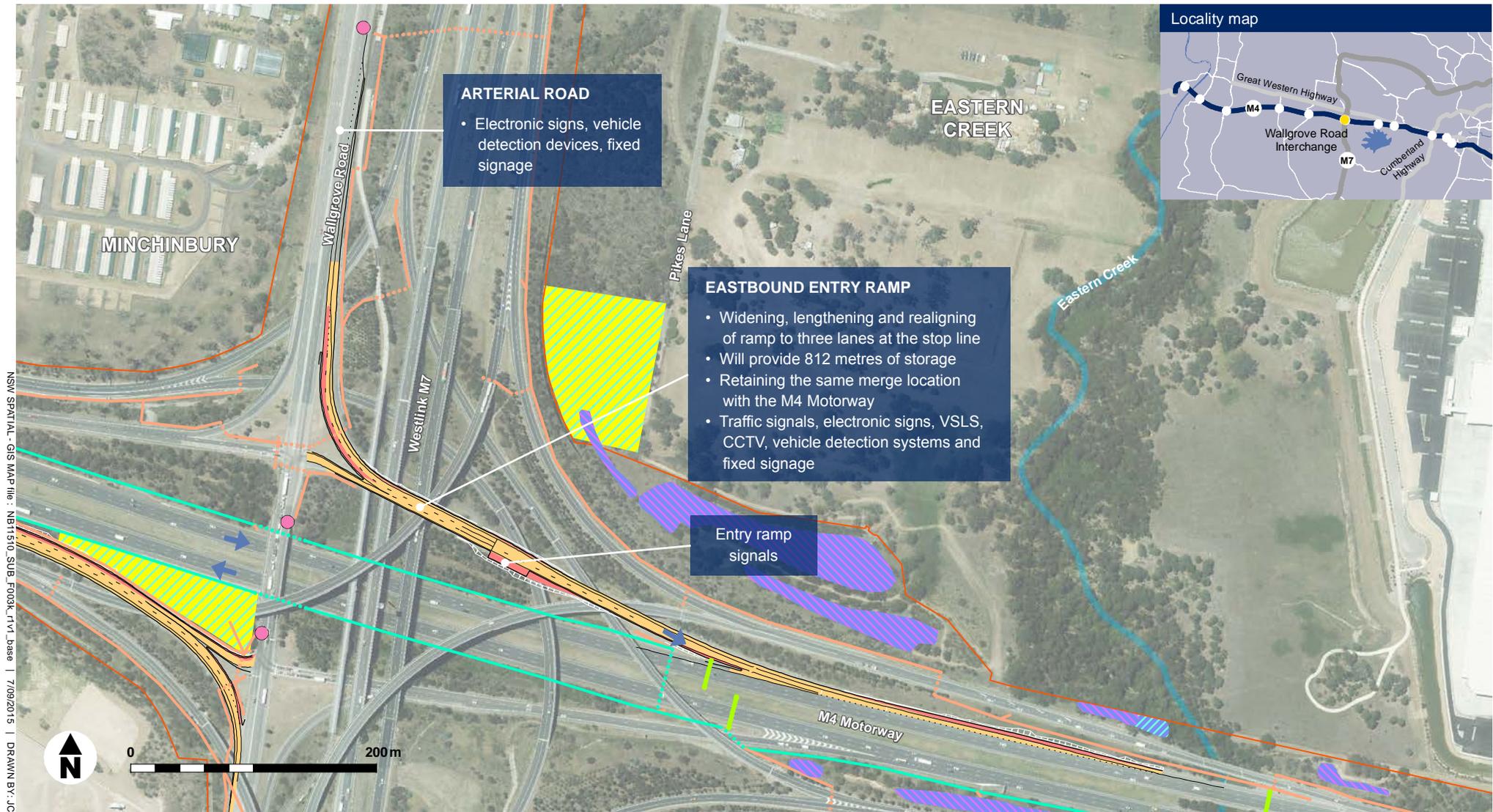
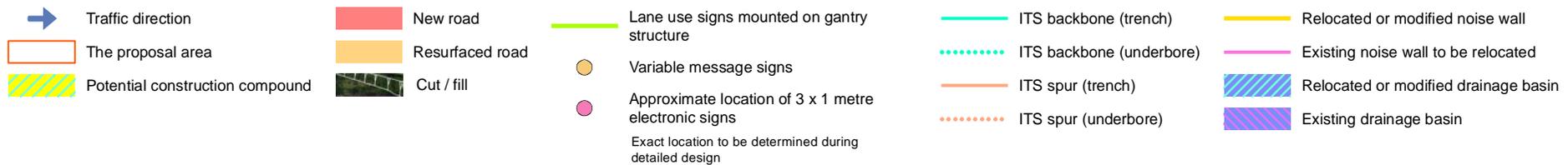


Figure 3-2k East of Wallgrove Road interchange upgrade



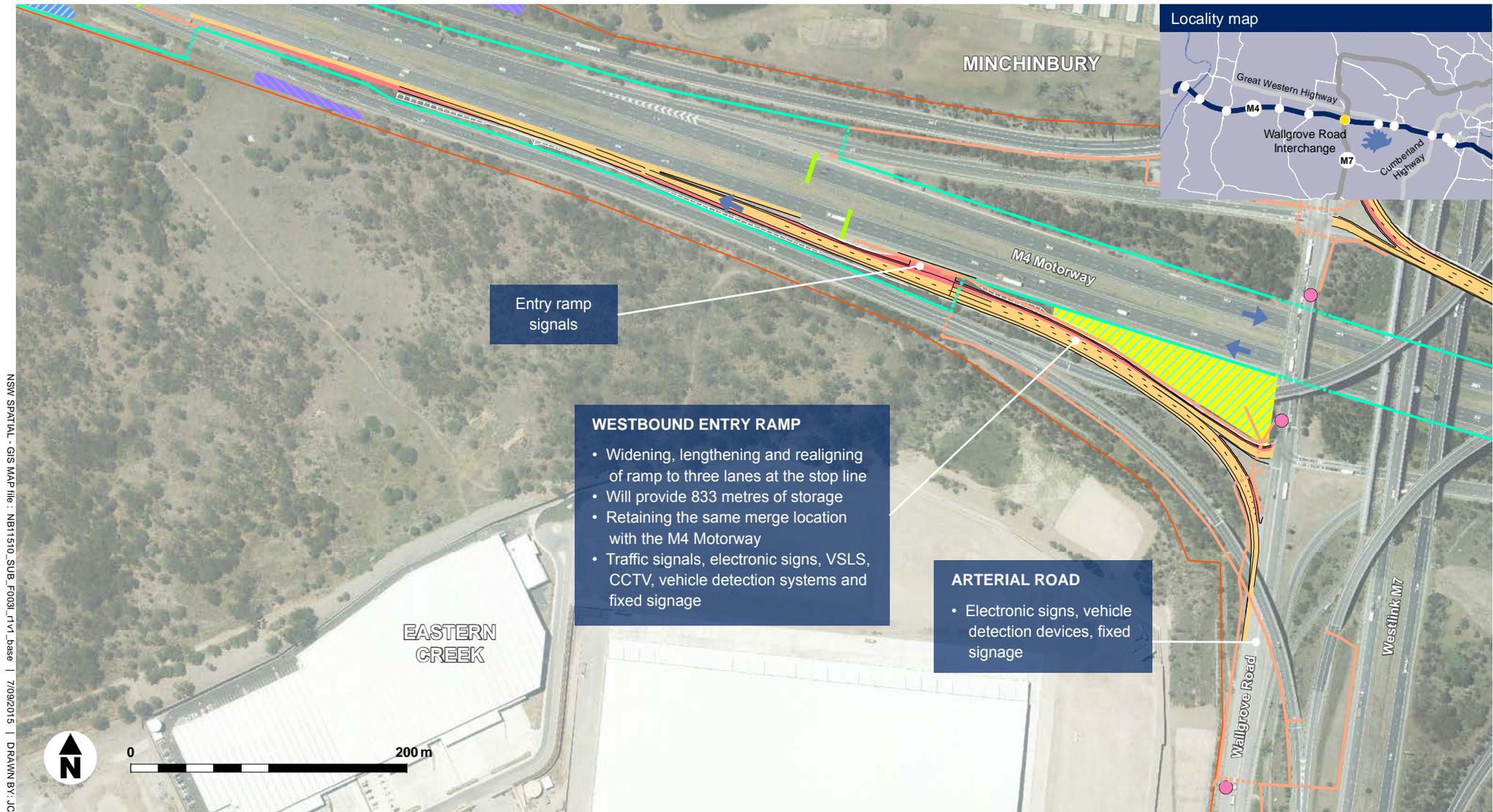
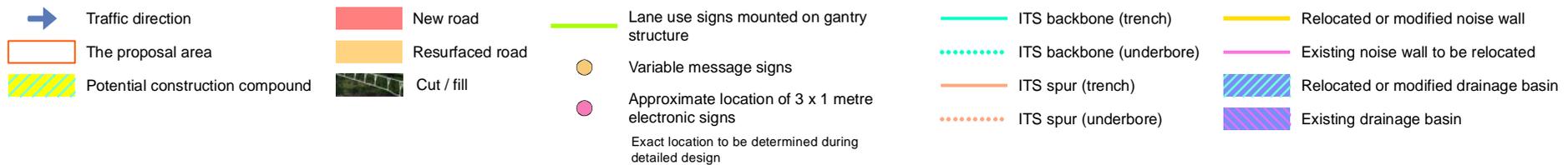


Figure 3-21 West of Wallgrove Road interchange upgrade



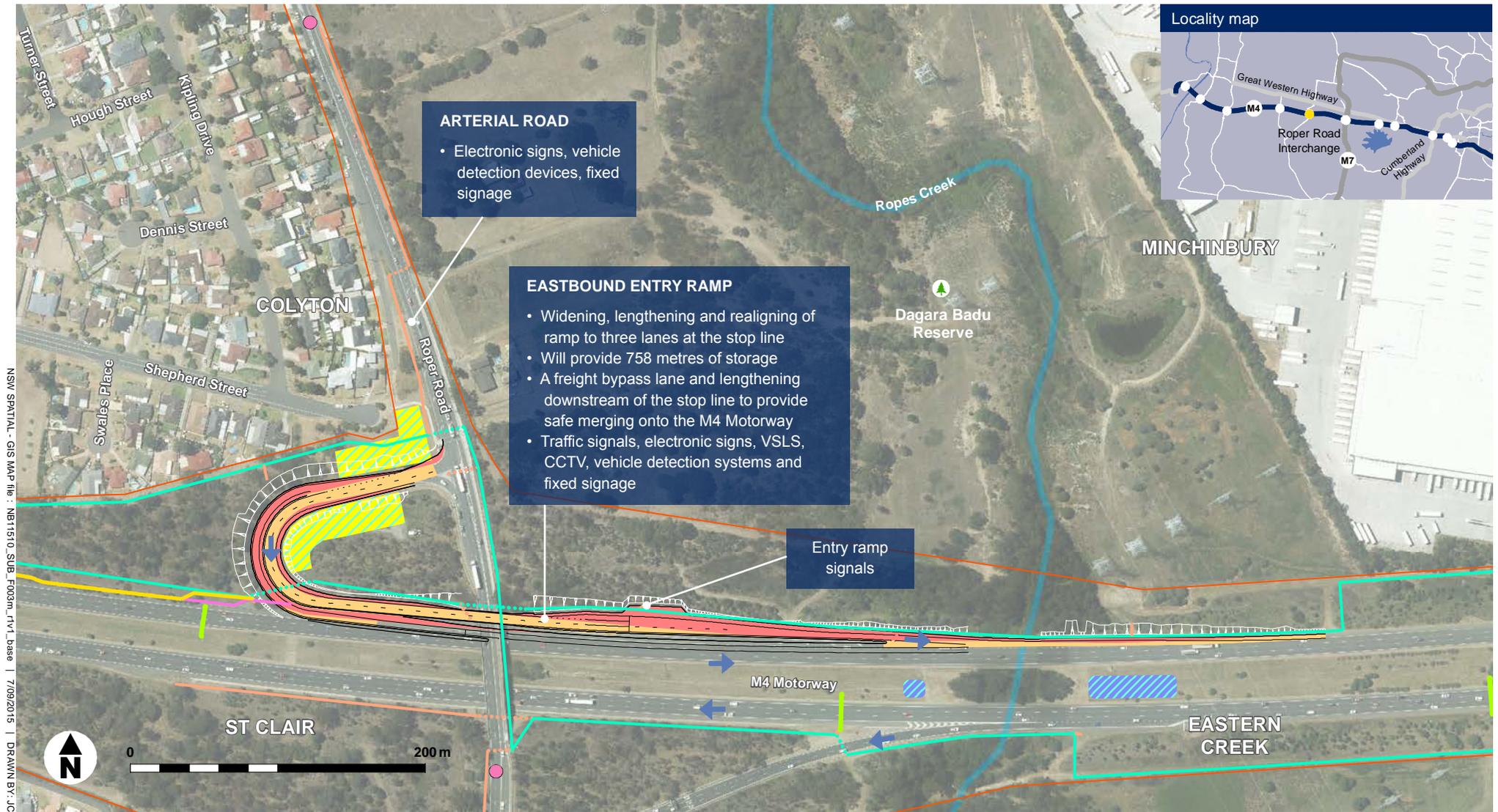
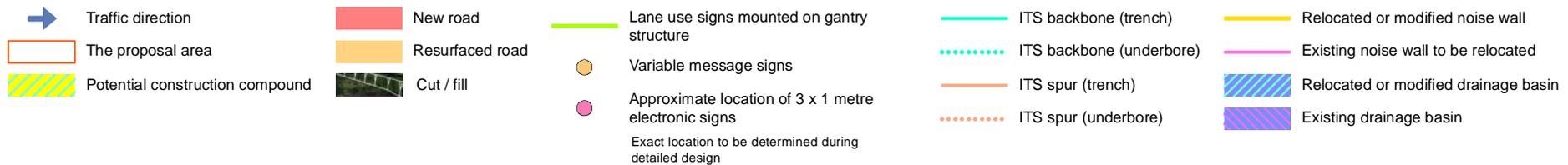


Figure 3-2m Roper Road interchange upgrade



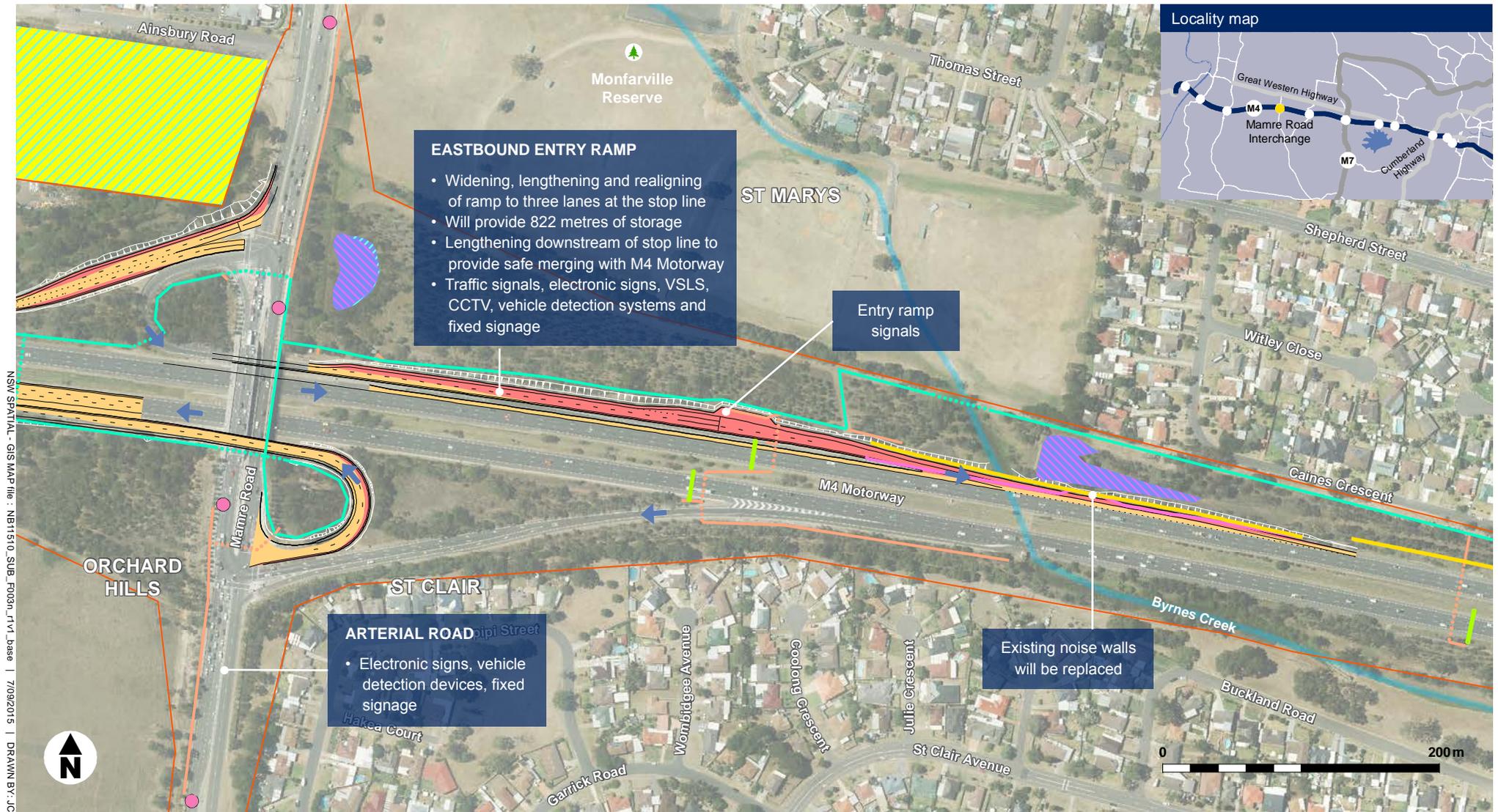
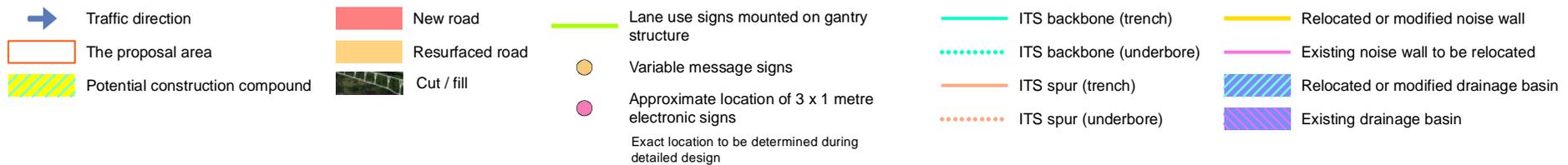


Figure 3-2n East of Mamre Road interchange upgrade



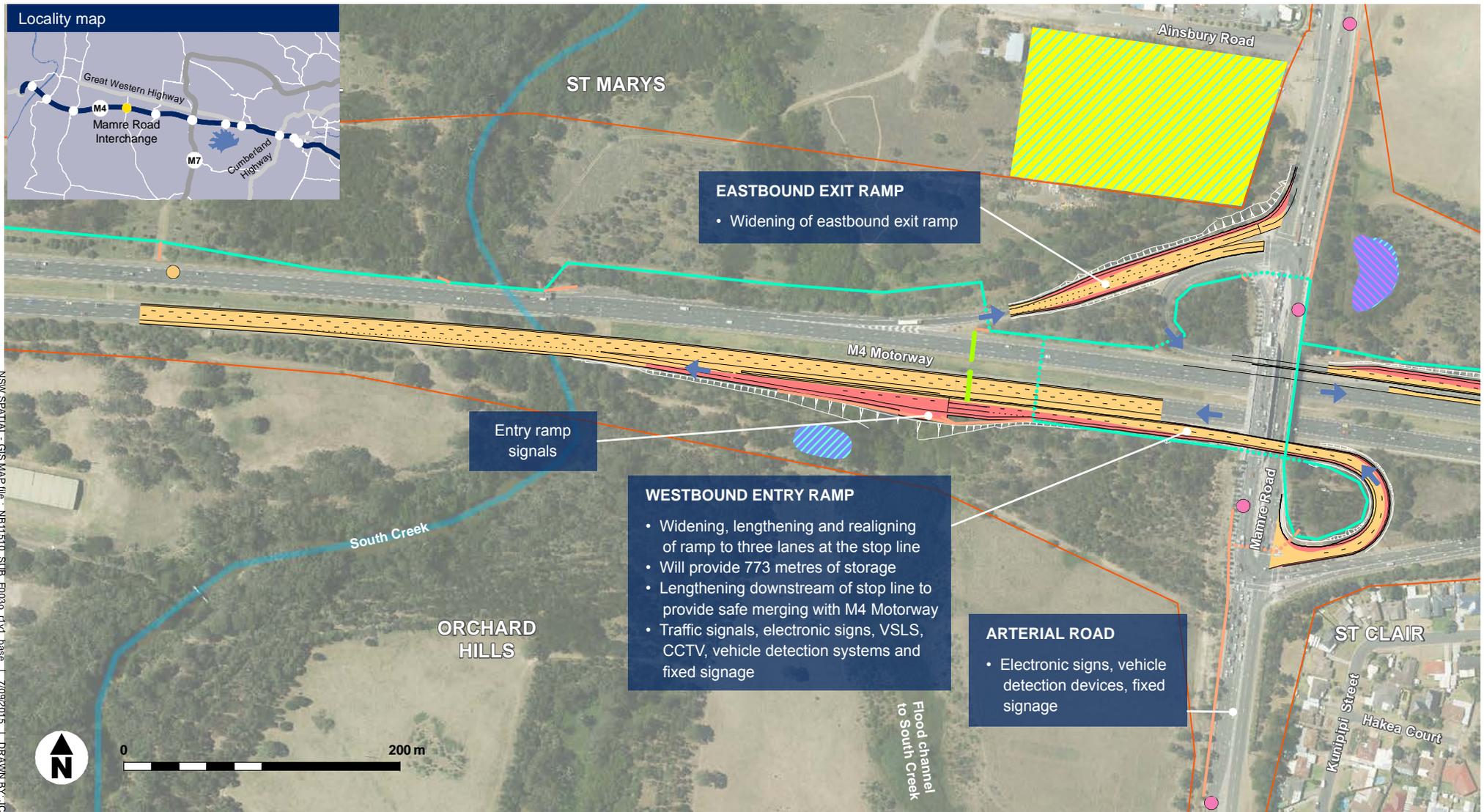
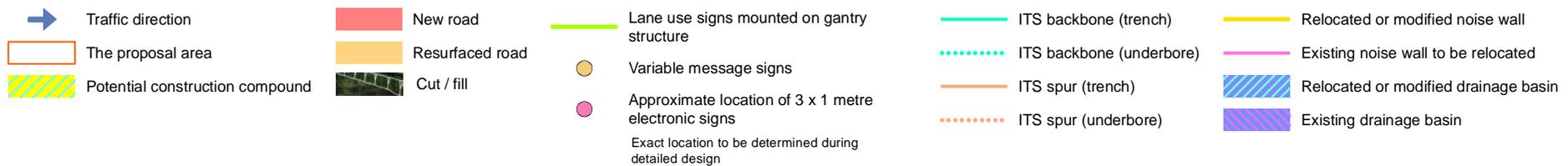


Figure 3-2o West of Mamre Road interchange upgrade



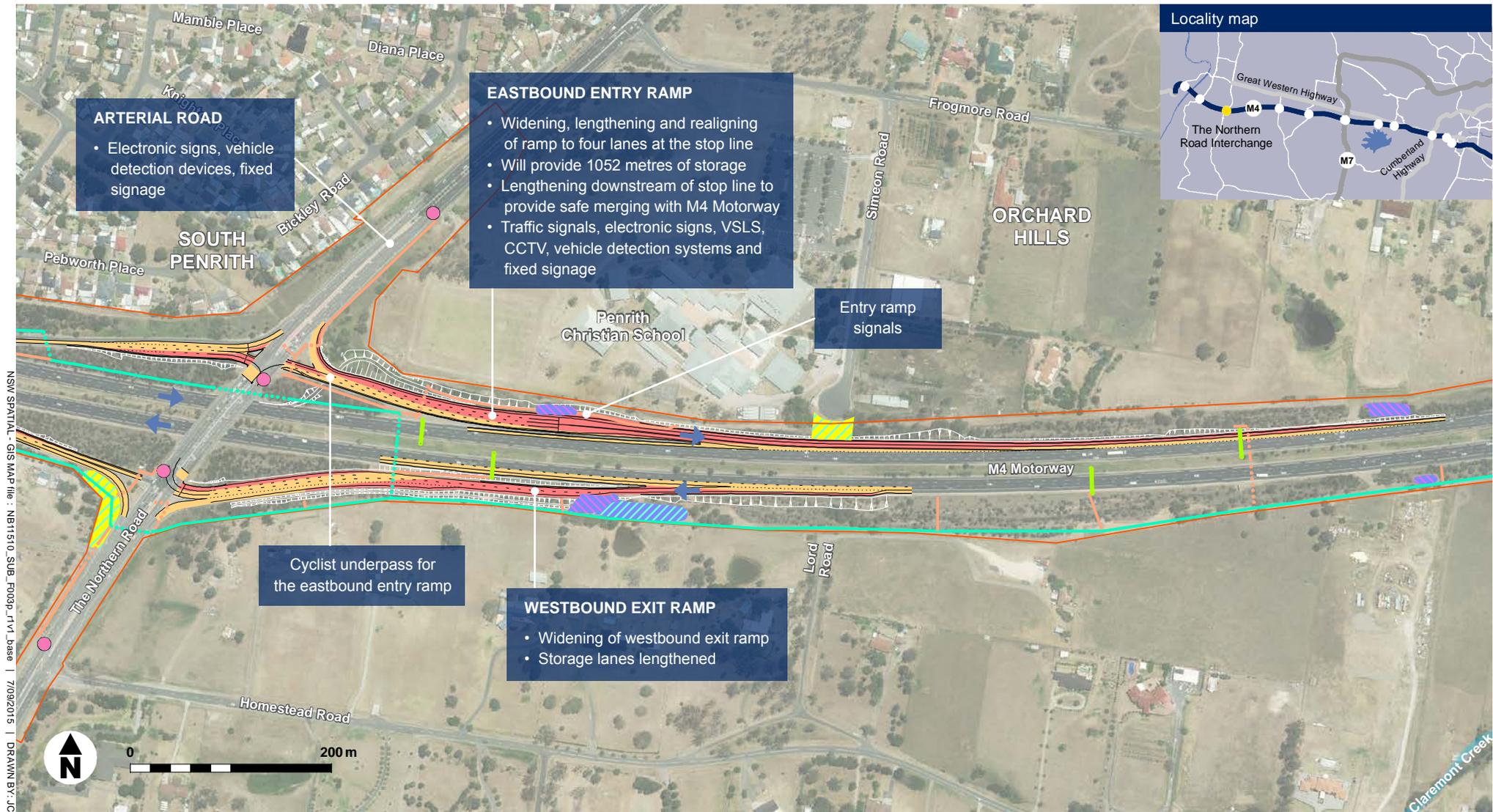
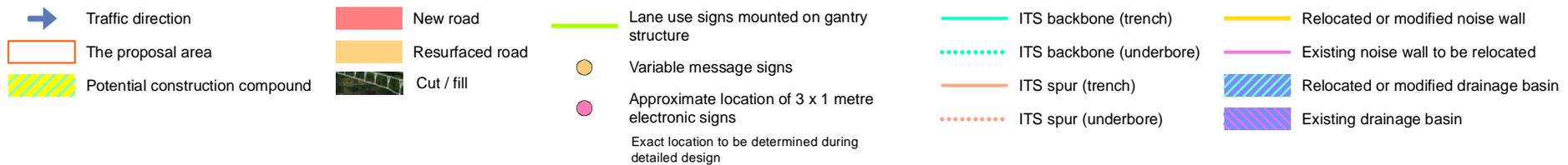


Figure 3-2p East of The Northern Road interchange upgrade



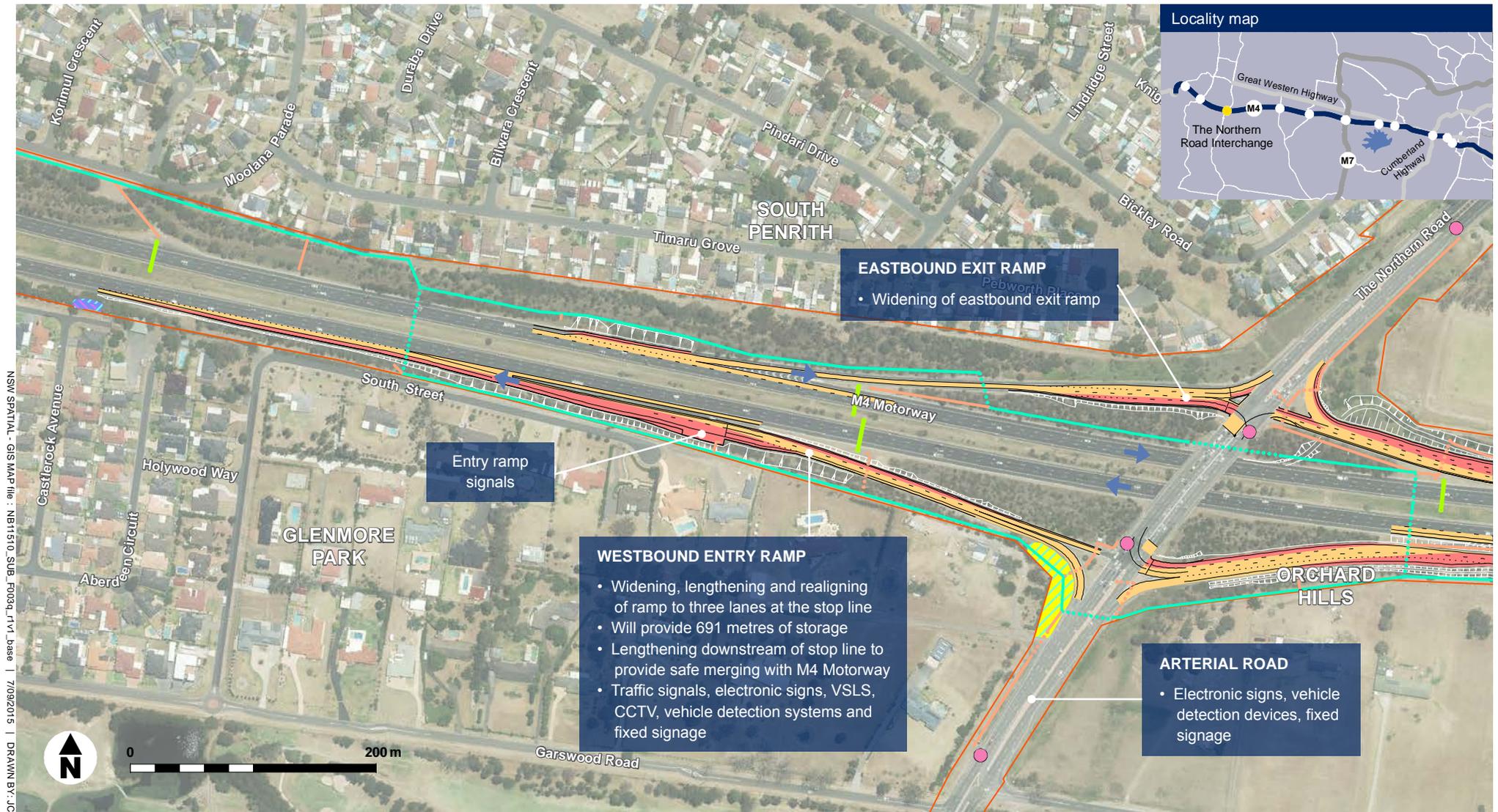
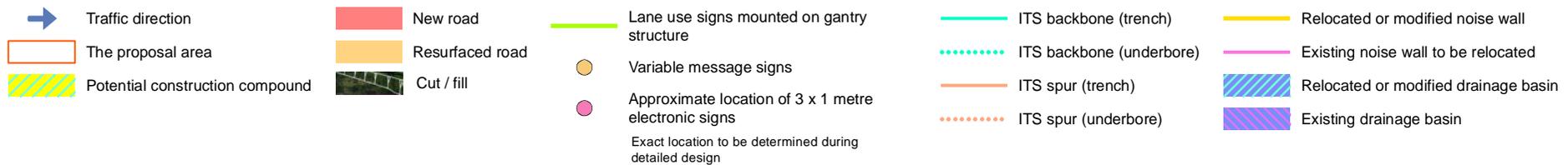


Figure 3-2q West of The Northern Road interchange upgrade



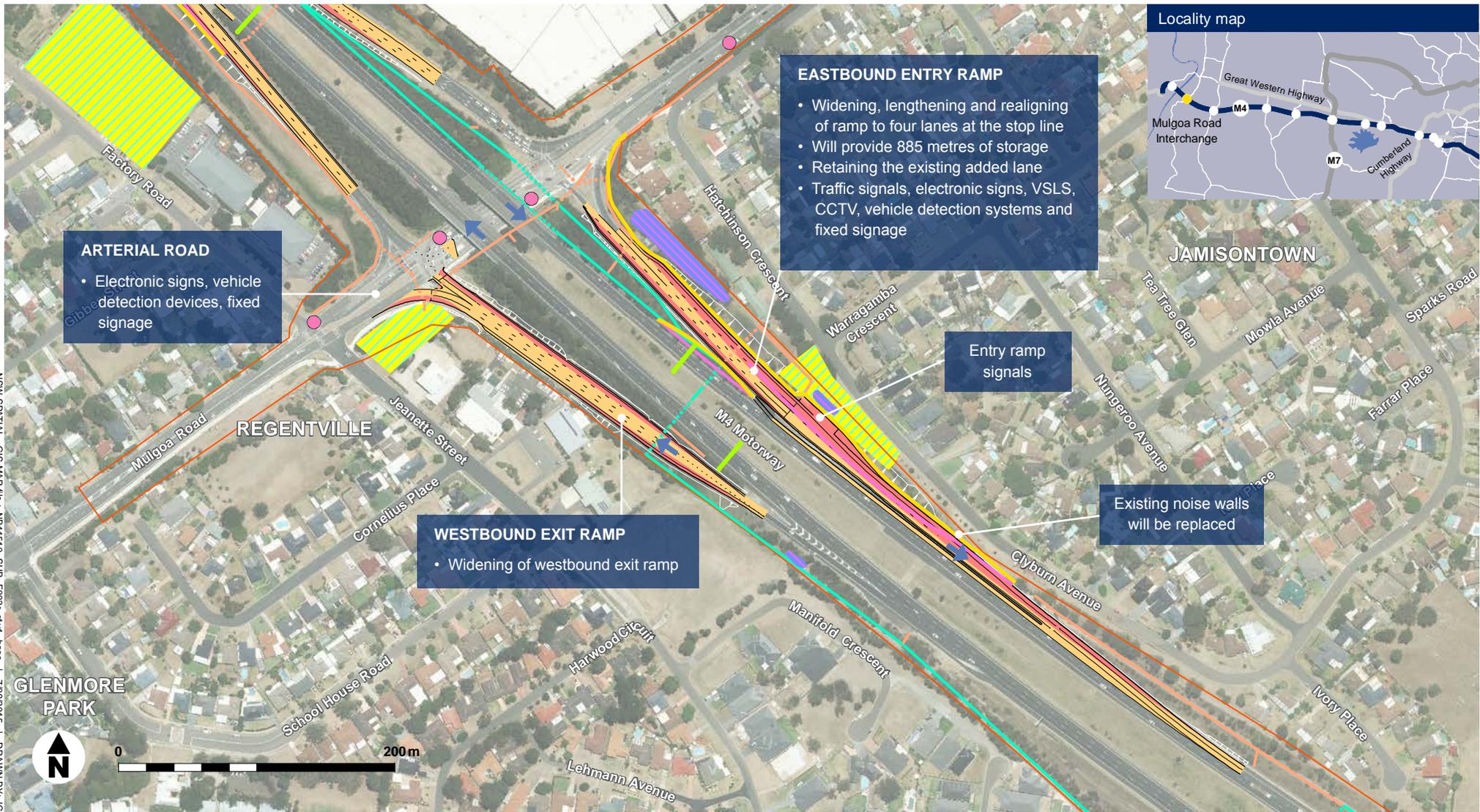
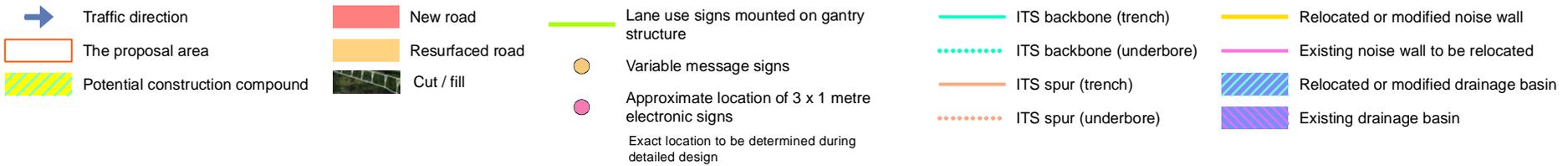


Figure 3-2r East of Mulgoa Road interchange upgrade



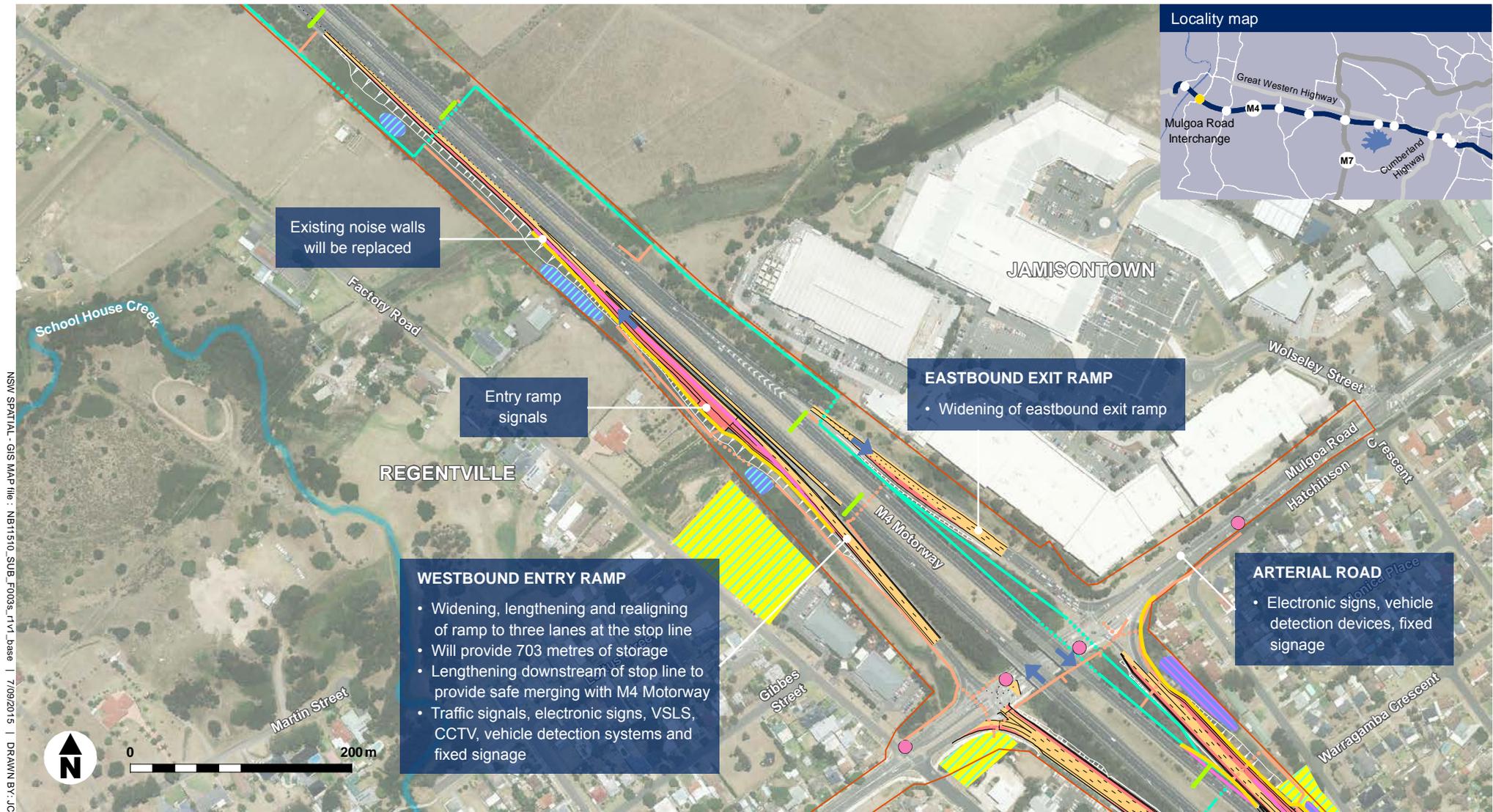
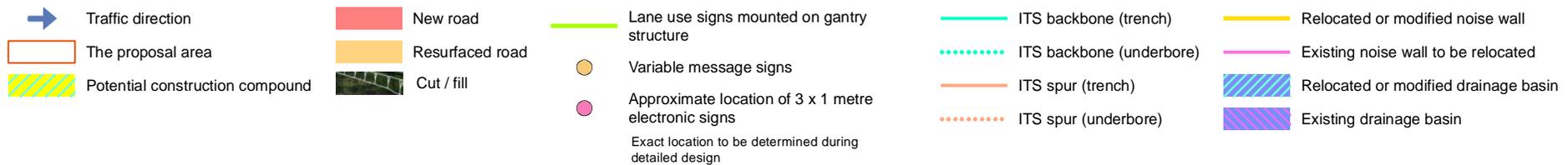


Figure 3-2s West of Mulgoa Road interchange upgrade



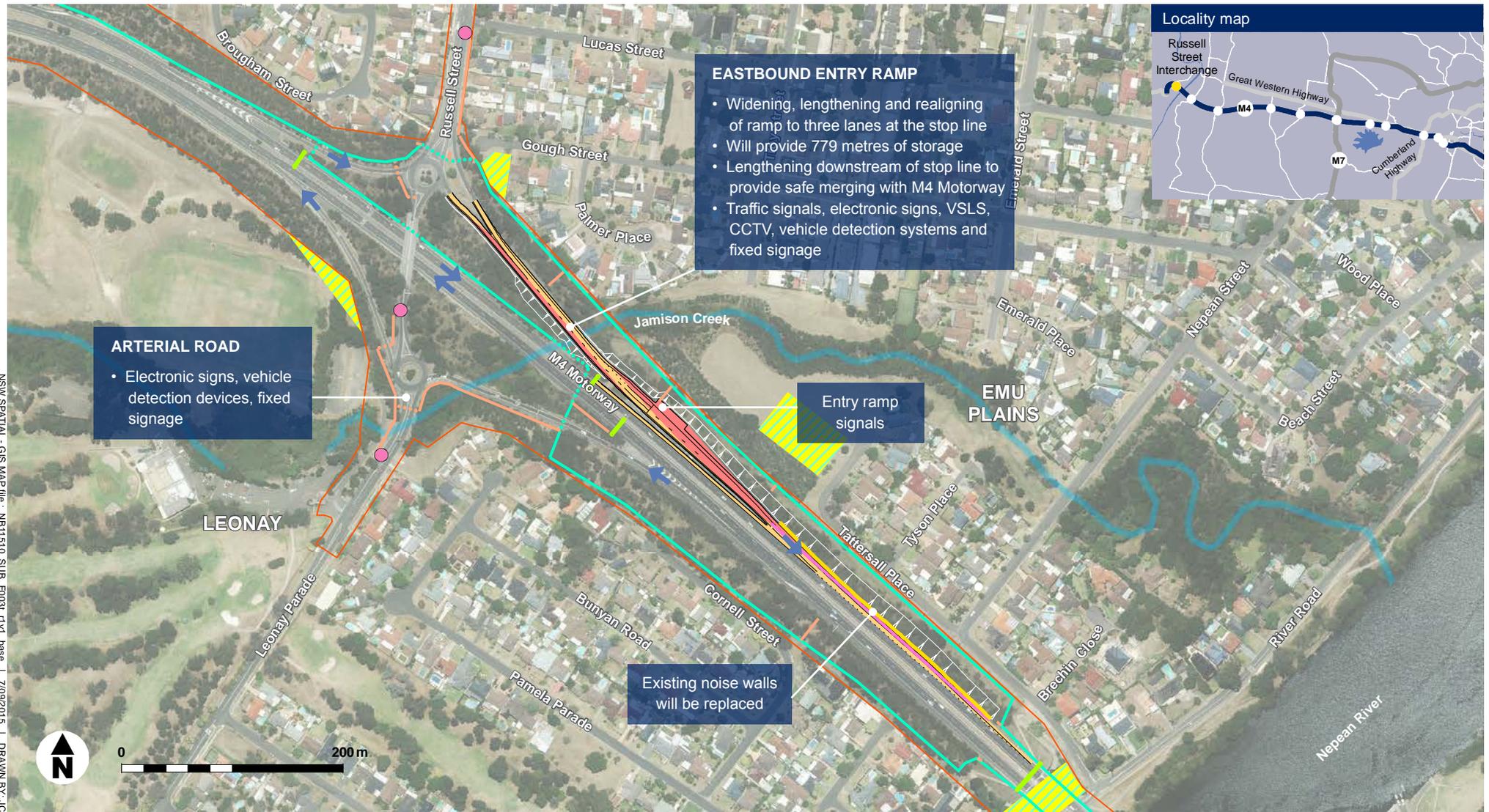
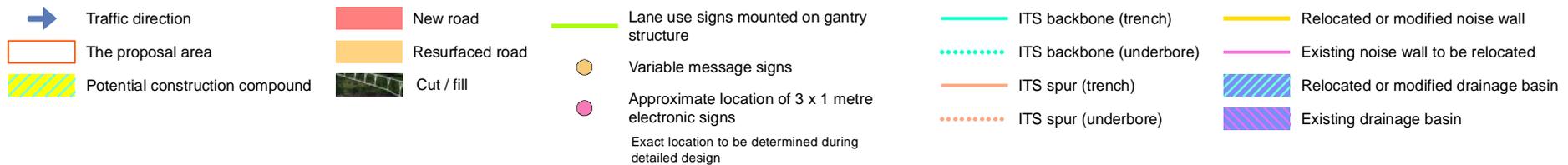


Figure 3-2t Russell Street interchange upgrade



## 4 Additional assessment

---

### 4.1 Biodiversity

#### 4.1.1 Summary

The extent and magnitude of potential impacts of the proposal on biodiversity was assessed in the original Biodiversity Assessment (Jacobs, 2015a). Since the display of the REF, the Biodiversity Assessment has been revised to consider the submission received from OEH and a review of the assumptions used to calculate clearing areas for the ITS infrastructure. The revised assessment also includes an updated study area boundary which encompasses design refinements and the location of potential ancillary facilities (Jacobs, 2015b). These are discussed in further detail below.

#### **Changes to the study area boundary**

The revised Biodiversity Assessment includes an updated study area boundary (refer to Figure 3-1 in Appendix B). The updated study area boundary includes design refinements, potential ancillary facility locations, additional noise walls and an assessment of the western end of the proposal between Emu Plains and Lapstone (refer to Figure 3-1 in Appendix B).

#### **Changes in assumptions used to calculate clearing requirements for ITS cabling**

The original Biodiversity Assessment assumed that a 10 metre clearing corridor would be required for the ITS backbone. The ITS backbone consists of a primary and secondary backbone with a minimum two metre separation between the two backbones. Even where the primary and secondary backbone would be located together (ie with the two metres separation), a 10 metre clearing corridor would be excessive. Also, in many locations (especially around the interchanges) the primary and secondary backbones diverge and can be on opposite sides of the M4 Motorway. In the original Biodiversity Assessment, the 10 metre clearing corridor was applied to each backbone even when they were on separate sides of the motorway. This led to a considerable overestimation of clearing impacts associated with the ITS infrastructure. The calculation of clearing estimates has been amended in the revised Biodiversity Assessment (refer to Appendix B).

#### **Recalculation and assessment of impacts from clearing Threatened Ecological Communities (TECs) and threatened flora**

The revised Biodiversity Assessment includes a reassessment of patch sizes of TECs, clearing impacts on local populations of threatened flora species and assessments of significance (refer to Appendix B).

#### **Other issues identified in the OEH submission**

Other issues identified in the OEH submission has been addressed in the revised Biodiversity Assessment (refer to Appendix B). This includes weed management, areas of proposed works lacking biodiversity information, other minor issues and biodiversity offsets.

A summary of the major differences between the original assessment and the revised Biodiversity Assessment is provided in this section and the assessment is provided in full in Appendix B.

#### 4.1.2 Methodology

The methodology for the Biodiversity Assessment is described in Section 6.2.1 of the REF. Two additional surveys were carried out over two days during July 2015 at potential ancillary facility locations and at the western end of the study area between Emu Plains and Lapstone (refer to Figure 3-1 in Appendix B).

#### 4.1.3 Existing environment

The existing environment of the proposal area in relation to biodiversity is described in Section 6.2.2 of the REF. A summary of the major differences between the existing environment of the original assessment and the revised Biodiversity Assessment (refer to Appendix B) is provided in this section.

### **Vegetation communities and threatened ecological communities**

In addition to those vegetation communities and habitats recorded within the study area listed in Table 6-10 of the REF, Map Unit 11: Remnant Shale Sandstone Transition Forest was recorded within the revised study area boundary. This vegetation community is listed as critically endangered under the TSC Act and EPBC Act (refer to Table 3-1 in Appendix B). Remnant Shale Sandstone Transition Forest has also been identified as a threatened ecological community (refer to Table 3-4 of Appendix B).

### **Groundwater dependent ecosystems**

The level of water dependence of vegetation communities on the Cumberland Plain have been identified in the Risk Assessment Guidelines for Groundwater Dependant Ecosystems released by the NSW Department of Primary Industries (Kuginis *et al.* 2012). The level of groundwater dependence identified for ecological communities in the study area is identified in Table 6-12 of the REF. The level of groundwater dependence for Map Unit 11: Remnant Shale Sandstone Transition Forest was identified to be high.

### **Threatened flora**

On the basis of regional records and reports and the presence of suitable habitat, a total of 64 threatened flora species have been previously recorded or listed as having potential to occur within the locality. Of these, six species are present in the study area. Two other species are considered to have a moderate chance of occurring based on the presence of suitable habitat and records in the locality (refer to Table 6-13 of the REF).

Field surveys identified seven threatened flora species within the study area (refer to Section 3.7.2 in Appendix B).

### **Threatened fauna**

On the basis of regional records, reports and the presence of suitable habitat, a total of 82 threatened fauna species have been identified within the locality (refer to Section 3.8.1 of Appendix B).

#### 4.1.4 Potential construction impacts

Potential construction impacts of the proposal are detailed in Section 6.2.3 of the REF. A summary of the major differences between the potential construction impacts of the original assessment and the revised Biodiversity Assessment (refer to Appendix B) is provided in this section.

#### Loss of vegetation and habitat

The construction footprint associated with the proposal would impact on about 29.45 hectares of planted and remnant vegetation. This total area of clearing includes 3.88 hectares of remnant vegetation (refer to Table 4-1). The majority of vegetation removal would occur along the M4 Motorway corridor.

**Table 4-1 Revised direct impacts on vegetation and fauna habitat**

Vegetation Community Type	Fauna habitat type	Biometric Vegetation Type	Conservation Status	Condition	Direct impact (ha)
Map Unit 1: Remnant Shale-Gravel Transition Forest	Grassy Woodland	Broad-leaved Ironbark - Grey Box - <i>Melaleuca decora</i> grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	Endangered, TSC Act  Critically endangered, EPBC Act  Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)	High	0.30
Map Unit 2: Remnant Shale Plains Woodland	Grassy Woodland	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act  Critically endangered, EPBC Act  Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)	Moderate	2.51
Map Unit 3: Remnant Alluvial Woodland	Riparian Woodland	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin	Endangered, TSC Act	Moderate	0.79
Map Unit 4: Freshwater Wetlands (4a Broadleaf Cumbungi; 4b Common Reed; 4c Urban Drainage Lines)	Disturbed Freshwater Wetland	<i>Phragmites australis</i> and <i>Typha orientalis</i> coastal freshwater wetlands of the Sydney Basin	Endangered, TSC Act	Low – Moderate	0.15

Vegetation Community Type	Fauna habitat type	Biometric Vegetation Type	Conservation Status	Condition	Direct impact (ha)
Map Unit 5: Planted Shale Plains Woodland	Planted Forest/ Woodland Habitats	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin (restored example of)	Endangered, TSC Act	Moderate	8.48
Map Unit 6: Planted Shale-Gravel Transition Forest	Planted Forest/ Woodland Habitats	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	Endangered, TSC Act	Moderate	0.57
Map Unit 7: Planted Shale Sandstone Transition Forest	Planted Forest/ Woodland Habitats	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act and EPBC Act	Moderate	0.4
Map Unit 8: Planted Monocultures (8a Casuarina species; 8b Eucalyptus species; 8c Fig species)	Planted Forest/ Woodland Habitats	N/A	N/A	N/A	2.43
Map Unit 9: Mixed Plantings (9a Native trees; 9b Native shrubs; 9c Sparse plantings)	Planted Forest/ Woodland Habitats	N/A	N/A	N/A	11.56
Map Unit 10: Exotic vegetation	Exotic vegetation	N/A	N/A	N/A	1.98
Map Unit 11: Remnant Shale Sandstone Transition Forest	Grassy Woodland	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act and EPBC Act	Moderate	0.28
TOTALS	All vegetation (All map units)				29.45
	Remnant, planted and modified communities (Map units 1, 2, 3, 4, 5, 6, 7 and 11)				13.48
	Remnant vegetation only (Map units 1, 2, 3 and 11)				3.88

The direct and indirect impacts of the proposal on larger vegetation patches are provided in Table 4-2.

**Table 4-2 Direct and indirect impacts to larger vegetation patches**

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
S1	Map Unit 1: Remnant Shale-Gravel Transition Forest	2.5	0.08	0.0	3.2%
S2		1.03	0.18	0.07	17.5%
S3		3.1	0	0.0	0%
S4		0.54	0.04	0.0	7.4%
S5		2.02	0	0.0	0%
S6	Map Unit 6: Planted Shale-Gravel Transition Forest	4.69	0.38	0.0	8.1%
C1	Map Unit 2: Remnant Shale Plains Woodland	51.28	0.23	0.0	0.4%
C2		15.44	0.59	0.33	3.8%
C3		12.61	0.1	0.0	0.8%
C4		8.96	0.05	0.0	0.6%
C5		2.09	0	0.0	0%
C6		4.04	0.02	0.06	0.5%
C7		1.28	0.03	0.0	2.3%
C8		0.63	0.01	0.0	1.6%
C9	Map Unit 5: Planted Shale Plains Woodland	1.69	0.17	0.33	10.1%
A1	Map Unit 3: Remnant Alluvial Woodland	14.92	0.05	0.0	0.3%
A2		11.83	0.03	0.0	0.3%
A3		10.26	0	0.0	0.0%
A4		10.08	0.04	0.0	0.4%
A5		7.83	0.1	0.0	1.3%
A6		4.9	0.13	0.2	2.7%
A7		3.2	0.07	0.0	2.2%
A8		2.61	0.02	0.0	0.7%
A9		0.69	0.04	0.0	5.8%
SS1	Map Unit 11: Remnant Shale Sandstone Transition Forest	8.92	0	0	0%
SS2		11.2	0	0	0%
SS3		6.71	0.04	0	0.6%
SS4		40.41	0.24	0.4	0.6%

### Threatened ecological communities

Potential construction impacts of the proposal on TECs include the removal of about 13.48 hectares of communities listed under the TSC Act. The majority of TECs to be removed (9.6 hectares) have been planted and occur as highly modified remnants within an urban landscape. When considering only the remnant TECs, impacts are considerably less comprising about 3.88 hectares.

Predicted impacts to TECs listed under the EPBC Act are limited to about 1.77 hectares of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest and about 0.28 hectares of vegetation with affinities to Shale Sandstone Transition Forest (limited to areas of vegetation that meet the required condition criteria). The impacts to TECs are summarised in Table 4-3.

**Table 4-3 Revised impacts on threatened ecological communities**

Threatened ecological community	Status	Area (ha)			Proportion of habitat impacted adjoining and within the study area
		Extent within locality*	Extent within and adjoining study area	Extent to be removed	
<b>EPBC Act</b>					
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered, EPBC Act	3,990	107.8 (remnant)	1.77	1.6%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered EPBC Act	324	67.25 (remnant)	0.28	0.4%
<b>TSC Act</b>					
Cumberland Plain Woodland in the Sydney basin Bioregion	Critically Endangered TSC Act	3,472	154.7 (107.8 remnant, 46.9 planted)	10.99 (2.51 remnant, 8.48 planted)	7.1%
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered TSC Act	518	15.95 (9.26 remnant, 6.7 planted)	0.87 (0.3 remnant, 0.57 planted)	5.5%
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC Act	13	1.47 (modified)	0.15 (modified)	10.2%
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC Act	1,712	67.97 (remnant/modified)	0.79	1.2%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered TSC Act	324	70.35 (67.25 remnant, 3.1 planted)	0.68 (0.28 remnant, 0.4 planted)	1%

### Threatened species

Construction of the proposal would have direct and indirect impacts on threatened flora and fauna within the study area (refer to Table 4-4). The proposal would require the removal of about 50 individual threatened species. These include:

- A single *Dillwynia tenuifolia* plant from a population of 87 individuals (1.1 per cent impacted).
- A total of 49 *Grevillea juniperina* subsp. *juniperina* plants from two separate local populations, comprising one population at Ropers Road interchange of which 40 of a large population of greater than 824 individuals would be impacted (maximum 4.9 per cent) and another population near the Kent Road overpass consisting of 204 individuals of which nine individuals would be impacted (4.4 per cent).

**Table 4-4 Revised impacts on threatened species**

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
<b>Flora</b>			
Downy Wattle ( <i>Acacia pubescens</i> )	V	V	Up to 11 - No individuals impacted
<i>Dillwynia tenuifolia</i>	-	V	0.3 1 plant at Roper Rd interchange
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	V	V	N/A (planted) cannot predict
Juniper-leaf Grevillea ( <i>Grevillea juniperina</i> subsp. <i>juniperina</i> )	-	V	Up to 11 - Impacts to 49 plants in total
<i>Marsdenia viridiflora</i> subsp. <i>viridiflora</i> (endangered population)	-	E2	Up to 11 - No individuals impacted
Nodding Geebung ( <i>Persoonia nutans</i> )	E	E	0.3 - No individuals impacted
Spiked-rice Flower ( <i>Pimelea spicata</i> )	E	E	2.51 - No individuals impacted
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	E	E	0.3 - No individuals impacted
Magenta Lilly Pilly ( <i>Syzygium paniculatum</i> )	V	E	N/A (planted) cannot predict - No individuals impacted
<b>Fauna</b>			
<b>MAMMALS</b>			
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii oceanensis</i> )	-	V	29.45
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	-	V	0.68
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	-	V	29.45
Eastern Freetail Bat ( <i>Mormopterus norfolkensis</i> )	-	V	29.45
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	-	V	29.45
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	V	24.89
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	V	29.45
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	-	V	29.45
Southern Myotis ( <i>Myotis macropus</i> )	-	V	29.45
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	E	V	0.68
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	-	V	0.68
Yellow-bellied Glider ( <i>Petaurus australis</i> )	-	V	0.68
Yellow-bellied Sheathtail-bat ( <i>Saccolaimus flaviventris</i> )	-	V	29.45
<b>BIRDS</b>			
Barking Owl ( <i>Ninox connivens</i> )	-	V	0.68
Flame Robin ( <i>Petroica phoenicea</i> )	-	V	0.68
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	-	V	0.68
Glossy Black-Cockatoo ( <i>Calyptorhynchus lathamii</i> )	-	V	0.68
Little Eagle ( <i>Hieraaetus morphnoides</i> )	-	V	13.48

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	-	V	24.89
Masked Owl ( <i>Tyto novaehollandiae</i> )	-	V	0.68
Powerful Owl ( <i>Ninox strenua</i> )	-	V	0.68
Scarlet Robin ( <i>Petroica boodang</i> )	-	V	0.68
Speckled Warbler ( <i>Chthonicola sagittatus</i> )	-	V	0.68
Swift Parrot ( <i>Lathamus discolor</i> )	E, M	E	24.89
Varied Sittella ( <i>Daphoenositta chrysoptera</i> )	-	V	24.89
<b>REPTILES AND AMPHIBIANS</b>			
Broad-headed Snake ( <i>Hoplocephalus bungaroides</i> )	V	V	0.68
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	-	V	0.28
<b>INVERTEBRATES</b>			
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	-	E	1.2 (0.1 high quality, 1.1 moderate quality)

Other minor changes to the construction impacts of the proposal on biodiversity are provided in the revised Biodiversity Assessment (refer to Appendix B).

#### 4.1.5 Potential operational impacts

Potential operational impacts of the proposal on biodiversity are discussed in Section 6.2.4 of the REF.

#### 4.1.6 Additional safeguards and management measures

In addition to the biodiversity safeguards and management measures described in Section 6.2.5 of the REF, the clearing of both planted and remnant TECs would qualify for offsetting under Roads and Maritimes' Biodiversity Guidelines (Roads and Maritime, 2011). Therefore, a new mitigation measure has been included which relates to the development of a biodiversity offset strategy in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011). The strategy would be prepared once detailed design has been completed so the full extent of clearing can be identified (refer to Table 5-1).

## 4.2 Aboriginal heritage

### 4.2.1 Summary

The extent and magnitude of potential impacts of the proposal on Aboriginal heritage was assessed in the original Cultural Heritage Assessment Report (CHAR) (Kelleher Nightingale Consulting, 2015a). Since the display of the REF, the CHAR has been revised to include the assessment of an updated study area boundary, which encompasses design refinements and the location of potential ancillary facilities (Kelleher Nightingale Consulting, 2015b). A summary of the revised assessment is provided in this section and provided in full in Appendix C.

### 4.2.2 Methodology

Details of the methodology used for the assessment is provided in Section 6.4.1 of the REF. An additional survey was completed in 2015 by Kelleher Nightingale

Consulting to assess areas within the revised study area boundary (refer to Appendix C). Archaeological sites previously identified during the 2013 field surveys were also reassessed.

#### 4.2.3 Existing environment

The existing environment of the proposal area in relation to Aboriginal heritage is described in Section 6.4.2 of the REF. Further to 30 previously recorded Aboriginal sites within the study area, the revised assessment identified an additional site (South Creek 5) (refer to Appendix C).

South Creek 5 is an artefact scatter located on the northern side of the M4 Motorway, west of the Mamre Road interchange. Two silcrete flake fragments were identified and assessed as forming part of a larger artefact scatter that extended across a raised landform north of the M4 Motorway boundary. The portion of the site within the M4 Motorway study area has been disturbed by the construction of a drainage channel and was assessed to be of low archaeological significance (refer to Appendix C).

An artefact scatter at South Creek 7 was also identified, however this was a duplicate recording of Location 10 South Creek 3, which was previously identified during the 2013 field surveys.

#### 4.2.4 Potential construction impacts

Potential construction impacts of the proposal on Aboriginal heritage items are discussed in Section 6.4.3 of the REF. During construction, the proposal would have potential direct and indirect impacts on 32 recorded Aboriginal sites within the M4 Motorway corridor (refer to Appendix C).

The majority of impacts would be due to the direct disturbance of Aboriginal heritage sites from construction activities associated with the modification of the ramps and the installation of the ITS infrastructure.

Three of the 32 Aboriginal sites have been determined to have a moderate or higher level of archaeological significance. The remaining sites are determined to be of low archaeological significance due to the impacts of previous ground disturbance or the sites contain very few low value artefacts.

As discussed in Section 6.4.3 of the REF, due to the number and distribution of Aboriginal archaeological sites within the proposal area, a corridor-wide Aboriginal Heritage Impact Permit (AHIP) would be required for all sites prior to construction. An archaeological salvage would be carried out for the three sites determined to have a moderate or higher level of archaeological significance.

#### 4.2.5 Potential operational impacts

Potential operational impacts of the proposal on Aboriginal heritage are discussed in Section 6.4.4 of the REF.

#### 4.2.6 Additional safeguards and management measures

Safeguards and management measures for Aboriginal heritage are described in Section 6.4.5 of the REF. No additional safeguards and management measures for potential Aboriginal heritage impacts are proposed.

## 4.3 Visual impacts of additional noise walls

The extent and magnitude of potential impacts of the proposal on landscape character and visual amenity were assessed in the Urban Design Concept, Landscape Character and Visual Impact Assessment Report (Spackman Mossop and Michaels, 2015), which is provided in Appendix D of the REF. As discussed in Section 3.1 of the Submissions Report, the location and extent of noise walls included as part of the proposal has been modified based on the outcomes of the Construction and Operational Road Traffic Noise and Vibration Impact Assessment (SLR, 2015) (refer to Figure 3-1 and Figure 3-2).

### 4.3.1 Methodology

Details of the methodology used for the landscape character and visual impact assessment are provided in Section 6.3.1 of the REF. The visual impacts associated with changes to the location and extent of noise walls was determined based on the conclusions of the landscape character and visual impact assessment.

### 4.3.2 Existing environment

The existing landscape character and visual amenity of the proposal area is described in Section 6.3.1 of the REF.

### 4.3.3 Potential construction impacts

Potential construction impacts of the proposal on landscape character and visual amenity are discussed in Section 6.3.3 of the REF. Visual impacts associated with changes to the location and extent of noise walls would result from construction activities, including vegetation removal, the generation of wastes, areas of earthworks, stockpiling of spoil and materials, light spill, and the presence of large-scale construction plant and equipment. These impacts would be greatest where noise walls would be constructed in areas with high visual sensitivity, such as near residential areas and sensitive viewers.

### 4.3.4 Potential operational impacts

Potential operational impacts of the proposal on landscape character and visual amenity are discussed in Section 6.3.4 of the REF. Changes to the location and extent of noise walls have the potential to result in additional visual impacts.

Changes to the location and extent of noise walls would include:

- Noise wall located on the northern side of the M4 Motorway, between Pitt Street and the Burnett Street interchange (refer to Figure 3-1a): this noise wall would be located within Landscape Character Zone (LCZ) 1, which was identified to have high sensitivity due to the residential character of the area
- Extension of the noise wall between the Burnett Street and Coleman Street interchange (refer to Figure 3-1a): this noise wall would be located within LCZ 1, which was identified to have high sensitivity due to the residential character of the area
- Noise walls on the northern and southern side of the M4 Motorway, east and west of the Cumberland Highway interchange (refer to Figure 3-1b): these noise walls would be located within LCZ 2 (north), LCZ 2 (south), and LCZ 3. LCZ 2 (north) was identified to have a moderate sensitivity, due to the extent of commercial land use between the M4 Motorway corridor and residential areas to the north. LCZ 2 (south) and LCZ 3 were identified to have high sensitivity

- due to the residential character of the area
- Noise wall on the northern side of the M4 Motorway, to the west of the Westlink M7 interchange (refer to Figure 3-1e): this noise wall would be located within LCZ 8 (north), which was identified to have a high sensitivity due to the consistent urban character of the area
- Noise wall to the west of the Roper Road interchange, on the northern side of the M4 Motorway (refer to Figure 3-1f): this noise wall would be located within LCZ 11, which was identified to have high sensitivity due to its cohesive suburban landscape character
- Noise wall on the northern side of the M4 Motorway, east of the Mamre Road interchange (refer to Figure 3-1g): this noise wall would be located within LCZ 11, which was identified to have high sensitivity due to its cohesive suburban landscape character
- Noise wall on the northern side of the M4 Motorway, east of the Mulgoa Road interchange (refer to Figure 3-1i): this noise wall is located within LCZ 14, which was identified to have high sensitivity due to the residential character of the area.

The proposal was identified to have either a 'moderate' or 'high to moderate' impact on these LCZs in the landscape character and visual impact assessment (refer to Section 6.3.4 of the REF). Changes to the location and extent of noise walls have the potential to result in additional visual impacts, particularly where noise walls would be located near sensitive viewers.

#### 4.3.5 Additional safeguards and management measures

Safeguards and management measures for landscape character and visual amenity are described in Section 6.3.5 of the REF. No additional safeguards and management measures for potential visual impacts are proposed.

## 5 Environmental management

---

The REF for the M4 Smart Motorway identified the framework for environmental management, including management and mitigation measures that would be adopted to avoid or reduce environmental impacts (refer to Chapter 7 of the REF).

After consideration of the comments raised in the public submissions and changes to the proposal, Roads and Maritime has revised the management and mitigation measures in the REF. The key change includes the preparation of a Biodiversity Offset Strategy for the proposal.

Should the proposal proceed, environmental management will be guided by the framework and measures outlined below.

### 5.1 Environmental management plans (or system)

The proposal includes a number of safeguards and management measures to minimise adverse environmental and social impacts (refer to Chapter 6 of the REF). Should the proposal proceed, these measures would be incorporated into the detailed design and applied during construction and operation.

These safeguards and management measures would be contained in a Project Environmental Management Plan (PEMP) and a Contractor's Environmental Management Plan (CEMP). These two plans would provide a framework for establishing how these measures would be implemented and who would be responsible for their implementation.

The plans will be prepared before construction of the proposal and must be reviewed and certified by the Roads and Maritime Services Environmental Officer, Sydney Region, before any on-site works can begin. The CEMP would be a working document, subject to ongoing change and updated as necessary to respond to specific requirements. The CEMP and PEMP would be developed in accordance with the specifications set out in the QA Specification G36 – Environmental Protection (Management System), QA Specification G38 – Soil and Water Management (Soil and Water Plan) and the QA Specification G40 – Clearing and Grubbing.

### 5.2 Summary of safeguards and management measures

Environmental safeguards outlined in this document would be incorporated into the detailed design phase of the proposal and during construction and operation of the proposal, should it proceed. These safeguards would minimise any potential adverse impacts arising from the proposed works on the surrounding environment. The safeguards and management measures are summarised in Table 5-1.

Changes made to the previous safeguards and management measures are identified in ***blue italicised text*** in Table 5-1.

**Table 5-1 Summary of safeguards and management measures**

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>General</b>				
G-1	General	<p>All environmental safeguards will be incorporated within the following documents:</p> <ul style="list-style-type: none"> <li>• Project <b>Environmental</b> Management Plan</li> <li>• Detailed design stage</li> <li>• Contract specifications for the proposal</li> <li>• Contractor's Environmental Management Plan.</li> </ul>	Project manager	Pre-construction
G-2	General	<p>A risk assessment will be carried out in accordance with the Roads and Maritime Audit Pack and Operations and Services Directorate (OSD) risk assessment procedures to determine an audit and inspection program for the works. The recommendations of the risk assessment will be implemented.</p> <p>A review of the risk assessment will be carried out after the initial audit or inspection to evaluate if the level of risk chosen for the project is appropriate.</p> <p>Any works resulting from the proposal and as covered by this REF may be subject to environmental audit(s) and/or inspection(s) at any time during their duration.</p>	Project manager and regional environmental staff	<p>Pre-construction</p> <p>After first audit</p>
G-3	General	<p>The environmental contract specification G30 – Environmental Protection (Management System) will be forwarded to the Roads and Maritime Senior Environmental Officer for review at least 10 working days before the tender stage.</p> <p>A contractual hold point must be maintained until the CEMP is reviewed by the Roads and Maritime Senior Environmental Officer.</p>	Project manager	Pre-construction
G-4	General	The Roads and Maritime Project Manager will notify the Roads and Maritime Environmental Officer, Western Sydney Region, at least 5 days prior to work begins.	Project manager	Pre-construction
G-5	General	All businesses and residences likely to be affected by the proposed works will be notified at least 5 working days before the proposed activities begin.	Project manager	Pre-construction
G-6	General	The contractor will provide environmental awareness training to all field personnel and subcontractors.	Contractor	Pre-construction and during construction as required.

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Traffic and transport</b>				
T1	Construction traffic and access	<p>A detailed Construction Traffic Management Plan (CTMP) will be prepared in accordance with the Roads and Maritime Traffic Control at Work Sites (Roads and Maritime, 2010a) and Roads and Maritime Specification G10 - Control of Traffic, to provide a comprehensive and objective approach to minimise any potential impacts on-road network operations during construction.</p> <p>The CTMP will include (as a minimum):</p> <ul style="list-style-type: none"> <li>• Measures to minimise heavy vehicle usage on local roads. Where practicable, deliveries of construction plant and materials will be carried out outside of peak traffic periods</li> <li>• Consultation with emergency services and maintenance of access for emergency vehicles</li> <li>• Traffic control provided to manage and regulate traffic movements during construction, including minimising traffic switching</li> <li>• Maintain the continuous, safe and efficient movement of traffic for both the public and construction workers</li> <li>• Entry and exit ramps to/from the M4 Motorway to generally remain open throughout the construction period with suitable alternative access arrangement provided where this is not achievable</li> <li>• Haulage routes/access arrangements to minimise impacts on local routes</li> <li>• Access to local roads and properties will be considered when determining the final location of construction compounds</li> <li>• Construction and delivery vehicles entering/leaving site compounds, and/or stockpile sites to be limited in peak periods</li> <li>• Access to local roads and properties will be maintained, where practicable</li> <li>• Maintain pedestrian and cyclists access throughout construction, with adequate planning and consultation undertaken relating to any temporary detours</li> <li>• Provision of appropriate warning and advisory signposting</li> </ul> <p>Include requirements and methods to consult and inform local community of impacts on local road network and traffic Consider other developments that may also be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic.</p>	Construction contractor	Pre-construction
T2	Construction compounds	Detailed assessment of construction compound locations and access arrangements. Including the main site compound.	Construction contractor	Detailed design
T3	Incident response	Consultation with emergency service authorities will be carried out during development of the detailed design including NSW Rural Fire Service and Fire Rescue.	Construction contractor	Detailed design

ID	Impact	Environmental safeguards	Responsibility	Timing
T4	Property access	Vehicular property access will be maintained where possible including pre-schools, places of worship and all commercial premises.	Construction contractor	Construction
T5	Pedestrians and cyclists	Pedestrian and cyclist access is to be maintained throughout construction. Provision of signposted outlining the pedestrians and cyclists diversion routes will be displayed during construction. There will be advance notification of any construction works that affect pedestrians and cyclists.	Construction contractor	Construction
T6	Public transport	Access to appropriate bus stop locations will be maintained during construction in consultation with bus operators.	Construction contractor	Construction
<b>Biodiversity</b>				
BI-1	Impacts to threatened species associated with ancillary facilities and water facilities (including basins and treatments)	Assessment of biodiversity impacts associated with ancillary facilities, basins and other water quality treatment devices will be carried out following finalisation of their location and design. Appropriate safeguards will be identified to mitigate these impacts.	Roads and Maritime	Before or during detailed design

ID	Impact	Environmental safeguards	Responsibility	Timing
BI-2	Impacts to threatened species	<p>A Biodiversity Management Plan (BMP) will be prepared and included within the CEMP. The BMP will include (but not be limited to) the following:</p> <ul style="list-style-type: none"> <li>• A site walk with appropriate site personnel including Roads and Maritime representatives to confirm clearing boundaries, roosting sites and sensitive locations and identify nearby habitats on both sides of the existing highway, along the length of the proposal, suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal.</li> <li>• Identification (marking) of the clearing boundary and identification (marking) of habitat features and riparian areas to be protected eg use of flagging tape</li> <li>• A map which clearly shows vegetation clearing boundaries and sensitive areas/no go zones, as well as potential release sites for the relocation of fauna during clearing works</li> <li>• A map which clearly shows designated parking areas for construction vehicles and workers, stockpile locations away from the dripline of trees</li> <li>• Incorporation of management measures identified as a result of the pre-clearing survey report, completed by an ecologist, (G40, section 2.4) and nomination of actions to respond to the recommendations made. This will include details of measures to be implemented to protect clearing limits and no go areas.</li> <li>• A detailed and staged clearing process in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011) including requirements of Guide 1,2, 4 &amp; 9. This process will consider the safe and ethical handling of fauna.</li> <li>• Identify in toolbox talks where biodiversity will be included such as staged vegetation clearing, or works in or adjacent to sensitive locations and stop work procedures</li> <li>• Identify control/mitigations measures to prevent impacts on sensitive locations or no go zones</li> </ul> <p>A stop works procedure in the event of identification of previously unidentified species, habitats or populations in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011).</p>	Construction contractor	Pre-construction
BI-3	Potential impacts to Cumberland Plain Land Snail	<p>A plan for the management of potential impacts to the Cumberland Plain Land Snail will be prepared. The plan will include but not be limited to:</p> <ul style="list-style-type: none"> <li>• Inspection of locations where the Cumberland Plain Land Snail has been identified</li> <li>• The development of a Translocation Plan</li> <li>• The relocation of potential Cumberland Plain Land Snails will be carried out by an appropriately qualified ecologist.</li> </ul>	Construction contractor	Pre-construction, construction
BI-4	Habitat removal and re-establishment (including wildlife connectivity)	<p>A Vegetation Management Plan (VMP) will be developed as part of the CEMP. It will provide specific details for the re-establishment of native vegetation on batters, sediment basins, cut faces and other areas disturbed during construction as appropriate. These details will be in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011a) and will be consistent with the landscape and urban design strategy.</p>	Construction contractor	Pre-construction, construction, post- construction

ID	Impact	Environmental safeguards	Responsibility	Timing
BI-5	Injury and mortality of fauna during the clearing of vegetation	A licensed wildlife carer and/or ecologist will be present to supervise native forest vegetation clearing, to capture and relocate fauna where required. Fauna handling and vegetation clearing will be carried out in accordance with the procedures in the Biodiversity Guidelines (Roads and Maritime, 2011).	Construction contractor	Pre-construction, construction
BI-6	Weeds and pathogens	<p>A Weed Management Plan will be prepared in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011) and incorporated into the BMP and will address:</p> <ul style="list-style-type: none"> <li>• Identification of the weeds on site (confirm during ecologist pre-clearing inspection)</li> <li>• Weed management priorities and objectives</li> <li>• Sensitive environmental areas within or adjacent to the site</li> <li>• Location of weed infested areas</li> <li>• Weed control methods</li> <li>• Measures to prevent the spread of weeds, including machinery hygiene procedures and disposal requirements</li> <li>• A monitoring program to measure the success of weed management</li> <li>• Communication with local Council noxious weed representative</li> <li>• If the detailed design risk assessment determines that hygiene procedures are required on site, the BMP will include hygiene protocols to prevent the introduction and spread of such pathogens as specified in the Biodiversity Guideline (Roads and Maritime, 2011)</li> <li>• Site induction and toolbox talks will include regular communication of risks and hygiene requirements relating to pathogens</li> <li>• Construction activities will be programmed so vehicles move from uninfected areas to known infected areas</li> <li>• Vehicles will be parked in designated roadsides and parking spaces only</li> <li>• All pathogens (eg Chyrid, Myrtle Rust and <i>Phytophthora</i>) will be managed in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011) and the Statement of Intent 1: Infection of Native Plants by <i>Phytophthora cinnamomi</i> (DECC, 2008).</li> </ul>	Construction contractor	Pre-construction, construction
<i>BI-7</i>	<i>Biodiversity offsets</i>	<p><i>A biodiversity offset strategy will be prepared for the proposal. The following offset options from Principle 6 of the OEH Offset Principles will be considered on the chosen offset site:</i></p> <ul style="list-style-type: none"> <li>• <i>Enhancing habitat</i></li> <li>• <i>Reconstructing habitat in strategic areas to link areas of conservation value</i></li> <li>• <i>Increasing buffer zones around areas of conservation value</i></li> <li>• <i>Removing threats by conservation agreements or reservation.</i></li> </ul>	<i>Construction contractor</i>	<i>Pre-construction</i>

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Landscape character and visual amenity</b>				
V-1	General	During detailed design, the landscape design principles and streetscape (planting) will be reviewed to ensure that they are consistent with the outcomes of the biodiversity assessment. This will be done in consultation with Roads and Maritime environment staff.	Roads and Maritime	Detailed design
V-2	Landscape character and visual impacts	During detailed design, the design including landscape plans will incorporate the design principles outlined in the Urban Design, Landscape Character and Visual Impact Assessment (Spackman Mossop and Michaels, 2015). These include: <ul style="list-style-type: none"> <li>To ensure that existing land uses is considered and integrated in to the design of the interchanges and M4 Motorway widening</li> <li>To contribute to the future urban planning of the adjoining development precincts including its transport and access needs</li> <li>To respond to natural patterns including creek lines and drainage corridors and vegetation communities. This includes the use of local plants consistent with the existing communities either side of the alignment in order to unify the crossing with the existing corridor, and, use of advance stock to escalate the revegetation where appropriate.</li> <li>To provide a unified and consistent approach to the design of gantries and ITS infrastructure along the corridor</li> <li>To provide a unified and consistent approach to the design and colour of noise walls in keeping with the local character</li> <li>The consideration of landscaping treatment to reduce the incidence of graffiti</li> <li>To achieve an integrated, safe and minimal maintenance design.</li> </ul>	Roads and Maritime	Detailed design
V-3	Landscape character and visual impacts	If cut-off drains or swales are required as a permanent fixture, their location, size and treatment will be finalised during detailed design so that they blend into the landform and landscape character.	Roads and Maritime	Detailed design
V-4	Visual impacts of construction activities	To reduce the potential visual impact of construction activities: <ul style="list-style-type: none"> <li>Work sites will be left tidy at the end of each work day</li> <li>Where appropriate, fencing with material attached (eg shade cloth) will be provided around the construction compound to screen views from adjoining properties</li> <li>Lighting for night-time work will comply with relevant Australian Standards, including AS4282-1997 (Control of the obtrusive effects of outdoor lighting).</li> </ul>	Construction contractor	Construction
V-5	Visual impacts of VMS on residences and sensitive receivers	Guidelines to be prepared to assist with the siting of electronic signage on arterial roads and VMS on the mainline during detailed design. This guidelines will include the requirement for the following: <ul style="list-style-type: none"> <li>Electronic signage to be located between 50-75 m from the intersection</li> <li>Electronic signage to be placed on property boundary lines, where reasonably practicable</li> <li>Identification of existing or potential screening opportunities.</li> </ul>	Roads and Maritime	Detailed design

ID	Impact	Environmental safeguards	Responsibility	Timing
V-6	Planting to reduce visual impacts	<p>A Vegetation Management Plan (VMP) will be prepared as part of the CEMP. This will include replanting of Cumberland Plain woodland species to replace those removed through vegetation clearing and will take into consideration the urban design requirements to include:</p> <ul style="list-style-type: none"> <li>Planting to provide screening at interchanges including grasses, groundcovers and shrubs, depending on sight line requirements</li> <li>Provide screening on the M4 Motorway mainline and to reduce perceived corridor width</li> <li>Shrub species will be planted in the median (where the width of the median allows, taking into account clear zone requirements)</li> <li>Landscape treatments to highlight the western entry of the M4 Motorway in the vicinity of Russell Street, and the major interchanges with additional landscape treatments.</li> </ul>	Roads and Maritime	Detailed design
<b>Aboriginal heritage</b>				
AH-1	Impacts to Aboriginal heritage items	<p>An Aboriginal Heritage Management Plan (AHMP) will be prepared and incorporated into the CEMP. The plan will include as a minimum:</p> <ul style="list-style-type: none"> <li>A map identifying locations of no-go areas, items or sites which are to be protected and those which are to be destroyed/impacted</li> <li>All measures recommended in the CHAR and AHIP, including notification requirements</li> <li>Identification of potential environmental risks/impacts due to the works/activities</li> <li>Management measures to minimise the potential risk</li> <li>Mitigation measures to avoid risk of harm and the interface with work activities on site</li> <li>Identify in toolbox talks where management of Aboriginal heritage is required such as identification of no go zones and responsibilities under the <i>National Parks and Wildlife Act 1974</i> and any obtained permits.</li> <li>A stop works procedure in the event of actual or suspected potential harm to a heritage feature/place</li> <li>Requirement to comply with the Standard Management Procedure-Unexpected Archaeological Finds (Roads and Maritime, 2012).</li> </ul>	Roads and Maritime	Pre-construction
AH-2	Aboriginal heritage training	All construction personnel will be trained on Aboriginal heritage issues and unexpected find protocol.	Construction contractor	Pre-construction
AH-3	Aboriginal Heritage Impact Permit (AHIP)	Roads and Maritime will apply for a corridor wide AHIP under Part 6 of the NPW Act, for all Aboriginal sites that will be directly or indirectly impacted, prior to any construction activities.	Roads and Maritime	Pre-construction
AH-4	Archaeological salvage of moderate-high significance sites	<p>Archaeological salvage will be carried out for the three sites identified as having a moderate or higher level of significance, including:</p> <ul style="list-style-type: none"> <li>Location 8 South Creek 1 (AHIMS 45-5-1070)</li> <li>Location 9 South Creek 2 (AHIMS 45-5-1071)</li> <li>Location 20A Clyburn Avenue (AHIMS 45-5-1074).</li> </ul>	Roads and Maritime	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Noise and vibration</b>				
NV-1	Operational noise	During the detailed design stage of the proposal, further investigations of all feasible and reasonable mitigation options will be carried out for affected receivers in accordance with the Road Noise Policy (DECCW, 2011), Noise Criteria Guideline (Roads and Maritime, 2014) and Noise Mitigation Guideline (Roads and Maritime, 2014).	Roads and Maritime	Detailed design
NV-2	Construction noise and vibration	<p>A Construction Noise and Vibration Management Plan (CNVMP) will be prepared as part of the CEMP. This plan will include but not be limited to:</p> <ul style="list-style-type: none"> <li>• A map indicating the locations of sensitive receivers including residential properties</li> <li>• A quantitative noise assessment in accordance with the EPA Interim Construction Noise Guidelines (DECCW, 2009)</li> <li>• Management measures to minimise the potential noise impacts from the quantitative noise assessment and for potential works outside of standard working hours (including implementation of EPA Interim Construction Noise Guidelines (DECCW, 2009)</li> <li>• A risk assessment to determine potential risk for activities likely to affect receivers (for activities undertaken during and outside of standard working hours)</li> <li>• Mitigation measures to avoid noise and vibration impacts during construction activities including those associated with truck movements</li> <li>• A process for assessing the performance of the implemented mitigation measures</li> <li>• A process for documenting and resolving issues and complaints</li> <li>• A construction staging program incorporating a program of noise and vibration monitoring for sensitive receivers</li> <li>• A process for updating the plan when activities affecting construction noise and vibration change.</li> <li>• Identify in toolbox talks where noise and vibration management is required.</li> </ul>	Contractor	Pre-construction
NV-3	Construction noise and vibration	Consider construction compound layout so that primary noise sources are at a maximum distance from sensitive receivers (primarily residential receivers), with solid structures (sheds and containers) placed between sensitive receivers and noise sources (and as close to the noise sources as is practical).	Contractor	Pre-construction, construction
NV-4	Construction noise and vibration	Compressors, generators, pumps and any other fixed plant will be located as far from residences as possible and behind site structures where practicable.	Contractor	Construction
NV-5	Construction noise and vibration	Alternatives to reversing alarms will be considered for site equipment subject to WHS compliance requirements and risk assessments.	Contractor	Construction
NV-6	Construction noise and vibration	Vehicle delivery times will be scheduled where reasonably practicable and feasible to the recommended construction hours to minimise noise impacts from heavy vehicle movements and deliveries.	Contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
NV-7	Out of hours construction	Any out of hours works will comply with G36 community notification requirements and the mitigation measures specified within the Noise Management Manual – Practice Note VII (RTA, 2001).	Contractor	Construction
NV-8	Construction noise and vibration	During work hours, a community liaison phone number and site contact will be provided.	Contractor	Construction
NV-9	Construction noise and vibration	If deemed necessary, attended compliance noise and vibration monitoring will be carried out upon receipt of a complaint. Monitoring will be reported as soon as possible. If exceedances are detected, the situation will be reviewed in order to identify means to minimise the impacts to residences.	Contractor	Construction
NV-10	Construction noise and vibration	The environmental induction program will include specific noise and vibration issues awareness training including, but not limited to, the following: <ul style="list-style-type: none"> <li>• Avoiding use of radios during work outside normal hours</li> <li>• Avoiding shouting and slamming doors</li> <li>• Where practical, operating machines at low speed or power and switching off when not being used rather than left idling for prolonged periods</li> <li>• Minimising reversing</li> <li>• Avoiding dropping materials from height and avoiding metal to metal contact on material.</li> </ul>	Contractor	Construction
NV-11	Construction noise and vibration	If exceedances are detected for noise and vibration monitoring, the situation will be reviewed in order to identify means to minimise impacts to residents and the appropriate changes made and the NVMP updated accordingly.	Contractor	Construction
NV-12	Construction noise and vibration	A vibration assessment will be prepared and included in the NVMP. The vibration assessment will include (as a minimum): <ul style="list-style-type: none"> <li>• Identification of potentially affected properties/receivers</li> <li>• A risk assessment to determine the potential for discrete work activities to affect receivers</li> <li>• A map indicating the locations considered likely to be impacted and those requiring building condition surveys</li> <li>• Outline a monitoring program</li> <li>• A process for assessing the performance of the implemented mitigation measures</li> <li>• A process for resolving issues and conflicts.</li> </ul>	Pre-construction	Contractor
NV-13	Construction and operational noise	Any mitigation measures provided to control operational noise impacts will be implemented as early as practicable to also provide a benefit during some of the construction phase.	Contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
NV-14	Operational noise	A post-construction noise monitoring program (including simultaneous traffic counts) will be carried out in accordance with the Environmental Noise Management Manual (RTA, 2001) within 6 to 12 months of opening once traffic flows have stabilised in order to verify the noise assessment.	Roads and Maritime	Post- construction
<b>Hydrology</b>				
HY-1	Erosion and sedimentation	<p>An Erosion and Sedimentation Management Report will be prepared. The report will include (as a minimum):</p> <ul style="list-style-type: none"> <li>• Identify site catchment and sub-catchments, high risk areas and sensitive areas</li> <li>• Sizing of each of the above areas and catchments</li> <li>• Proposed staging plans for the proposal to ensure appropriate erosion and sediment controls measures are possible</li> <li>• The likely volume of run-off from each catchment and sub-catchment in accordance with the Managing Urban Stormwater: Soils and Construction, Volume 1 and 2 (Landcom, 2004)</li> <li>• Direction of water flow, both off and on site</li> <li>• Diversion of off-site water around or through the site or details of separation of on-site and off-site water</li> <li>• The direction of runoff and drainage points during each stage of construction</li> <li>• The locations and sizing of water management basins as well as associated drainage to direct site water to the basins</li> <li>• A mapped plan identifying the above at all major construction stages</li> <li>• A review process by a soil conservationist and a process for updating the report to address any recommendations.</li> </ul>	Construction contractor	Detailed design
HY-2	Erosion and sedimentation	The Erosion and Sedimentation Management Report will be provided to Roads and Maritime's Environment Manager for review and verification prior to the construction tender.	Construction contractor	Detailed design
HY-3	Erosion and sedimentation	Final layout and detail of the drainage system including swale design and water management basins will be refined during detailed design in consultation with the Roads and Maritime's Senior Environmental Officer.	Construction contractor	Detailed design
HY-4	Erosion and sedimentation	Further flood modelling including a detailed afflux assessment will be carried out during detailed design to confirm impacts to surrounding land uses.	Construction contractor	Detailed design

ID	Impact	Environmental safeguards	Responsibility	Timing
HY-5	Impact of the proposal on existing drainage basins	An Operational Basin Management Plan (OBMP) will be prepared for each basin and include (as a minimum): <ul style="list-style-type: none"> <li>• Location of the basin on a map</li> <li>• Volume of the basin with calculations</li> <li>• Description of the proposed works</li> <li>• Basin design, including drainage.</li> </ul>	Construction contractor	Detailed design
HY-6	Erosion and sedimentation	Operation water quality measures will be further investigated during detailed design including bio filtration at the water quality basin and swale treatment.	Construction contractor	Detailed design
HY-7	Stormwater	Where an upgraded section of the M4 Motorway drains to Council stormwater systems options to identify and reduce any increased discharge of stormwater would be investigated and implemented.	Design contractor	Detailed design
HY-8	Flooding	A contingency plan will be prepared to manage a potential flood event during construction and will outline procedures to reduce risk including removal of all plant/equipment and stabilising exposed areas.	Construction contractor	Detailed design
HY-9	Erosion and sedimentation	A soil conservationist from the Roads and Maritime's Erosion, Sedimentation and Soil Conservation Consultancy Services Register will be engaged to review the Erosion and Sedimentation Management Report and conduct routine inspections of the construction works.	Construction contractor	Detailed design, construction

ID	Impact	Environmental safeguards	Responsibility	Timing
HY-10	Erosion and sedimentation	<p>A Soil and Water Management Plan (SWMP) will be prepared as part of the CEMP in accordance with the requirements of the Roads and Maritime contract specification G38 prior to the commencement of construction. The SWMP will also address the following:</p> <ul style="list-style-type: none"> <li>• Roads and Maritime Code of Practice for Water Management, the Roads and Maritime Erosion and Sedimentation Procedure</li> <li>• The NSW Soils and Construction – Managing Urban Stormwater Volume 1 “the Blue Book” (Landcom, 2004) and Volume 2 (DECC, 2008)</li> <li>• Roads and Maritime Technical Guideline: Temporary Stormwater Drainage for Road Construction, 2011</li> <li>• Roads and Maritime Technical Guideline: Environmental Management of Construction Site Dewatering, 2011.</li> </ul> <p>The SWMP will detail the following as a minimum:</p> <ul style="list-style-type: none"> <li>• Identification of catchment and sub-catchment areas, high risk areas and sensitive areas</li> <li>• Sizing of each of the above areas and catchment</li> <li>• The likely volume of run-off from each road sub-catchment</li> <li>• Direction of flow of on-site and off-site water</li> <li>• Separation of on-site and off-site water</li> <li>• The direction of run-off and drainage points during each stage of construction</li> <li>• The locations and sizing of sediment traps such as sump or basin as well as associated drainage</li> <li>• Dewatering plan which includes process for monitoring, flocculating and dewatering water from site (ie sediment basin and sumps)</li> <li>• The staging plans, location, sizing and details of creek alignment and realignment controls for scour protection and bank and bed stabilisation including those used during construction and long term.</li> <li>• A mapped plan identifying the above</li> <li>• Include progressive site specific Erosion and Sedimentation Control Plans (ESCPs). The ESCP is to be updated at least fortnightly.</li> <li>• A process to routinely monitor the BOM weather forecast</li> <li>• Preparation of a wet weather (rain event) plan which includes a process for monitoring potential wet weather and identification of controls to be implemented in the event of wet weather. These controls are to be shown on the ESCPs.</li> <li>• Provision of an inspection and maintenance schedule for ongoing maintenance of temporary and permanent erosion and sedimentation controls</li> </ul>	Construction contractor	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
HY-11	Erosion and sedimentation	<p>An Erosion and Sedimentation Control Plan (ESCP) will be prepared prior to construction and is to include as a minimum:</p> <ul style="list-style-type: none"> <li>• Identify site catchment and sub-catchments, high risk areas and sensitive areas</li> <li>• Sizing of each of the above areas and catchments</li> <li>• The likely run-off from each sub-catchment</li> <li>• Separation of on-site and off-site water</li> <li>• The direction of run-off and drainage points during each stage of construction</li> <li>• Direction of flow of on-site and off-site water</li> <li>• The locations and sizing of sediment basins or sumps and associated catch drains and/or bunds</li> <li>• The locations of other erosion and sediment control measures (eg rock check dams, swales and sediment fences)</li> <li>• Controls/measures to be implemented on wet weather events</li> <li>• A mapped plan identifying the above</li> <li>• A dewatering procedure for onsite water and basins</li> <li>• A process for reviewing and updating the plan on a fortnightly basis and/or when works alter.</li> </ul>	Contractor	Pre-construction
HY-12	Erosion and sedimentation	<p>Erosion and sediment control measures will be implemented and maintained to:</p> <ul style="list-style-type: none"> <li>• Prevent sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets</li> <li>• Reduce water velocity and capture sediment on site</li> <li>• Minimise the amount of material transported from site to surrounding pavement surfaces</li> <li>• Divert clean water around the site (in accordance with the Landcom/Department of Housing Managing Urban Stormwater, Soils and Construction Guidelines (the Blue Book)).</li> </ul>	Construction contractor	Construction
HY-13	Erosion and sedimentation	Erosion and sedimentation controls will be checked and maintained on a regular basis and after a rain event of 10mm or greater (including clearing of sediment from behind barriers) and records kept and provided on request.	Construction contractor	Construction
HY-14	Erosion and sedimentation	Controls will be implemented at exit points to minimise tracking soil and particulates onto pavement surfaces.	Construction contractor	Construction
HY-15	Erosion and sedimentation	Any material transported onto pavements will be swept and removed at the end of each working shift and prior to rainfall.	Construction contractor	Construction
HY-16	Water quality	Emergency wet and dry spill kits will be kept on site at all times and all staff will be made aware of the location of the spill kit and trained in its use.	Construction contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
HY-17	Water quality	All refuelling and storage of fuels, chemicals and liquids will be within an impervious bunded area within the construction compound, sited a minimum of 50 metres away from: <ul style="list-style-type: none"> <li>• Rivers, creeks or any areas of concentrated water flow</li> <li>• Flooded areas</li> <li>• Slopes above 10%.</li> </ul>	Construction contractor	Construction
HY-18	Water quality	The vehicles refuelling process will include a person attending the refuelling facility / vehicle and a spill kit on the vehicle.	Construction contractor	Construction
HY-19	Water quality	Vehicle wash down and/or cement truck washout is to occur in a designated bunded area and least 50 metres away from water bodies and surface water drains.	Construction contractor	Construction
HY-20	Erosion and sedimentation	If an incident (eg spill) occurs, the Roads and Maritime's Environmental Incident Classification and Management Procedure will be followed and the Roads and Maritime Services Contract Manager notified as soon as practicable.	Construction contractor	Construction
<b>Soils</b>				
TO-1	Stabilisation and revegetation	A Stabilisation Plan will be prepared and included in the Soil and Water Management Plan (SWMP). The stabilisation plan will include but not be limited to the following: <ul style="list-style-type: none"> <li>• Identification and methodology of techniques for stabilisation of site</li> <li>• Identification of area on site for progressive stabilisation</li> <li>• Stabilisation will be carried out, including stockpiles and batters, exposed for a duration of two weeks or greater. For example covering with geotextile fabric, stabilised mulch, soil binder or spray grass.</li> <li>• Identification of areas on site for progressive permanent stabilisation such as implementation of landscaping.</li> </ul>	Construction contractor	Pre-construction
TO-2	Stockpiles	All stockpiles will be designed, established, operated and decommissioned in accordance with the Stockpile Site Management Guideline (Roads and Maritime, 2011).	Construction contractor	Detailed design, construction, post-construction
TO-3	Acid sulphate soils	The SWMP will include a contingency plan for any acid sulphate soils or salinity identified during the construction phase.	Construction contractor	Pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Contamination</b>				
CL-1	Management of contaminated land	<p>A Contamination Management Plan (CMP) will be prepared in accordance with the <i>Contaminated Land Act 1997</i> and relevant EPA Guidelines. This plan will be form part of the CEMP and will include at a minimum:</p> <ul style="list-style-type: none"> <li>Contaminated Land Legislation and guidelines including any relevant licences and approvals to be obtained</li> <li>Identification of locations of known or potential contamination and preparation of a map showing these locations</li> <li>Identification of rehabilitation requirements, classification, transport and disposal requirements of any contaminated land within the construction footprint</li> <li>Contamination management measures including waste classification and reuse procedures and unexpected finds procedures</li> <li>Monitoring and sampling procedure for landfill seepage (leachate)</li> <li>A procedure for dewatering and disposal of potentially contaminated liquid waste</li> <li>In the event that indications of contamination are encountered (known and unexpected, including odorous or visual indicators), work in the area will immediately cease until a contamination assessment can be prepared to advise on the need for remediation or other action, as deemed appropriate</li> <li>A process for reviewing and updating the plan.</li> </ul> <p>The CMP would be reviewed by Roads and Maritime's Senior Environment Officer and Roads and Maritime's Land Management Specialist prior to the commencement of works.</p>	Construction contractor	Pre-construction, construction
CL-2	Human Exposure to contaminated land	The CEMP will include environmental awareness training for construction staff to include the procedures for identification, reporting and management of contaminated land.	Construction contractor	Pre-construction, construction
CL-3	Identification of contaminated land	In the event that indications of contamination are encountered (known and unexpected, such as odorous or visually contaminated materials), work in the area will cease until a contamination assessment can be prepared to advise on the need for remediation or other action, as deemed appropriate.	Construction contractor	Construction
CL-4	Handling and disposal of contaminated materials	Any soils that are contaminated through accidental spills or fuels or chemicals will be removed from site by a licenced contractor and disposed of at an appropriately licenced facility.	Construction contractor	Construction
CL-5	Notification of contaminated land	NSW EPA will be notified of contaminated land in accordance with Section 60 of the <i>Contaminated Land Management Act 1997</i> .	Roads and Maritime	Construction, operation

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Air quality</b>				
AQ-1	Impacts to air quality during construction	<p>An Air Quality Management Plan (AQMP) will be prepared as part of the CEMP. The plan will include but not be limited to:</p> <ul style="list-style-type: none"> <li>• A map identifying locations of sensitive receivers</li> <li>• Identification of potential risks/impacts due to the work/activities as dust generation activities</li> <li>• Management measures to minimise risk including a progressive stabilisation plan</li> <li>• A process for monitoring dust on site and weather conditions</li> <li>• A process for altering management measures as required.</li> </ul>	Construction contractor	Pre-construction
AQ-2	Impacts to air quality during construction	<p>The management measures within the AQMP will include but not limited to:</p> <ul style="list-style-type: none"> <li>• Vehicles transporting waste or other materials that have a potential to produce odours or dust are to be covered during transportation</li> <li>• Dust will be suppressed on stockpiles and unsealed or exposed areas using methods such as water trucks, temporary stabilisation methods, soil binders or other appropriate practices</li> <li>• Disturbed areas will be minimised in extent and rehabilitated progressively</li> <li>• Speed limits will be imposed on unsealed surfaces</li> <li>• Stockpiles will be located as far away from residences and other sensitive receivers</li> <li>• Works (including the spraying of paint and other materials) will not be carried out during strong winds or in weather conditions where high levels of dust or air borne particulates are likely</li> <li>• Plant, vehicles and equipment will be maintained in good condition and in accordance with manufacturer's specifications</li> <li>• Plant and machinery will be turned off when not in use</li> <li>• No burning of any timbers or other combustible materials will occur on site</li> <li>• Visual monitoring of air quality will be undertaken to verify the effectiveness of controls and enable early intervention</li> <li>• Work activities will be reprogrammed if the management measures are not adequately restricting dust generation.</li> </ul>	Construction contractor	Pre-construction
AQ-3	Air quality monitoring	In locations in close proximity to sensitive receivers a dust monitoring program will be prepared to identify appropriate dust monitoring parameters, locations, monitoring frequencies and corrective actions should results indicate adverse dust impacts.	Construction contractor	Pre- construction

ID	Impact	Environmental safeguards	Responsibility	Timing
<b>Non-Aboriginal heritage</b>				
NA-1	Impacts to non-Aboriginal heritage items during construction	<p>A Non-Aboriginal Heritage Management Plan (AHMP) will be prepared and included in the CEMP. This plan will include but not be limited to the following:</p> <ul style="list-style-type: none"> <li>• A map identifying locations of items or sites (including curtilages) which are to be protected and those which are to be destroyed/impacted and no-go zones</li> <li>• Identification of potential environmental risks/impacts due to the works/activities</li> <li>• Management measures to minimise the potential risk</li> <li>• Mitigation measures to avoid risk of harm and the interface with work activities on site</li> <li>• Implementation of mitigation measures to protect identified heritage items or areas</li> <li>• Identify in toolbox talks where management of non-aboriginal heritage is required such as identification of no go zones and responsibilities under the <i>Heritage Act 1977</i> and any obtained permits or exemptions</li> <li>• A stop works procedure in the event of actual or suspected potential harm to a heritage feature/place</li> <li>• Requirement to comply with Roads and Maritime's Standard Management Procedure - Unexpected Archaeological Finds, 2012.</li> </ul>	Pre-construction	Construction contractor
NA-2	Discovery of non-Aboriginal heritage items	If unexpected heritage item/s, archaeological remains or potential relics are uncovered during the works, all works will cease in the vicinity of the material/find and the Standard Management Procedure- Unexpected Archaeological Finds (Roads and Maritime, 2012) will be followed.	Construction contractor	Construction
<b>Socio-economic impacts</b>				
SE-1	Community relations	<p>A Communication Plan will be prepared and included in the CEMP. The Communication Plan will include (as a minimum):</p> <ul style="list-style-type: none"> <li>• Requirements to provide details and timing of proposed activities to affected residents</li> <li>• A complaint handling procedure including a contact name and number</li> <li>• A procedure to notify adjacent land users for changed conditions during the construction period such as traffic, pedestrian or driveway access.</li> </ul> <p>The communications plan will be prepared in accordance with G36 requirements and Community Engagement and Communications Manual (Roads and Maritime, 2012).</p>	Construction contractor	Pre-construction, construction
SE-2	Community relations	A complaints handling procedure and register will be included in the CEMP and maintained for the duration of the project.	Construction contractor	Construction
SE-3	Interruptions to utility services	Residents will be informed prior to any interruptions to utility services that may be experienced as a result of utilities relocation.	Construction contractor	Construction

ID	Impact	Environmental safeguards	Responsibility	Timing
SE-4	Access and connectivity	Road users, pedestrians and cyclists will be informed of changed conditions, including likely disruptions to access during construction.	Construction contractor	Construction
SE-5	Amenity and community values	Fencing with material attached (eg shade cloth) will be provided around the construction compounds and other areas to screen views of the construction compounds from adjoining properties. At the end of construction, the construction site compounds will be decommissioned and the site rehabilitated and re-landscaped.	Construction contractor	Construction
SE-6	Social infrastructure	Impacted social infrastructure and community facilities, including emergency services, will be consulted during detailed design to identify any feasible impact mitigation measures.	Roads and Maritime	Pre-construction, construction
<b>Waste and resource management</b>				
WR-1	Re-use of construction wastes	The following resource management hierarchy principles will be followed: <ul style="list-style-type: none"> <li>• Avoid unnecessary resource consumption as a priority</li> <li>• Avoidance will be followed by resource recovery (including reuse of materials, reprocessing, and recycling and energy recovery)</li> <li>• Disposal will be carried out as a last resort in accordance with the <i>Waste Avoidance and Resource Recovery Act, 2001</i>.</li> </ul>	Construction contractor	Detailed design, pre-construction, construction
WR-2	Procurement of materials and products	Procurement will endeavour to use materials and products with a recycled content where that material or product is cost and performance effective.	Roads and Maritime, construction contractor	Detailed design, pre-construction

ID	Impact	Environmental safeguards	Responsibility	Timing
WR-3	Management of waste	<p>A Resource and Waste Management Plan (RWMP) will be prepared, which will include the following (as a minimum):</p> <ul style="list-style-type: none"> <li>• The type, classification and volume of all materials to be generated and used on site including identification of recyclable and non-recyclable waste in accordance with EPA Waste Classification Guidelines</li> <li>• Quantity and classification of excavated material generated as a result of the proposal (refer to the Waste Management Fact sheets 1-6, (Roads and Maritime, 2012))</li> <li>• Interface strategies for cut and fill on site to ensure re-use, where possible</li> <li>• Strategies to 'avoid', 'reduce', 'reuse' and 'recycle' materials.</li> <li>• Classification and disposal strategies for each type of material.</li> <li>• Destinations for each resource/waste type either for on-site reuse or recycling, offsite reuse or recycling, or disposal at a licensed waste facility</li> <li>• Details of how material will be stored and treated on-site.</li> <li>• Identification of available recycling facilities on and off site</li> <li>• Identification of suitable methods and routes to transport waste</li> <li>• Procedures and disposal arrangements for unsuitable excavated material or contaminated material</li> <li>• Site clean-up for each construction stage.</li> </ul>	Construction contractor	Pre-construction, construction
WR-4	Disposal of cleared weed species	Any weed species that are cleared for the proposal will be collected in plastic bags and disposed of at a licensed green waste disposal facility or landfill.	Construction contractor	Construction
WR-5	Generation of construction waste	The construction contractor will regularly address housekeeping at the construction site. Working areas will be maintained, kept free of rubbish and cleaned up at the end of each working day. This will include collection and sorting of recycling, general waste and green waste.	Construction contractor	Construction
WR-6	Management of waste	A dedicated concrete washout facility that is impervious would be provided during construction so that runoff from the washing of concrete machinery, equipment and concrete trucks can be collected and disposed of at an appropriate waste facility.	Construction contractor	Construction
WR-7	Management of waste	All wastes would be managed in accordance with the Protection of the Environment Operations Act 1997.	Construction contractor	Construction
<b>Greenhouse gas emissions and climate change</b>				
GG-1	Impacts of the proposal on climate change	Detailed design will take into consideration the potential effect of climate change on the proposal, including drainage requirements.	Roads and Maritime	Detailed Design

ID	Impact	Environmental safeguards	Responsibility	Timing
GG-2	Impacts of the proposal on climate change	A Greenhouse Gas Assessment will be carried out for the proposal in accordance with the Greenhouse Gas Assessment Workbook for Road Project, Transport Authorities Greenhouse Group, February 2013.	Roads and Maritime	Detailed Design
GG-3	Climate change risks to construction	Environmental safeguards and management measures in the CEMP will be designed to accommodate and respond to the increased frequency and severity of rainfall events.	Construction contractor	Pre-construction
GG-4	Impacts on climate change from construction activities	<p>During construction, the following measures will be considered and implemented where possible:</p> <ul style="list-style-type: none"> <li>• Plant and equipment will be switched off when not in use</li> <li>• Vehicles, plant and construction equipment will be appropriately sized for the task and properly maintained so as to achieve optimum fuel efficiency</li> <li>• Materials will be delivered with full loads and will come from local suppliers, where possible</li> <li>• Energy efficiency and related carbon emissions will be considered when selecting vehicles and equipment</li> <li>• Vegetation clearing will be reduced as much as feasible, and re-established in suitable areas when construction is completed</li> <li>• Waste will be reduced and recycled as a preference before disposing to landfill.</li> </ul>	Construction contractor	Construction
<b>Cumulative impacts</b>				
CE-1	Cumulative traffic impacts from construction of multiple projects	<p>The CEMP will be updated as required to incorporate potential cumulative impacts from surrounding development activities as they become known.</p> <p>This will include a process to review and update mitigation measures as new work begins or if complaints are received.</p>	Construction contractor	Detailed design, pre-construction, construction

### 5.3 Licensing and approvals

Licences and approvals required for the proposal are listed in Table 5-2

**Table 5-2 Summary of licensing and approval required**

<b>Requirement</b>	<b>Timing</b>
Environment Protection Licence under the Protection of Environment Operations Act 1997 for the regulation of noise, air, waste and water management during construction	Before construction commences
Approval under Section 90 of the National Parks & Wildlife Act 1975 for the destruction and salvage of Aboriginal archaeological sites	Before construction commences

## 6 References

---

Department of Environment and Climate Change (DECC) (2009) *Interim Construction Noise Guideline*, July 2009

Department of Environment and Climate Change (DECC) (2008) *Statement of Intent 1: Infection of native plants by *Phytophthora cinnamomi**, April 2008

Department of Environment and Climate Change (DECC) (2008) *Soils and Construction – Managing Urban Stormwater*, Volume 2, June 2008

Department of Environment, Climate Change and Water (DECCW) (2011) *NSW Road Noise Policy*, March 2011

Jacobs (2015a) *Draft Biodiversity Assessment*, March 2015

Jacobs (2015b) *Final Draft Biodiversity Assessment*, July 2015

Kelleher Nightingale Consulting (2013) *M4 Managed Motorway from Lapstone (western end) to Church Street, Parramatta (eastern end), Review of Environmental Factors*, August 2013

Kelleher Nightingale Consulting (2015b) *M4 Managed Motorway from Lapstone (western end) to Church Street, Parramatta (eastern end), Review of Environmental Factors*, August 2015

Landcom (2004) *Soils and Construction – Managing Urban Stormwater*, Volume 1, March 2004

NSW Environment Protection Authority (2014) *Waste Classification Guidelines*, November 2014

Roads and Maritime (2015) *M4 Smart Motorway Review of Environmental Factors*, March 2015

Roads and Maritime (2015) *Noise Mitigation Guideline*, April 2015

Roads and Maritime (2015) *Noise Criteria Guideline*, April 2015

Roads and Maritime (2012), *Standard Management Procedure: Unexpected Archaeological Finds*, July 2012

Roads and Maritime (2012) *Community Engagement and Communications Manual*

Roads and Maritime (2011) *Biodiversity Guidelines: Protection and managing biodiversity on RTA projects*, September 2011

Roads and Maritime (2011) *Technical Guideline: Temporary stormwater drainage for road construction*, December 2011

Roads and Maritime (2011) *Technical Guideline: Environmental management of construction site dewatering*, April 2011

Roads and Traffic Authority (now Roads and Maritime) (2001) *Environmental Noise Management Manual*, December 2001

Spackman Mossop and Michaels (2015), *Urban Design Concept, Landscape Character and Visual Impact Assessment Report*, February 2015

Transport Authorities Greenhouse Group (2013) *Greenhouse Gas Assessment Workbook for Road Project*, February 2013.

# Appendix A

## Community updates

# Community Update



MARCH 2015



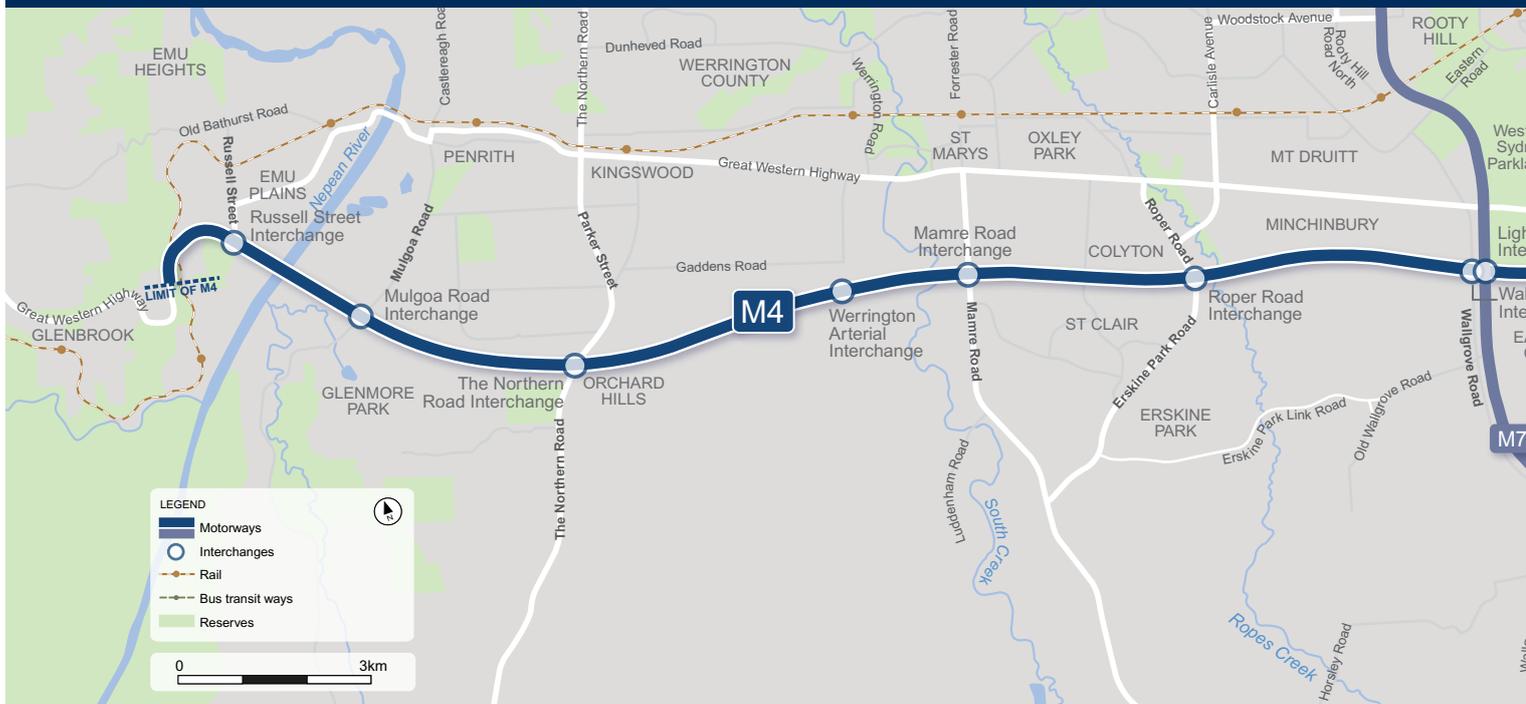
## M4 Smart Motorway Review of Environmental Factors

The Australian and NSW governments are proposing to introduce intelligent technology, known as a Smart Motorway system, to Sydney's M4 Motorway between Pitt Street, Mays Hill and Lapstone.

Smart Motorways are the future of Sydney's road network. They will slash congestion and improve travel times by providing real-time information, communication and traffic management tools.

The proposed concept design and Review of Environmental Factors is on display for community comment until Friday 10 April 2015.

## M4 Smart Motorway



### Key features

Smart Motorways, also known as ‘managed motorways’ use complementary technologies to monitor traffic conditions, manage congestion and respond to incidents in real-time.

The proposed M4 Smart Motorway would connect with the WestConnex project at Mays Hill. The M4 Smart Motorway would be the first Smart Motorway for NSW. The Smart Motorway would reduce congestion and slash travel times along the M4 by up to 15 minutes in peak periods, meaning less wear and tear on vehicles in stop start traffic, less time in the car and more time doing business.

Key features of the proposal include:

- More Variable Message Signs on the motorway and approach roads to inform drivers about expected travel times and traffic conditions ahead
- Ramp signals and realignment, extension and widening of 20 entry ramps to smooth traffic flow onto the motorway
- Lane use signs on around 90 gantries along the motorway to open and close lanes in response to incidents
- Variable speed limit signs to vary speed limits if there is heavy traffic, an incident or bad weather
- Additional emergency telephones and stopping bays
- Additional traffic sensors and traffic cameras to continually monitor traffic conditions
- The addition of a freight bypass lane to the Prospect Highway and M7 Motorway westbound entry ramps and the Roper Road eastbound entry ramp to provide a dedicated entry lane for slow-moving heavy vehicles

- Realignment, extension and widening of some exit ramps to reduce queuing onto the motorway
- Traffic signalling improvements and minor adjustments at intersections
- Widening the motorway between the M7 Motorway and Roper Road to four lanes in each direction to improve traffic flow.

Some individual elements of Smart Motorway technology are already in place on Sydney roads.

### Key benefits

- Travel time savings along the M4 by up to 15 minutes in peak periods
- Safer, smoother and more reliable journeys
- Reduction of up to 30 per cent of crashes per year
- Improved incident management
- Savings on vehicle running costs and reduction in vehicle emissions
- \$5.4 billion of benefits to individuals and the community.

### More information

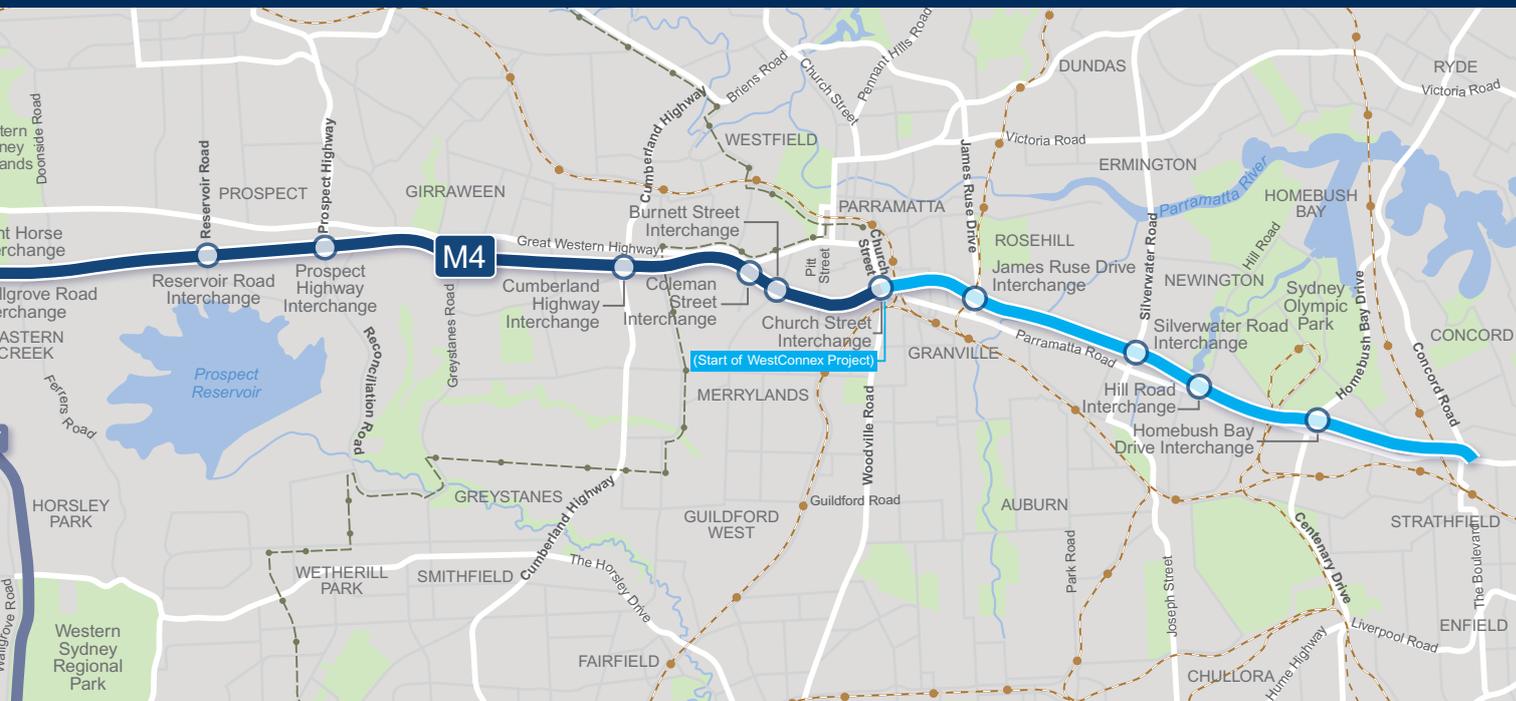
Watch the online video to see how the Smart Motorway system would work and view maps of the proposed changes at each interchange at:

[rms.nsw.gov.au/m4sm](https://rms.nsw.gov.au/m4sm)



A smarter way of travelling the M4





## Project information

The Review of Environmental Factors is on display on the project website at [rms.nsw.gov.au/m4sm](http://rms.nsw.gov.au/m4sm) and at the display locations detailed below until **Friday 10 April 2015**.

View concept plans and speak to the project team at one of the following community drop-in sessions:

## Community drop-in sessions

### Wednesday 18 March 2015

6–9pm

St Marys Memorial Hall - meeting room  
29 Swanston Street (Corner Great Western Highway and Mamre Road), St Marys

### Saturday 21 March 2015

1–4pm

Penrith Library Theatre  
601 High Street, Penrith

### Tuesday 24 March 2015

6–9pm

Max Webber Library Function Centre  
Level 1, Corner Flushcombe Road and Alpha Street, Blacktown

### Wednesday 25 March 2015

6–9pm

Minchinbury Neighbourhood Centre,  
46 Minchin Drive, Minchinbury

### Tuesday 31 March 2015

6–9pm

Merrylands Community Centre – Prospect Room  
17 Miller Street, Merrylands

## Display locations

### Roads and Maritime Services

Level 9, 101 Miller Street, North Sydney  
Opening hours: Monday to Friday 8.30am–5pm

### Holroyd City Council

16 Memorial Avenue, Merrylands  
Opening hours: Monday to Friday 8am–4.30pm

### Parramatta City Council

30 Darcy Street, Parramatta  
Opening hours: Monday to Friday 8.30am–5pm

### Wentworthville Branch Library

2 Lane Street, Wentworthville  
Opening hours: Monday, Tuesday,  
Wednesday and Friday 9.30am–5.30pm,  
Thursday 9.30am–8pm, Saturday 9am–4pm

### Blacktown City Council

62 Flushcombe Road, Blacktown  
Opening hours: Monday to Friday 8am–5.30pm

### Service NSW – Mount Druitt Registry

23-27 Luxford Road, Mount Druitt  
Opening hours: Monday to Friday 8.30am–5pm,  
Saturday 8.30am–12pm

### Service NSW – St Marys Registry

33-43 Phillip Street, Shop M04, Station Plaza, St Marys  
Opening hours: Monday to Friday 8.30am–5pm,  
Saturday 8.30am–12pm

### Penrith City Council

601 High Street, Penrith  
Opening hours: Monday to Friday 8.30am–4pm

### Blue Mountains City Council (Springwood)

104 Macquarie Road, Springwood  
Opening hours: Monday to Friday 10am–5pm



## Have your say

You are invited to make a written submission on the proposal by Friday 10 April 2015. Submissions can be sent to Roads and Maritime by:

Email: [m4smartmotorway@rms.nsw.gov.au](mailto:m4smartmotorway@rms.nsw.gov.au)

Mail: Att: Motorways and Maritime Communication  
M4 Smart Motorway  
Locked Bag 928  
North Sydney NSW 2059

Your submission should include:

- Your name and address
- Your comments on the proposal
- Whether you support or object to the proposal or if you are just providing comments.

All submissions made during the display period will be addressed by Roads and Maritime with responses published in a submissions report. Issues raised will be considered by Roads and Maritime in finalising the concept design for project approval.

## What happens next?



If you would like further information, to register to receive project updates, would like to provide feedback or discuss the proposal, please contact the project team by email [m4smartmotorway@rms.nsw.gov.au](mailto:m4smartmotorway@rms.nsw.gov.au), call the project information line (free call) 1800 989 929 or visit our Facebook page [www.facebook.com/m4smartmotorway](http://www.facebook.com/m4smartmotorway).



australian  
made



carbon  
neutral



recycled



NATIONAL CARBON  
OFFSET STANDARD  
CARBON NEUTRAL PAPER



## Translating and Interpreting Service

If you need an interpreter, please call the Translating and Interpreting Service (TIS National) on **131 450** and ask them to telephone Roads and Maritime Services on 1800 989 929.

### Arabic

إذا كنتم بحاجة إلى مترجم، الرجاء الاتصال بخدمة الترجمة الخطية والشفوية على الرقم **131 450**. والطلب منهم الاتصال بوكالتكم Roads and Maritime Services على الرقم **1800 989 929**.

### Cantonese

若你需要口譯員，請致電 **131 450** 聯絡翻譯和口譯服務署 (TIS National)，要求他們致電 1800 989 929 聯絡 Roads and Maritime Services。

### Mandarin

如果你需要口译员，请致电 **131 450** 联系翻译和口译服务署 (TIS National)，要求他们致电 1800 989 929 联系 Roads and Maritime Services。

### Greek

Αν χρειάζεστε διερμηνέα, παρακαλείστε να τηλεφωνήσετε στην Υπηρεσία Μετάφρασης και Διερμηνείας (Εθνική Υπηρεσία ΤΙΣ) στο **131 450** και ζητήστε να τηλεφωνήσουν Roads and Maritime Services στο 1800 989 929.

### Italian

Se desiderate l'assistenza di un interprete, prego telefonare al Servizio Interpreti e Traduttori (TIS National) al **131 450** chiedendo di contattare Roads and Maritime Services al 1800 989 929.

### Korean

통역사가 필요하시면 번역통역서비스 (TIS National) 에 **131 450** 으로 연락하여 이들에게 1800 989 929 번으로 Roads and Maritime Services 에 전화하도록 요청하십시오.

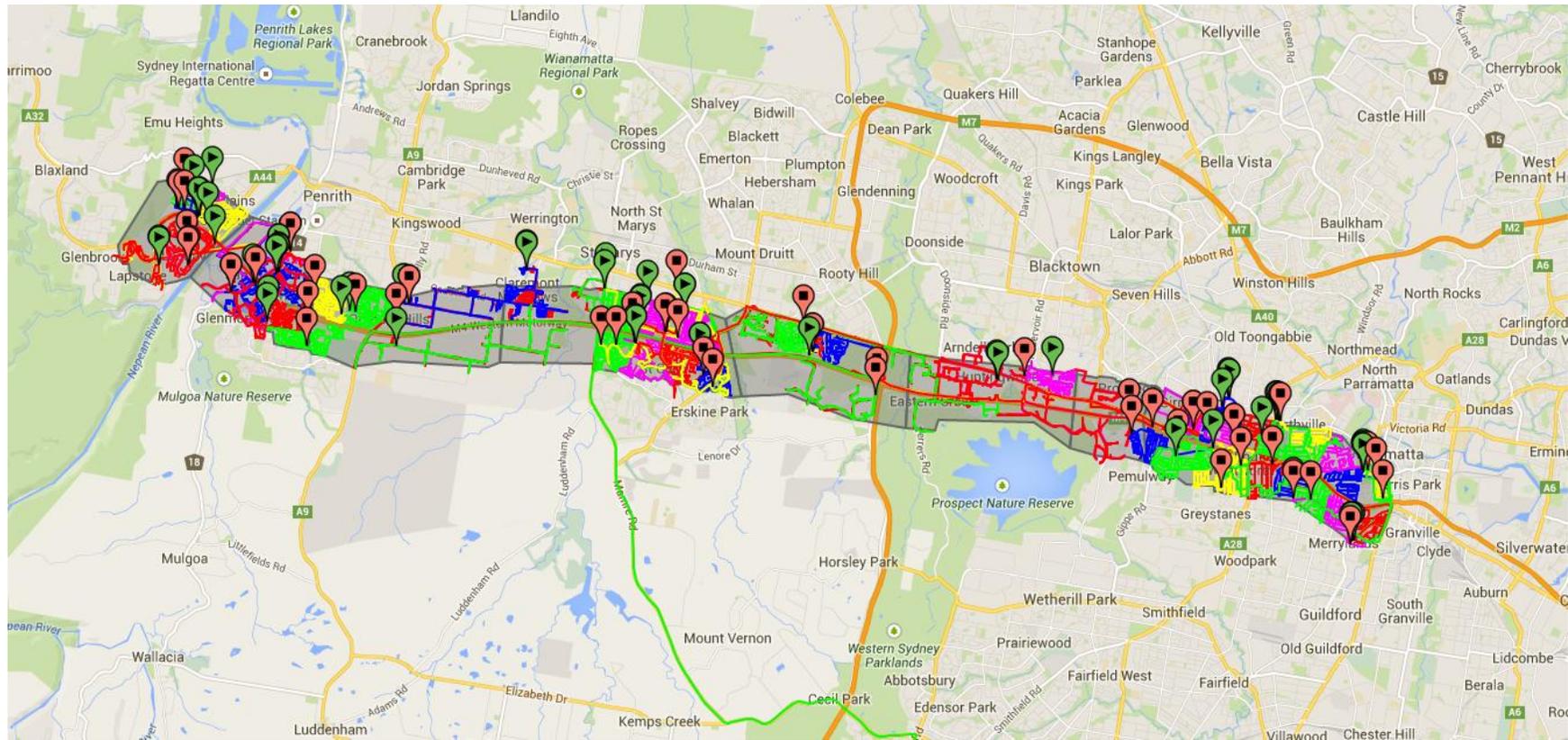
### Vietnamese

Nếu cần thông ngôn viên, xin quý vị gọi cho Dịch Vụ Thông Phiên Dịch (TIS Toàn Quốc) qua số **131 450** và nhờ họ gọi cho Roads and Maritime Services qua số 1800 989 929.

### © Roads and Maritime Services

**Privacy:** Roads and Maritime Services ('RMS') is subject to the *Privacy and Personal Information Protection Act 1998* ('PPIIP Act'), which requires that we comply with the Information Privacy Principles set out in the PPIIP Act. All information in correspondence is collected for the sole purpose of assisting in the assessment of this proposal. The information received, including names and addresses of respondents, may be published in subsequent documents unless a clear indication is given in the correspondence that all or part of that information is not to be published. Otherwise RMS will only disclose your personal information, without your consent, if authorised by the law. Your personal information will be held by RMS at Level 9, 101 Miller Street, North Sydney NSW 2060. You have the right to access and correct the information if you believe that it is incorrect.

## M4 Smart Motorway – Distribution map of community update letterbox drop, 13-20 March 2015



# Appendix B

## Revised Biodiversity Assessment



Australian Government

**BUILDING OUR FUTURE**



# M4 Smart Motorway Biodiversity Assessment

October 2015



(blank page)

# Roads and Maritime Services

---

## M4 Managed Motorway

Biodiversity Assessment

October 2015

Prepared by

Jacobs Group (Australia) Pty Limited  
ABN 37 001 024 095

100 Christie Street  
St Leonards NSW 2065 Australia

PO Box 164 St Leonards NSW 2065 Australia

T +61 2 9928 2100  
F +61 2 9928 2500  
[www.jacobs.com](http://www.jacobs.com)

# Contents

---

1	Introduction .....	1
1.1	Overview and purpose .....	1
1.2	Project description.....	2
1.3	Study area.....	6
1.4	Legislative context.....	6
2	Methodology .....	10
2.1	Personnel.....	10
2.2	Database search and literature review .....	10
2.3	Vegetation and flora field survey .....	11
2.4	Fauna field survey.....	14
2.5	Survey effort.....	21
2.6	Limitations.....	23
2.7	Threatened species assessment.....	23
3	Existing environment.....	26
3.1	Landscape context .....	26
3.2	Surrounding land use .....	26
3.3	Vegetation communities and fauna habitat.....	26
3.4	Threatened ecological communities .....	60
3.5	Groundwater dependant ecosystems .....	62
3.6	Aquatic habitats.....	63
3.7	Threatened flora species.....	64
3.8	Threatened fauna species.....	67
3.9	Migratory species.....	84
3.10	General flora and fauna .....	85
3.11	Wildlife connectivity corridors.....	86
3.12	Critical habitat .....	87
3.13	State Environmental Planning Policy No.44 – Koala Habitat Protection.....	87
3.14	Weeds.....	87
4	Potential impacts.....	91
4.1	Loss of vegetation and habitat.....	91
4.2	Wildlife connectivity and habitat fragmentation .....	100
4.3	Injury and mortality.....	101
4.4	Proliferation of weeds.....	102
4.5	Pests and pathogens .....	103
4.6	Changed hydrology .....	104
4.7	Groundwater-dependent ecosystems.....	104
4.8	Aquatic impacts.....	105
4.9	Noise and vibration and light .....	106
4.10	Impact on relevant key threatening processes .....	106
4.11	Cumulative impacts .....	108
5	Avoidance and mitigation measures.....	110

5.1	Avoid and minimise .....	110
5.2	Recommended construction mitigation measures .....	111
5.3	Habitat re-establishment .....	115
5.4	Wildlife connectivity .....	115
5.5	Aquatic habitats and riparian zones.....	116
5.6	Offsetting.....	116
6	Significance assessments .....	119
6.1	<i>Environmental Planning and Assessment Act 1979</i> .....	119
6.2	<i>Environment Protection and Biodiversity Conservation Act 1999</i> .....	124
7	References.....	128
	Appendix A Threatened subject species assessment.....	131
	Appendix B Flora species list .....	188
	Appendix C Fauna species inventory .....	220
	Appendix D Assessment of significance .....	226

## Glossary of terms and abbreviations

Term	Meaning
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: <ul style="list-style-type: none"> <li>• Genetic diversity — the variety of genes (or units of heredity) in any population</li> <li>• Species diversity — the variety of species</li> <li>• Ecosystem diversity — the variety of communities or ecosystems.</li> </ul>
Bioregion	The broader bioregional context defined by Thackway and Creswell (1995) as the Sydney Bioregion as defined in the Interim Biogeographic Regionalisation for Australia.
Carrying capacity	The carrying capacity of a species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment.
CEMP	Construction Environmental Management Plan.
CMA	Catchment Management Authority.
Critical habitat	Critical habitat is listed under the TSC Act and a register is maintained of this habitat.
DBH	Diameter at breast height.
DEC	Department of Environment and Conservation.
DECC	Department of Environment and Climate Change.
DECCW	Department of Environment, Climate Change and Water.
DoE	Commonwealth Department of the Environment.
DPI	Department of Primary Industries.
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities. The most recent former name of the Commonwealth Department of the Environment (DoE).
Ecological community	An assemblage of species occupying a particular area.
EIS	Environmental Impact Statement.
EP&A Act	<i>Environmental Planning and Assessment Act 1979.</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
GPS	Global positioning system. A navigational tool that uses radio receivers to pick up signals from four or more satellites to provide determination of location.
Habitat	An area or areas permanently, periodically or occasionally occupied by a species, population or ecological community, including any and all biotic and abiotic features of the area or areas occupied.
Key Threatening Processes	A process that threatens, or could threaten, the survival, abundance or evolutionary development of native species, populations or ecological communities. Key threatening processes are listed under the TSC Act, the FM Act and the EPBC Act.
Km	Kilometre.

Term	Meaning
Local population	The population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated.
Locality	The area within 10 kilometres of the Study Area.
m	Metre.
m <sup>2</sup>	Metres squared.
Migratory species	Species listed as migratory under the EPBC Act relating to international agreements to which Australia is a signatory. These include Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention on the Conservation of Migratory Species of Wild Animals.
MNES	Matter of National Environmental Significance.
Noxious weed	An introduced species listed under the <i>Noxious Weeds Act 1993</i> . Under the Act, noxious weeds have specific control measure and reporting requirements.
NPW Act	<i>National Parks and Wildlife Act 1974</i> .
NPWS	National Parks and Wildlife Service (now included under OEH).
NSW	New South Wales.
OEH	NSW Office of Environment and Heritage.
Patch (vegetation), Patch size	Under the EPBC Act, a patch is defined as a discrete and continuous area of the ecological community. However, a patch may include small-scale disturbances, such as tracks or breaks or small-scale variations in vegetation that do not significantly alter its overall functionality (for instance the movement of wildlife or dispersal of plant propagules).
Proposal footprint	Refers to the area of bridge replacement and includes any ancillary locations or drainage structures.
Riparian	Transition zone between land and watercourse.
REF	Review of Environmental Factors.
RMS	Roads and Maritime Services NSW.
RTA	Roads and Traffic Authority NSW (now known as the RMS).
SEPP	State Environmental Planning Policy.
Significant, Significant Impact	Important, weighty or more than ordinary as defined by Department of Environment, Climate Change and Water. A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of the Environment 2013).
SIS	Species impact Statement.
Study area	Encompasses the proposal footprint and any adjoining or adjacent habitat where potential indirect impacts may occur.

Term	Meaning
TEC	Threatened Ecological Communities. For the purposes of this report this includes ecological communities listed or nominated under the EPBC Act and ecological communities listed or nominated under the TSC Act.
Threatened biodiversity	Threatened species, populations or ecological communities as listed under the TSC Act or the EPBC Act.
Threatened species, populations and ecological communities	Species, populations and ecological communities listed as Vulnerable, Endangered or Critically Endangered (collectively referred to as Threatened) under the TSC Act or the EPBC Act.
TSC Act	<i>Threatened Species Conservation Act 1995.</i>
Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references.

## Executive Summary

Roads and Maritime Services (Roads and Maritime) propose to install traffic management and on-road information systems and upgrade entry and exit ramps for the existing M4 Motorway between the Pitt Street overbridge at Parramatta and the connection to the Great Western Highway at Lapstone (the proposal).

Ecological surveys were conducted in the study area during the development of the proposal and included targeted surveys for threatened flora species and some threatened fauna species, rapid habitat assessments and condition assessments. The work was designed to inform the likely impacts of the proposal on listed species, populations and ecological communities under the NSW *Threatened Species Conservation Act 1995* (TSC Act) the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and to identify appropriate mitigation measures. Surveys were conducted over a single season during April and May 2013 with an additional follow-up survey undertaken during July 2015 to assess ancillary compound sites and the western end of the study area between Emu Plains and Lapstone.

Planted vegetation occupies the majority of the study area and includes a diverse mix of plant species, both exotic and non-indigenous native species, as well as species representative of the local Cumberland Plain vegetation communities. Previous disturbance and modification of the vegetation from clearing, road works, vegetation maintenance regimes and landscaping has altered the species composition and vegetation structure of remnant vegetation communities in the study area. Four remnant vegetation communities were identified in addition to seven modified and planted map units, described as:

- Remnant Shale-Gravel Transition Forest
- Remnant Shale Plains Woodland
- Remnant Alluvial Woodland
- Remnant Shale Sandstone Transition Forest
- Artificial Freshwater Wetlands (Cumbungi; Common Reed; Urban Drainage Lines)
- Planted Shale Plains Woodland
- Planted Shale-Gravel Transition Forest
- Planted Shale Sandstone Transition Forest
- Planted Monocultures (Casuarina species, Eucalyptus species; Ficus species)
- Mixed Plantings (Native trees; Native shrubs; Sparse plantings)
- Exotic vegetation.

The modified and planted vegetation within the study area consists of small to medium sized vegetation patches occurring as linear fragments along the edge of the M4 Motorway. Several larger patches of vegetation extend into the road corridor which have been identified and assessed on an individual basis. Natural habitats for fauna are largely absent having been extensively removed for rural and urban development. The historical clearing of land adjacent to the study area has significantly reduced the value of the habitat by removing habitat connectivity, and resources required for foraging, shelter and breeding. The better quality fauna habitats were found near Ropes Creek on the northern and southern side of the M4 Motorway corridor. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered

throughout the study area.

The ecosystem health of the freshwater creek habitats within the study area was identified as poor, as a result of clearing and development pressure. These creeks are unlikely to provide significant or important fish habitat.

The following threatened ecological communities are present within the study area:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered, EPBC Act)
- Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered, TSC Act)
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)
- Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act)
- Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Critically Endangered, TSC Act and EPBC Act).

Seven threatened flora species were identified during surveys including the Downy Wattle (*Acacia pubescens*) (vulnerable – TSC Act and EPBC Act), *Dillwynia tenuifolia* (vulnerable – TSC Act), Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) (vulnerable – TSC Act and EPBC Act), Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*) (vulnerable – TSC Act), Nodding Geebung (*Persoonia nutans*) (endangered – TSC Act and EPBC Act), Sydney-bush Pea (*Pultenaea parviflora*) (endangered – TSC Act and EPBC Act) and the Magenta Lilly Pilly (*Syzygium paniculatum*). These species are predominantly located in remnant vegetation near Roper Road. One additional threatened flora species, the Spiked-rice Flower (*Pimelea spicata*) (endangered – TSC Act and EPBC Act) and an endangered population listed under the TSC Act, the *Marsdenia viridiflora* R. Br. subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas, are considered moderately likely to occur in the study area based on the presence of suitable habitats. The Narrow-leaved Black Peppermint and Magenta Lilly Pilly have been planted in the study area and do not naturally occur in habitats of the Cumberland Plain.

Two of the seven identified threatened plant species are present in the construction footprint, comprising two local populations of Juniper-leaf Grevillea and a single population of *Dillwynia tenuifolia*. A total of 55 Juniper-leaf Grevillea plants will potentially be impacted from two separate local populations, comprising one population at Ropers Road interchange of which 47 of the estimated 800+ individuals will be impacted (~5.9 per cent) and another population near the Kent Road overpass consisting of 204 individuals of which 7 individuals will be impacted (~3.4 per cent). A single *Dillwynia tenuifolia* plant from a population of 87 individuals (1.1 per cent impacted).

Twelve threatened fauna species are considered to have a moderate chance of occurring based on the presence of nearby records and suitable habitat within the study area. Three of these species were confirmed from the field survey: Eastern Bentwing-bat (*Miniopterus schreibersii*) (vulnerable – TSC Act), Southern Myotis (*Myotis macropus*) (vulnerable – TSC Act) and Cumberland Plain Land Snail (*Meridolum corneovirens* – vulnerable TSC Act). Cumberland Plain Land Snails were confirmed at five locations, including Chainage 27350, two sites between Chainage 28800 and 29100, Chainage 34450, and Chainage 34700. A diurnal roost site of the Eastern Bentwing-bat and Southern Myotis was identified in a series

of box culverts (3 x 3.0 x 3.0 m) located under the M4 Motorway at Chainage 35700. Migratory species are unlikely to be affected by the proposal.

The construction footprint would impact on up to 29.45 hectares of planted and remnant vegetation/habitat in various states of condition. This total area of clearing includes 3.88 hectares of remnant vegetation (Map Units 1, 2, and 3). The majority of impacts to remnant vegetation occur on the edges of several small and large patches at interchanges including Roper Road, M7/Wallgrove Road, Northern Road and Mamre Road and the ITS infrastructure will require minor incursions into the edges of some patches. The majority of vegetation removal will occur in planted vegetation alongside the M4 motorway (i.e. ~15 hectares of planted vegetation and ~8.5 hectares of planted Cumberland Plain Woodland). The largest impacts to planted vegetation occur from the ITS infrastructure and ramps at the Roper Road interchange and The Northern Road interchange. Impacts from road widening between Roper Road and the M7 are minimal. Impacts from construction compounds and facilities are predicted to be minimal. The proposal will not increase fragmentation in the locality, bioregion or catchment. Importantly, no large blocks of high quality continuous habitat will be fragmented by the proposal. No further habitat fragmentation on a landscape scale will occur as a result of the proposal as all areas of vegetation occur in linear strips along the road corridor and minor clearing will occur around the edges in the locality of the intersection upgrades. Fauna injury or death can occur during the clearing phase of construction via the removal of habitat, as well as throughout the life-time of the road operation as a result of collision with vehicles.

Apart from direct removal of vegetation and habitat other impacts may be associated with the spread of weeds during construction and the dispersal of resident feral pest species (rabbits, cats, foxes) across the surrounding landscape due to habitat removal, noise, and human presence during construction and operation of the Project. While pathogens were not observed or tested in the study area the potential for disease or soil pathogens to occur should also be treated as a risk during construction. Due to the absence of significant in stream or stream bank works, aquatic impacts from the proposal are predicted to be minimal.

Specific avoidance and minimisation measures associated with the design of the proposal will include the need to avoid vegetation clearance during construction. Avoidance of key areas of biodiversity value is proposed and mitigation measures as outlined in the Roads and Maritime Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects (RTA 2011) are recommended for implementation including Pre-clearing surveys. Management of unexpected species finds, implementing exclusion zones, minimising fauna injury and mortality, weed management, pest and disease management, and habitat re-establishment are also recommended.

An Assessment of Significance under the NSW Environmental Planning and Assessment Act, 1979 (EP&A Act) and the EPBC Act was conducted for species, populations and ecological communities that were confirmed in the study area or identified as having a moderate or high potential to occur. The assessments concluded that the proposal is unlikely to have a significant impact on threatened species and communities due to the predicted minor impact of the proposal on edges of remnant vegetation and the low ecological value of the vegetation and habitat in planted roadside areas along the M4 which dominates the landscape. Impacts to known threatened flora populations are considered unlikely to be significant given the relatively small proportion of the population potentially impacted and the potential for further avoidance during detailed design of the ITS infrastructure. The magnitude of the predicted impacts of the proposal on biodiversity is not considered significant with regard to their context or intensity.

Given the potential impact of the proposal on TSC Act listed threatened ecological communities, direct and indirect impacts should be appropriately offset. It is Roads and

Maritime policy that biodiversity offsets are to be provided where more than 1 hectare of high conservation value vegetation is cleared. As 13.48 hectares of Threatened Ecological Communities (planted and remnant) will be cleared, an offset strategy will be prepared for the project.

# 1 Introduction

---

## 1.1 Overview and purpose

Roads and Maritime Services (Roads and Maritime) propose to install traffic management and on-road information systems and upgrade entry and exit ramps for the existing M4 Motorway between the Pitt Street overbridge at Parramatta and the connection to the Great Western Highway at Lapstone (the proposal). This is further described in the following sections.

This report details the methods and results of a biodiversity field survey and assessment to identify the presence of threatened species, populations and ecological communities in the M4 Motorway corridor and associated arterial roads in order to assess the extent and magnitude of ecological impacts associated with the proposal. In assessing the impacts to listed biota, the report addresses the Assessment of Significance required under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Mitigation measures to ameliorate and offset ecological impacts arising from the proposal are also provided.

The biodiversity assessment provides field data for the distribution and abundance of terrestrial flora and fauna species, populations, ecological communities, habitat features, migratory species, and vegetation and habitat condition in the study area. The methodology was designed to provide specific focus on areas of remnant vegetation identified in broad-scale mapping projects (NPWS 2002) as well as threatened species records (OEH 2013). Areas of planted vegetation were also assessed and mapped. The aims of the biodiversity assessment were to:

- Describe the characteristics and ecological condition of the vegetation communities and habitats within the study area
- Determine the occurrence, or likelihood of occurrence of threatened species, populations and communities listed under the *Threatened Species Conservation 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and EPBC Act within the study area
- Describe the potential impacts on biodiversity in the study area as a result of the proposal
- Undertake an Assessment of Significance for threatened species and communities that are confirmed or considered likely to occur within the study area
- Propose further investigations and/or mitigation measures to mitigate impacts on the ecological values of the study area
- Conduct a condition assessment using the BioBanking Assessment Methodology (BBAM) to identify the condition of the vegetation and habitat to be impacted for use in determining future offset options.

## 1.2 Project description

Roads and Maritime Services (Roads and Maritime) propose to install traffic management and on-road information systems and upgrade entry and exit ramps for the existing M4 Motorway between the Pitt Street overbridge at Parramatta and the connection to the Great Western Highway at Lapstone (the proposal). The proposal comprises the following key features:

- Installation and operation of traffic management and on-road traffic information systems, including Intelligent Traffic System (ITS) infrastructure and other supporting elements
- Minor infrastructure upgrades to support the new traffic management and on-road traffic information systems as follows:
  - **Widening, lengthening and re-alignment of entry ramps** – Burnett Street (eastbound), Coleman Street (eastbound), Cumberland Highway (westbound and eastbound), Prospect Highway (westbound and eastbound), Reservoir Road (westbound), M7 Westlink (westbound and eastbound), Wallgrove Road (westbound and eastbound), Roper Road (eastbound), Mamre Road (westbound and eastbound), The Northern Road (westbound and eastbound), Mulgoa Road (westbound and eastbound) and Russell Street (eastbound).
  - **Widening, lengthening and re-alignment of exit ramps** – Cumberland Highway (eastbound), Reservoir Road (westbound), The Northern Road (westbound and eastbound), Mulgoa Road (westbound) and Russell Street (westbound).
  - **Improvements to interchanges and arterial roads** – Minor realignment of kerbs and extra road pavement at all interchanges and arterial road intersections.
  - **Localised motorway widening** – Provision of two additional lanes within the existing road median between the M7 Westlink and Roper Road interchanges.
- Power and communications connections to support new ITS infrastructure
- Minor adjustments to services such as electricity, gas, water and wastewater
- Installation of temporary construction facilities, including construction compounds.

The vast majority of the works would be undertaken within the existing M4 Motorway corridor. Works outside the M4 Motorway corridor would be limited to:

- Minor works on connecting arterial roads as described above and utility connections
- Installation of temporary construction facilities
- Temporary works associated with gaining access to some construction sites (i.e. access roads).

The location of the proposal is shown in **Figure 1-1**. Key elements of the proposal are outlined in **Figure 1-2**. The proposal is jointly funded by the Australian and NSW governments and was announced on 24 August 2012. Similar works would be undertaken along the remaining section of the M4 Motorway between the Pitt Street overbridge and Parramatta Road as part of the proposed WestConnex project (which would link the M4 Motorway with the M5 Motorway, the airport and Port Botany). These works would be examined as part of the environmental impact assessment for Stage 1 of the WestConnex project.

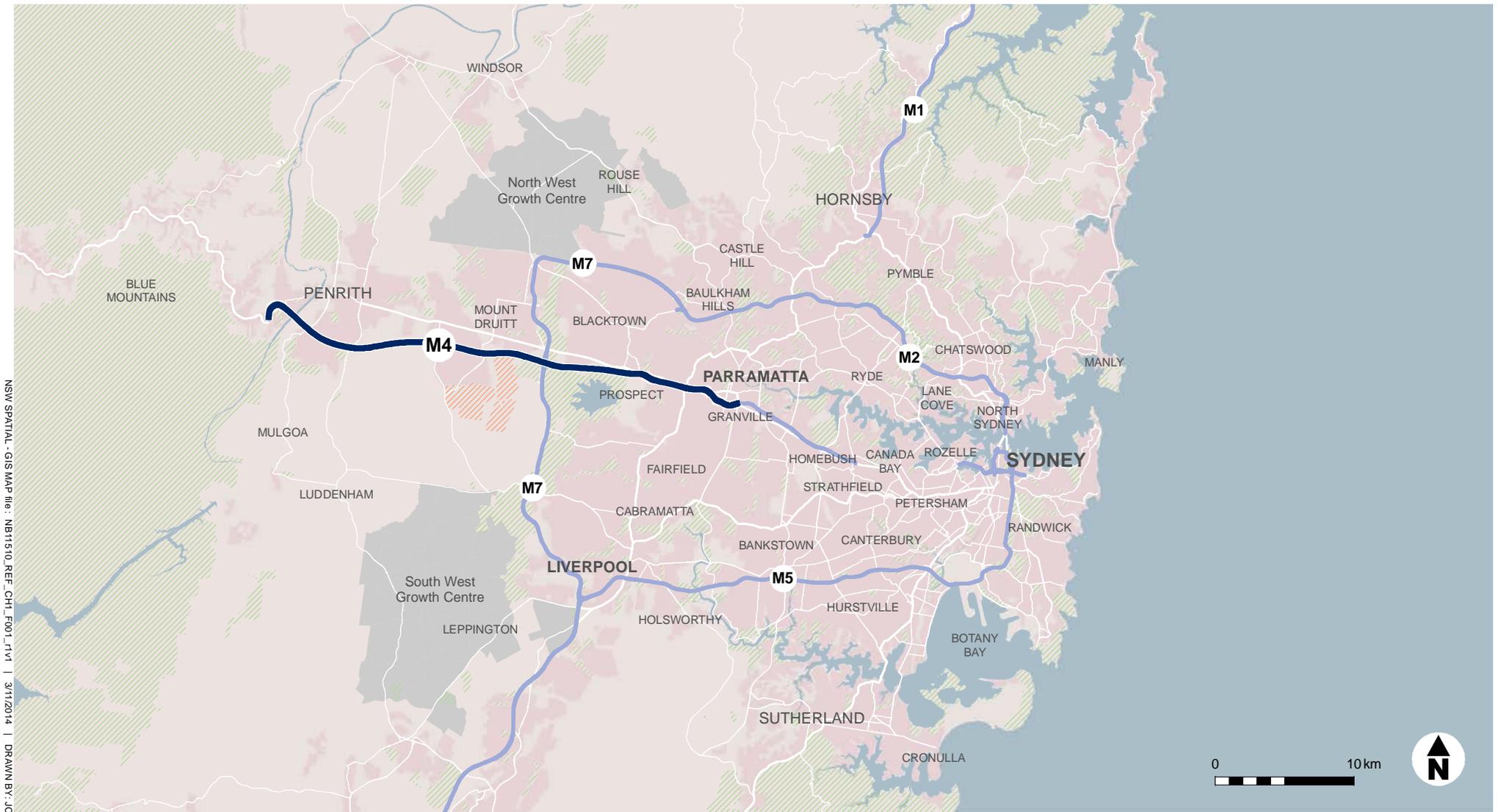


Figure 1-1 Location of proposal

- The proposal area
- Western Sydney Employment Lands
- Reserves and parklands
- Growth centres
- Built areas



NSW SPATIAL - GIS MAP file: NB11510\_REF\_CH1\_F002.rvt | 3/11/2014 | DRAWN BY: JC

Figure 1-2 Key elements of the proposal

-  Interchange locations
-  Western Sydney Employment Lands
-  Reserves and parklands
-  Industrial areas

### 1.3 Study area

The proposal is located along the M4 Motorway in western Sydney extending from the Pitt Street overbridge at Parramatta and the connection to the Great Western Highway at Lapstone. The following areas are discussed throughout the report and are defined as:

- Proposal footprint: this area comprises the limits of the upgrade design with a five metre buffer to allow for a small contingency surrounding the proposal for construction activities
- Study area: includes the proposal footprint and surrounding area, and for the purposes of this project comprises the M4 Motorway corridor and associated arterial roads where ITS infrastructure may be installed to take into considerations any potential indirect impacts from the proposal
- Locality: This area comprises a 10 kilometre radius surrounding the proposal footprint.

The study area is located in the Sydney Basin bioregion (Thackway and Cresswell 1995) and within the Hawkesbury-Nepean Catchment Management Area (CMA) and the Sydney Metro CMA in the Cumberland sub-region in both CMAs. This region is significant for biodiversity because it supports several endemic flora and fauna species found only on the Cumberland Plain.

### 1.4 Legislative context

The information presented in this report identifies the potential biodiversity impacts of the proposal in relation to the relevant State and Commonwealth environmental and threatened species legislation and policy. Relevant legislation and policy includes the:

- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)
- NSW *Threatened Species Conservation 1995* (TSC Act)
- NSW *Fisheries Management Act 1994* (FM Act)
- NSW *Noxious Weeds Act 1993* (NW Act)
- NSW *National Parks and Wildlife Act 1974* (NPW Act)
- State Environment Planning Policy No 44 - Koala Habitat Protection (SEPP 44)
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

#### 1.4.1 Environmental Planning and Assessment Act 1979

Under Part 5 of the EP&A Act (section 111 and section 112), all proposals must include an assessment of threatened flora and fauna and their habitats that are likely to occur within the area of the activity or that may be indirectly affected by the construction and operation of an activity. The assessment has to address whether the proposed activity 'is likely to have a significant effect' on the threatened biodiversity identified, and a decision made on whether an Environmental Impact Statement (EIS) or Species Impact Statement (SIS) is required. In

order to make this decision, a determining authority must consider the effect of an activity on:

- Threatened species, populations and ecological communities, and their habitats (listed under the TSC Act or FM Act) and whether there is likely to be a significant effect on these (as determined in section 5A of the EP&A Act)
- Critical habitat (listed under the TSC Act or FM Act)
- Any other protected fauna or protected native plants within the meaning of the NPW Act.

Section 5A of the EP&A Act outlines the seven factors that must be taken into account when deciding whether a proposal would be likely to have a significant impact on threatened species, populations or communities or their habitats (Assessment of Significance).

#### 1.4.2 NSW Threatened Species Conservation Act, 1995

The TSC Act identifies threatened species, populations and ecological communities, as listed under Schedules 1, 1A and 2 that are to be identified as potential subject species and therefore require a significance assessment under section 5A of the EP&A Act. The TSC Act also lists Key Threatening Processes comprising matters that threaten the survival or evolutionary development of a species, population or ecological community.

#### 1.4.3 Fisheries Management Act, 1994

The FM Act establishes provisions for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. This Act also covers the identification and management of key threatening processes which affect threatened species or could cause other species to become threatened.

The Minister for Fisheries would need to be notified of any proposed dredging (Part 7 Division 3 of the FM Act) or reclamation works associated with the proposal in accordance with Section 199 of the Act.

#### 1.4.4 NSW Noxious Weeds Act 1993

The objectives of this NW Act are to reduce the negative impact of weeds on the economy, community and environment of NSW. This involves: establishing control mechanisms to prevent the establishment of significant new weeds; prevent, eliminate or restrict the spread of particular significant weeds; effectively manage widespread significant weeds; and to provide for the monitoring of and reporting on the effectiveness of the management of weeds in NSW.

#### 1.4.5 State Environment Planning Policy No 44 - Koala Habitat Protection

SEPP 44 aims to encourage the 'proper conservation and management of areas of natural vegetation that provide habitat for Koalas (*Phascolarctos cinereus*) to ensure a permanent free-living population over their present range and reverse the current trend of Koala population decline'.

Schedule 1 of SEPP 44 identifies areas of land that are classified as being 'Core Koala Habitat' or 'Potential Koala Habitat'. 'Core Koala Habitat' is defined as an area of land with a resident population of koalas, evidenced by attributes such as breeding females and recent sightings of and historical records of a population. 'Potential Koala Habitat' comprises areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15 per cent of the total number of trees in the upper or lower strata of the tree component.

While SEPP 44 does not apply to projects that are being assessed under Part 5 of the EP&A Act, the Koala is however listed as vulnerable under the Commonwealth EPBC Act and in NSW under the TSC Act and hence targeted surveys were conducted for this species and further consideration given throughout the report on the impacts of the project.

#### 1.4.6 National Parks and Wildlife Act 1974

The NPW Act is administered by the OEH and provides for the:

- Protection of flora and fauna, including threatened species listed under the TSC Act and protected flora and fauna listed under the NPW Act
- Protection of Aboriginal sites or remains
- Reservation of land for protection under the Act, including reservation of National Parks.

The harming of threatened species, populations and ecological communities is prohibited under section 118A of the Act. However, given that the proposal constitutes an activity by a determining authority under Part 5 of the EP&A Act, section 118A does not apply.

#### 1.4.7 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act protects the environment, particularly matters of national environmental significance (Matters of NES) and assessment of the environment on Commonwealth land. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places. The EPBC Act identifies nine Matters of NES:

- World Heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar convention)
- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource, in relation to coal seam gas development and large coal mining development.

The EPBC Act is triggered by actions that would be likely to have a significant impact upon Matters of NES. Under the EPBC Act, such actions require approval from the Commonwealth Environment Minister and should be referred to the Commonwealth Department of the Environment (DoE) for consideration. Actions deemed by DoE to require Commonwealth approval would be 'controlled actions' which require an environmental assessment. The EPBC Act also lists Key Threatening Processes comprising matters that threaten the survival or evolutionary development of a native species or ecological community.

## 2 Methodology

### 2.1 Personnel

Ecological surveys were conducted in the study area during the development of the proposal and included targeted terrestrial flora and fauna surveys. Surveys were conducted over a single season during April and May 2013, comprising a total of 13 days fieldwork. Additional surveys were undertaken over two days during July 2015 at ancillary compound sites and at the western end of the study area between Emu Plains and Lapstone. Weather conditions during fieldwork included clear and overcast days as well as several days of rain.

Jacobs's ecologists are licensed to conduct field surveys under the NPW Act (Scientific Research Permit SL100044) and hold ethical approval to conduct research by the Department of Primary Industries Animal Care and Ethics Committee (Animal Research Authority (09/1895)). The qualifications and role of personnel involved in the field assessments are provided in **Table 2-1**.

**Table 2-1 Qualifications and role of key personnel**

Personnel	Qualifications	Project tasks
Andrew Carty	BEnvSc; DipBushRegen; Accredited Biobanking Assessor	Biodiversity assessment report; flora surveys, vegetation mapping, BioBanking assessment
Chris Thomson	BAppSc; GradCertNatRes	Biodiversity assessment report, fauna surveys
Jonathan Carr	BEnvSc	Field assistant flora and fauna surveys, BioBanking assessment
Brenton Hays	BEnvSc (Hons)	Field assistant, flora and fauna surveys, reporting

### 2.2 Database search and literature review

A review of existing reports and government maintained databases was undertaken as the first stage of the investigation. The following information was reviewed:

- NSW vegetation types database (OEH 2012). <http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm>
- NSW threatened species profile database (OEH 2013). <http://www.environment.nsw.gov.au/biobanking/biobankingtspd.htm>
- Native Vegetation of the Cumberland Plain - Final Edition (NPWS 2002).
- The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities (Tozer 2003).
- NSW BioNet (OEH 2013).
- DPI Threatened and Protected Species – Records Viewer <http://www.dpi.nsw.gov.au/fisheries/species-protection/records/viewer>

- DPI Noxious Weed listings.  
<http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed>
- Atlas of NSW Wildlife maintained by the NSW Office of Environment and Heritage (OEH June 2015).
- The Protected Matters Search Tool provided under the EPBC Act (June 2015).
- Australian Museum Business Services (AMBS) 2003. Baseline Fauna Inventory of the Orchard Hills Defence Establishment. Report prepared for Parsons Brinkerhoff and Department of Defence.

The review focused on identifying and listing the threatened flora and fauna species, populations and ecological communities previously recorded from a 10 kilometre radius of the project. The background review also aimed to identify any sensitive ecological sites such as National Parks and other reserves, fish habitat and areas protected by State Environment Planning Policies. Following collation of database records and species and community profiles a 'likelihood of occurrence' assessment was prepared with reference to the broad habitats contained within the study area. This was further refined following field surveys and assessment of habitat present. The list of threatened species recorded from the locality is provided as **Appendix A**.

## 2.3 Vegetation and flora field survey

A combination of aerial photograph interpretation, broad-scale vegetation mapping (NPWS 2002) and elevation data was used to stratify the vegetation and habitats in the study area. The stratification of vegetation map units was based on a number of factors including the provenance (i.e. remnant or planted/landscaped), the vegetation structure, dominant species, soil types and landscape position. The location and number of sampling sites used in the field survey was determined according to the extent and condition of each vegetation type present to ensure adequate representation.

The flora survey aimed to provide baseline data for the presence of threatened plant species, populations and ecological communities to provide a basis for the prediction of impacts. It comprised the following steps:

- A thorough review of the broad-scale vegetation mapping, previous specialist reports conducted in close proximity, threatened species records, and other available literature and scientific databases to gain an appreciation of the diversity of flora including threatened species that could potentially occur in the study area.
- Stratified sampling techniques to classify and map vegetation communities, threatened species habitat and develop an inventory of flora species specific to each vegetation association.
- Targeted searches for threatened flora species in areas of suitable habitat.

### 2.3.1 Vegetation association classification and mapping

Transect sampling was used to identify vegetation community types and boundaries. The number of transects sampled was proportional to the size of the stratification units identified

with a minimum of two 100 metre transects sampled per 2-50 hectares of each stratification unit and three 100 metre transects sampled per 51-250 hectares of stratification unit in accordance with DEC (2004).

Digital mapping of vegetation communities was conducted using ArcGIS® software. A combination of field data, aerial photograph interpretation and biophysical data such as elevation and soil type were used to delineate community boundaries. Description of the vegetation communities was based on their structure and dominant canopy species (Specht 1981) and correlated with Keith (2004), Tozer (2003) and NPWS (2002) and compared with final determinations and listing advice for threatened ecological communities.

Following field identification the vegetation communities in the study area were matched to relevant Biometric vegetation types as reported in OEH (2012) as well as broad-scale vegetation classification for the region produced by Tozer (2003).

### 2.3.2 Plot sampling

Standard quadrat based sampling was used in conjunction with general traverses of the study area, and in particular those areas associated with the concept design. Quantitative data on plant species richness were collected from a series of 20 x 20 metre plots (400 m<sup>2</sup>) sampled within remnant vegetation associations. Data collected within each plot included:

- Heights of structural layers (i.e. canopy, sub-canopy, shrub and groundcovers)
- The abundance/cover of each species and vegetation layer
- Landscape features (e.g. slope, gully, and aspect)
- Soil features (e.g. soil type, rocks, organic matter)
- Geographical coordinates and a photographic record.

### 2.3.3 Transects and traverses

General traverses comprised random searches throughout targeted areas to develop a flora inventory (**Appendix B**) and to complete searches for threatened species, as well as to opportunistically record the distribution of vegetation communities, significant habitat attributes and any other factors that may be of interest. The location of all threatened species, vegetation community boundaries and any other ecological factors were recorded with a Geographic Positioning System (GPS).

### 2.3.4 Threatened Ecological Community assessment

Federal and state listed threatened ecological communities were delineated using the NSW final determinations and federal listing advice for Commonwealth threatened ecological communities. Condition thresholds are not provided for the state-listed community. Two federally listed threatened ecological communities are present in the study area, which are both listed as critically endangered. Condition thresholds for federally listed communities have been developed and these are detailed in **Table 2-2** for Cumberland Plain Woodland and Shale-Gravel Transition Forest and **Table 2-3** for Shale Sandstone Transition Forest. These guidelines were assessed and followed to identify the status of the vegetation in the study area.

**Table 2-2 Conditions thresholds for the federally listed Cumberland Plain Woodland and Shale-Gravel Transition Forest (DEWHA 2010)**

No	Category	Yes	No
1.	Are diagnostic native tree species dominant ( <i>Eucalyptus fibrosa</i> , <i>E. tereticornis</i> , <i>E. moluccana</i> ) with a minimum projected foliage cover of 10%?	Go to 2	Not the listed ecological community
2.	Is the patch size of the ecological community 0.5 hectares or greater in size?	Go to 3	Not the listed ecological community
3.	Of the perennial understorey vegetation cover present does greater than 50% consist of native species?	The listed ecological community is present	Go to 4
4.	Is the patch 5 hectares or greater in size?	Go to 7	Go to 5
5.	Is the patch contiguous with a native vegetation patch 5 hectares or greater in size?	Go to 7	Go to 6
6.	Does the patch contain at least one tree per hectare that is larger (>80 cm DBH) or has a hollow?	Go to 7	Not the listed ecological community
7.	Of the perennial understorey vegetation cover present does greater than 30% consist of native species?	The listed ecological community is present	Not the listed ecological community

Condition thresholds for the federally listed Shale Sandstone Transition Forest are specified below in **Table 2-3**.

**Table 2-3 Conditions thresholds for the federally listed Shale Sandstone Transition Forest**

Category and rationale	Thresholds
<p>A. <b>Moderate condition class</b></p> <p>Represented by medium to large-size patch as part of a larger native vegetation remnant and/or with mature trees</p>	<p>Patch Size <math>\geq 0.5</math> ha</p> <p><b>And</b></p> <p><math>\geq 30\%</math> of the perennial understorey vegetation cover is made up of native species.</p> <p><b>And</b></p> <p>The patch is contiguous with a native vegetation remnant (any native vegetation where cover in each layer present is dominated by native species) <math>\geq 1</math>ha in area.</p> <p><b>Or</b></p> <p>The patch has at least one tree with hollows or at least one large locally indigenous tree (&gt;80cm DBH).</p>

Category and rationale		Thresholds
B.	<b>Moderate condition class</b> Represented by medium to large size patch with high quality native understorey	Patch Size $\geq 0.5$ ha <b>And</b> $\geq 30\%$ of the perennial understorey vegetation cover is made up of native species.
C.	<b>High condition class</b> Represented by medium to large size patch with very high quality native understorey	Patch Size $\geq 0.5$ ha <b>And</b> $\geq 70\%$ of the perennial understorey vegetation cover is made up of native species.
D.	<b>High condition class</b> Represented by larger size patch with high quality native understorey	Patch size $\geq 2$ ha <b>And</b> $\geq 50\%$ of the perennial understorey vegetation cover is made up of native species.

*Perennial understorey vegetation cover* includes vascular plant species of both the ground layer and mid/shrub layer (where present) with a lifecycle of more than two growing seasons. Measurements of perennial understorey vegetation cover exclude annuals, cryptogams, leaf litter or exposed soil.

*Contiguous* means the patch of the ecological community is continuous with, or in close proximity (within 100 m) to another area of vegetation that is dominated by native species in each vegetation layer present.

The area of each vegetation patch assessed was determined using a Geographic Information System (GIS). The cover of perennial understorey species was determined using the vegetation and condition assessment methods as specified in **Section 2.3.2**.

### 2.3.5 Vegetation and habitat condition assessment

A vegetation and habitat condition assessment was conducted using the BioBanking Assessment Methodology (DECC 2008). The assessment aimed to provide a measure of habitat condition for each of the vegetation types impacted by the proposal and identify the floristic diversity, structure of the vegetation, the type and distribution of plant communities present as well as the density of fauna habitat features in the study area. The location of condition assessment plots are shown in **Figure 3-1a** to **Figure 3-1m**.

## 2.4 Fauna field survey

### 2.4.1 Overview

The fauna survey was targeted within the road reserve along the M4 Motorway corridor within the study area including proposed upgrade areas with notes taken from observations outside the corridor where adjoining habitat was present, particularly in relation to habitat condition and connectivity to the road reserve.

The fauna survey method was selected based on the predominance of planted and

disturbed vegetation, the narrow linear nature of the habitat along the road corridor and adjoining densely urban landscape. The method included rapid habitat assessment at multiple sites (n=84) along both sides of the corridor concentrated in vegetated areas, searches for evidence of threatened fauna and opportunistically recording fauna species active at the time of the survey. Targeted surveys were undertaken for threatened fauna where suitable habitat was encountered, including searches of ground habitats and culverts.

Habitat assessment sites were selected to sample the range of habitat present within the road reserve based on interpretation from aerial photographs and former M4 landscape plans. Sites were selected on the basis of their being habitat present (planted or otherwise) and access, as many areas are cleared of vegetation. Four habitat types were surveyed which included;

- A planted native landscape mix (dominant vegetation type)
- Remnant or regrowth open forest or woodland (occurred in very small fragments)
- Riparian habitat
- Freshwater aquatic habitat (artificially created drainage areas and ephemeral or permanent creeks)
- Opportunistic fauna surveys were conducted in all habitat types and in cleared areas.

#### 2.4.2 Habitat assessment

Habitat assessment data were collected at eighty-four (84) sites over six days to gather information on the type and condition of the fauna habitats within the road reserve. The location of the habitat assessment sites are shown on **Figure 3-1a** to **Figure 3-1m**. At each site details of the habitat type and condition were noted from variable plot sizes depending on the width of the road reserve and size of the vegetation patch. The details and habitat criteria assessed included:

- Geographic coordinates and photograph.
- Type and structure of the vegetation, including an assessment of the 'naturalness' in terms of the presence of native remnant vegetation or planted and regrowth areas.
- Dominant flora species and a subjective assessment of the floristic diversity at different structural layers, flowering and fruiting resources
- Tree species and height of canopy trees including the proportion of each species
- Presence of significant keystone species and critical habitat elements for threatened fauna.
- Disturbance regimes including the presence key threatening processes such invasion of exotic perennial grasses and exotic vines and scramblers
- The presence of tree hollows, standing dead trees (stags) rock outcrops and boulders, and hollow logs providing potential shelter for hollow-dependent fauna
- The structure or the habitat in terms of complexity and presence of shelter and food

resources for fauna, in particular threatened species

- Presence and condition of wet areas or waterbodies, significant aquatic habitats where present
- Size of remnant patches and extent of connectivity to habitats outside the road reserve.

The data was used in combination with the opportunistic fauna survey to identify habitats of conservation value for fauna, in particular threatened fauna known from the locality. The condition of the habitat at each site was rated and mapped based on a combination of the assessment criteria as summarised in **Table 2-4**.

**Table 2-4 Fauna habitat condition assessment criteria**

Condition	Characteristics	Patch size / connectivity	Naturalness	Floristic diversity	Ground cover	Habitat features	Weed abundance
High	Vegetation still retains the majority of native species and structural characteristics of the pre-European equivalent. Such vegetation is usually in a near natural state and displays resilience to weed invasion due to intact ground cover, shrub and canopy layers and lack of soil disturbance. Some limited weed cover is present in edge habitats.	>2 hectares and well connectivity outside the road reserve and along road corridor	Remnant woodland / forest	High	Intact	Habitat for threatened fauna, mature trees abundant and tree hollows, dead trees and natural logs	Low
Moderate	Vegetation generally still retains most of its structural integrity but has been partially disturbed and has lost some component of its original species complement. Weed invasion varies from slight to high.	>2 hectares and tentative links to other vegetation outside the road reserve	Disturbed Remnant woodland / forest	Moderate	Intact with few or no invasive grasses	Some habitat for threatened fauna, mature trees low density, few hollows and logs	Moderate - High
Low	Modified areas where most of the native diversity and vegetation structure has been lost. Includes thin strips of roadside vegetation, areas of derived grassland and shrubby vegetation. Environmental weeds are often co-dominant with the original indigenous species, particularly invasive grasses.	< 1-2 hectares and fragmented	Roadside landscape plantings	Low-Moderate	Partial with high proportion of invasive grasses	Limited habitat for threatened fauna, mature trees absent, no hollows or logs	High - Moderate

Condition	Characteristics	Patch size / connectivity	Naturalness	Floristic diversity	Ground cover	Habitat features	Weed abundance
Very Low	Includes cleared paddock areas and roadside clearings dominated by exotic species including noxious weeds. Some regenerating shrubs and native groundcovers may be present in low abundance. Some of these areas support planted trees and shrubs including native and exotic species.	< 1-2 hectares and isolated	Roadside landscape plantings	Low	None dominated by invasive grasses	No habitat for threatened fauna, mature trees absent, no hollows or logs	High

### 2.4.3 Inspections for roosting bats

Physical inspections were conducted in artificial drainage structures under the motorway to search for roosting microchiropteran bats. The inspections focused on larger culverts (>2.4 metres in height) and those that were not flooded at the time of the survey or considered at risk to enter.

### 2.4.4 Bird survey

A time-based bird survey was conducted at each of the 84 habitat assessment sites. This involved a 10-20 minute survey depending on the size of the habitat. The survey was conducted by one observer using a random meander within the habitat patch and recording all birds seen and heard during the survey period. Ten minute searches were conducted in small patches and planted areas (<0.5 ha) and the longer 20-minute survey was conducted in larger habitat patches (>0.5 ha) and habitat continuous with other woodland outside the road reserve.

### 2.4.5 Threatened species searches

#### Cumberland Plain Land Snail

At each habitat assessment site (n=84) an assessment was made on the potential presence of the Cumberland Plain Snail (*Meridolum corneovirens*) (Endangered TSC Act) using the criteria described in

**Table 2-5** to rate the value of the habitat for the species. Targeted searches for the species were carried out all sites that scored a moderate to high condition rating (n=17). This involved a time-based search of 20 minutes duration and using a general traverse of the site and lifting any logs and building refuse when encountered and raking through patches of dense leaf litter. Opportunistic searches under logs and debris were also conducted whilst walking between habitat assessment sites.

**Table 2-5 Habitat condition criteria for Cumberland Plain Land Snail**

Condition	Sheltering habitat	Leaf litter	Naturalness	Patch size / Connectivity	Ground cover
High	Abundant logs and / or building refuse	Abundant	Remnant	Large patch or adjoins large remnant outside the road reserve	>10% open ground, low abundance of dense exotic grasses
Moderate	Low abundance of logs or building refuse	Moderate	Regrowth	Small patch in fragmented mosaic of woodland patches	<10% open ground, patchy mix of open ground and plant cover
Poor	Logs or building refuse absent	None	Planted	Small isolated patch	100% cover of tall exotic grasses, no open patches of leaf litter

#### Searches for threatened fauna usage

The occurrence of specific habitat features appropriate for threatened fauna species known

or potentially occurring at site was evaluated as part of the habitat assessment. Features known to be used by threatened species were assessed such as hollow-bearing trees, nest trees, watercourses, specific food trees, wetland habitats, leaf litter and artificial structures suitable for roosting or denning purposes. A search was conducted at each habitat assessment site for evidence of habitat use by threatened fauna species including:

- Koala scats around the base of suitable feed trees (scat searches were carried out at any of these feed trees that were encountered in the habitat assessment plots or opportunistically when a tree was encountered along random meander traverses between these plots)
- Diggings in the soil and scats attributed to the Long-nosed Bandicoot (Endangered Population, TSC Act)
- Regurgitation pellets and nest/roost sites for forest owls, Powerful Owl and Masked Owl known from the locality and threatened diurnal raptors
- Inspection for 'whitewash' and pellets under any potential owl roost sites
- Chewed cones beneath Allocasuarina/Casuarina trees indicating Glossy Black Cockatoo feeding.

#### 2.4.6 Aquatic habitat assessment

A desktop assessment of the drainage and creek systems in the study area was conducted to prioritise the waterways for further field assessment. The majority of the waterways in the study area have a very small catchment and limited sources of water, although provide potential fish habitat, including the named creeks, Ropes Creek, South Creek and Blaxland's Creek. The study area crosses the Nepean River at the western end.

As the proposal involves works or impacts to waterways, aquatic habitat assessments were undertaken that was limited to visual assessments of habitat attributes. Targeted fish surveys were not conducted. For the visual habitat assessment information was gathered and verified on the condition of the waterway, including presence of pollutants, turbidity, weed invasion and sedimentation. The criteria assessed included:

- Watercourse geomorphology and flow regime
- Water quality (visual assessment)
- Surrounding land use and impacts on the waterway
- Condition and extent of riparian vegetation and in-stream vegetation
- Presence of downstream wetlands and their condition
- Presence of fish habitat including spawning and refuge areas and any potential barriers to fish passage.

#### 2.4.7 Opportunistic surveys

Opportunistic fauna surveys were conducted during the six day survey period, and were based on direct observation, including the use of binoculars, and identifying bird and frog

calls as well as reptiles encountered during the targeted snail searches. A list of fauna species encountered was compiled and is presented as **Appendix C**.

## 2.5 Survey effort

A summary of the flora survey effort with respect to the number of quadrats and transects sampled per habitat type are summarised in **Table 2-6**. Not all map units were subject to plot assessments due to the highly modified and planted nature of these areas (Map Unit 8, 9 and 10) or due to the very small patch size (Map Unit 4).

**Table 2-6 Flora survey effort per habitat stratification unit**

Habitat	Area in study area (ha)	Sampling effort plot assessments
Map Unit 1: Remnant Shale-Gravel Transition Forest	6.3	3
Map Unit 2: Remnant Shale Plains Woodland	13.1	4
Map Unit 3: Remnant Alluvial Woodland	7.9	2
Map Unit 5: Planted Shale Plains Woodland	46.8	4
Map Unit 6: Planted Shale-Gravel Transition Forest	3.7	1
Map Unit 7: Planted Shale-Sandstone Transition Forest	3.1	1
Map Unit 11: Remnant Shale-Sandstone Transition Forest	6.1	2

The total survey effort for threatened flora species is summarised in **Table 2-7**.

**Table 2-7 Summary of threatened flora survey effort**

Survey date	Method and technique	Survey effort
3-5 April 2013	Targeted searches in preferred habitats for threatened flora, including threatened <i>Acacia pubescens</i> , <i>Grevillea juniperina</i> , <i>Persoonia nutans</i> and <i>Pultenaea parviflora</i> .	48 person hours
8-12 April 2013		80 person hours
8-10 May 2013		48 person hours
28-29 July 2015	Targeted searches for threatened flora species at proposed compound sites and in Shale Sandstone Transition Forest west of Emu Plains	16 person hours

The total terrestrial and aquatic fauna survey effort is summarised in **Table 2-8**.

**Table 2-8 Summary of fauna survey effort**

<b>Technique</b>	<b>Methodology</b>	<b>Survey effort</b>
Fauna habitat assessment	Habitat assessment data were collected at eighty-four (84) sites over six days to gather information on the type and condition of the fauna habitats within the road reserve. At each site details of the habitat type and condition were noted from variable plot sizes depending on the width of the road reserve and size of the vegetation patch. The assessment focused on identifying important features for threatened fauna species.	6 days
Cumberland Plain Land Snail	At each habitat assessment site (n=84) an assessment was made on the potential presence of habitat. Targeted searches for the species were carried out all sites that scored a moderate to high condition rating (n=17). This involved a time-based search of 20 minutes duration and using a general traverse of the site and lifting any logs and building refuse when encountered and raking through patches of dense leaf litter. Opportunistic searches under logs and debris were also conducted whilst walking between habitat assessment sites.	6 person hours
Diurnal bird census	Time-based survey (either 10-minute or 20-minute) was conducted at each of the 84 habitat assessment sites. Involved a single observer moving along a random meander within the patch areas. The survey aimed to record all birds seen or heard.	Approximately 19 hours over 6 days
Amphibian searches	Amphibian habitat was centred on drains and riparian areas. Frogs were identified by calls and capture when encountered.	2 person-hours
Reptiles searches	Reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris. The survey was opportunistic during the targeted Cumberland Plain Land snail surveys.	6 person-hours
Scats, tracks and opportunistic records of threatened fauna	The species and location of mammal scats, scratches and other evidence of threatened fauna presence when encountered were noted to provide locality records.	Opportunistic during all site survey times over 6 days
Inspection of culverts for microbats	Physical inspections were conducted in artificial drainage structures under the motorway to search for roosting microchiropteran bats. The inspections focused on larger culverts (>2.4 metres in height) and those that were not flooded at the time of the survey or considered at risk to enter. Where bats were encountered a sample of bats were captured and identified.	2 person hours
Visual aquatic habitat assessment	Habitat assessment data were collected at four locations and reported on the condition of the habitat, noting the presence of significant features for fish and aquatic fauna.	1 person hour

## 2.6 Limitations

The methods used and time spent surveying the motorway road corridor were constrained by the Roads and Maritime regulations in relation to daytime surveys only in the road reserve for safety reasons. Access to the road corridor was restricted to 9.30 am to 3.00 pm to avoid peak traffic periods and potential distraction to motorists. Nocturnal surveys using hand-held spotlights were not permitted. The entire motorway corridor is fenced and access was permitted only where gates are located, and there was no provision for parking on the motorway or pulling over to the side of the carriageway. As access to private property was not permitted, including industrial areas, select areas of the road corridor could not be accessed by foot.

The list of flora and fauna species recorded from this study should not be seen to be fully comprehensive, but rather an indication of the species present at the time of the survey. A period of several seasons or years is often needed to identify all the species present in an area, especially as some species are only apparent at certain times of the year e.g. orchids or migratory birds and require specific weather conditions for optimum detection e.g. frogs. The conclusions of this report are therefore based upon available data and the field surveys and are therefore merely indicative of the environmental condition of the site at the time of the survey. It should be recognised that site conditions, including the presence of threatened species, can change with time. To address this limitation, a precautionary approach was used which aimed to identify the presence and suitability of the habitat for threatened species as discussed in the following section.

A precautionary approach was used with regards to presence of threatened species in areas of suitable habitat where there is insufficient evidence to discount the presence of the species due to seasonal limitations or other constraints. For example cryptic flora species such as Spiked Rice-flower (*Pimelea spicata*) which is potentially present in the study area is most-readily detectable whilst in flower during summer and therefore could not be targeted during the surveys. Therefore this species has been assumed to be present in areas of suitable habitat, and surveys during the appropriate season are recommended.

## 2.7 Threatened species assessment

### 2.7.1 Likelihood of occurrence

State and nationally listed threatened species identified from the background reviews were considered in terms of their likelihood to occur in the habitats present within the study area based on their identified habitat requirements. The results of this review are provided in **Appendix A**. The likelihood of occurrence was classified according to the criteria described in **Table 2-9**. The presence of all potentially occurring threatened species were targeted during the surveys with particular emphasis on those species with a high or moderate likelihood of occurrence. Species with a high or moderate likelihood of occurrence were subject to assessments of significance under the TSC Act and/or EPBC Act as appropriate.

**Table 2-9 Likelihood of occurrence includes one or more of the following criteria**

Likelihood of Occurrence	Criteria
Unlikely	<ul style="list-style-type: none"> <li>• Species highly restricted to certain geographical areas not within the proposal footprint</li> <li>• Specific habitat requirements are not present in the study area</li> </ul>
Low	<p>Species not recorded during field surveys and fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>• Have not been recorded previously in the study area/surrounds and for which the study area is beyond the current distribution range</li> <li>• Use specific habitats or resources not present in the study area</li> <li>• Are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded</li> </ul>
Moderate	<p>Species not recorded during the field surveys that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>• Have infrequently been recorded previously in the study area/surrounds</li> <li>• Use specific habitats or resources present in the study area but in a poor or modified condition</li> <li>• Are unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration</li> <li>• Are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded</li> </ul>
High	<p>Species recorded during the field surveys or species not recorded that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>• Have frequently been recorded previously in the study area/surrounds</li> <li>• Use habitat types or resources that are present in the study area that are abundance and/or in good condition within the study area</li> <li>• Are known or likely to maintain resident populations surrounding the study area</li> <li>• Are known or likely to visit the site during regular seasonal movements or migration</li> </ul>

### 2.7.2 Assessment of Significance

Significance assessments were conducted for species, populations and communities that have been positively identified or that have a moderate or high potential to occur in the study area based on the above assessment criteria. Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats.

For threatened biodiversity listed under the TSC Act the threatened species assessment was undertaken as outlined under Section 5A of the EP&A Act (known as the 7-part test). The document *Threatened Species Assessment Guidelines: The Assessment of Significance* (Department of Environment and Climate Change 2007) outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of assessment in the 7-part test. The guidance provided by the

Department of Environment and Climate Change (2007) has been used in this report.

For threatened biodiversity listed under the EPBC Act significance assessments have been completed in accordance with the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (Department of the Environment 2013).

## 3 Existing environment

---

### 3.1 Landscape context

The study area is located in the Sydney Basin bioregion (Thackway and Cresswell 1995) and within the Hawkesbury-Nepean Catchment Management Area (CMA) and the Sydney Metro CMA in the Cumberland sub-region in both CMAs. This region is important for biodiversity because it supports several endemic flora and fauna species found only on the Cumberland Plain.

The Cumberland Plain comprises gently undulating plains and low hills. The Cumberland Plain is formed on sediments derived from Wianamatta Shale comprising clay-based soils. On the fringes of the Cumberland Plain these clay soils grade into sandstone-derived soils. There are also alluvial soils associated with major creeks and rivers of the plain including the Nepean River, Eastern Creek, Blaxland Creek and South Creek which cross the M4 corridor.

### 3.2 Surrounding land use

Areas surrounding the M4 Motorway corridor are utilised for a variety of uses, including:

- Rural residential properties
- Agricultural lands
- Industrial estates
- Densely populated residential suburbs
- Public parklands.

### 3.3 Vegetation communities and fauna habitat

#### 3.3.1 Vegetation communities

The remnant vegetation communities in the study area represent recognised vegetation types as described by Tozer (2003). Planted vegetation occupies the majority of the study area and includes a wide mix of species, both exotic and non-indigenous native species, as well as species representative of the local Cumberland Plain vegetation communities. A large range of previous disturbances from clearing, road works, vegetation maintenance regimes and landscaping has altered the species composition and vegetation structure of remnant vegetation communities in the study area.

Planted vegetation includes a broad mix of native species associated with landscaping activities of the original M4 Motorway development, including species indigenous to the surrounding vegetation communities as well as some non-indigenous native species. Planted vegetation could be readily identified based on the age of trees and shrubs, the lack of or low diversity of native groundcovers and dominance by exotic grasses. Planted vegetation could also be identified based on the species composition of tree and shrub species including species occurring in atypical habitat types in comparison to the natural distribution.

The vegetation communities were classified according to the work by Tozer (2003), threatened ecological communities and the Biometric Vegetation Types database (OEH 2012). These are described in **Table 3-1** including the conservation status and regional cleared estimate according to OEH (2012) and the approximate area of each type in the study area. Five separate remnant vegetation community types were identified in addition to six additional map units consisting of planted and exotic vegetation including several subtypes, described as:

- Map Unit 1: Remnant Shale-Gravel Transition Forest
- Map Unit 2: Remnant Shale Plains Woodland
- Map Unit 3: Remnant Alluvial Woodland
- Map Unit 4: Freshwater Wetlands (4a Cumbungi; 4b Common Reed; 4c Urban Drainage Lines)
- Map Unit 5: Planted Shale Plains Woodland
- Map Unit 6: Planted Shale-Gravel Transition Forest
- Map Unit 7: Planted Shale Sandstone Transition Forest
- Map Unit 8: Planted Monocultures (9a Casuarina species, 9b Eucalyptus species; 9c Ficus species)
- Map Unit 9: Mixed Plantings (10a Native trees; 10b Native shrubs; 10c Sparse plantings)
- Map Unit 10: Exotic vegetation
- Map Unit 11: Remnant Shale Sandstone Transition Forest.

A summary of the vegetation community descriptions and corresponding fauna habitat types is provided in **Table 3-1**. The distribution of these communities in the study area is displayed in **Figure 3-1a** to **Figure 3-1j**. A comprehensive list of the flora species present within the study area has been included as **Appendix B**.

**Table 3-1 Vegetation and fauna habitat types in the study area**

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
Map Unit 1: Remnant Shale-Gravel Transition Forest	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	<p>Shale Gravel Transition Forest occurs primarily in areas where shallow deposits of Tertiary alluvium overlie shale soils, but also in association with localised concentrations of iron-indurated gravel.</p> <p>The canopy of Shale Gravel Transition Forest in the study area is dominated by Broad-leaved Ironbark (<i>Eucalyptus fibrosa</i>) and to a lesser degree Woollybutt (<i>Eucalyptus longifolia</i>). There is a frequent sub-canopy dominated by <i>Melaleuca decora</i>. Other tree species occurring infrequently include Grey Box (<i>Eucalyptus moluccana</i>) and Forest Red Gum (<i>Eucalyptus tereticornis</i>).</p> <p>A sparse shrub stratum is present and typically includes Blackthorn (<i>Bursaria spinosa</i>), <i>Dillwynia sieberi</i>, Gorse Bitter-pea (<i>Daviesia ulicifolia</i>), and Prickly-leaved Paperbark (<i>Melaleuca nodosa</i>). Several threatened flora species are also common in the shrub stratum of higher condition patches including Juniper-leaved Grevillea (<i>Grevillea juniperina</i> subsp.</p>	<p>Endangered, TSC Act</p> <p>Critically endangered, EPBC Act</p> <p>Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)</p>	75%	6.2	<p>Moderate to high quality habitat, present as a mosaic of small fragmented habitats patches. Generally moderate to high structural diversity with large mature trees scattered throughout in medium density and occasional logs. Presence of mature trees provides food resources for nectivorous birds, bats and insects as well as occasional tree hollows for hollow dependent fauna.</p> <p>Density of native shrubs and groundcovers present and providing habitat for a range of smaller birds, including woodland bird species.</p> <p>General habitat condition varies from moderate to high depending on the size of the patch and disturbance in the</p>	<p>Several threatened flora species are common in the shrub stratum of higher condition patches including Juniper-leaved Grevillea (<i>Grevillea juniperina</i> subsp. <i>juniperina</i>), Sydney Bush-pea (<i>Pultenaea parviflora</i>) and <i>Dillwynia tenuifolia</i>.</p> <p>Habitat high quality for Cumberland Plain Land Snail where Rhodes Grass is sparse or absent.</p> <p>Suitable although limited resources for a range of threatened fauna, including Powerful Owl, and</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p><i>juniperina</i>), Sydney Bush-pea (<i>Pultenaea parviflora</i>) and <i>Dillwynia tenuifolia</i>.</p> <p>Where a native understorey is present a variety of grass and herb species were recorded with high frequency, including Weeping Grass (<i>Microlaena stipoides</i> subsp. <i>stipoides</i>), Kangaroo Grass (<i>Themeda australis</i>), Poison Rock Fern (<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>), White Root (<i>Pratia purpurascens</i>), and Kidney Weed (<i>Dichondra repens</i>).</p> <p>There is a high diversity and abundance of exotic flora present in disturbed examples of this community including Rhodes Grass (<i>Chloris gayana</i>), Paddy's Lucerne (<i>Sida rhombifolia</i>), Boneseed (<i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i>) and Bridal Creeper (<i>Asparagus asparagoides</i>).</p> <p>The condition of this community varied depending on the degree of soil disturbance, however this community is generally in a high condition with vegetation condition assessments recording score between 73 and 79 out of 100. A high condition was still recorded in disturbed examples of this</p>				<p>groundcover. Suitable resources for a range of threatened fauna, in particular woodland birds and Powerful Owl, and insectivorous bats.</p>	<p>insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		community due to the presence of a partially intact overstorey and midstorey layers.					
Map Unit 2: Remnant Shale Plains Woodland	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin	<p>Shale Plains Woodland is the most widely distributed community on the Cumberland Plain. It predominantly occurs on soils derived from Wianamatta Shale, but also occurs on Holocene alluvium in well-drained areas.</p> <p>This community is dominated by Grey Box and Forest Red Gum. Other tree species occurring less frequently include Narrow-leaved Ironbark (<i>Eucalyptus crebra</i>), Narrow-leaved Stringybark (<i>Eucalyptus eugenioides</i>) and Spotted Gum (<i>Corymbia maculata</i>).</p> <p>There is a sub-canopy including younger canopy species listed above as well as Cherry Ballart (<i>Exocarpos cupressiformis</i>) and Parramatta Wattle (<i>Acacia parramattensis</i> subsp. <i>parramattensis</i>).</p> <p>A shrub stratum dominated by Blackthorn and <i>Dillwynia sieberi</i> is usually present. Several smaller shrub species are also commonly</p>	<p>Critically endangered, TSC Act</p> <p>Critically endangered, EPBC Act</p> <p>Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)</p>	95%	12.5	<p>Moderate to high quality habitat, present as a mosaic of small fragmented habitats patches. Generally moderate to high structural diversity with large mature trees scattered throughout in medium density and occasional logs. Presence of mature trees provides food resources for nectivorous birds, bats and insects as well as occasional tree hollows for hollow dependent fauna.</p> <p>Density of native shrubs and groundcovers present and providing habitat for a range of smaller birds, including woodland bird species.</p> <p>General habitat condition varies from moderate to high depending on the size of the patch and</p>	<p>Habitat high quality for Cumberland Plain Land Snail where Rhodes Grass is sparse or absent.</p> <p>Suitable resources for a range of threatened fauna, including Powerful Owl, and insectivorous bats.</p> <p>Threatened flora in this community is limited to several populations of Juniper-leaved Grevillea.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>encountered in the ground layer including <i>Pultenaea microphylla</i>, <i>Bossiaea prostrata</i> and <i>Phyllanthus virgatus</i>. Threatened flora in this community is limited to several populations of Juniper-leaved Grevillea.</p> <p>Where a native understorey is present common ground stratum species include a diversity of grass species such as Weeping Grass, Kangaroo Grass, Three-awned Spear Grass (<i>Aristida spp.</i>), Wallaby Grass (<i>Rytidosperma spp.</i>) and Shorthair Plumegrass (<i>Dichelachne micrantha</i>). Common herb species include Kidney Weed, Blue Trumpet (<i>Brunoniella australis</i>), Slender Tick Trefoil (<i>Desmodium varians</i>), <i>Opercularia diphylla</i> and Sprawling Bluebell (<i>Wahlenbergia gracilis</i>).</p> <p>There is a high diversity and abundance of exotic flora present in disturbed examples of this community including exotic grasses Rhodes Grass and African Lovegrass (<i>Eragrostis curvula</i>), and shrubs African Olive (<i>Olea europaea</i> subsp. <i>cuspidata</i>), African Boxthorn (<i>Lycium ferocissimum</i>) and Paddy's Lucerne.</p>				disturbance in the groundcover.	

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		The condition of this community varied depending on the degree of soil disturbance and vegetation modification. Areas of derived grassland included under this map unit are generally in a moderate condition with a condition score 51 recorded in these areas. Intact and partially intact areas of this community are generally in a high condition with vegetation condition assessments recording scores between 66 and 88 out of 100.					
Map Unit 3: Remnant Alluvial Woodland	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin	<p>This community occurs along minor creeks draining soils derived from Wianamatta Shale, and on the floodplains larger creeks and rivers.</p> <p>This community has canopy dominated by Cabbage Gum (<i>Eucalyptus amplifolia</i>), Swamp Oak (<i>Casuarina glauca</i>), Rough-barked Apple (<i>Angophora floribunda</i>) and Forest Red Gum. In some areas the community is exclusively dominated by thick regrowth of Swamp Oak.</p> <p>There is also a small tree layer commonly present including Swamp Oak, Flax-leaved Paperbark (<i>Melaleuca linariifolia</i>) and Prickly-leaved Tea Tree (<i>Melaleuca</i></p>	Endangered, TSC Act	95%	7.8	<p>Low to moderate quality habitat. There is a high diversity and abundance of exotic flora present in disturbed examples of this community including shrub/small tree species Small-leaved Privet and Large-leaved Privet. There is often a range of exotic vine species including Balloon Vine and Morning Glory. Common exotic flora species in ground layer include Wandering Jew and Cobblers Pegs.</p> <p>The habitat was ranked</p>	<p>Suitable resources for a range of threatened fauna, in particularly insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p><i>stypelioides</i>).</p> <p>A shrub stratum is usually present including native and exotic flora. In lower elevated areas close to the drainage line there is often a dense shrub layer or sub-canopy of Privet species (<i>Ligustrum sinense</i> and <i>L. lucidum</i>). In some areas of this community areas higher on the bank usually also include Blackthorn.</p> <p>In undisturbed areas there is usually a sparse layer of grasses and herbs including weeping grass, Creeping Beard Grass (<i>Oplismenus aemulus</i>), Bordered Panic (<i>Entolasia marginata</i>), White Root, Native Wandering Jew (<i>Commelina cyanea</i>) and Indian Pennywort (<i>Centella asiatica</i>).</p> <p>There is a high diversity and abundance of exotic flora present in disturbed examples of this community including shrub/small tree species Small-leaved Privet (<i>Ligustrum sinense</i>) and Large-leaved Privet (<i>Ligustrum lucidum</i>). There is often a range of exotic vine species including Balloon Vine (<i>Cardiospermum grandiflorum</i>) and Morning Glory (<i>Ipomoea indica</i>). Common exotic flora species in ground layer include</p>				<p>low for fauna with some areas very low. Areas with large mature trees have greater value however these were largely reduced by the high density of exotic flora. Habitat for Cumberland Plain Snail low.</p> <p>Avifauna dominated by urban and disturbance tolerant species such as Australian Magpie (<i>Gymnorhina tibicen</i>), Magpie-Lark (<i>Grallina cyanoleuca</i>), Noisy Miner (<i>Manorina melanocephala</i>).</p>	

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>Wandering Jew (<i>Tradescantia fluminensis</i>) and Cobblers Pegs (<i>Bidens pilosa</i>).</p> <p>These areas are generally in a moderate condition with high levels of weed invasion affecting native flora diversity and a modified vegetation structure. Vegetation condition assessments in this map unit recorded scores between 66 and 88 out of 100.</p>					
<p>Map Unit 4: Freshwater Wetlands (4a Broadleaf Cumbungi; 4b Common Reed; 4c Urban Drainage Lines)</p>	<p><i>Phragmites australis</i> and <i>Typha orientalis</i> coastal freshwater wetlands of the Sydney Basin</p>	<p>This map unit occurs in natural and constructed drainage channels where there is continuous moisture in open situations.</p> <p>This community is generally dominated almost exclusively by Broadleaf Cumbungi (<i>Typha orientalis</i>) in Map Unit 4a and Common Reed (<i>Phragmites australis</i>) in Map Unit 4b.</p> <p>Other native flora species present on the margins of this community includes Knotweed species (<i>Persicaria</i> spp.) and Common Rush (<i>Juncus usitatus</i>).</p> <p>Exotic flora species commonly present include Wandering Jew, Umbrella Sedge (<i>Cyperus eragrostis</i>) and colonising exotic trees and shrubs on the edges of drainage lines such as</p>	<p>Endangered, TSC Act</p>	<p>70%</p>	<p>1.5</p>	<p>Low quality habitat. Occupies natural and constructed drainage channels where there is continuous moisture in open situations. Dominated almost exclusively by Broadleaf Cumbungi and Common Reed. No native riparian vegetation present and no trees.</p> <p>Water quality poor and dominated by the introduced <i>Gambusia holbrooki</i>.</p> <p>Habitat for common frogs, such as Brown Toadlet</p>	<p>Migratory wetland birds may utilise this habitat occasionally. Poor habitat for Green and Golden Bell Frog.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>Privet and Mulberry (<i>Morus alba</i>).</p> <p>This map unit occurs mostly as thin strips along modified drainage lines. These areas are considered to be in a moderate condition due to the highly modified nature of these areas. One high condition freshwater wetland area was recorded in the study area in Driftway Reserve between the Clunies Ross Street and Greystanes Road overpasses. No BioBanking condition assessments were undertaken in this map unit due to the very small patch sizes. Condition was moderate from visual inspection.</p>				<p>(<i>Pseudophryne bibronii</i>), Red-groined Toadlet (<i>Uperoleia laevigata</i>) and Common Eastern Froglet (<i>Crinia signifera</i>) and also the Eastern Water Skink (<i>Eulamprus quoyii</i>). Common birds in this habitat include the Superb Fairy-wren (<i>Malurus cyaneus</i>) and Red-browed Finch (<i>Neochmia temporalis</i>).</p>	
Map Unit 5: Planted Shale Plains Woodland	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin (restored example of)	<p>This community has been planted in the corridor. The age of the plantings varies throughout the corridor with the oldest being planted 10-15 years ago. These areas rarely support any native groundcovers and often have a sparse planted shrub layer.</p> <p>Experience from rehabilitation projects on the Cumberland Plain Woodland suggests that sites with a history of soil disturbance will be extremely slow to recover. The majority of this community in the corridor has been subject to significant soil disturbance</p>	Endangered, TSC Act	95%	46.9	<p>Low quality habitat. These areas rarely support any native groundcovers and often have a sparse planted shrub layer and dominated by dense tall exotic grasses, such that there is little to no open patchy in the ground cover and no leaf litter present.</p> <p>Common tree species planted comprise Grey Box, Forest Red Gum, Narrow-leaved Ironbark</p>	<p>Suitable resources for insectivorous bats.</p> <p>Habitat for Cumberland Plain Snail is typically low to very low and influenced by the dense cover of exotic grasses; lack of microhabitat features, small patch size and lack</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>from former land uses and/or by earth works and other disturbances from the construction of the M4 Motorway. Subsequently this map unit is dominated by exotic flora.</p> <p>Common tree species planted comprise Grey Box, Forest Red Gum, Narrow-leaved Ironbark and Spotted Gum. Other common planted species include Flax-leaved Paperbark, Tick Bush (<i>Kunzea ambigua</i>), Blackthorn, Prickly-leaved Tea Tree and Falcate Wattle (<i>Acacia falcata</i>).</p> <p>Many areas also include species not typical of Cumberland Plain Woodland such as Mugga Ironbark (<i>Eucalyptus sideroxylon</i>), Weeping Bottlebrush (<i>Callistemon viminalis</i>), <i>Grevillea juniperina</i> subsp. <i>trinervis</i> and Fringed Wattle (<i>Acacia fimbriata</i>).</p> <p>There is some evidence of natural regeneration of shrubs species from planted individuals and from wild populations. The threatened flora species Juniper-leaved Grevillea was recorded in some locations of this map unit where it occurs near remnant populations.</p> <p>This map unit was delineated from</p>				<p>and Spotted Gum with tree height uniform throughout and generally ranging from only 5-10 metres in height.</p> <p>The habitat structure is simplified and lacks structural maturity or important features such as hollows, timber on the ground and shrubs or tall canopy.</p> <p>Common fauna species include the introduced Blackbird (<i>Turdus merula</i>), Spotted Turtle-dove (<i>Streptopelia chinensis</i>) and Common Myna (<i>Acridotheres tristis</i>) as well as Australian Magpie, Crested Pigeon (<i>Ocyphaps lophotes</i>) and Garden Sunskink (<i>Lampropholis guichenoti</i>).</p>	<p>of connectivity.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>other map units based on the presence of a mixed planting dominated by Forest Red Gum and Grey Box.</p> <p>The condition varied according to the maturity and success of the plantings, the degree of previous disturbance and presence of derived grassland patches. Some areas of this map unit support small patches of derived grassland with species typical to Cumberland Plain Woodland such as Kangaroo Grass, Weeping Grass and Kidney Weed.</p> <p>Areas include high and moderate condition areas with vegetation condition assessments recording scores between 54 and 70 out of 100.</p>					
Map Unit 6: Planted Shale-Gravel Transition Forest	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney	This community occurs in the median areas of the off and on ramps at the Roper Road intersection and to the west of the remnant patches of Map Unit 1. Species characteristic of Map Unit 1 have been planted in these locations including Broad-leaved Ironbark, Forest Red Gum, Grey Box and Falcate Wattle. The groundcover is generally dominated by exotic flora such as Rhodes Grass, Green Panic	Endangered, TSC Act	75%	3.7	As per Map Unit 5	<p>Suitable resources for insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
	Basin	<p>(<i>Megathyrsus maximus</i> var. <i>pubiglumis</i>) Boneseed and Bridal Creeper.</p> <p>Some areas of this map unit support small patches of derived grassland with species typical to Shale-Gravel Transition Forest such as Purple Burr-daisy (<i>Calotis cuneifolia</i>), Shorthair Plumegrass and Poison Rock Fern.</p> <p>These areas are generally in a moderate condition being dominated by a mix of native and exotic species in the understorey with some minor mid-storey cover. Vegetation condition assessments recording a score of 60 out of 100 in this map unit.</p>					
Map Unit 7: Planted Shale Sandstone Transition Forest	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	<p>This community naturally occurs on transitional shale-sandstone soils around the edge of the Cumberland Plain. This map unit occurs at the western end of the study area at Emu Plains being planted in the corridor in a transitional area between the Cumberland Plain and sandstone environments of the Blue Mountains to the west.</p> <p>A mix of tree species has been planted in this area including Grey Gum</p>	Critically Endangered, TSC Act and EPBC Act	80%	3.1	As per Map Unit 5	<p>Suitable resources for insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>(<i>Eucalyptus punctata</i>), Smooth-barked Apple (<i>Angophora costata</i>), Red Bloodwood (<i>Corymbia gummifera</i>), Turpentine (<i>Syncarpia glomulifera</i>), Forest Red Gum and Yellow Bloodwood (<i>Corymbia eximia</i>).</p> <p>Understorey shrubs have also been planted and include Coast Myall (<i>Acacia binervia</i>), Black She-oak (<i>Allocasuarina littoralis</i>), Falcate Wattle, Blackthorn, Cherry Ballart and Hickory Wattle (<i>Acacia implexa</i>).</p> <p>The ground layer is dominated by exotic species mainly comprising African Lovegrass as well as Rhodes Grass and Paddy's Lucerne. There are some minor occurrences of native ground layer species where patches of adjacent vegetation patches adjoin the corridor. Native understorey species observed includes Kangaroo Grass, Weeping Grass, Two-colour Panic (<i>Panicum simile</i>), Wiry Panic (<i>Entolasia stricta</i>) and Three-awned Spear Grass (<i>Aristida ramosa</i>).</p> <p>This map unit includes relatively mature plantings and is in a moderate condition. The understorey is dominated by exotic species and there is some midstorey and overstorey</p>					

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		cover. Vegetation condition assessments recording a score of 57 out of 100 in this map unit.					
Map Unit 8: Planted Monocultures (8a Casuarina species; 8b Eucalyptus species; 8c Fig species)	N/A	<p>This map unit comprises monoculture plantings of various species including Swamp Oak and River Oak (<i>Casuarina cunninghamii</i>) (Map Unit 9a), several Eucalypt/Gum species such as Mugga Ironbark, Spotted Gum and Blackbutt (<i>Eucalyptus pilularis</i>) (Map Unit 9b) and Hill's Weeping Fig (<i>Ficus microcarpa var. hillii</i>) (Map Unit 9c).</p> <p>The understorey is dominated by exotic flora including a wide range of environmental and noxious weed species.</p> <p>This map unit is distributed throughout the study area with Map Unit 9c being present in eastern sections.</p>	N/A	N/A	18.3	<p>These areas rarely support any native groundcovers and often have a sparse planted shrub layer and dominated by dense tall exotic grasses, such that there is little to no open patchy in the ground cover and no leaf litter present.</p> <p>The habitat structure is simplified and lacks structural maturity or important features such as hollows, timber on the ground and shrubs or tall canopy.</p> <p>Habitat for Cumberland Plain Snail is typically low to very low and influenced by the dense cover of exotic grasses; lack of microhabitat features, small patch size and lack</p>	<p>Suitable resources for insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
						of connectivity. Common fauna species include the introduced Blackbird ( <i>Turdus merula</i> ), Spotted Turtle-dove ( <i>Streptopelia chinensis</i> ) and Common Myna ( <i>Acridotheres tristis</i> ) as well as Australian Magpie, Crested Pigeon ( <i>Ocyphaps lophotes</i> ) and Garden Sunskink ( <i>Lampropholis guichenoti</i> ).	
Map Unit 9: Mixed Plantings (9a Native trees; 9b Native shrubs; 9c Sparse plantings)	N/A	This map unit consists of mixed plantings which are not characteristic of native vegetation community types. The species composition varies greatly throughout the distribution of this unit being subject to planting mixes of landscaping activities during the time of construction. Flora species include local native species and native flora not naturally occurring in local vegetation communities and native species from other regions of NSW.  Tree species occurring in Map Unit 10a include Sydney Blue Gum ( <i>Eucalyptus saligna</i> ), Swamp Mahogany ( <i>Eucalyptus robusta</i> ), Silky	N/A	N/A	66.1	As per Map Unit 5	Suitable resources for insectivorous bats.  Refer to Appendix A for more detailed description of threatened species.

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>Oak (<i>Grevillea robusta</i>), Spotted Gum, Mugga Ironbark, Forest Red Gum, Brush Box (<i>Lophostemon confertus</i>) and Flooded Gum (<i>Eucalyptus grandis</i>). Native shrubs species commonly occurring in Map Unit 10b include Fringed Wattle, Flax-leaved Paperbark, Dwarf Apple (<i>Angophora hispida</i>), Coast Myall, Tick Bush, Crimson Bottlebrush (<i>Callistemon citrinus</i>), Coastal Rosemary (<i>Westringia fruticosa</i>) and Rosemary Grevillea (<i>Grevillea rosmarinifolia</i> subsp. <i>rosmarinifolia</i>).</p> <p>Map Unit 10c comprises sparse plantings of shrubs and tree including those species listed above with dense areas of exotic grasses and herbs.</p>					
Map Unit 10: Exotic vegetation	N/A	<p>This map unit includes areas dominated by exotic trees, shrubs and groundcovers. Dominant species vary although common species include: trees such as Lombardy Poplar (<i>Populus nigra</i>), Jacaranda (<i>Jacaranda mimosifolia</i>), Privet species (<i>Ligustrum spp.</i>), African Olive and Box-elder Maple (<i>Acer negundo</i>); shrubs such as Paddy's Lucerne, African Boxthorn, Jerusalem Cherry</p>	N/A	N/A	7.7	Poor habitat value for fauna lacks food resources to attract foragers. May be used by a range of introduced fauna and wide-ranging common fauna only.	<p>Suitable resources for insectivorous bats.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		( <i>Solanum pseudocapsicum</i> ) and Green Cestrum ( <i>Cestrum parqui</i> ); exotic groundcovers mainly include grass species such as Rhodes Grass, African Lovegrass and Green Panic; and exotic vines and scramblers species dominate some areas including Blackberry, Balloon Vine and Morning Glory.					
Map Unit 11: Remnant Shale Sandstone Transition Forest	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	<p>This community naturally occurs on transitional shale-sandstone soils around the edge of the Cumberland Plain. This map unit occurs at the western end of the study area between Emu Plains and Lapstone. This is a transitional area between the shale soils of the Cumberland Plain and sandstone environments of the Blue Mountains to the west.</p> <p>Many diagnostic species are present including species typical of both sandstone and shale soils. Dominant canopy species include Grey Gum (<i>Eucalyptus punctata</i>), Yellow Bloodwood (<i>Corymbia eximia</i>), ironbarks (<i>Eucalyptus crebra</i>, <i>E. fibrosa</i> and <i>E. siderophloia</i>), stringybarks (<i>Eucalyptus eugeniooides</i> and <i>E. sparsifolia</i>) and Turpentine</p>	Critically Endangered, TSC Act and EPBC Act	80%	6.1	<p>Generally high quality habitat present as larger patches of relatively contiguous habitats. Generally moderate to high structural diversity with large mature trees scattered throughout in medium density and occasional logs. Presence of mature trees provides food resources for nectivorous birds, bats and insects as well as occasional tree hollows for hollow dependent fauna.</p> <p>Density of native shrubs and groundcovers present and providing habitat for a range of smaller birds,</p>	<p>Several threatened flora species have potential to occur in this habitat type, however no threatened flora species were recorded in this map unit, and there are limited records of threatened flora species in this locality.</p> <p>Suitable resources present for a wide range of threatened fauna, in particular arboreal mammals</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>(<i>Syncarpia glomulifera</i>).</p> <p>The understorey comprises a mix of shrub and grassy habitats. Dominant shrubs species include Coast Myall (<i>Acacia binervia</i>), Black She-oak (<i>Allocasuarina littoralis</i>), Blackthorn and Dogwood (<i>Jacksonia scoparia</i>). The ground layer is dominated by native grasses and forbs including the grass species Weeping Grass, Kangaroo Grass, Three-awned Spear Grass (<i>Aristida vagans</i>), Barbed Wire Grass (<i>Cymbopogon refractus</i>), Two-colour Panic (<i>Panicum simile</i>) and Wiry Panic (<i>Entolasia stricta</i>), and common forb species include mat rushes (<i>Lomandra</i> species), flax lilies (<i>Dianella</i> species), Poison Rock Fern (<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>), White Root (<i>Pratia purpurascens</i>), and Kidney Weed (<i>Dichondra repens</i>).</p> <p>There is a high abundance of exotic flora present in disturbed examples of this community mainly including African Lovegrass (<i>Eragrostis curvula</i>) and Lantana (<i>Lantana camara</i>). The condition of this community varied depending on the degree of soil disturbance and vegetation</p>				including woodland bird species.	<p>such as Yellow-bellied Glider and Eastern Pygmy Possum, as well as Spotted-tail Quoll, Glossy Black-cockatoo and Gang Gang Cockatoo.</p> <p>Refer to Appendix A for more detailed description of threatened species.</p>

Map Unit	Biometric Vegetation Type	Description	Status	Cleared estimate <sup>#</sup>	Extent within study area (ha)	Fauna habitat type and characteristics	Suitability as threatened species habitat
		<p>modification with areas adjacent to the M4 Motorway being generally in lower condition.</p> <p>Intact and partially intact areas of this community are generally in a high condition with vegetation condition assessments recording scores between 87 and 96 out of 100.</p>					

# Cleared estimate for the Biometric Vegetation Types database (DECC 2009a)



NSW SPATIAL - GIS MAP file : NB11510\_REF\_BIO\_F003\_15v2 | 13/08/2015 | DRAWN BY: JC

Figure 3-1a Distribution of vegetation communities and fauna habitats

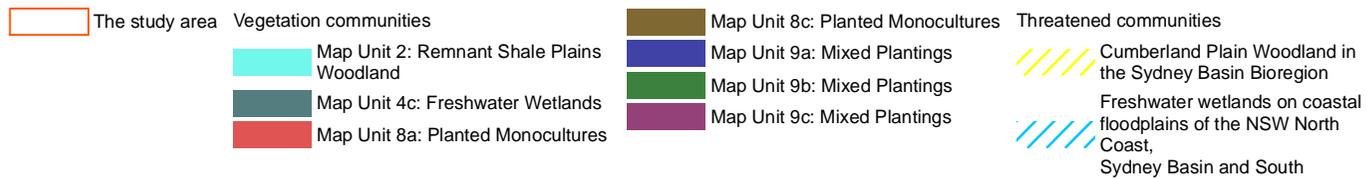




Figure 3-1b Distribution of vegetation communities and fauna habitats

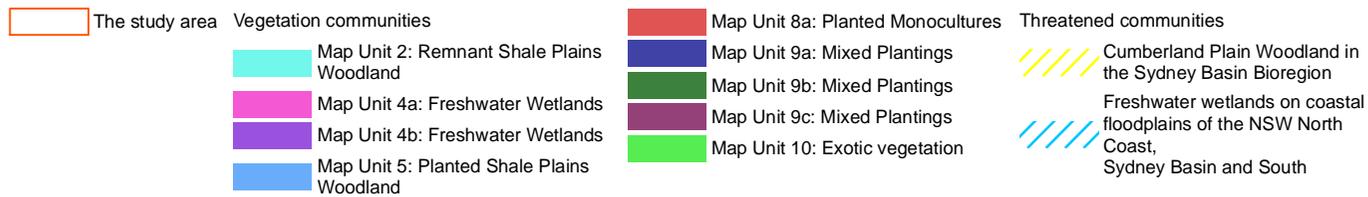




Figure 3-1c Distribution of vegetation communities and fauna habitats



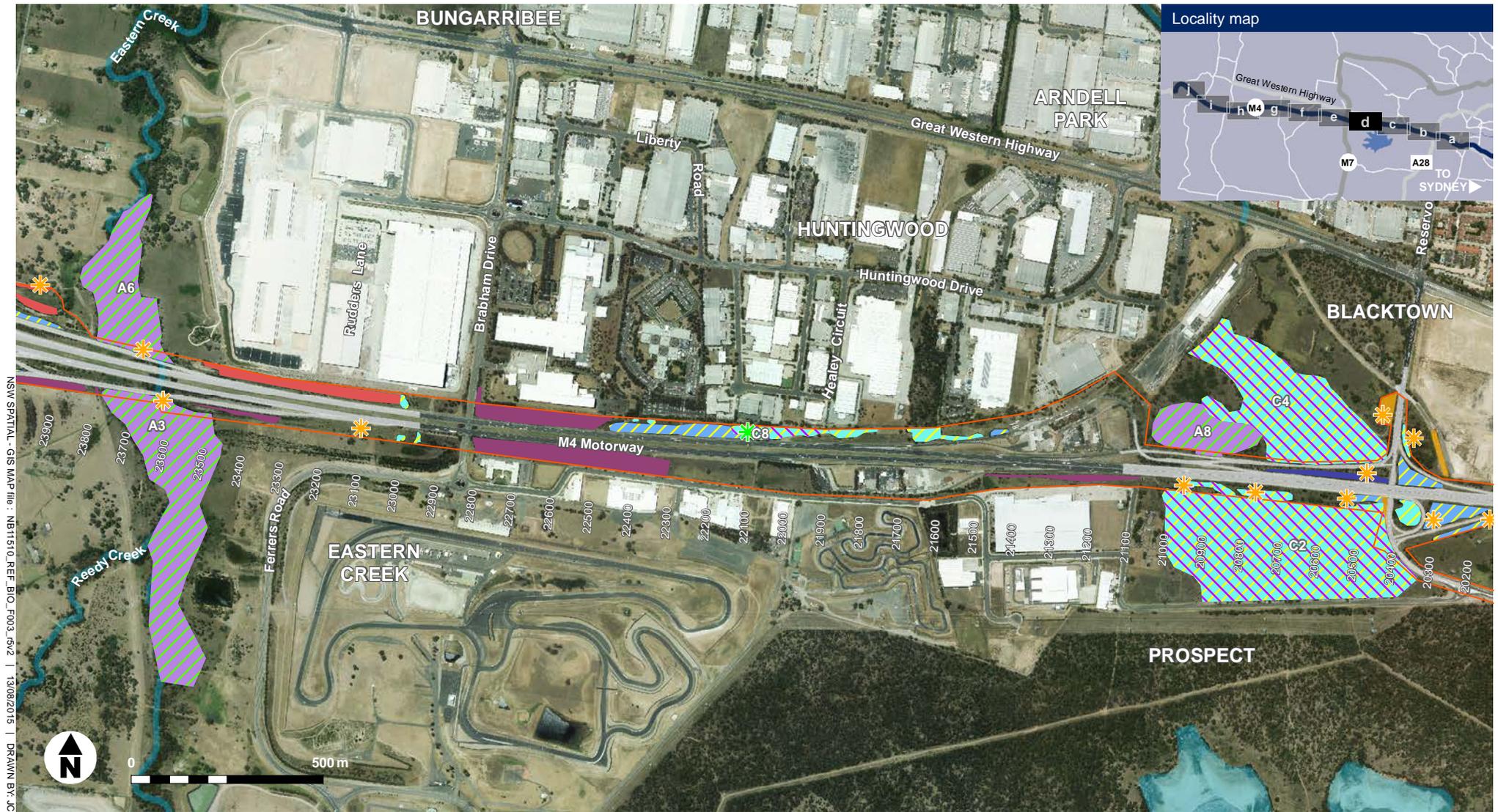


Figure 3-1d Distribution of vegetation communities and fauna habitats





Figure 3-1e Distribution of vegetation communities and fauna habitats



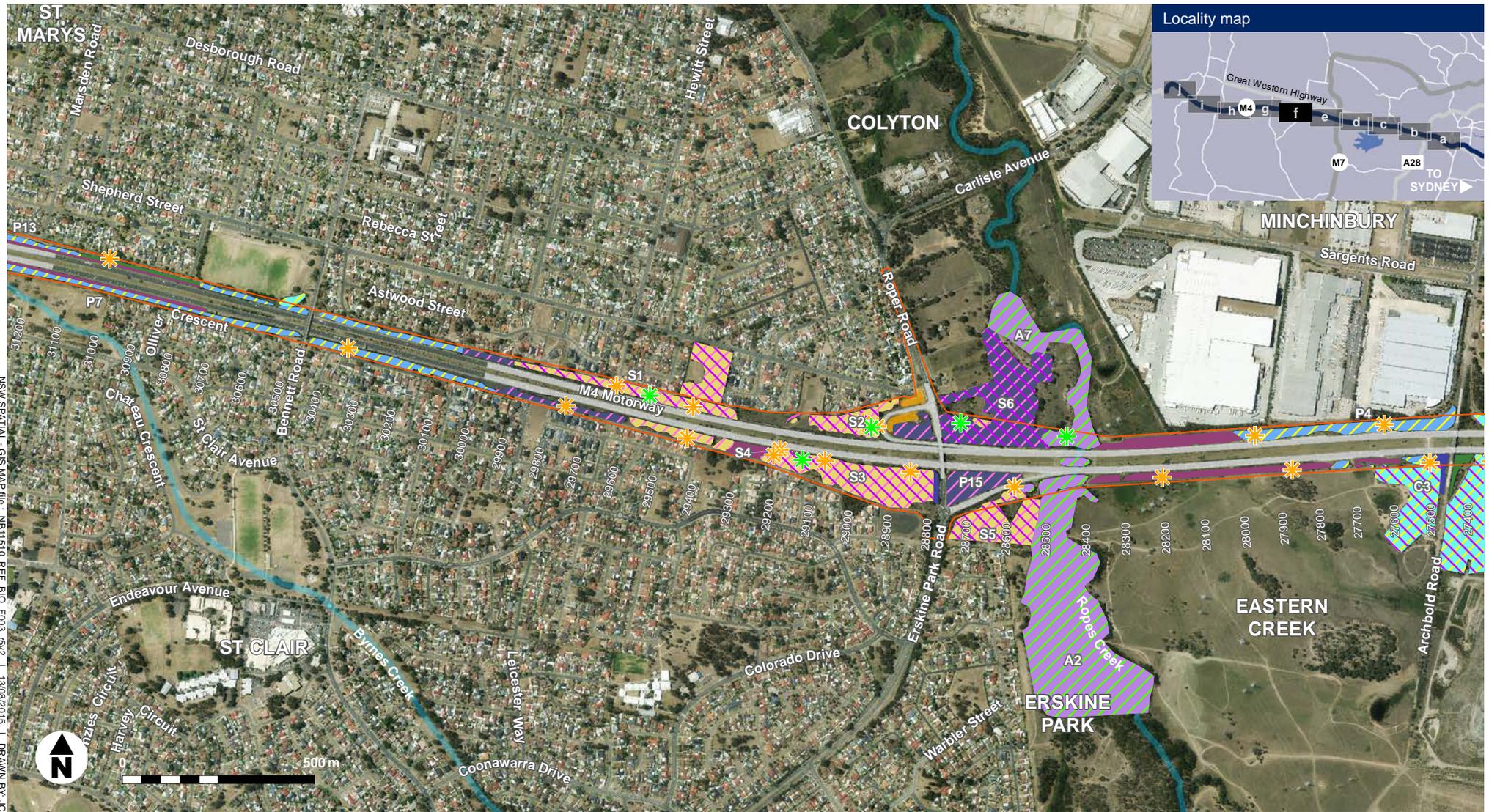


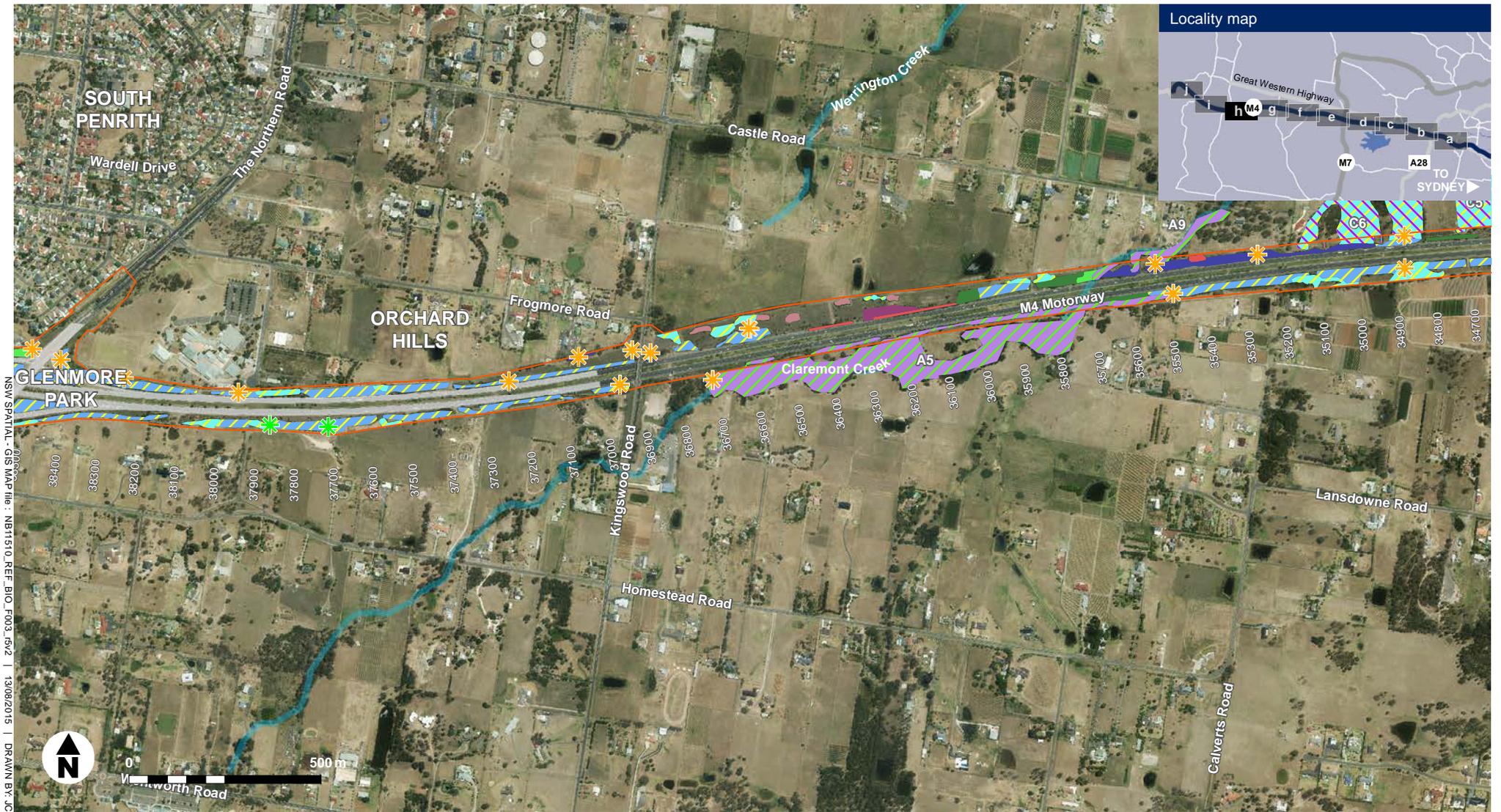
Figure 3-1f Distribution of vegetation communities and fauna habitats





Figure 3-1g Distribution of vegetation communities and fauna habitats





NSW SPATIAL - GIS MAP file : NB1151D\_REF\_BIO\_F003\_15v2 | 13/08/2015 | DRAWN BY: JC

Figure 3-1h Distribution of vegetation communities and fauna habitats



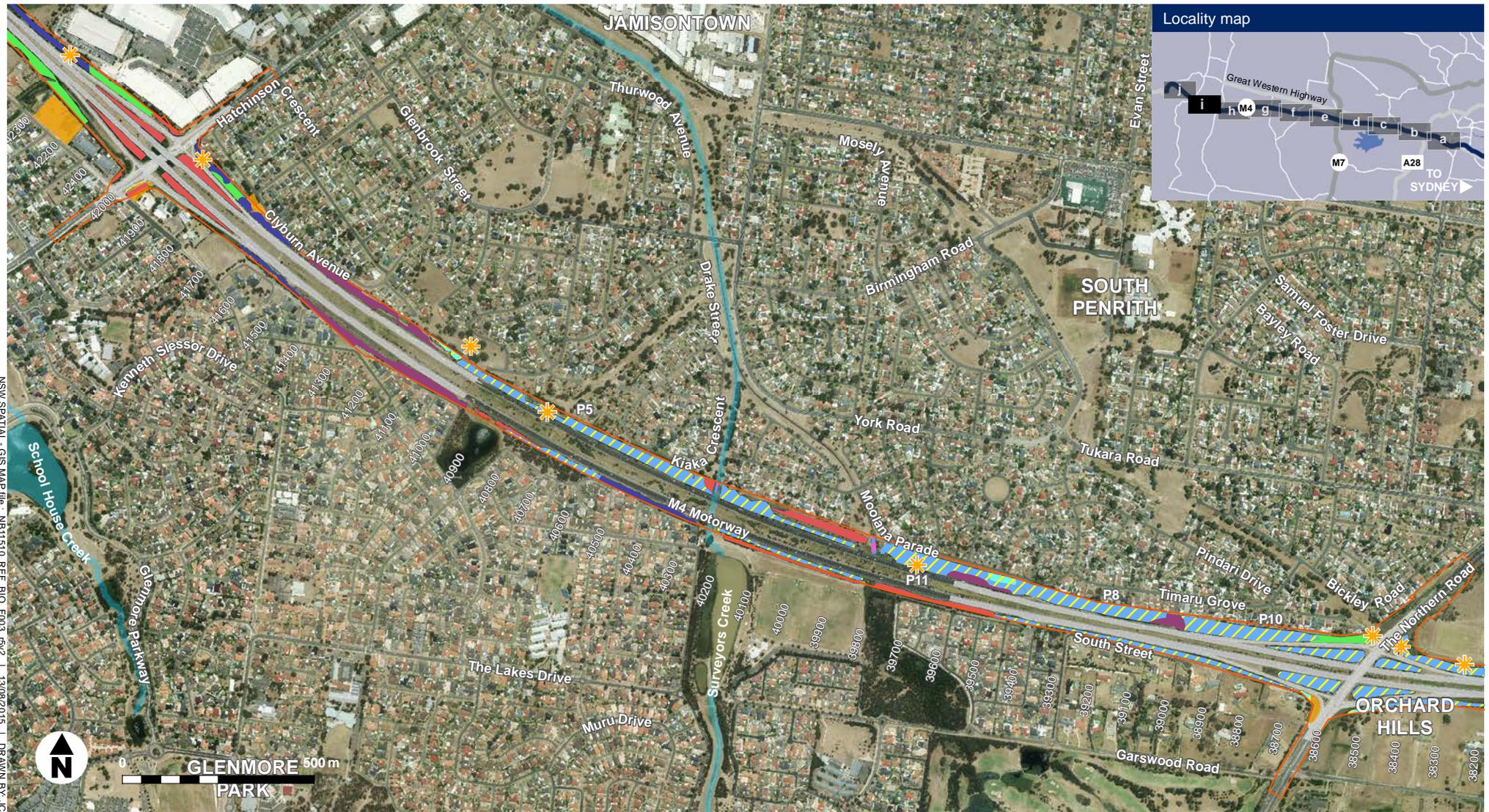


Figure 3-1i Distribution of vegetation communities and fauna habitats

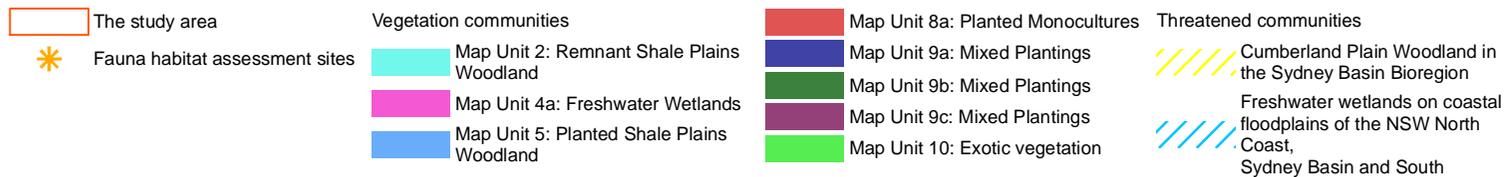
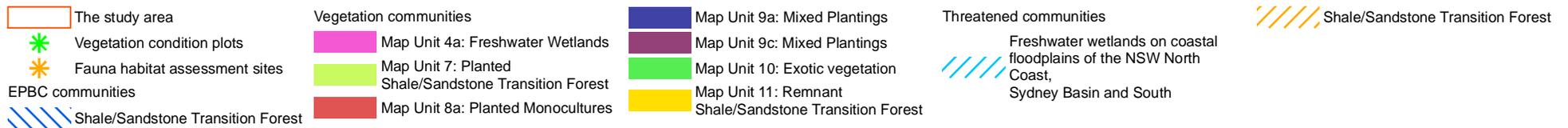




Figure 3-1j Distribution of vegetation communities and fauna habitats



NSW SPATIAL - GIS MAP file : NB11510\_REF\_B10\_F003\_15v2 | 13/08/2015 | DR:AMW BX:JC

### 3.3.2 Vegetation condition and patch size

Vegetation condition was assessed using the vegetation condition assessment plots as defined under the BioBanking methodology (DECCW 2008). Not all map units were subject to plot assessments due to the highly modified and planted nature of these areas (Map Unit 8, 9 and 10) or due to the very small patch size (Map Unit 4). The results of the plot assessments are summarised for each relevant map unit in **Table 3-2** including corresponding threatened ecological communities. Habitat condition for fauna species in each map unit is broadly described in **Table 3-1**.

**Table 3-2 Vegetation and habitat condition assessment plots**

Plot	Map Unit	Patch ID	Threatened ecological community	Condition category	Biobanking score (1-100)
1	2	n/a	Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered, TSC Act)	Moderate	66
2	5	n/a		High	68
3	5	n/a		Moderate	54
4	2	C5		High	78
5	2	n/a		Moderate	51
6	3	A1	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)	Moderate	58
7	5	C10	Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered, TSC Act)	High	70
8	5	n/a		Moderate	58
9	1	S1	Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act)	High	75
10	1	S2	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered, EPBC Act)	High	79
11	6	S6	Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act)	Moderate	60
12	3	A7	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act)	Moderate	34
13	2	C8	Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered, TSC Act) Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered, EPBC Act)	High	88
14	1	S3	Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act) Cumberland Plain Shale Woodlands and Shale-Gravel	High	73

Plot	Map Unit	Patch ID	Threatened ecological community	Condition category	Biobanking score (1-100)
			Transition Forest (Critically Endangered, EPBC Act)		
15	7	SS1	Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act and EPBC Act)	Moderate	57
16	11	SS4	Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act and EPBC Act)	High	96
17	11	SS2	Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Endangered, TSC Act and EPBC Act)	High	87

Large to moderate sized remnant vegetation patches ( $\geq 1$  hectare) are important for retaining species diversity, connecting habitats, improving species gene flow and are generally resilient to disturbances and diseases. Remnant vegetation patches that intersect the study area have been mapped and a summary of these is provided in Table 3-3.

**Table 3-3 Larger remnant vegetation patches contiguous with the study area**

Patch ID	Map Unit	Approximate Chainage	Condition (BioBanking score where applicable)	Patch size (ha)	Appx. area within footprint (ha)
S1	Map Unit 1: Remnant Shale-Gravel Transition Forest	29500	High (75)	2.5	0.08
S2		29000	High (79)	1.03	0.1
S2		29000	Moderate		0.08
S3		29000	High (73)	3.1	0
S4		29460	Moderate	0.54	0.04
S5		28640	Moderate	2.02	0
S6		28640	Moderate (60)	4.69	0
S6	Map Unit 6: Planted Shale-Gravel Transition Forest	28640	Moderate		0.38
C1	Map Unit 2: Remnant Shale Plains Woodland	25500	Moderate	51.28	0.23
C2		20700	Moderate	15.44	0.59
C3		27300	Moderate	12.61	0.08
		27300	High		0.02
C4		20700	Moderate	8.96	0.05

Patch ID	Map Unit	Approximate Chainage	Condition (BioBanking score where applicable)	Patch size (ha)	Appx. area within footprint (ha)
C5		34620	High (78)	2.09	0
C6		34920	High	4.04	0.02
C7		33740	Moderate	1.28	0.03
C8		22000	High (88)	0.63	0.01
C9	Map Unit 5: Planted Shale Plains Woodland	32000	High (70)	1.69	0.17
A1	Map Unit 3: Remnant Alluvial Woodland	32840	Moderate (58)	14.92	0.05
A2		28420	Moderate	11.83	0.03
A3		23660	Moderate	10.26	0
A4		32840	Moderate	10.08	0.04
A5		36100	Moderate	7.83	0.1
A6		23660	Moderate	4.9	0.13
A7		28420	Moderate (34)	3.2	0.07
A8		20900	Moderate	2.61	0.02
A9		36000	Moderate	0.69	0.04
SS1		Map Unit 11: Remnant Shale Sandstone Transition Forest	45700	High	8.92
SS2	44800		High (87)	11.2	0
SS3	45500		Moderate	6.71	0.04
SS4	45400		High (96)	40.41	0.24

### 3.3.3 Fauna habitat and condition

Natural habitats for fauna have been extensively removed for agriculture and rural and residential development. Remaining patches of habitat are relatively small and fragmented and comprise:

- Remnant or regrowth grassy and shrubby woodland
- Riparian and aquatic habitats
- Planted native species mix
- Cleared and modified agricultural landscapes.

The road reserve varied in width from five up to 70 metres and consisted of vegetation and adjacent wide mown strips typically along boundary fences and the road edge used to maintain firebreaks and utility easements. The vegetation comprises native landscape plantings established as part of the original motorway landscaping works undertaken 10-15 years ago. Small fragments of remnant and regrowth vegetation are dispersed among this particularly along creek lines which extend beyond the road corridor.

The woodland habitat types and value for fauna vary across the landscape in conjunction with the age and structure of the vegetation and dominant canopy species (refer **Table 3-1**). Both mature and regrowth forest elements are present as well as cleared and modified habitats. The historical clearing of land particularly on private rural properties adjacent to the project corridor has significantly reduced the value of the habitat by removing connectivity, foraging, shelter and breeding resources for fauna. The best quality fauna habitats were found in proximity to Ropes Creek on the northern and southern side of the M4 Motorway corridor and associated with larger fragments of Grey Box or Forest Red Gum Woodland with a well-developed structure of canopy, midstorey and lower groundcover flora, including shrubs, graminoids and herbs. These remnant habitats were also found to comprise abundant leaf litter, low densities of fallen timber, logs and rubbish and support populations of Cumberland Plain Land Snail (*Meridolum corneovirens*). The overall habitat condition was considered moderate to high. However, there is generally an absence of structural maturity and only occasional tree hollows were present reducing the value of the habitat as sheltering or refuge areas for larger or hollow dependent fauna and providing only mostly foraging habitat for common urban species.

There are larger patches of remnant vegetation at the western end of the study area between Emu Plains and Lapstone including areas of Shale Sandstone transition Forest adjacent to the M4 Western Motorway. These habitats are likely to provide habitat for a range of threatened fauna species for which there are numerous records in the area including Gang Gang Cockatoo (*Callocephalon fimbriatum*), Glossy-black Cockatoo (*Calyptorhynchus lathami*), Red-crowned Toadlet (*Pseudophyrne australis*), Spotted-tail Quoll (*Dasyurus maculatus*) and Eastern Pygmy-possum (*Cercartetus nanus*). The edges of these habitat patches adjacent the M4 Western Motorway have been subject to previous disturbances and mainly comprise planted and regenerating vegetation.

The condition of the riparian habitats in Map Unit 3 in the study also varies widely depending on the size of the patch, the degree of disturbance associated with rubbish dumping and accumulation, clearing, and the extent of weeds. In general all riparian areas are in low condition and provide minimal resources for fauna in terms of breeding and foraging opportunities. Examples are South Creek and Blaxlands Creek riparian zones. The dense canopy provides shelter and refuge for some bird and arboreal mammal species, particularly Common Ringtail Possum. No Cumberland Plain Land Snails were found in this habitat, and this species is not expected due to the absence of leaf litter and bark and sheltering opportunities. These habitats provide shelter, breeding and foraging resources for several common frog and reptile species and a diversity of woodland and forest bird species, as well as mammals such as the Common Ringtail and Common Brushtail Possum.

The remainder and majority of the road corridor landscape comprise planted vegetation 10-15 years old. These areas rarely support any native groundcovers and often have a sparse planted shrub layer and dominated by dense tall exotic grasses, such that there is little to no open patchiness in the ground cover and no leaf litter present. There is an absence of structural maturity and few tree hollows or logs, reducing the value of the habitat as sheltering or refuge

areas for larger or hollow dependent fauna and providing only mostly foraging habitat for common urban species. Some sheltering habitat is provided for reptiles and invertebrates through extensive rubbish dumping and dense grasses. The overall habitat condition was considered low.

**Hollow-bearing trees**

A total of 22 hollow-bearing trees were located in the study area during the field survey with the eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining scattered throughout the study area as shown in **Figure 3-1a** to **Figure 3-1j**. The lack of hollow-bearing trees throughout much of the study area is a symptom of the historic land clearing that has taken place in the locality. The majority of the vegetation has been planted after construction of the M4 motorway and as such lacks maturity and the majority of trees lack habitat features such as hollows.

**3.4 Threatened ecological communities**

**3.4.1 Literature and database review**

Based on the background review a number of other potentially occurring TECs are noted for the region as listed **Table A-3** of **Appendix A**. Targeted follow-up survey confirmed the presence or absence of these communities as identified in **Table 3-4**.

**3.4.2 Survey results**

A brief description of the TECs recorded in the study area is provided in **Table 3-4** and these are mapped in **Figure 3-1a** to **Figure 3-1m**. Detailed descriptions of threatened ecological communities are provided in Final Determinations for state listed communities on the OEH website (OEH 2012) and for the Commonwealth listed areas of Cumberland Plain Woodland refer to the listing advice on the DOE website (DoE 2013).

**Table 3-4 Description threatened ecological communities recorded in the study area**

Threatened ecological community	Status	Description	Area (ha)	
			Study area and adjoining areas	Locality*
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered, EPBC Act	The federally listed community includes patches which comply with condition thresholds detailed in EPBC Act listing advice (see Section 2.3.4).  The main condition thresholds that patches in the study area comply with is a diagnostic canopy with foliage cover >10%, a minimum patch size of 0.5 hectares and an understorey dominated by native species.	107.8 (remnant)	3,990

Threatened ecological community	Status	Description	Area (ha)	
			Study area and adjoining areas	Locality*
Cumberland Plain Woodland in the Sydney basin Bioregion	Critically Endangered, TSC Act	In addition to higher condition patches covered under the federal listing, the state-listed community also includes lower condition patches such as remnant and regenerating trees with an exotic-dominated understorey as well as planted vegetation.  Areas planted with diagnostic overstorey species (i.e. Forest Red Gum and Grey Box) in a suitable landscape position have been identified as being the state-listed community.	154.7 (107.8 remnant, 46.9 planted)	3,472
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered, TSC Act	This community occurs along drainage lines in the study area supporting dense sedges and reeds including Cumbungi ( <i>Typha orientalis</i> ) and Common Reed ( <i>Phragmites australis</i> ) as well as areas of open water.	1.47 (modified)	13
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered, TSC Act	This community comprises forested vegetation along drainage lines. Much of this community in the study area is highly infested with noxious weeds such as Privet species ( <i>Ligustrum</i> species).  Areas planted with diagnostic overstorey species (i.e. Swamp Oak) in a suitable landscape position in proximity to creek lines and associated floodplains have been identified as this state-listed community.	68 (remnant/modified)	1712
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered, TSC Act  Critically Endangered, EPBC Act	In addition to higher condition patches covered under the federal listing, the state-listed community also includes lower condition patches such as remnant and regenerating trees with an exotic-dominated understorey.  Areas planted with diagnostic overstorey species (i.e. Broad-leaved Ironbark) in a suitable landscape position have been identified as being the state-listed community.	16 (9.3 remnant, 6.7 planted)	518

Threatened ecological community	Status	Description	Area (ha)	
			Study area and adjoining areas	Locality*
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered, TSC Act and EPBC Act	The federally listed community includes patches which comply with condition thresholds detailed in EPBC Act listing advice (see Section 2.3.4).  Both moderate and high condition classes are present. High condition areas include patches greater than 2ha with at least 50% native understorey cover.	67.25 (remnant)	324
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered, TSC Act	Areas planted with diagnostic overstorey species (i.e. Grey Gum, Smooth-barked Apple, Ironbark species) and mid-storey species (i.e. Coastal Myall, Cherry Ballart) are present at the western end of the M4 corridor. This area is considered to be a transitional landscape between shale soil landscapes of the Cumberland Plain and sandstone environments of the Blue Mountains to the west.	70.35 (67.25 remnant, 3.1 planted)	324

Notes: \* = Predicted amount of vegetation in the locality based on vegetation mapping layer by Tozer *et al.* 2010

### 3.4.3 Cumberland plain priority conservation lands

The Department of Environment Climate Change and Water (DECCW) (now known as OEH) (2010) completed an assessment of remaining remnant vegetation patches based on recovery principles to protect and manage large intact remnants and conserve representative samples of threatened biota on the Cumberland Plain. This identified Priority Conservation Lands (PCLs) which represent the best remaining opportunities in the region to secure long term biodiversity benefits.

Three hectares of PCLs have been identified in the study area located to the south of the motorway on the east and west of the Roper Road interchange. Vegetation mapped in this area comprises map units 1, 3, 4a, 10a and 10c which includes approximately 2.7 hectares of intact Shale-Gravel Transition Forest. A small area of this PCL (around 0.3 hectares) will be temporarily impacted by the project to install cabling for the ITS infrastructure, which will generally be restricted to the disturbed edges of vegetation patches.

### 3.5 Groundwater dependant ecosystems

The level of water dependence of vegetation communities on the Cumberland Plain have been identified in the Risk Assessment Guidelines for Groundwater Dependiant Ecosystems released by the NSW Department of Primary Industries (Kuginis *et al.* 2012). The level of groundwater dependence identified for ecological communities in the study area is identified in **Table 3-5**.

**Table 3-5 Level of groundwater dependence of vegetation in study area**

Map Unit	Level of groundwater dependence (Kuginis <i>et al.</i> 2012)
Map Unit 1: Remnant Shale-Gravel Transition Forest	High
Map Unit 2: Remnant Shale Plains Woodland	High
Map Unit 3: Remnant Alluvial Woodland	High
Map Unit 4: Freshwater Wetlands (4a Broadleaf Cumbungi; 4b Common Reed)	High
Map Unit 5: Planted Shale Plains Woodland	Potentially
Map Unit 6: Planted Shale-Gravel Transition Forest	Potentially
Map Unit 7: Planted Shale Sandstone Transition Forest	Potentially
Map Unit 8: Planted Monocultures (9a Casuarina species; 9b Eucalyptus species; 9c Fig species)	Potentially
Map Unit 9: Mixed Plantings (10a Native trees; 10b Native shrubs; 10c Sparse plantings)	Unlikely
Map Unit 10: Exotic vegetation	Unlikely
Map Unit 11: Remnant Shale Sandstone Transition Forest	High

### 3.6 Aquatic habitats

The M4 Motorway crosses the Nepean River at the western end, South Creek, Eastern Creek and Ropes Creek, and a number of smaller creeks including Surveyors Creek, Claremont Creek, Blaxland Creek, Byrnes Creek, Greystanes Creek and Finlayson's Creek. The aquatic habitat assessment focused on the larger waterways of Ropes Creek and South Creek and provided a visual assessment of the habitat value for aquatic fauna (fish and macroinvertebrates). South Creek and Ropes Creek have been identified as priority restoration areas for western Sydney (Department of Planning 2008) which recognises their value for flora and fauna and landscape connectivity.

The M4 crosses South Creek at Chainage 33000 and vegetation is continuous to the north and south of the M4 linking with Blaxlands Creek to the south which traverses through to the Defence Establishment Orchard Hills. The M4 crosses Ropes Creek at Chainage 28500 and vegetation is continuous to the north and south of the M4, but severed by the motorway. A visual site assessment of South Creek and Ropes Creek was undertaken at which time the following were observed:

- A number of aquatic macrophytes were observed including duckweed floating on the surface, water ribbon (*Triglochin procerum*), pond weed (*Potamogeton tricarlinatus*) and filamentous algae (possibly *Cladophora*), sedges (*Juncus* spp.), slender knotweed (*Persicaria decipiens*), frogmouth (*Philydrum lanuginosum*) and milfoil (*Myriophyllum gracile*). These habitats provide shelter, breeding and foraging resources for several common frog and reptile species. One fish species was observed the introduced Eastern

*Gambusia (Gambusia holbrooki)*.

- Water quality was generally poor and consisted of high levels of silt/sediment and in some instances small algal blooms at both creeks. This is expected to be a result of nutrient enrichment.
- Channel typically 3-4 metres wide and moderately step sloping banks with riparian vegetation dominated by Swamp Oak (*Casuarina glauca*) in the canopy and Large-leaved Privet in the midstorey. Water depth near the M4 approximately 1.5 metres deep however visibility only 0.5 metres. Clay substrate with no riffles, however series of smaller connected pools present and abundant logs and debris and overhanging vegetation providing cover and shelter for fish and macroinvertebrates.

The general observations indicate that the ecosystem health of these creeks is poor, as a result of poor land practices, agriculture and urban development. These creeks are unlikely to provide significant or important fish habitat.

### 3.7 Threatened flora species

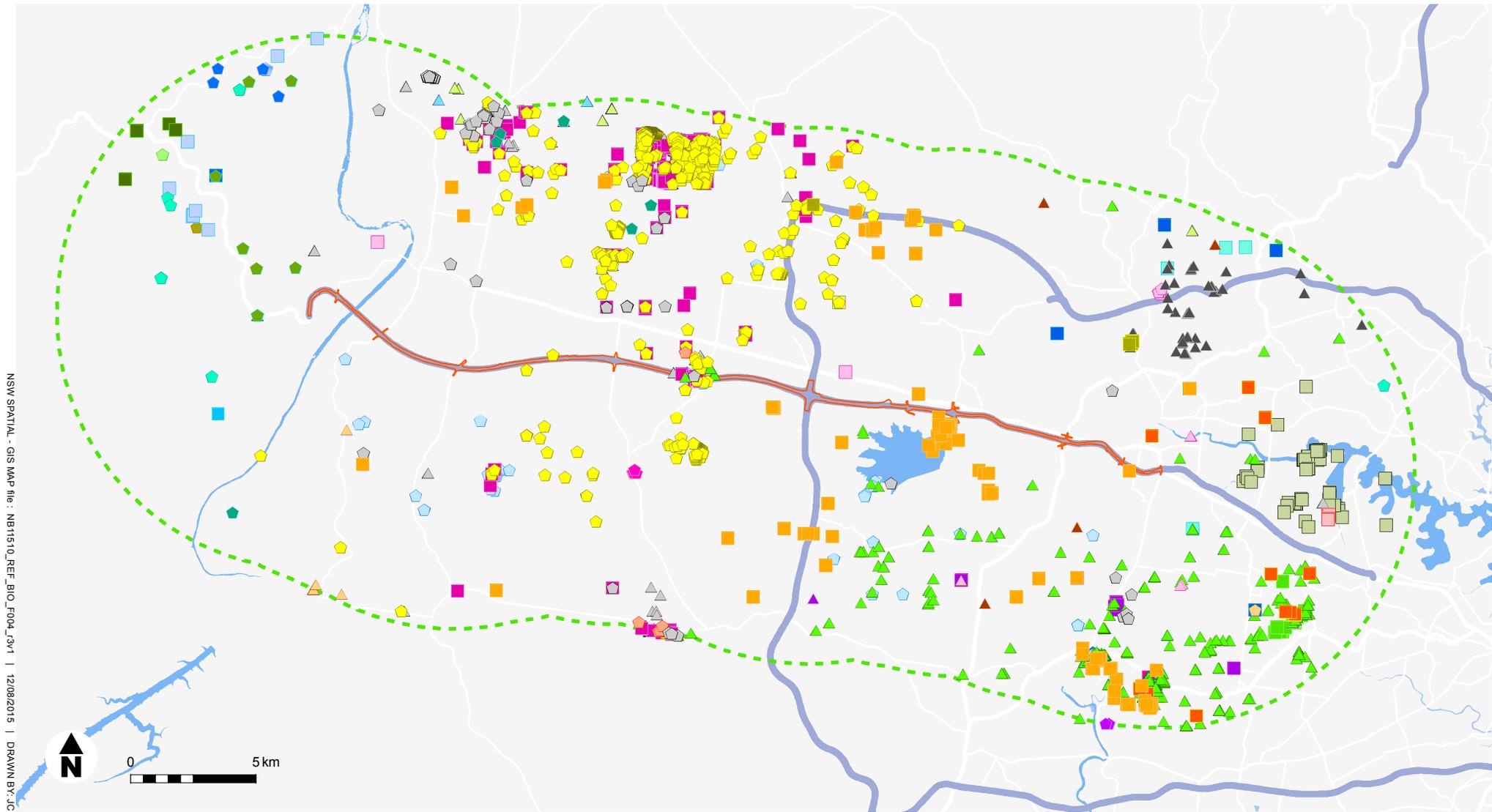
#### 3.7.1 Literature and database review

On the basis of regional records and reports and the presence of suitable habitat, a total of 64 threatened flora species have been previously recorded or listed as having potential to occur in the locality. Of these, six species are present in the study area. Two other species are considered to have a moderate chance of occurring based on the presence of suitable habitat and records in the locality (refer to **Table 3-6**). The full list of flora species considered in this assessment is provided in **Appendix A** and the distribution of threatened flora species records in the study area is provided in **Figure 3 2**.

**Table 3-6 Threatened flora species and endangered populations recorded or considered to have a moderate to high likelihood of occurring**

Species	Status		Likelihood of occurrence
	EPBC Act	TSC Act	
Downy Wattle ( <i>Acacia pubescens</i> )	V	V	Present
<i>Dillwynia tenuifolia</i>	-	V	Present
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	V	V	Present
Juniper-leaf Grevillea ( <i>Grevillea juniperina subsp. juniperina</i> )	-	V	Present
<i>Marsdenia viridiflora subsp. viridiflora</i> (endangered population)	-	E2	Moderate
Nodding Geebung ( <i>Persoonia nutans</i> )	E	E	Present
Spiked-rice Flower ( <i>Pimelea spicata</i> )	E	E	Moderate
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	E	E	Present

V- vulnerable; E – endangered; E2 – endangered population \* species recorded from the survey (refer Section 3.8.2)



NSW SPATIAL - GIS MAP file : NB11510\_REF\_BIO\_F004\_3v1 | 12/08/2015 | DRAWN BY: JC

**Figure 3-2** Threatened flora records within a 10 km radius of the study area



### 3.7.2 Survey results

The field surveys resulted in the identification of seven threatened flora species, and their distribution and abundance are described in **Table 3-7** and displayed in **Figure 3-4a** to **Figure 3-4j**. Habitat for these species was restricted to higher condition areas of Map Unit 1 Shale-Gravel Transition Forest and Map Unit 2 Cumberland Plain Woodland.

The local populations of each species have been identified based on potential for cross-pollination between plants and/or population clusters. Local populations have been defined based on the main pollination vectors for each flora species, with insect/bird pollinated species comprising all plants within 500 metres of another plant, and wind pollinated species comprising all plants within 150 metres of another plant. This is based on evidence of pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003), and considering the high mobility of some pollinator species such as insects, birds and bats a maximum dispersal distance 500 metres has been identified.

**Table 3-7 Threatened flora populations in the study area**

Threatened flora species	Status	Distribution and abundance
Downy Wattle <i>Acacia pubescens</i>	V, TSC Act V, EPBC Act	Four individuals were recorded at one location in the study area to the west of the Ropers Road intersection on the southern side of the M4 Motorway. These four individuals were growing in a small cluster consisting of two medium sized plants (1.2-1.7 metres high) and two small plants (c. 1 metre high). These individuals were growing in a disturbed remnant of Shale-Gravel Transition Forest (Map Unit 1) approximately four metres from the existing M4 motorway road pavement.
<i>Dillwynia tenuifolia</i>	V, TSC Act	A total of 135 individuals were directly counted in the study area, in four main population clusters west of the Ropers Road interchange. These three clusters are associated with higher condition Shale-Gravel Transition Forest (Map Unit 1) and are greater than 150 metres apart and so are considered to be four separate local populations.  Two clusters occur directly west of the Ropers Road interchange on the northern and southern side of the M4 Motorway approximately 200 metres apart within fenced remnants . There are approximately 91 individuals in these clusters.  There is another cluster approximately 400 metres further west on the northern side of the M4 Motorway on top of an existing cutting on both sides of an existing sound wall. Some individuals in this cluster are approximately seven metres from the existing M4 Motorway road pavement. There are 42 individuals in this cluster. An additional 2 individuals occur approximately 300 metres west of this cluster.
Narrow-leaved Black Peppermint <i>Eucalyptus nicholii</i>	V, TSC Act, V, EPBC Act	A single individual of this species was recorded on the northern side of the M4 Motorway corridor south of the major service centre and rest stop area. This species has been planted in the corridor.  The natural distribution of this species is on the New England Tablelands, typically growing in dry grassy woodland, on shallow soils of slopes and ridges, primarily on infertile soils derived from granite or metasedimentary rock.  This species is widely planted as an ornamental tree.

Threatened flora species	Status	Distribution and abundance
Juniper-leaf Grevillea <i>Grevillea juniperina</i> subsp. <i>juniperina</i>	V, TSC Act	<p>Over 1000 individuals were directly counted in the study area, however not all individuals were directly counted in high density areas that are remote from the existing M4 Motorway road pavement around the Roper Road interchange.</p> <p>Large populations of this species occur in the study area surrounding the Ropers Road interchange on both sides of the M4 Motorway (&gt;800 individuals). There are also several population clusters further west surrounding the Kent Road overpass (c. 204 individuals). These two occurrences are considered to be two separate local populations.</p> <p>Another non-threatened subspecies of <i>Grevillea juniperina</i> has been planted in the corridor suspected to be <i>Grevillea juniperina</i> subsp. <i>allojohnsonii</i>. This species was possibly originally planted to compensate for impacts to <i>Grevillea juniperina</i> subsp. <i>juniperina</i> as a result of the original M4 development.</p>
Nodding Geebung <i>Persoonia nutans</i>	E, TSC Act E, EPBC Act	<p>Only a single individual of this species was recorded in high condition Shale-Gravel Transition Forest (Map Unit 1) directly west of Ropers Road on the northern side of the M4 motorway in a fenced off remnant. This individual is approximately 55 metres from the existing M4 Motorway road pavement.</p>
Sydney-bush Pea <i>Pultenaea parviflora</i>	E, TSC Act E, EPBC Act	<p>A total of 29 individuals were directly counted in the study area to the west of the Ropers Road interchange on both sides of the M4 Motorway in two main clusters that are greater than 150 metres apart and so are considered to be four separate local populations.</p> <p>One cluster occurs directly west of the Ropers Road interchange on the northern and southern side of the M4 Motorway within fenced remnants. There are approximately 26 individuals in this cluster</p> <p>The other cluster occurs further west on the northern side of the M4 Motorway on top of an existing cutting on the road side of an existing sound wall comprising four individuals. These individuals are approximately eight metres from the existing M4 Motorway road pavement.</p>
Magenta Lilly Pilly <i>Syzygium paniculatum</i>	E, TSC Act V, EPBC Act	<p>Six individuals of this species have been planted adjacent to the M4 Motorway corridor in Leonay Park at Emu Plains. These individuals occur in a maintained parkland setting.</p> <p>Emu Plains is outside of the natural distribution of this species, which is generally restricted to coastal areas. The natural habitat of the species includes rainforest and wet sclerophyll forests, often in coastal (littoral) environments.</p> <p>This species is widely planted as an ornamental tree.</p>

### 3.8 Threatened fauna species

#### 3.8.1 Literature and database review

On the basis of regional records, reports and the presence of suitable habitat, a total of 82 threatened fauna species have been identified from locality, which encompasses a range of terrestrial and aquatic habitats within a 10 kilometre radius of the study area. These species are listed in **Appendix A** which presents an assessment of their likelihood of occurrence in the

study area using the criteria described in Section 2.7.1. Many of these species favour habitats that are not represented in the study area, only exist in high quality vegetation remnants, or may only be occasional vagrant visitors, and these were considered unlikely to occur (n=41) or have a low likelihood of occurring (n=23). From the review, 12 species were considered to have a moderate chance of occurring due to the presence of nearby records and suitable habitat within the study area. Three species were confirmed to be present from the field survey: Eastern Bent-wing Bat, Southern Myotis and Cumberland Plain Land Snail. The species recorded from the site surveys and those considered to have a moderate chance of occurring near the study area are presented in **Table 3-8** and all threatened fauna records within a 10 kilometre radius of the study area are graphically displayed in **Figure 3-3**.

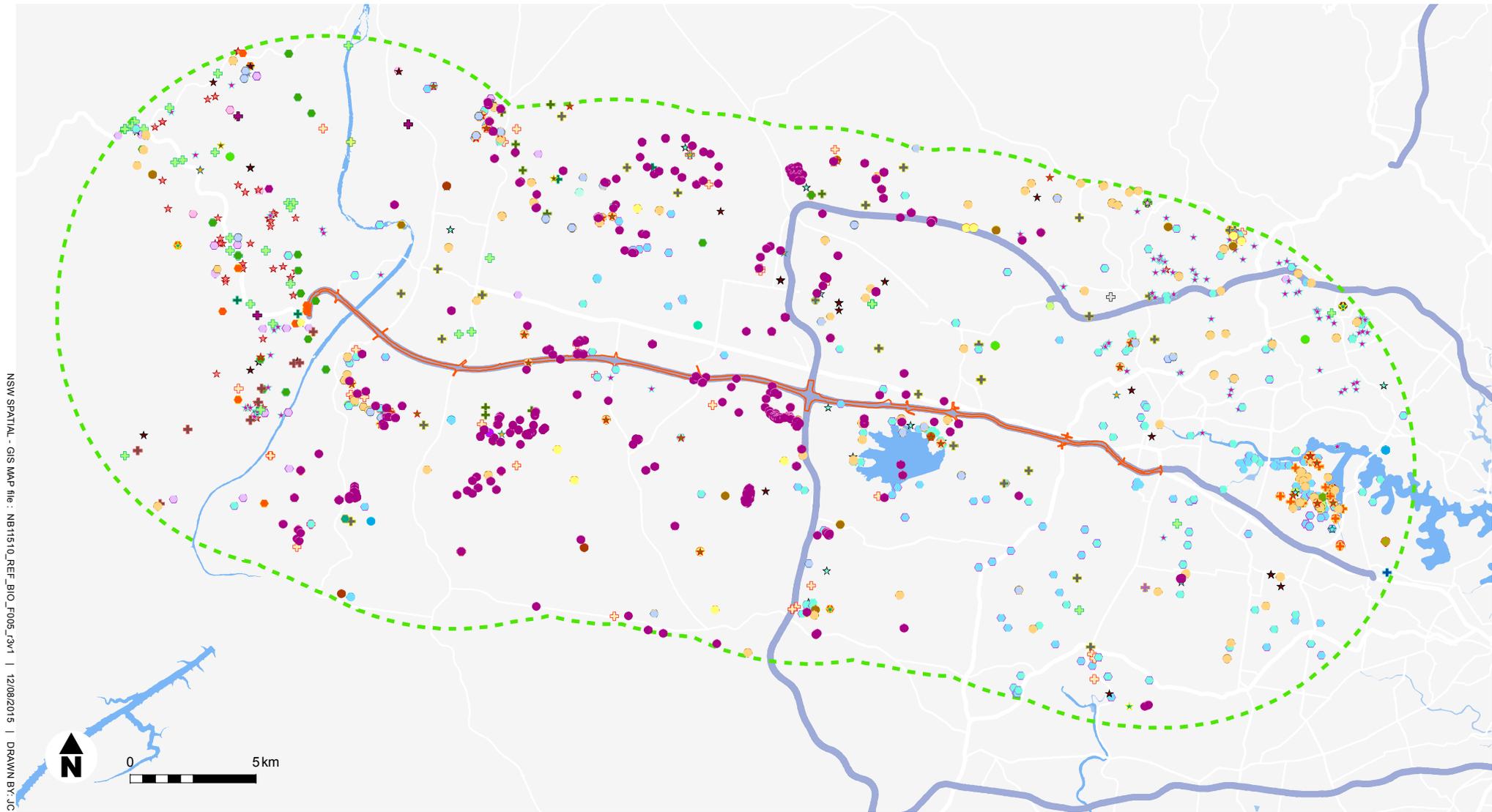
**Table 3-8 Threatened fauna species recorded or considered to have a moderate to high likelihood of occurring**

Species	Status		Likelihood of occurrence
	EPBC Act	TSC Act	
<b>MAMMALS</b>			
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii oceanensis</i> )	-	V	Present *
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	-	V	Moderate
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	-	V	Moderate
Eastern Freetail Bat ( <i>Mormopterus norfolkensis</i> )	-	V	Moderate
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	-	V	Moderate
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	V	Moderate
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	V	Moderate
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	-	V	Moderate
Southern Myotis ( <i>Myotis macropus</i> )	-	V	Present *
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	E	V	High
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	-	V	Moderate
Yellow-bellied Glider ( <i>Petaurus australis</i> )	-	V	High
Yellow-bellied Sheathtail-bat ( <i>Saccolaimus flaviventris</i> )	-	V	Moderate
<b>BIRDS</b>			
Barking Owl ( <i>Ninox connivens</i> )	-	V	Moderate
Flame Robin ( <i>Petroica phoenicea</i> )	-	V	Moderate
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	-	V	High
Glossy Black-Cockatoo ( <i>Calyptorhynchus latham</i> )	-	V	High

Species	Status		Likelihood of occurrence
	EPBC Act	TSC Act	
Little Eagle ( <i>Hieraaetus morphnoides</i> )	-	V	Moderate
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	-	V	Moderate
Masked Owl ( <i>Tyto novaehollandiae</i> )	-	V	Moderate
Powerful Owl ( <i>Ninox strenua</i> )	-	V	Moderate
Scarlet Robin ( <i>Petroica boodang</i> )	-	V	Moderate
Speckled Warbler ( <i>Chthonicola sagittatus</i> )	-	V	Moderate
Swift Parrot ( <i>Lathamus discolor</i> )	E, M	E	Moderate
Varied Sittella ( <i>Daphoenositta chrysoptera</i> )	-	V	Moderate
<b>REPTILES AND AMPHIBIANS</b>			
Broad-headed Snake ( <i>Hoplocephalus bungaroides</i> )	V	V	Moderate
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	-	V	Moderate
<b>INVERTEBRATES</b>			
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	-	E	Present *

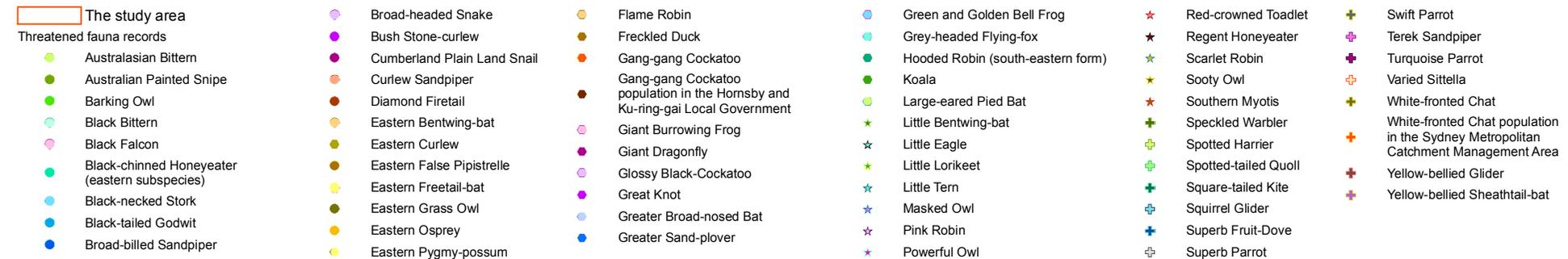
V- vulnerable; E – endangered; E2 – endangered population; M – migratory species

\* species recorded from the survey (refer Section 3.8.2)



NSW SPATIAL - GIS MAP file : NB11510\_REF\_BIO\_F005\_J3V1 | 12/08/2015 | DRAWN BY: JC

**Figure 3-3** Threatened fauna records within a 10 km radius of the study area



### 3.8.2 Survey results

#### **Cumberland Plain Land Snail (Endangered TSC Act)**

Select parts of the M4 corridor were identified as potential habitat for the Cumberland Plain Land Snail and the species was found to be present at five locations. Of the 84 sites surveyed high quality habitat for the species was identified at five locations all associated with remnant Shale-Gravel Transition Forest or a mix of remnant and regrowth forest with a relatively lower density of exotic grasses in the understorey and an abundance of leaf litter and natural or artificial debris. Moderate condition habitat was identified at 12 sites also containing remnant woodland although three planted woodland sites were considered to provide moderate potential habitat on the basis of the connectivity to larger remnant woodland patches, the low abundance of weeds and presence of sheltering habitat for this species. A series of maps showing the distribution and condition of habitat for the Cumberland Plain Land Snail is shown as **Figure 3-4a** to **Figure 3-4j**.

The remaining 69 sites surveyed were considered low condition for Cumberland Plain Land Snail and rated as a low likelihood of the species occurring. Such sites were dominated by planted young aged roadside vegetation, a high density of weeds, particularly dense growth of exotic grasses and a lack of sheltering habitat or connectivity with remnant vegetation. Cumberland Plain Land Snails were confirmed at five locations, including:

- Four live snails found on the south side of the M4 Motorway corridor and east of Archbold Road at Chainage 27350. Remnant vegetation is present in the road corridor and part of a larger fragment of moderate to high quality woodland extending both sides of Archbold Road and on land occupied by the quarry.
- Three live snails and snail shells found south west side of Erskine Park Road at a number of locations in a large fragment of remnant Shale-Gravel Transition Forest between Chainage 28800 and 29100.
- One live snail and snail shells found on the North west side of Erskine Park Road in a small remnant area of Shale-Gravel Transition Forest between Chainage 28800 and 29100.
- Snail shells found to the west of Kent Road on south side of the M4 at Chainage 34450 in a very small patch of remnant Shale Plains Woodland surrounded by planted vegetation.
- Snail shells found to the west of Kent Road and on the northern side of the M4 at Chainage 34700 in remnant Shale Plains Woodland and part of a larger patch of high quality woodland extending across private land to the north of the road corridor.



**Plate 1. Cumberland Plain Land Snail**



**Plate 2. Shale-Gravel Transition forest habitat**



NSW SPATIAL - GIS MAP file : NB11510\_REF\_BIO\_F006\_r3v1 | 12/08/2015 | DRAMW.BY.JC

Figure 3-4a Threatened flora and fauna species and habitats recorded in the study area

- |   |   |   |  |
|---|---|---|--|
|  The study area              |  <i>Acacia pubescens</i>     |  <i>Pultenaea parviflora</i> |  Cumberland Plain Land Snail habitat condition High |
|  <i>Dillwynia tenuifolia</i> |  <i>Syzygium paniculatum</i> |  Microbat Roost              |  Moderate   |
|  <i>Eucalyptus nicholii</i>  |  Cumberland Plain Land Snail |  Habitat Trees               |  Poor   |
|  <i>Grevillea juniperina</i> |   |   |  |
|  <i>Persoonia nutans</i>     |   |   |  |

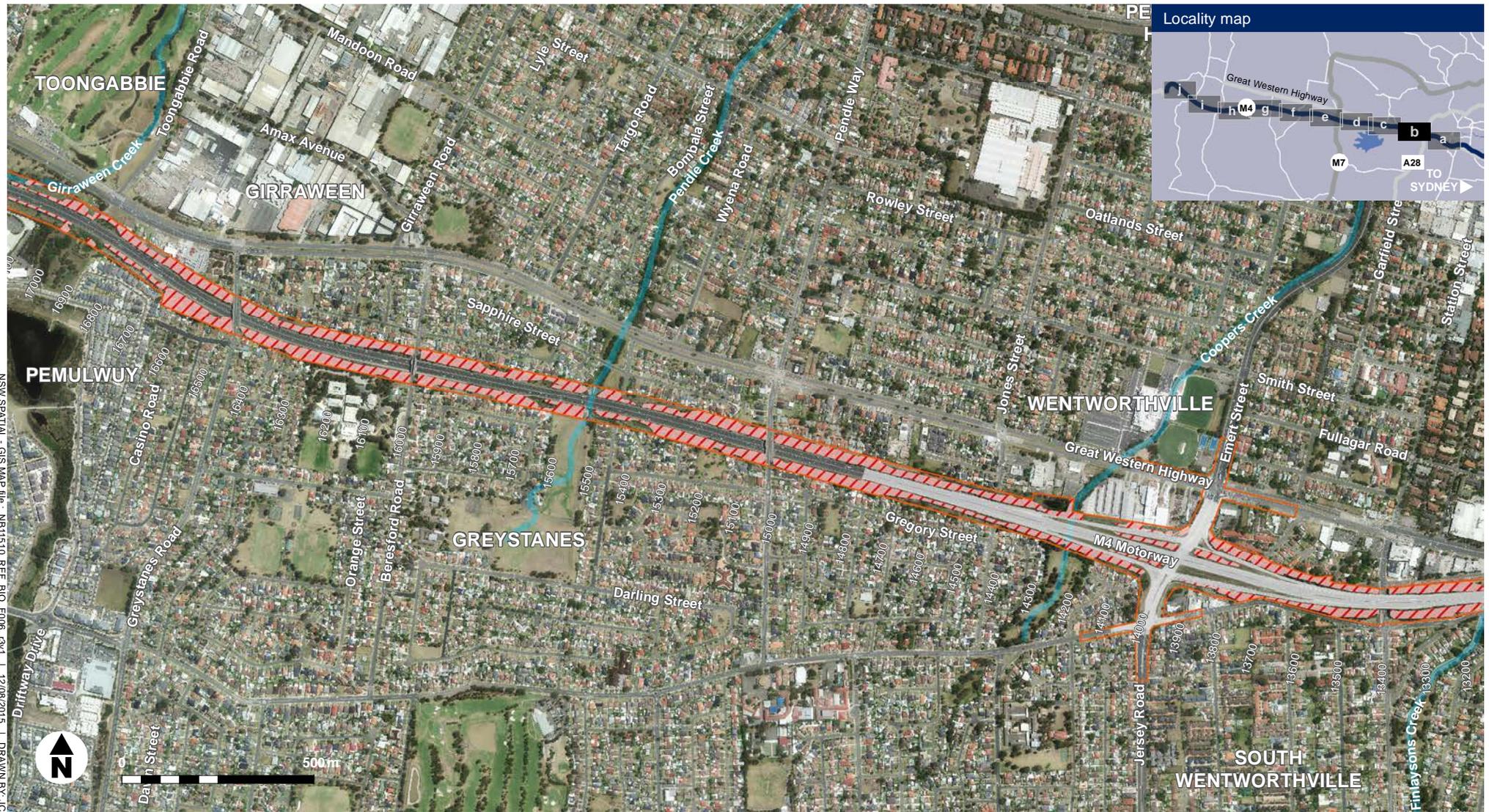


Figure 3-4b Threatened flora and fauna species and habitats recorded in the study area





Figure 3-4c Threatened flora and fauna species and habitats recorded in the study area



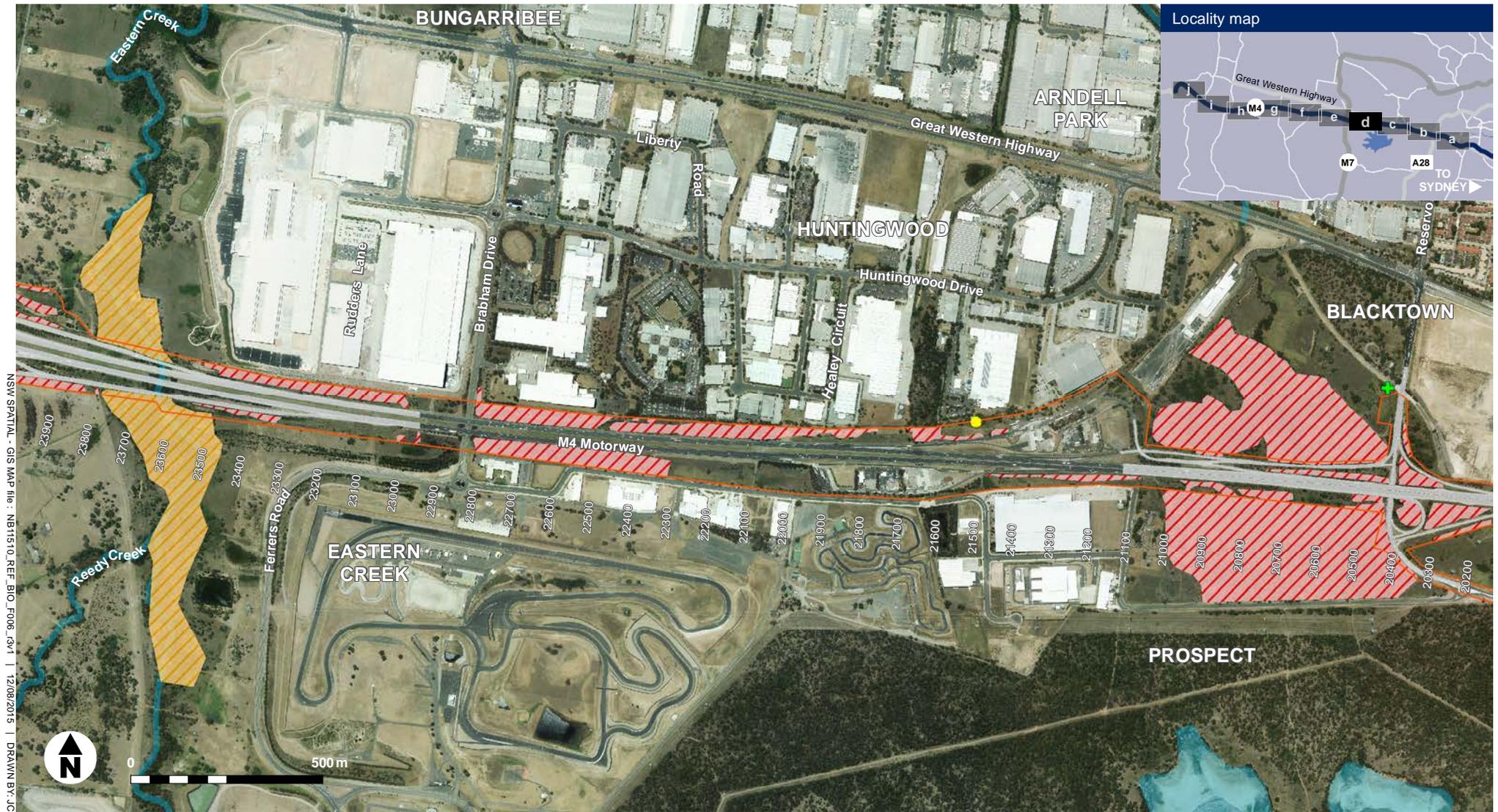


Figure 3-4d Threatened flora and fauna species and habitats recorded in the study area





Figure 3-4e Threatened flora and fauna species and habitats recorded in the study area

- |  |                             |  |                             |  |                             |  |   |
|--|-----------------------------|--|-----------------------------|--|-----------------------------|--|---|
|  | The study area              |  | <i>Acacia pubescens</i>     |  | <i>Pultenaea parviflora</i> |  | Cumberland Plain Land Snail habitat condition |
|  | <i>Dillwynia tenuifolia</i> |  | <i>Syzygium paniculatum</i> |  | <i>Syzygium paniculatum</i> |  | Moderate                                      |
|  | <i>Eucalyptus nicholii</i>  |  | Microbat Roost              |  | Microbat Roost              |  | Poor  |
|  | <i>Grevillea juniperina</i> |  | Cumberland Plain Land Snail |  | Cumberland Plain Land Snail |  |   |
|  | <i>Persoonia nutans</i>     |  | Habitat Trees               |  | Habitat Trees               |  |   |

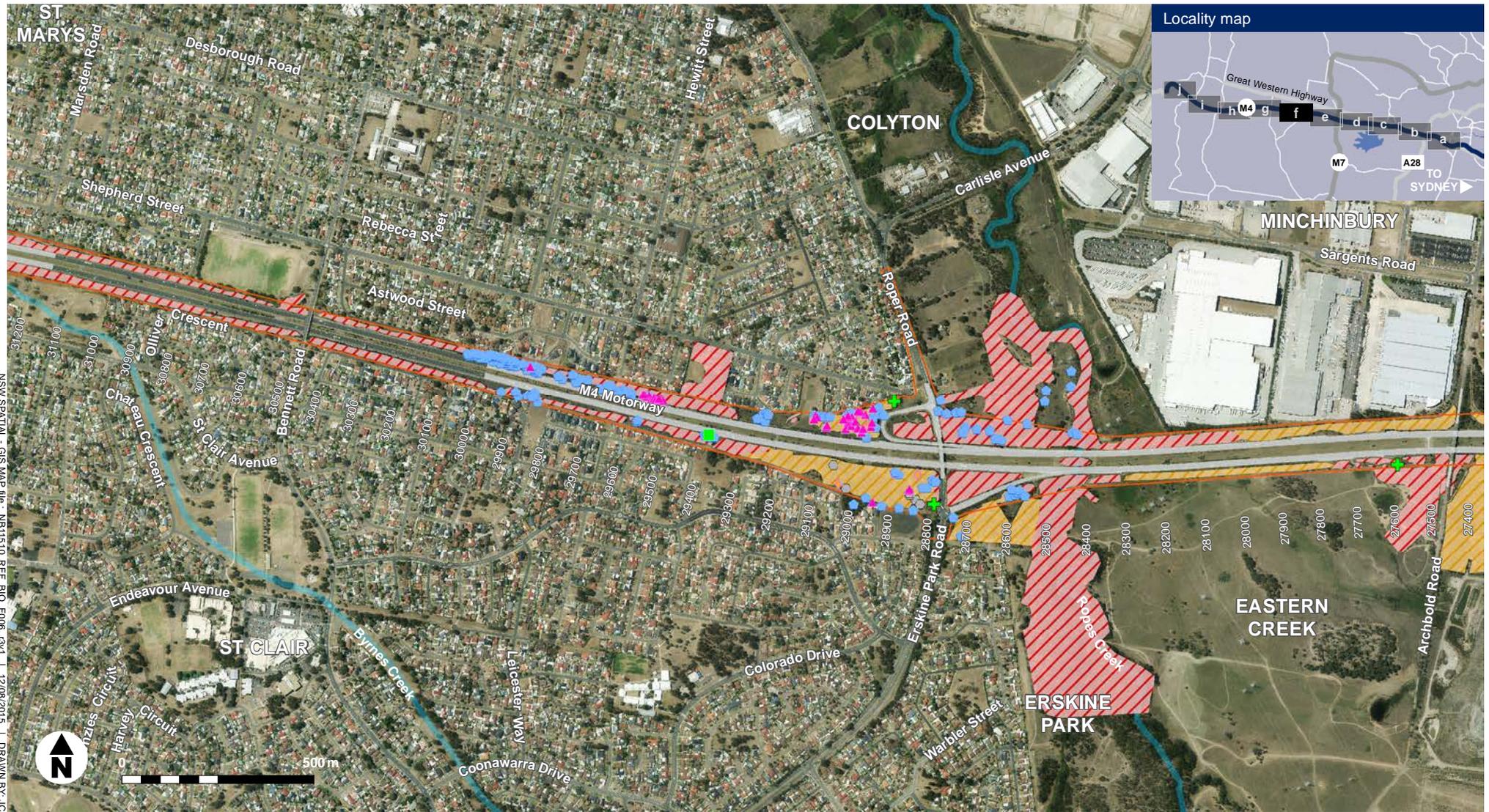
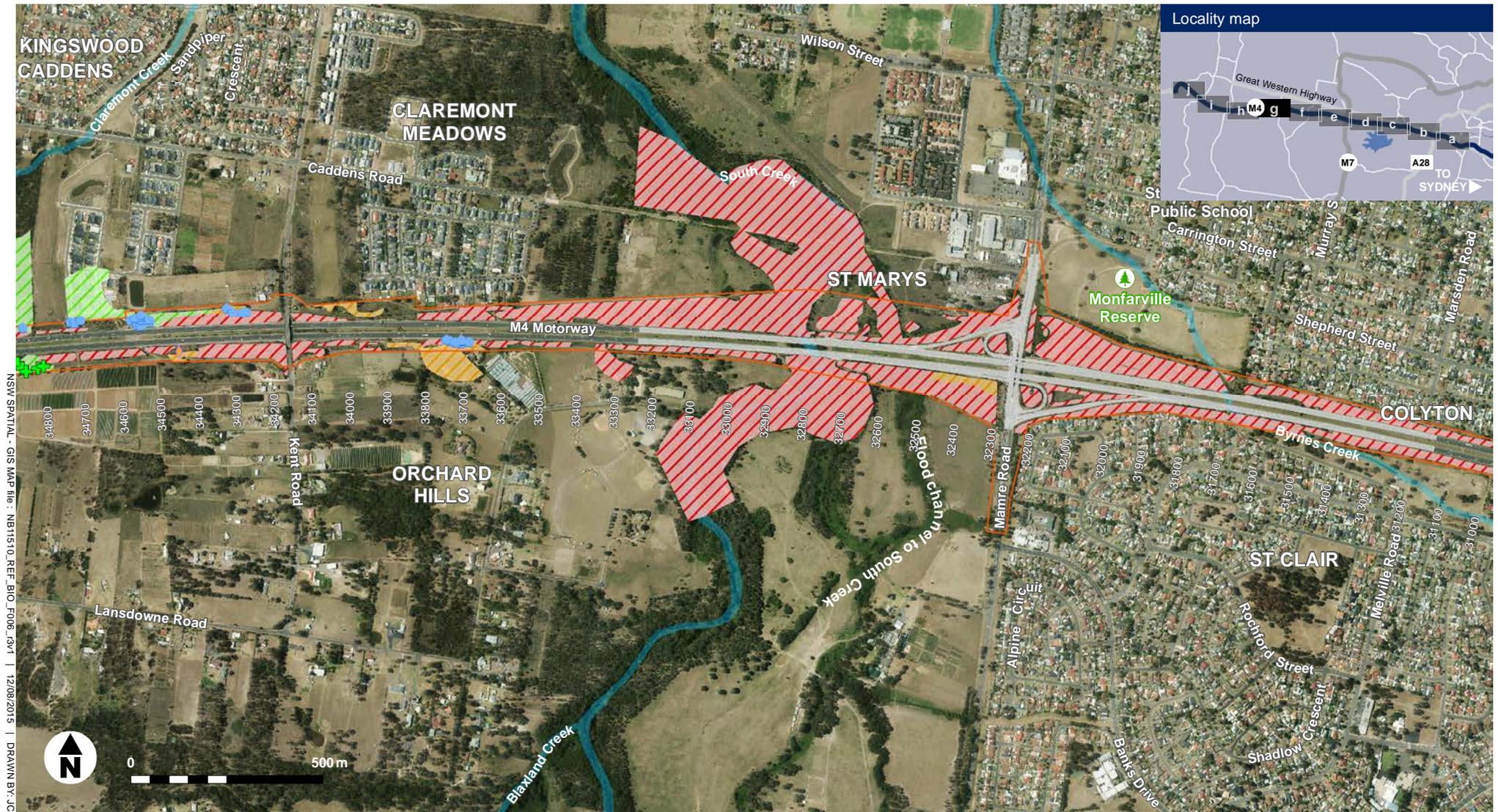


Figure 3-4f Threatened flora and fauna species and habitats recorded in the study area





NSW SPATIAL - GIS MAP file : NBH1510\_REF\_BIO\_F006\_r3v1 | 12/08/2015 | DRAMW.BY.JC

Figure 3-4g Threatened flora and fauna species and habitats recorded in the study area

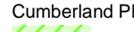
- |   |                             |   |                             |   |                             |   |   |
|---|-----------------------------|---|-----------------------------|---|-----------------------------|---|---|
|  | The study area              |  | <i>Acacia pubescens</i>     |  | <i>Pultenaea parviflora</i> |  | Cumberland Plain Land Snail habitat condition |
|  | <i>Dillwynia tenuifolia</i> |  | <i>Syzygium paniculatum</i> |  | Moderate                    |   |   |
|  | <i>Eucalyptus nicholii</i>  |  | Microbat Roost              |  | Poor                        |   |   |
|  | <i>Grevillea juniperina</i> |  | Cumberland Plain Land Snail |  | Habitat Trees               |   |   |
|  | <i>Persoonia nutans</i>     |   |                             |   |                             |   |   |



Figure 3-4h Threatened flora and fauna species and habitats recorded in the study area





Figure 3-4i Threatened flora and fauna species and habitats recorded in the study area





Figure 3-4j Threatened flora and fauna species and habitats recorded in the study area



### Eastern Bentwing-bat and Southern Myotis

A diurnal roost site of the Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Southern Myotis (*Myotis macropus*) was identified in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700 (Plate 3). Both species are listed as vulnerable in NSW under the TSC Act.

The roost site was dominated by Eastern Bentwing-bats, with only a small number of Southern Myotis. Bats were found roosting in all three culverts and utilising holes located in the ceiling of the culverts (plates 4 and 5). The culvert was approximately 50 metres in length and spanned the width of the M4 corridor. Riparian vegetation at this location was in moderate condition with a high diversity and abundance of weeds, the water in the creek was brown and highly turbid with algae. A small subset of bats was captured to confirm the species and sex, and no lactating bats were found suggesting the roost was not currently being used for breeding.



Plate 3. Bat roost in three (3 x 3 metre box culverts) under the M4 on south creek



Plate 4. Southern Myotis



Plate 5. Eastern Bentwing-bat

For *Miniopterus* spp. the microclimatic conditions of a maternity roosts typically have high temperatures and humidity (Dwyer 1995), which are not present at this site. Winter roosts are known to be colder than maternity roosts, and the lower temperatures facilitate torpor over the winter months. Studies of the Eastern Bentwing-bat in NSW indicated a microclimate preference of 9 – 12° C for winter roosts (Hall and Richards 2003) and these conditions are more closely aligned with the roost located in this study.

The Southern Myotis is unusual among Australian bats for its habit of feeding on aquatic prey over streams. Because of its close association with waterways, it is considered a species of conservation concern (Duncan *et al.* 1999). Law and Urquhart (2000) found that aquatic invertebrates associated with the water surface were the main prey of *M. macropus* and that these insects are reasonably tolerant of low water quality (e.g. water boatmen, water striders, whirligig beetles).

### Other threatened fauna

No other threatened fauna species were recorded from the diurnal surveys however potential habitat for threatened woodland birds, microchiropteran bats and the Grey-headed Flying-foxes was noted in the larger remnants particularly near Ropes Creek. The list of species expected to occur is discussed previously in **Section 3.8.1**. These species and their habitats are discussed further in **Appendix A**. A description of the potential habitat for threatened fauna is provided previously in Table 3-1.

## 3.9 Migratory species

A total of 30 migratory fauna species were identified in the EPBC Act Protected Matters Search Too as potentially occurring in the locality based on the distributional range of the species. These migratory species, along with their preferred habitat requirements and an assessment of their likely presence in the study area are listed in **Appendix A**. From this review a list of eight migratory species are considered to have a moderate likelihood of occurring in the study area (**Table 3-9**).

**Table 3-9 Migratory species considered to have a moderate likelihood of occurring**

Species	Potential habitat in the study area
Swift Parrot ( <i>Lathamus discolor</i> )	Map Unit 1, 2 and 3 and planted areas with feed trees
Fork-tailed Swift ( <i>Apus pacificus</i> )	Potential habitat widespread
Cattle Egret ( <i>Ardea ibis</i> )	Potential habitat widespread
Great Egret ( <i>Ardea modesta</i> )	Map Unit 3 and 4
Rainbow Bee-eater ( <i>Merops ornatus</i> )	Map Unit 1, 2 and 3
White-bellied Sea-eagle ( <i>Haliaeetus leucogaster</i> )	Map Unit 3
White-throated Needletail ( <i>Hirundapus caudacutus</i> )	Potential habitat widespread
Latham's snipe ( <i>Gallinago hardwickii</i> )	Map Unit 3 and 4

Further assessment was conducted in considering the significance of potential impacts from the project on listed migratory species via consideration of the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (Department of the Environment 2013) (refer Appendix D and Section 6.2). According to the guidelines an action is likely to have a significant impact on a migratory species if there is a real

chance or possibility that it will:

- Substantially modify (including by fragmenting, altering fire regimes and nutrient cycles or;
- Altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

While migratory species of bird do use the study area and locality, the study area would not be classed as an 'important habitat' as defined under the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (Department of the Environment 2013), in that the Project area does not contain:

- Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

As such, it is unlikely that the proposal would significantly affect migratory species.

### 3.10 General flora and fauna

A complete list of flora and fauna including common and threatened species identified from the field surveys is provided in **Appendix B** for flora species and **Appendix C** for fauna species.

Native floral species richness was relatively high within the naturally vegetated portions of the study area. As can be expected the disturbed areas supporting plantings and open grassland areas were relatively low in native species diversity and richness due primarily to the long term effects of significant soil disturbance and removal of the native seed bank. A total of 438 flora species were recorded within the study area. This total comprises 131 exotic species including 24 noxious weed species (refer to **Table 3-9**) and 34 native flora species not native to the vegetation communities of the local area. There is a total of 273 native flora species that were recorded in the corridor occurring in remnant vegetation communities and also includes planted species typical of local vegetation communities. Exotic and non-indigenous native flora represents approximately 38 per cent of the floral diversity in the corridor.

A total of 628 vertebrate fauna species were recorded from this survey along the M4 corridor. This includes 39 bird species, eight mammal species including three introduced species, four frog species and seven reptile species. The list of fauna species recorded is provided in **Appendix C**. For comparison a list of fauna recorded from a comprehensive fauna survey conducted at the Defence Establishment Orchard Hills (DEOH) is presented. The DEOH is located on the southern side of the

M4 Motorway along The Northern Road less than one kilometre from the current study area. The DEOH contains one of the largest remnants of Cumberland Plain Woodland remaining in western Sydney and the study reported 110 vertebrate fauna species (76 birds, 17 mammals, 5 amphibians, and 10 reptiles). Two additional macropods the Common Wallaroo (*Macropus robustus*) and Red Kangaroo (*Macropus rufus*) were reported by AMBS (2003) however these species were introduced to DEOH. Many of the bird species reported at DEOH could be expected to occur widely over the locality including smaller remnants along the M4 Motorway.

### 3.11 Wildlife connectivity corridors

The M4 Motorway traverses across the low-lying fertile valley of the Cumberland Plain between the Parramatta River in the east and the Nepean River in the west. The area was once covered in Cumberland Plain Shale Woodland and Shale-Sandstone Transition Forest, with Alluvial Woodland along drainage lines. As a consequence of land clearing and weed invasion, this vegetation is now restricted to small and fragmented bushland patches nestled among a largely urban to peri-urban environment.

The M4 Motorway in its present state presents an approximate north south barrier to wildlife movement. Currently, the connectivity of habitats to the north and south of the motorway are severed. This is best exemplified in the area of vegetation directly to the west of the Reservoir Road interchange. However, the bridges over waterways such as Eastern Creek, Ropes Creek, South Creek and the Nepean River provide for some level of connectivity for riparian habitats (i.e. the waterways still flow under bridges) and these should be maintained where possible. The vegetation that is present in the study area exists in a highly fragmented state with most vegetation occurring as small patches or linear strips along the motorway that are connected to riparian vegetation along creek lines, street trees, paddock trees, and occasionally vegetation remnants.

The larger patches of native vegetation including those at Chainages 20700, 25600, 27300 and 34900 and the vegetation on either side of the M4 Motorway at the far western end of the study area near Jamison Creek do have some level of functional east west connectivity (i.e. while the vegetation may not be physically connected along the length of the M4 Motorway, some species can still move between habitat patches). The planted linear strips of roadside vegetation and the few remaining vegetation remnants function as a movement corridor for some more mobile species tolerant of disturbance such as birds, bats and any ground dwelling animals that are willing to cross open space (e.g. possums).

The north south riparian corridors of South Creek and Ropes Creek have been recognised as important priority areas for restoration (Department of Planning 2008) which recognises their value as regional corridors. The M4 currently poses a barrier to these riparian corridors by severing the physical connectivity of riparian vegetation. The areas where the M4 Motorway currently severs north south connectivity include:

- At Ropes Creek (Chainage 28500) where vegetation is continuous to the north and south of the M4 Motorway, but severed by the motorway.
- At South Creek (Chainage 33000) where vegetation is continuous to the north

and south of the M4 Motorway linking with Blaxlands Creek to the south which traverses through to the Defence Establishment at Orchard Hills. South Creek is severed by the motorway.

Three other local connectivity corridors were noted in the assessment, two of which are currently severed by the M4 Motorway including:

- A link between the large woodland fragments surrounding Prospect Reservoir with a moderately large habitat patch to the north of the M4 Motorway
- An unnamed creek at Chainage 35800 which comprises a very narrow corridor continuing north and south of the M4.

An additional local corridor was noted and has been formed through the landscape planting along the M4 Motorway. Planted roadside vegetation along the south side of the motorway between chainage 26000 and 27100, represents the only link between two large woodland remnants outside the road corridor.

### 3.12 Critical habitat

No areas of declared critical habitat under the TSC Act or EPBC Act are present in the study area.

### 3.13 State Environmental Planning Policy No.44 – Koala Habitat Protection

Consideration of State Environmental Planning Policy No.44 – Koala Habitat Protection (SEPP 44) is not required under the provisions of Part 5 of the EP&A Act. The Koala is however listed as vulnerable under the Commonwealth EPBC Act and in NSW under the TSC Act and hence targeted surveys were conducted for this species. As such, consideration is given throughout the report to the potential impacts of the proposal on the Koala.

The proposal is within the Local Government Areas (LGA) of Penrith, Blacktown, Holroyd, Parramatta, Auburn, Strathfield, Canada Bay and Burwood. None of these LGAs listed under Schedule 1 of SEPP 44.

### 3.14 Weeds

Of the total 410 species of flora recorded, 131 introduced species and non-indigenous native flora were identified, representing approximately 33 per cent of the total species. Of these, 24 species are listed as noxious in the Penrith, Blacktown, Holroyd, Parramatta, Auburn, Strathfield, Canada Bay and Burwood control areas were recorded (refer to **Table 3-10**). All areas of the study area support some level of noxious weed abundance including areas of remnant vegetation.

**Table 3-10 Noxious weed species listed in the Penrith, Blacktown, Holroyd, Parramatta, Auburn, Strathfield, Canada Bay and Burwood control areas**

Species	Prevalence on Site	Noxious Class
African Boxthorn <i>Lycium ferocissimum</i>	Low to moderate abundance at several locations throughout the study area	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction
African Olive <i>Olea europaea</i> subsp. <i>cuspidata</i>	Low to high abundance throughout the study area. Widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Asparagus Fern <i>Asparagus aethiopicus</i>	Widespread throughout the study area, recorded in low to moderate abundance. Seed spread by bird species. Common and Widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed  Weed of national significance
Balloon Vine <i>Cardiospermum grandiflorum</i>	High abundance in several drainage line areas. Not widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Bathurst Burr <i>Xanthium occidentale</i>	Low abundance at a single location near Clunies Ross Street overpass	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction
Bitou Bush <i>Chrysanthemoides monilifera</i> subsp. <i>rotundata</i>	Low to moderate abundance at several locations throughout the study area. Not widespread.	Class 3: The plant must be fully and continuously suppressed and destroyed  Weed of national significance
Blackberry <i>Rubus fruticosus</i> aggregate species	Moderate to high abundance throughout the study area. Common and Widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Boneseed <i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i>	High abundance in several locations throughout the corridor.	Class 2: The plant must be eradicated from the land and the land must be kept free of the plant  Weed of national significance

Species	Prevalence on Site	Noxious Class
Bridal Creeper <i>Asparagus asparagoides</i>	Low to high abundance throughout the corridor. Common and Widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed  Weed of national significance
Castor Oil Plant <i>Ricinus communis</i>	Low abundance in several areas of the study area.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction
Climbing Asparagus Fern <i>Asparagus plumosus</i>	Low abundance in several areas of the study area.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Crofton Weed <i>Ageratina adenophora</i>	Moderate abundance at several locations in study area. Not widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction
Giant Reed <i>Arundo donax</i>	A single clump recorded in the study area east of the Mamre Road interchange. Not widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Green Cestrum <i>Cestrum parqui</i>	Low to high abundance throughout the study area. Common and Widespread	Class 3: The plant must be fully and continuously suppressed and destroyed
Johnson Grass <i>Sorghum halepense</i>	Moderate abundance at several locations in study area. Not widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction
Lantana <i>Lantana camara</i>	Moderate abundance throughout the study area. Widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed.  Weed of national significance
Madeira Vine <i>Anredera cordifolia</i>	Low to moderate abundance throughout study area. Widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed

Species	Prevalence on Site	Noxious Class
Coastal Morning Glory <i>Ipomoea cairica</i>	High abundance at several locations. Not widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed
Morning Glory <i>Ipomoea indica</i>	High abundance at several locations. Not widespread.	
Mother of Millions <i>Bryophyllum</i> species	Recorded in high to moderate abundance at a two locations one west of the Ropers Road interchange and the other west of Emu Plains	Class 3: The plant must be fully and continuously suppressed and destroyed and the plant must not be sold propagated or knowingly distributed
Pampas Grass <i>Cortaderia</i> species	Moderate abundance at several locations in study area. Not widespread	Class 3: The plant must be fully suppressed and destroyed
Privet species <i>Ligustrum sinense</i> <i>L. lucidum</i>	Low to high abundance throughout the study area, with dense thickets occurring along drainage lines. Common and widespread.	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its flowering and reproduction
St John's Wort <i>Hypericum perforatum</i>	Low to moderate abundance throughout the study area. Widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction

## 4 Potential impacts

---

### 4.1 Loss of vegetation and habitat

Vegetation clearance is known as the primary cause of the past and current loss of biodiversity experienced in Australia and contributes to the process of habitat modification and fragmentation, which are recognised as threats to biological diversity. Loss of vegetation and habitats result in a range of direct and indirect impacts to vegetation communities and species of plant and animal including:

- Reduction in the extent of vegetation communities and associated habitats
- Loss of local populations of individual species
- Fragmentation of remnants of vegetation communities or local populations of individual species
- Increased edge effects and habitat for invasive species
- Reduction in the viability of ecological communities resulting from loss or disruption of ecological functions (e.g. increased desiccation, light penetration, herbivory, weed invasion, predation, parasitism)
- Destruction of flora and fauna habitat and associated loss of biological diversity (habitat removal may include removal of hollow bearing trees, loss of leaf litter layer, and resultant changes to soil biota)
- Riparian zone degradation
- Soil exposure and altered water flow patterns resulting in increased erosion and sedimentation.

#### 4.1.1 Direct impacts

The potential loss of vegetation and habitat associated with the proposal is summarised in **Table 4-1**. The construction footprint would impact on up to 29.45 hectares of planted and remnant vegetation in various states of condition. This total area of clearing includes 3.88 hectares of remnant vegetation (Map Units 1, 2, 3 and 11), 9.6 hectares of planted and/or highly modified vegetation communities (Map Units 4, 5, 6 and 7), 13.99 hectares of horticultural plantings (Map Units 8 and 9) and 1.98 hectares of exotic vegetation. The majority of vegetation removal will occur in planted and highly modified vegetation alongside the M4 motorway. Loss of native vegetation is a Key Threatening Process listed as 'Clearing of native vegetation' under Schedule 3 of the TSC Act and listed as 'Land Clearance' under the EPBC Act.

These impacts are quantified on the basis of the design, with an added buffer to account for potential disturbance during construction as well as communications infrastructure likely to be trenched along edges of the M4 Motorway. The predicted impacts are approximate and the impact of each component of the proposal was calculated with the following assumptions:

- Impact of the ITS infrastructure calculated based on a two metre buffer
- Impact of the ITS backbone combined primary and secondary calculated based

on a three metre buffer

- Impact of the ITS backbone spur calculated based on a two metre buffer
- Impact of the Ramp design calculated based on a five metre buffer
- Impacts from modification of existing and the construction of new noise walls calculated based on a five metre buffer
- Impacts from the construction and/or modification of drainage channels and detention basins calculated based on a three metre buffer.

**Table 4-1 Direct impacts on vegetation and fauna habitat**

Vegetation Community Type	Fauna habitat type	Biometric Vegetation Type	Conservation Status	Condition	Direct impact (ha)
Map Unit 1: Remnant Shale-Gravel Transition Forest	Grassy Woodland	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	Endangered, TSC Act  Critically endangered, EPBC Act  Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)	High	0.30
Map Unit 2: Remnant Shale Plains Woodland	Grassy Woodland	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act  Critically endangered, EPBC Act  Condition thresholds apply for the EPBC Act listed ecological community (see Section 2.3.1)	Moderate	2.51
Map Unit 3: Remnant Alluvial Woodland	Riparian Woodland	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin	Endangered, TSC Act	Moderate	0.79

Vegetation Community Type	Fauna habitat type	Biometric Vegetation Type	Conservation Status	Condition	Direct impact (ha)
Map Unit 4: Freshwater Wetlands (4a Broadleaf Cumbungi; 4b Common Reed; 4c Urban Drainage Lines)	Disturbed Freshwater Wetland	<i>Phragmites australis</i> and <i>Typha orientalis</i> coastal freshwater wetlands of the Sydney Basin	Endangered, TSC Act	Low – Moderate	0.15
Map Unit 5: Planted Shale Plains Woodland	Planted Forest/ Woodland Habitats	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin (restored example of)	Endangered, TSC Act	Moderate	8.48
Map Unit 6: Planted Shale-Gravel Transition Forest	Planted Forest/ Woodland Habitats	Broad-leaved Ironbark - Grey Box - <i>Melaleuca decora</i> grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	Endangered, TSC Act	Moderate	0.57
Map Unit 7: Planted Shale Sandstone Transition Forest	Planted Forest/ Woodland Habitats	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act and EPBC Act	Moderate	0.4
Map Unit 8: Planted Monocultures (8a <i>Casuarina</i> species; 8b <i>Eucalyptus</i> species; 8c Fig species)	Planted Forest/ Woodland Habitats	N/A	N/A	N/A	2.43
Map Unit 9: Mixed Plantings (9a Native trees; 9b Native shrubs; 9c Sparse plantings)	Planted Forest/ Woodland Habitats	N/A	N/A	N/A	11.56

Vegetation Community Type	Fauna habitat type	Biometric Vegetation Type	Conservation Status	Condition	Direct impact (ha)
Map Unit 10: Exotic vegetation	Exotic vegetation	N/A	N/A	N/A	1.98
Map Unit 11: Remnant Shale Sandstone Transition Forest	Grassy Woodland	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin	Critically endangered, TSC Act and EPBC Act	Moderate	0.28
<b>TOTALS</b>	<b>All vegetation (All map units)</b>				<b>29.45</b>
	<b>Remnant, planted and modified communities (Map units 1, 2, 3, 4, 5, 6, 7 and 11)</b>				<b>13.48</b>
	<b>Remnant vegetation only (Map units 1, 2, 3 and 11)</b>				<b>3.88</b>

Direct and indirect impacts to larger patches are summarised in Table 4-2 including indirect impacts.

#### 4.1.2 Indirect impacts

Indirect impacts have been calculated for the proposed impacts for areas that are not currently subject to substantial edge effects. The indirect impacts are based on a 10 metre buffer from the footprint in larger patches of remnant vegetation where new edges will be created. Large to moderate sized remnant vegetation patches ( $\geq 1$  hectare) are important for retaining species diversity, connecting habitats, improving species gene flow and are generally resilient to disturbances and diseases. There is potential for direct and indirect impacts to alter the current ecological viability of a patch of remnant vegetation. Considering the high degree of fragmentation in the study area, the large majority of vegetation is currently edge affected and further indirect impacts as a result of small-scale clearing along the edges of some patches are not anticipated to be substantial. Direct and indirect impacts to larger patches are summarised in **Table 4-2**.

**Table 4-2 Direct and indirect impacts to larger vegetation patches**

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
S1	Map Unit 1: Remnant Shale-Gravel Transition Forest	2.5	0.08	0.0	3.2%
S2		1.03	0.18	0.07	17.5%

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
S3		3.1	0	0.0	0%
S4		0.54	0.04	0.0	7.4%
S5		2.02	0	0.0	0%
S6	Map Unit 6: Planted Shale-Gravel Transition Forest	4.69	0.38	0.0	8.1%
C1	Map Unit 2: Remnant Shale Plains Woodland	51.28	0.23	0.0	0.4%
C2		15.44	0.59	0.33	3.8%
C3		12.61	0.1	0.0	0.8%
C4		8.96	0.05	0.0	0.6%
C5		2.09	0	0.0	0%
C6		4.04	0.02	0.06	0.5%
C7		1.28	0.03	0.0	2.3%
C8		0.63	0.01	0.0	1.6%
C9	Map Unit 5: Planted Shale Plains Woodland	1.69	0.17	0.33	10.1%
A1	Map Unit 3: Remnant Alluvial Woodland	14.92	0.05	0.0	0.3%
A2		11.83	0.03	0.0	0.3%
A3		10.26	0	0.0	0.0%
A4		10.08	0.04	0.0	0.4%
A5		7.83	0.1	0.0	1.3%
A6		4.9	0.13	0.2	2.7%
A7		3.2	0.07	0.0	2.2%
A8		2.61	0.02	0.0	0.7%
A9		0.69	0.04	0.0	5.8%
SS1	Map Unit 11: Remnant Shale Sandstone Transition Forest	8.92	0	0	0%
SS2		11.2	0	0	0%
SS3		6.71	0.04	0	0.6%

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
SS4		40.41	0.24	0.4	0.6%

Indirect impacts are limited to several larger higher condition patches where there is potential for further indirect impacts as a result increased edge effects. Patch S2 will be subject to direct/indirect impacts as a result of the Roper Road interchange with 17.5-24 per cent of the patch potentially impacted. Other patches subject to indirect impacts include C2 at the Reservoir Road, Patch C6 and Patch A6.

#### 4.1.3 Threatened ecological communities

Impacts to TECs predicted include the removal of approximately 13.48 hectares of communities listed under the TSC Act. The majority of TECs to be removed (9.6 hectares) have been planted and occur as highly modified remnants within an urban landscape. When considering only the remnant TECs, impacts are considerably less comprising around 3.88 hectares (**Table 4-3**).

Much of the planted examples of TECs have minimal ecological importance in terms of floristic diversity, reproductive function, fauna habitat values and threatened flora habitat with the exception of several larger better quality examples of planted TECs (Patch S6 and C9).

Predicted impacts to TECs listed under the EPBC Act are limited to approximately 1.77 hectares of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest and approximately 0.28 hectares of vegetation with affinities to Shale Sandstone Transition Forest (limited to areas of vegetation that meet the required condition criteria). The impacts to TECs are summarised in **Table 4-3**, and the impacts to individual larger patches ( $\geq 1$  hectare) are identified in **Table 4-2**.

**Table 4-3 Impacts on threatened ecological communities**

Threatened ecological community	Status	Area (ha)			Proportion of habitat impacted adjoining and within the study area
		Extent within locality*	Extent within and adjoining study area	Extent to be removed	
<b>EPBC Act</b>					
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered, EPBC Act	3,990	107.8 (remnant)	1.77	1.6%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered EPBC Act	324	67.25 (remnant)	0.28	0.4%

Threatened ecological	Status	Area (ha)			Proportion of habitat
<b>TSC Act</b>					
Cumberland Plain Woodland in the Sydney basin Bioregion	Critically Endangered TSC Act	3,472	154.7 (107.8 remnant, 46.9 planted)	10.99 (2.51 remnant, 8.48 planted)	7.1%
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered TSC Act	518	15.95 (9.26 remnant, 6.7 planted)	0.87 (0.3 remnant, 0.57 planted)	5.5%
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC Act	13	1.47 (modified)	0.15 (modified)	10.2%
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC Act	1,712	67.97 (remnant/modified)	0.79	1.2%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered TSC Act	324	70.35 (67.25 remnant, 3.1 planted)	0.68 (0.28 remnant, 0.4 planted)	1%

Notes: \* = Predicted amount of vegetation in the locality based on vegetation mapping layer by Tozer *et al.* 2010.

It should be noted that the abovementioned impacts are conservative and the design has generally avoided conservation significant biota. Avoidance measures ensure that important areas would not be directly impacted during the construction phase. The impact buffers also take indirect impacts into account which are to be strictly mitigated and discussed further in Chapter 5.

#### 4.1.4 Threatened species

Predicted impacts to threatened species include habitat removal and loss of plants. The predicted habitat loss for each threatened species recorded in or considered likely to occur within the study area is outlined in **Table 4-4**. The direct impact to threatened plant species is as follows (considered without avoidance or mitigation):

- A single *Dillwynia tenuifolia* plant from a population of 87 individuals (1.1 per cent impacted).
- A total of 49 *Grevillea juniperina* subsp. *juniperina* plants from two separate local populations, comprising one population at Ropers Road interchange of

which 40 of a large population of greater than 824 individuals will be impacted (maximum 4.9 per cent) and another population near the Kent Road overpass consisting of 204 individuals of which 9 individuals will be impacted (4.4 per cent).

It should be noted that the abovementioned impacts to threatened flora are conservative and the design has generally avoided conservation significant biota. Avoidance measures ensure that important areas would not be directly impacted during the construction phase. The entire local population of *Grevillea juniperina* subsp. *juniperina* has not been surveyed in detail in areas more remote from the motorway and population numbers are considered to be conservative.

Impacts to fauna are largely limited to potential foraging resources (**Table 4-4**). Breeding habitat for Cumberland Plain Land Snail will be impacted including 0.1 hectares of high quality habitat and 1.1 hectares of moderate quality habitat. Potential impacts to breeding habitat for threatened fauna has been identified including several hollow-bearing trees and dead-standing trees, however these resources are within the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment.

**Table 4-4 Impacts on threatened species**

Species	Status		Predicted impact
	EPBC Act	TSC Act	
<b>Flora</b>			
Downy Wattle ( <i>Acacia pubescens</i> )	V	V	Up to 11 ha - No individuals impacted
<i>Dillwynia tenuifolia</i>	-	V	0.3 ha 1 plant at Roper Rd interchange
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	V	V	N/A (planted) cannot predict
Juniper-leaf Grevillea ( <i>Grevillea juniperina</i> subsp. <i>juniperina</i> )	-	V	Up to 11 ha - Impacts to 49 plants in total
<i>Marsdenia viridiflora</i> subsp. <i>viridiflora</i> (endangered population)	-	E2	Up to 11 ha - No individuals impacted
Nodding Geebung ( <i>Persoonia nutans</i> )	E	E	0.3 ha - No individuals impacted
Spiked-rice Flower ( <i>Pimelea spicata</i> )	E	E	2.51 ha - No individuals

Species	Status		Predicted impact
	EPBC Act	TSC Act	
			impacted
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	E	E	0.3 ha - No individuals impacted
Magenta Lilly Pilly ( <i>Syzygium paniculatum</i> )	V	E	N/A (planted) cannot predict - No individuals impacted
<b>Fauna</b>			
<b>MAMMALS</b>			
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii oceanensis</i> )	-	V	29.45 ha
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	-	V	0.68 ha
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	-	V	29.45 ha
Eastern Freetail Bat ( <i>Mormopterus norfolkensis</i> )	-	V	29.45 ha
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	-	V	29.45 ha
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	V	24.89 ha
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	V	29.45 ha
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	-	V	29.45 ha
Southern Myotis ( <i>Myotis macropus</i> )	-	V	29.45 ha
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	E	V	0.68 ha
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	-	V	0.68 ha
Yellow-bellied Glider ( <i>Petaurus australis</i> )	-	V	0.68 ha
Yellow-bellied Sheathtail-bat ( <i>Saccolaimus flaviventris</i> )	-	V	29.45 ha
<b>BIRDS</b>			
Barking Owl ( <i>Ninox connivens</i> )	-	V	0.68 ha
Flame Robin ( <i>Petroica phoenicea</i> )	-	V	0.68 ha
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	-	V	0.68 ha
Glossy Black-Cockatoo ( <i>Calyptorhynchus latham</i> )	-	V	0.68 ha

Species	Status		Predicted impact
	EPBC Act	TSC Act	
Little Eagle ( <i>Hieraaetus morphnoides</i> )	-	V	13.48 ha
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	-	V	24.89 ha
Masked Owl ( <i>Tyto novaehollandiae</i> )	-	V	0.68 ha
Powerful Owl ( <i>Ninox strenua</i> )	-	V	0.68 ha
Scarlet Robin ( <i>Petroica boodang</i> )	-	V	0.68 ha
Speckled Warbler ( <i>Chthonicola sagittatus</i> )	-	V	0.68 ha
Swift Parrot ( <i>Lathamus discolor</i> )	E, M	E	24.89 ha
Varied Sittella ( <i>Daphoenositta chrysoptera</i> )	-	V	24.89 ha
<b>REPTILES AND AMPHIBIANS</b>			
Broad-headed Snake ( <i>Hoplocephalus bungaroides</i> )	V	V	0.68 ha
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	-	V	0.28 ha
<b>INVERTEBRATES</b>			
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	-	E	1.2 ha (0.1 ha high quality, 1.1 ha moderate quality)

## 4.2 Wildlife connectivity and habitat fragmentation

Habitat fragmentation per se is the division of a single area of habitat into two or more smaller areas, with the occurrence of a new habitat type in the area between the new habitat fragments. The proposal will result in little increase to fragmentation in the locality, bioregion or catchment. Importantly, no large blocks of high quality continuous habitat will be transected by the proposal. The landscape in which the proposal is situated has been highly modified due to past land clearing and the subsequent farming which removed most vegetation in the Cumberland Plain region. More recent urban development and development of infrastructure including the original M4 Motorway has also led to increased modification of habitats. Due to this historic disturbance, the majority of vegetation within the study area has been planted and has restricted connectivity.

Importantly, the proposal will not result in the breaking apart of large blocks of high quality habitat. No further habitat fragmentation on a landscape scale will occur as a result of the proposal. However, installation of the ITS may cause some temporary local disturbance to sessile species (e.g. reptiles and amphibians) that cannot move large distances. Overall, habitat connectivity will remain in a similar state after

construction of the proposal and a similar level of functional east west habitat connectivity will remain. Connectivity of aquatic habitats would be maintained. There is unlikely to be declines in population density or species richness within vegetation patches as a result of the proposal. There is also unlikely to be a significant alteration to community composition, species interactions or ecosystem functioning in the locality due to the proposal. These factors are already highly impacted by historic land use. Therefore, habitat fragmentation is considered a minor impact of the proposal in regard to its context and intensity.

#### 4.2.1 Impacts to priority conservation lands

Three hectares of PCLs have been identified in the study area located to the south of the motorway on the east and west of the Roper Road interchange. Vegetation mapped in this area comprises map units 1, 3, 4a, 10a and 10c which includes approximately 2.7 hectares of intact Shale-Gravel Transition Forest.

The proposed construction would avoid sensitive areas of this PCL considering impacts will be limited to the edges of patches of remnant vegetation and areas of core habitat will be retained with the PCL. Proposed landscaping and rehabilitation measures would supplement the existing habitat and minimise edge effects.

### 4.3 Injury and mortality

Fauna injury or death can occur during the clearing phase of construction via the removal of habitat, as well as throughout the life-time of the road operation as a result of collision with vehicles.

#### 4.3.1 Construction impacts

Fauna injury or death has the greatest potential to occur during the vegetation clearing and the extent of this impact will be proportionate to the extent of vegetation that is cleared. Some mobile species, such as birds, may be able to move away from the path of clearing and may not be greatly affected unless they are nesting. However, other species that are less mobile (e.g. ground dwelling reptiles and mammals), or those that are nocturnal and nest or roost in trees during the day (e.g. arboreal mammals and microchiropteran bat species), may find it difficult to move rapidly when disturbed. Mainly common species such as possums, reptiles, birds (particularly fledglings) and frogs are likely to be affected considering the highly urbanised environment and limited sheltering opportunities that are present.

Entrapment of wildlife in pits, trenches or other excavations is another potential cause of fauna injury or death. Species most likely to become trapped in pits or other excavations during construction are ground dwelling species (e.g. reptiles and frogs).

Roads and Maritime has developed biodiversity guidelines to protect and manage biodiversity on Roads and Maritime projects (RTA 2011). Further details on the procedures to be implemented are outlined in Chapter 5.

#### 4.3.2 Operational impacts

Roadkill is a direct impact that reduces local population numbers. However, mortality due to vehicle strike during operation of the proposal is considered to be uncommon considering the low abundance of fauna species prone to vehicle strike being present in the study area. Impacts to mobile species such as Grey-headed Flying-fox and

bird species are not considered to be substantially increased from existing levels associated with the current M4 Motorway. Mortality due to vehicle strike is considered a minor impact of the proposal in regard to its context and intensity.

Some indirect impacts to adjacent vegetation could be expected and typically involve weed invasion, which is common in all most vegetated areas. Some planted and remnant vegetation in the study area have a high proportion of weeds (>50 per cent) indicative of existing edge effects. The potential indirect impacts from weeds are discussed further below.

#### 4.4 Proliferation of weeds

Weeds pose some of the greatest threats to biodiversity as these species displace native species through competition and exclusion. Proliferation of weed species is an indirect impact (i.e. not a direct result of the proposal) that may have cumulative effects. Proliferation of weed species is likely to occur during construction as vegetation is removed, soil is disturbed and machinery move about the work sites. The effects of proliferation of weed species may not be experienced immediately or even in the short-term. However, these impacts will likely commence a few months after construction and gradually increase over months and seasons. Proliferation of weed species has the potential to impact on the quality and integrity of the native vegetation within the study area including habitat for threatened species.

One hundred and two exotic species including 23 noxious weed species were recorded within the study area during the survey. This indicates that weeds are common throughout the vegetation. Exotic and non-indigenous native flora represents approximately 33 per cent of the floral diversity in the corridor. As such, introduction of weed species to relatively weed free ecosystems is not an issue for this proposal. However, dispersal of weeds remains a potential impact of the project.

There are currently five key threatening processes listed under the TSC Act and EPBC Act that relate to the invasion and establishment of weeds. Each of these has potential to be exacerbated by construction and operation of the project, and includes the following:

- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by Bitou Bush and Boneseed
- Invasion of native plant communities by exotic perennial grasses
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*)
- Invasion, establishment and spread of Lantana (*Lantana camara*).

The noxious species recorded in the study area are relatively common in roadside habitats along the M4 Motorway. During construction there is potential to disperse weed seeds and plant material into adjoining areas where weed species do not currently occur. The most likely causes of weed dispersal are associated with clearing of vegetation and stockpile of contaminated mulch and topsoil during earthworks, and movement of soil and attachment of seed (and other propagules) to construction vehicles and machinery.

There is a risk these species could be spread during construction of the project. However, mitigation measures undertaken in accordance with those outlined in Roads and Maritime Biodiversity Guidelines (RTA 2011) would limit the spread and germination of noxious weeds (section 5.2.4). Further, landscaping of surrounding disturbed areas including weed management would limit the establishment and spread of weed species during operation.

## 4.5 Pests and pathogens

### 4.5.1 Pests

The study area is likely to provide habitat for a range of pest species including rabbits, foxes and cats. Construction activities have the potential to disperse pest species out of the study area across the surrounding landscape due to habitat removal, noise, and human presence during construction and operation of the Project.

There are currently five key threatening processes listed under the TSC Act and three under the EPBC Act that relate to the invasion and establishment of pests. Each of these has potential to be exacerbated by construction and operation of the project, which includes:

- Competition and grazing by the feral European Rabbit (TSC Act and EPBC Act)
- Competition from feral honeybees (TSC Act)
- Predation by feral cats (TSC Act and EPBC Act)
- Predation by the European Red Fox (TSC Act and EPBC Act)
- Predation by the Plague Minnow (*Gambusia holbrooki*) (TSC Act).

The clearing of vegetation is unlikely to significantly increase the value of the habitat for rabbits (*Oryctolagus cuniculus*) in the study area over the long-term. Rabbits tend to colonise more disturbed and modified open habitats. After construction of the project, revegetation of redundant sections would assist in reducing potential habitat for rabbits in the project area.

The proposal will not directly increase feral honeybee numbers. However, the removal of hollow-bearing trees would indirectly increase competition for hollows with native fauna.

The project is unlikely to contribute to increased levels of predation on native fauna from foxes and cats. The M4 Motorway currently presents limited fauna habitat in a fragmented and highly urbanised landscape. It is unlikely that the proposal would create a more favourable habitat for foxes or cats.

The proposal will not result in the introduction of the Plague Minnow to any waterbodies. The Plague Minnow is already well established in the locality.

### 4.5.2 Pathogens

Pathogens are agents that cause disease in flora and fauna and are usually living organisms such as bacterium, virus or fungus. Several pathogens known from NSW have potential to impact on biodiversity as a result their movement and infection

during construction of the project. Of these, three are listed as a key threatening process under either the EPBC Act and/or TSC Act including:

- Dieback caused by Phytophthora (Root Rot; EPBC Act and TSC Act)
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (EPBC Act and TSC Act)
- Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae (TSC Act).

While these pathogens were not observed or tested in the study area the potential for pathogens to occur should be treated as a risk during construction. The risk is especially high in construction areas affecting waterways (**Table 4-5**).

**Table 4-5 Pathogens that may affect flora and fauna during construction**

Phytophthora ( <i>Phytophthora cinnamomi</i> )	A soil-borne fungus that causes tree death (dieback). Attacks the roots of a wide range of native plant species.	Spores can be dispersed over relatively large distances by surface and sub-surface water flows. Infected soil/root material may be dispersed by vehicles (e.g. earth moving equipment)
Myrtle rust ( <i>Uredo rangelli</i> )	An introduced fungus that attacks the young leaves, short tips and stems of Myrtaceous plants eventually killing the plant.	Myrtle rust is an air-borne fungus that may be spread by moving infected plant material, contaminated clothing, equipment and vehicles.
Chytrid fungus ( <i>Batrachomyxium dendrobatidis</i> ).	A soil and water-borne fungus which attacks keratin in frog skin and organs, causing death.	Chytrid is a water-borne fungus that may be spread as a result of handling frogs or through cross contamination of water bodies by vehicles and workers.

## 4.6 Changed hydrology

Hydrology regimes in the study area are currently highly modified from the construction of numerous concrete-lined drainage channels and the highly urbanised environment with large areas of impervious ground conditions limiting absorption of surface water. The proposed construction of the ITS along the existing bridges over creeks and rivers, or via horizontal directional drilling, would limit any further impacts to hydrology regimes. The current stream flow regime or velocities or the depths of the waterways in the study area are unlikely to be substantially modified. Altered hydrology is considered a minor impact of the proposal in regard to its context and intensity.

## 4.7 Groundwater-dependent ecosystems

Some remnant vegetation communities in the study area are considered to have an obligate or high level of potential groundwater dependence (**Table 3-5**). Areas of

Freshwater Wetland (Map Unit 4) and Remnant Alluvial Woodland along drainage lines (Map Unit 3) are considered to have an obligate level of groundwater dependence considering the presence in low-lying areas with direct access to groundwater. Shale Gravel Transition Forest (Map Unit 1) and Shale Plains Woodland potentially have a high-level of groundwater dependence as identified by Kuginis *et al.* (2012). The planted map units (Map Units 5, 6, 7 and 9) may potentially be dependent on ground water. Map Units 10 and 11 are considered unlikely to be dependent on groundwater.

Hydrological regimes including groundwater levels and flooding regimes are unlikely to be substantially altered from the project. Construction may include the intersection of the groundwater table during drilling however no substantial dewatering or depletion of ground water levels is expected. Intersection of the water table on elevated lands is considered unlikely. It is considered unlikely that there would be any groundwater drawdown as a result of the project. Potential for contamination of groundwater where groundwater intersection occurs during construction would be low.

Considering groundwater levels are unlikely to be altered as a result of the project, potential groundwater-dependant ecosystems are considered unlikely to be impacted.

## 4.8 Aquatic impacts

The potential impact on soil, water and aquatic habitat during the project is detailed in **Table 4-6**. Due to the absence of significant in stream or stream bank works, aquatic impacts from the proposal are predicted to be minimal.

**Table 4-6 Potential impacts on aquatic habitats during construction and operation**

Stage	Description
Construction	<ul style="list-style-type: none"> <li>• Direct erosion impacts due to the exposure and mobilisation of soils during construction.</li> <li>• Direct impacts to water quality from accidental chemical spills or materials during construction or improper management of run-off, sediment control and discharge from the construction site.</li> <li>• Low potential for contamination of groundwater where groundwater intersection occurs during construction.</li> <li>• Potential disturbance and exposure of acid sulphate soils to the air as a result of excavation and construction works, resulting in the potential for sulphuric acid to impact groundwater, soils and waterways in addition to the built environment.</li> <li>• Potential impact on salinity as a result of changes to the local landscape, which affects the way salt and water move through the environment and where they concentrate.</li> </ul>

Stage	Description
Operation	<ul style="list-style-type: none"> <li>Contamination of local waterways as a result of any spills that may occur during operation from maintenance activities or vehicle crashes.</li> <li>Increase in sediment and pollution loads in stormwater due to the removal of vegetation, increase in road surface and increase in vehicular traffic. This has the potential to impact on water quality through road runoff containing suspended solids, nutrients from atmospheric fallout and other pollutants from vehicle, tyre and pavement wear.</li> </ul>

#### 4.9 Noise and vibration and light

Considering the existing levels of noise, vibration and light from the M4 Motorway and surrounding roads, industrial, and commercial properties, it is unlikely there would be a significant increase in these factors resulting in any increased impacts to biodiversity within the study area. There is however potential for impacts to locally common fauna from noise and vibration during construction, which may result in fauna temporarily avoiding habitats adjacent to the project, however traffic noise on the existing M4 motorway is likely to be significant deterrent to fauna already.

Areas of pedestrian access beneath the existing M4 Motorway are lit during the night and there is potential for additional lighting to be installed with the project. It is considered unlikely there would be any additional impacts to native flora and fauna from any additional lighting installed as part of the proposal.

#### 4.10 Impact on relevant key threatening processes

Key threatening processes identified as being a result of the project include those associated with habitat degradation including vegetation clearing (**Table 4-7**). Mitigation measures would be implemented to minimise the extent of vegetation clearing and habitat disturbance (refer section 5.2). There is also potential for other key threatening processes to be further increased from their current condition (e.g. weed invasion, introduction of pests and diseases and alteration of hydrological regimes), however, mitigation measures would be implemented to minimise their effect.

**Table 4-7 Key threatening processes enacted by the project**

Threatening Process	Relevant legislation	Increased by the project?	Proposed Mitigation
<b><i>Habitat Degradation</i></b>			
Bushrock removal	TSC Act	No	section 5.2
Land clearance/Clearing of native vegetation	EPBC Act, TSC Act	Yes	
Loss of hollow-bearing trees	TSC Act	No	
Removal of dead wood and dead trees	TSC Act	Yes	

Threatening Process	Relevant legislation	Increased by the project?	Proposed Mitigation
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	TSC Act	No	n/a
<b>Feral Invertebrate Fauna</b>			
Competition from feral honey bees ( <i>Apis mellifera</i> )	TSC Act	Potential	n/a
<b>Feral Vertebrate Fauna</b>			
Predation by feral cats / Predation by the feral cat ( <i>Felis catus</i> )	EPBC Act, TSC Act	Unlikely	section 5.2
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs / Predation, habitat degradation, competition and disease transmission by feral pigs ( <i>Sus scrofa</i> )	EPBC Act, TSC Act	Unlikely	
Competition and land degradation by rabbits / Competition and grazing by the feral European rabbit ( <i>Oryctolagus cuniculus</i> )	EPBC Act, TSC Act	Potential	
Predation and hybridisation of feral dogs ( <i>Canis lupus familiaris</i> )	TSC Act	Unlikely	
Herbivory and environmental degradation caused by feral deer	TSC Act	Unlikely	
Predation by European red fox / Predation by the European red fox ( <i>Vulpes vulpes</i> )	EPBC Act, TSC Act	Unlikely	
<b>Hydrology and Riparian Zones</b>			
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	TSC Act	Unlikely	Section 5.2
The degradation of native riparian vegetation along NSW water courses	FM Act	Potential	Section 5.2
Removal of large woody debris from NSW rivers and streams	FM Act	Unlikely	Section 5.2
Installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams	FM Act	No	n/a

Threatening Process	Relevant legislation	Increased by the project?	Proposed Mitigation
<b>Pathogens</b>			
Infection of amphibians with chytrid fungus resulting in chytridiomycosis/Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	EPBC Act, TSC Act	Potential	Section 5.2
Dieback caused by the root-rot fungus ( <i>Phytophthora cinnamomi</i> )/Infection of native plants by <i>Phytophthora cinnamomi</i>	EPBC Act, TSC Act	Potential	
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Potential	
<b>Weeds</b>			
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	EPBC Act	Potential	Section 5.2
Invasion of native plant communities by exotic perennial grasses	TSC Act	Potential	
Invasion and establishment of exotic vines and scramblers	TSC Act	Potential	
Invasion of native plant communities by African Olive ( <i>Olea europaea L. subsp. cuspidata</i> )	TSC Act	Potential	
Invasion, establishment and spread of <i>Lantana camara</i>	TSC Act	Potential	
<b>Climate Change</b>			
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	EPBC Act	Potential	n/a
Anthropogenic climate change	TSC Act	Potential	n/a

#### 4.11 Cumulative impacts

Cumberland Plain Woodland and Shale Gravel Transition Forest as well as other vegetation communities on the Cumberland Plain have been extensively impacted by two centuries of agriculture and urban development in western Sydney. Cumberland Plain Woodland is now confined to less than 10 per cent of its original extent. In

2009, the ecological community occupied a maximum area of approximately 12,300 hectares (Tozer 2003).

The project would contribute to these cumulative impacts to these communities however impacts to remnant vegetation are largely limited to edge-effected narrow strips of vegetation along the edges of small and large patches. The large majority of impacts are limited to previously disturbed areas where plantings have been established with affinities to Cumberland Plain Woodland and Shale Gravel Transition Forest.

The proposal would result in the removal of around 11.86 hectares of Cumberland Plain Woodland and Shale Gravel Transition Forest comprising 2.81 hectares of remnant vegetation and 9.05 hectares of planted or highly modified vegetation with affinities to the above communities. This impact represents a small proportion (0.096 per cent) of the remaining area of Cumberland Plain Woodland in 2009, and when considering only remnant patches this proportion is much smaller (0.02 per cent).

The proposal would increase the existing area of disturbance created by the M4 Motorway as well as surrounding urban development. There would also be cumulative impacts from potential future upgrades.

## 5 Avoidance and mitigation measures

---

In managing biodiversity, the proposal aims to:

- Avoid and minimise impacts first
- Mitigate impacts where avoidance is not possible
- Offset where residual impacts cannot be avoided.

### 5.1 Avoid and minimise

Specific avoidance and minimisation measures associated with the design of the proposal will include avoidance of vegetation clearance during construction. Indeed, the proposed ITS infrastructure has been designed to avoid vegetation by following existing cleared easements and pathways at the edge of vegetation along the M4 and only cutting through vegetation where necessary. Additionally, the placement of proposed construction compounds has been selected to avoid impacts to native vegetation.

#### 5.1.1 Avoidance of key areas

The proposed ITS infrastructure and construction compounds should be designed to avoid the areas of highest biodiversity value within the study area. The most important areas within the study area in terms of biodiversity include:

- Shale Sandstone Transition Forest in the Sydney Basin Bioregion to the west of Chainage 44300 to the western end of the study area
- Cumberland Plain Woodland in the Sydney basin Bioregion where it occurs along the length of the study area (forms part of the EPBC Act listed TEC Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest)
- Shale Gravel Transition Forest in the Sydney Basin Bioregion in the vicinity of Roper Road (forms part of the EPBC Act listed TEC Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest)
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions where it occurs along the length of the study area
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions where it occurs in drainage lines including South Creek, Ropes Creek, and Eastern Creek.
- Threatened flora species and their habitats located primarily in two locations: the vegetation near Roper Road (Chainage 28400 to 30100) and the vegetation to the west of Kent Road (Chainage 34200 to 35000).
- Habitat for the Cumberland Plain Land Snail (predominantly in remnant Shale-Gravel Transition Forest and Shale Plains Woodland) at Chainage 27350, between Chainage 28800 and 29100, Chainage 34450, and Chainage 34700.
- Hollow-bearing trees (one tree located at Chainage 27600, one tree at Chainage 28800, one tree at Chainage 28900, six located between Chainage

34800 and 34900 and two trees west of Emu Plains).

- The roost site for the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*) in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700.

The areas listed above also form the best fauna habitats in the study area. By avoiding impacts to these areas listed above, the impacts of the project to threatened biodiversity would be minimal.

## 5.2 Recommended construction mitigation measures

The following mitigation measures as outlined in the Roads and Maritime Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects (RTA 2011) are recommended for implementation.

### 5.2.1 Pre-clearing

A construction environmental management plan (CEMP) should include details regarding pre-clearance surveys. The plan should include a clearing procedure, which in turn would specify the requirements for pre-clearing.

The construction footprint should be identified and marked before construction and exclusion zones established in retained areas of habitat particularly in riparian areas and areas of remnant vegetation.

Nearby habitats should be identified on both sides of the existing highway along the length of the project suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal.

### 5.2.2 Management of unexpected species finds (particularly roosting microchiropteran bats and Green and Golden Bell Frog)

Pre-clearing surveys should be undertaken by an experienced ecologist to identify any nesting/roosting animals present in the project area. The inspection is required to identify if threatened bat species are present and are using the structure for roosting and/or breeding habitat. The inspection would be conducted during the day and would ensure that all cracks, fissures, scuppers, lifting holes, etc., within concrete structures are inspected for microbats prior to any works commencing.

Because no structures are proposed to be demolished, it is unlikely that works will have a significant impact on any microbats roosting in adjacent structures. However, if bats are found, an appropriately qualified ecologist will be engaged and provide advice on work methods and timing to minimise impacts on the bats. If exclusions are required, these will be done in accordance with a Bat Management Plan prepared by an appropriately qualified ecologist.

While the study area has been assessed as containing sub-optimal habitat for Green and Golden Bell Frog, this species is known in proximal areas. Because of this, the unexpected threatened species finds procedure should be followed as outlined in the Roads and Maritime Biodiversity Guidelines (RTA 2011). This procedure is particularly relevant to the potential presence of microbats in artificial structures and the Green and Golden Bell Frog in freshwater aquatic habitats disturbed. The procedure is to be adopted through the construction phase of the project.

As a first step, photos and descriptions of roosting bats and the Green and Golden Bell Frog would be included in the CEMP and/or the flora and fauna management sub-plan. All personnel are to be inducted on the potential for these threatened species occurring on site and the unexpected threatened species finds procedure.

### 5.2.3 Exclusion zones

The location of exclusion zones should be established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease. Basic temporary fencing would need to be installed to indicate the limits of clearing. The location of exclusion fencing to be installed should be identified on plans in the CEMP and the function and importance of the exclusion zones communicated to construction personnel.

### 5.2.4 Minimising fauna injury and mortality

To prevent injury and mortality of fauna during the clearing of vegetation an experienced and licensed wildlife carer and/or ecologist should be present to supervise vegetation clearing and capture and relocate fauna where required. Further details regarding fauna handling and vegetation clearing procedures are provided in the Roads and Maritime Biodiversity Guidelines (RTA 2011). The following should be implemented to avoid injury and mortality of fauna:

- Allow fauna to leave an area without intervention as much as possible
- In circumstances where the handling of fauna is completely unavoidable, best practice methods need to be followed as outlined in the Roads and Maritime Biodiversity Guidelines – Guide 9 Fauna Handling (RTA 2011)
- Include the procedures in project inductions for construction staff to implement if fauna is found or injured on site and also the importance of not feeding any wildlife that may be encountered on construction sites
- Never deliberately kill any native fauna, including snakes, as all native species are protected under the *National Parks and Wildlife Act 1974*
- Keep records of fauna captured and relocated
- Report any injury to or death of a threatened species to Roads and Maritime environmental staff.

### 5.2.5 Translocation of Cumberland Plain Land Snail

Given the identified populations of Cumberland Plain Land Snail within the study area and potential impacts to suitable habitat associated with the proposal, it is recommended that a translocation management strategy be implemented for the species. The objective of the strategy would be to capture snails found within the construction corridor and relocate them outside of the corridor into suitable recipient sites.

Recipient sites should typically be adjacent to the works corridor as close as possible (within 50 metres) in order to retain snails within the same genetic neighbourhood from which they were collected. The recipient site should be a patch of remnant Cumberland Plain Woodland which has existing microhabitat elements that would provide protection to snails such as leaf litter, native grass cover, logs and/or rubbish.

An ecologist would complete search surveys immediately prior to clearing including any disturbances to ground cover, to minimise the number of individuals injured and killed during construction. Cumberland Plain Land Snails collected are to be temporarily housed in moist leaf litter within 20 litre buckets until collection is completed to minimise injury or fatality during storage and transportation.

Snails from different impact sites should not be mixed or translocated to a common recipient site to maintain the genetic structure of the population. Each impact site greater than 150 metres apart is to be treated as separate sites that may be part of a different genetic population. Sites within 150 metres are to be treated as sub-sites within the same population.

Snails would be placed in suitable microhabitat such as leaf litter and bark around the base of trees on the south side of the tree, under logs and at the base of dense grass clumps. Snails should be placed in similar clusters and densities as to those observed at the impact sites.

The number of Cumberland Plain Land Snails collected at each impact site should be recorded including the microhabitat elements the individuals were collected from. A relocation report should be prepared outlining the method of the relocation procedure and include details recorded regarding the location of impact sites and recipient sites and the number of Cumberland Plain Land Snail translocated.

#### 5.2.6 Translocation of threatened flora

To prevent injury and mortality of threatened plant species, the proposal will avoid removal of threatened plants as a priority. Exclusion zones will be erected around threatened plant species populations in accordance with the Roads and Maritime Biodiversity Guidelines (RTA 2011).

However, where the design of the proposal cannot be altered and plants need to be removed, translocation will be considered as an option and would be undertaken in accordance with the Guidelines for the Translocation of Threatened Plants in Australia (ANPC 1997). Potential candidates for translocation to other areas of habitat within the study area include a single individual of *Dillwynia tenuifolia* plants and 55 *Grevillea juniperina subsp. juniperina* individuals.

It is recommended that a translocation management strategy or offset / re-planting program is developed to replace lost individuals through translocation and/or seed collection, propagation and re-planting of new individuals into a suitable recipient site.

#### 5.2.7 Weed management

A weed management plan should be developed as part of the CEMP with reference to the Urban Design Report. The Roads and Maritime Biodiversity Guidelines (RTA 2011) and the Introductory Weed Management Manual (Natural Heritage Trust 2004) provide guidance for developing weed management plans. As part of the weed management plan a site assessment by an ecologist or person trained in weed identification and management would be required to assess the extent and severity of weed species in the construction footprint with particular emphasis on noxious weed species.

The weed management plan would include descriptions and mapping of major weed

infestations during pre-clearing surveys and appropriate management actions to be undertaken for each infestation. The details of the weed management plan would vary for each site but would include:

- Taxa and potential sources of the weed species
- Weed management priorities and objectives
- Sensitive environmental areas within or adjacent to the site
- Location of weed infested areas
- Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance
- Measures to prevent the spread of weeds
- A monitoring program to measure the success of weed management
- Strategic management with adjacent landowners
- Appropriate disposal of weed infested materials and soils to be identified in the CEMP
- Communication strategies to improve contractor awareness of weeds and weed management.

#### 5.2.8 Pest and disease management

No pests and diseases are currently known from the project footprint but could potentially be present. Measures to prevent the introduction and/or spread of pests and disease causing agents such as bacteria and fungi need to be incorporated into the CEMP for the project.

Measures to confirm the presence of pathogens/disease causing agents such as bacteria and fungi may be undertaken before construction. This includes a background search of government-maintained websites for the most recent known locations of contamination and for the most up-to-date hygiene protocols for each pathogen. If risks are identified in the vicinity of the project, testing from a National Association of Testing Authorities (NATA) approved laboratory may be required to confirm the presence of pathogens in the soil and/or water.

If pathogens/disease causing agents are found to be present, measures to prevent the introduction and/or spread of these pathogens/disease causing agents are to be incorporated into the CEMP for the project. If pathogens are identified exclusion zones with fencing and signage to restrict access into contaminated areas would be required. The pest and disease management plan should be developed in accordance with Guide 7 Pathogen Management of the Roads and Maritime Biodiversity Guidelines (RTA 2011), including:

- Providing vehicle and boot wash down facilities and ensuring vehicles and footwear are free of soil before entering or exiting the site.
- Regular communication to staff and contractors during inductions and toolbox talks, of the risk of spreading pathogens and the mitigation measures required on site.

- Programming construction works to move from uninfected areas to any known infected areas.
- Restricting vehicles to designated tracks, trails and parking areas.

### 5.3 Habitat re-establishment

A landscape management plan should be developed which provides specific details for the re-establishment of native vegetation on batters, surrounding sediment basins and other areas disturbed during construction. The landscape management plan would need to consider a range of constraints and opportunities associated with the project and be developed in conjunction with the Urban Design Report.

Detailed guidelines for the re-establishment of native vegetation on road projects are provided in Guide 3 Re-establishment of Native Vegetation of the Roads and Maritime Biodiversity Guidelines (RTA 2011) and supporting documentation, those of relevance to the project include the following:

- Ensure areas to be revegetated have an appropriate level of natural drainage.
- Avoid compaction of soils in areas identified for revegetation and where compaction has occurred, the soil would be loosened.
- When planting consider seasonal risks of frost, drought, flooding and sun exposure to avoid damaging plants and to encourage growth.
- Adhere to relevant specifications and guidelines including but not limited to the RTA Landscape Planting QA Specification R179, RTA Seed Collection QA Specification R176, the Florabank Guidelines, Model Code of Practice and Construction Quality Technical Direction 007, Quality Alert 7 – Hydro-seeding, hydro-mulching and other slope stabilisation methods.
- Inspection, monitoring and maintenance of revegetated areas would be conducted biannually for a minimum of two years after the completion of construction in accordance with the landscape management plan. Outline the roles and responsibilities in landscape management and revegetation plans including the schedule for monitoring and maintenance activities.

### 5.4 Wildlife connectivity

Impacts to connectivity from the proposal are predicted to be minimal. The existing bridges and culverts will remain allowing fauna to effectively cross beneath the M4 Motorway.

The existing levels of east west habitat connectivity along the M4 motorway can be enhanced through appropriate habitat re-establishment and protection of existing habitats where possible. Landscaping should use locally indigenous species to provide for functional habitat connectivity where physical connectivity is not possible. Riparian vegetation along the main north south wildlife corridors (South Creek, Ropes Creek, and Eastern Creek) is to be protected during construction works where possible and any areas of riparian vegetation impacted by construction are to be rehabilitated.

## 5.5 Aquatic habitats and riparian zones

Potential impacts to water quality, aquatic habitat and fish passage can be mitigated through the measures outlined in **Table 5-1**.

**Table 5-1 Mitigation measures for water quality and aquatic ecology**

Mitigation measures	Description
Water quality management and prevention	<ul style="list-style-type: none"> <li>• Construction traffic would be restricted to access tracks, fenced before the start of construction and maintained until construction is complete.</li> <li>• Chemicals and fuels would be appropriately stored and bundled.</li> <li>• Appropriate sediment and erosion control measures would be put in place during the construction process and may include sediment and erosion control curtains to control turbidity generated during the construction and restoration process.</li> <li>• No turbid water generated from the construction area would be discharged into any waterway.</li> <li>• The need for water quality monitoring during construction is addressed in the Soils, Water, Waste and Contamination Working Paper.</li> <li>• All construction materials (rocks and gravel) would be clean before being used for construction to minimise turbidity.</li> <li>• Lateral flow (i.e. stormwater) should be managed to avoid flow over exposed soils which may result in erosion and impacts to water quality.</li> </ul>
Riparian and aquatic habitat management	<ul style="list-style-type: none"> <li>• Minimise disturbance to riparian vegetation where possible.</li> <li>• Riparian vegetation and wetlands along the main wildlife corridors will be protected during construction works where possible with any affected areas to be rehabilitated.</li> </ul>
Sedimentation and erosion management	<ul style="list-style-type: none"> <li>• All standard sediment and erosion control measures for water quality management would be implemented.</li> <li>• Develop and conduct water quality monitoring.</li> </ul>

## 5.6 Offsetting

A number of documents were reviewed to identify the need for biodiversity offsets for this project. This included the:

- Roads and Maritime Guideline for Biodiversity Offsets (Roads and Maritime 2011b)
- EPBC Act Environmental Offsets Policy (DSEWPaC 2012)
- Principles for the Use of Biodiversity Offsets in NSW (Department of Environment, Climate Change and Water 2008).

This biodiversity assessment identifies that the project would not have a significant impact on any MNES listed under the EPBC Act. Accordingly there is no requirement for a referral under the EPBC Act and the EPBC Act environmental offsets policy does not apply.

The ecological values of the study area were considered at the preliminary environmental and planning stages of the project and ecological data gathered from the background review and field surveys was considered as a guide to the refinement of the development footprint, and to devise appropriate design features and mitigation measures to avoid and minimise long-term impacts on biodiversity.

The approach adopted has considered the *Principles for the use of biodiversity offsets in NSW* (DECCW, 2008). It is recognised that the project should aim to ensure a net improvement in biodiversity over time (Principle number 6; DECCW; 2008).

It is Roads and Maritime policy that biodiversity offsets are to be provided where more than 1 hectare of high conservation value vegetation is cleared. As 10.63 hectares of TECs (planted and remnant) will be cleared, an offset strategy will be prepared for the project. Although much of the TECs in the study area are generally in poor condition including large areas of planted trees and shrubs with strong affinities to TECs, equivalent vegetation types have a high conservation value being over 70 per cent cleared.

The greatest extent of impact likely is on planted roadside vegetation of low ecological value. In terms of remnant or native regrowth vegetation, these impacts relate to the potential loss of 13.48 hectares of TECs listed as endangered under the TSC Act. The TSC Act listed TECs to be impacted are outlined in **Table 5-2**.

**Table 5-2 TECs and threatened species to be impacted by the proposal for which offsets may be required.**

Threatened species and ecological communities	Conservation Status	Area (ha)
Cumberland Plain Woodland in the Sydney basin Bioregion	Critically Endangered, TSC Act and EPBC Act	10.99 (2.51 remnant, 8.48 planted)
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered, TSC Act	0.15
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered, TSC Act	0.79
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered, TSC Act Critically Endangered, EPBC Act	0.87 (0.3 remnant, 0.57 planted)
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered, TSC Act and EPBC Act	0.68 (0.28 remnant, 0.4 planted)
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	Endangered, TSC Act	1.2 (0.1 high quality, 1.1 moderate quality)
Juniper-leaf Grevillea ( <i>Grevillea juniperina subsp. juniperina</i> )	Vulnerable, TSC Act	49 individuals (Up to 11 ha of habitat)

It would be reasonable when determining the adequacy of the offset, to take into account the small area and isolated and fragmented nature of the areas to be directly and indirectly impacted. Principle 6 of the OEH Offset Principles includes a number of offset options, of these the following are to be considered on the chosen offset site:

- Enhancing habitat
- Reconstructing habitat in strategic areas to link areas of conservation value
- Increasing buffer zones around areas of conservation value
- Removing threats by conservation agreements or reservation.

The most appropriate form of offset for the project would likely be retirement of BioBanking credits at a BioBanking site.

## 6 Significance assessments

Significance assessments have been conducted for threatened biodiversity that have been positively identified or that have a moderate or high likelihood of occurring in the study area.

### 6.1 *Environmental Planning and Assessment Act 1979*

The EP&A Act requires that a 7-part test is undertaken to assess the likelihood of a significant impact occurring to a threatened species, population or ecological community listed under the TSC Act.

The document *Threatened Species Assessment Guidelines: The Assessment of Significance* (Department of Environment and Climate Change 2007) outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of assessment in the 7-part test. The guidance provided by the Department of Environment and Climate Change (2007) has been used here in preparing these 7-part tests.

Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats. Full details of assessment of significance under the EP&A Act are presented in **Appendix D**. The conclusions of the EP&A Act are provided in **Table 6-1**, which indicates that a significant impact is considered unlikely on any biota listed under the TSC Act.

**Table 6-1 Summary of EP&A Act assessments of significance**

Species	Status (TSC Act)	7-part test questions							Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f	g		
<b>Threatened ecological communities</b>										
Cumberland Plain Woodland in the Sydney basin Bioregion	CE	X	X	N	N	N	N	N	No	Present as small remnants and revegetation (planted)
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	X	X	N	N	N	N	N	No	Present in natural and man-made depressions

Species	Status (TSC Act)	7-part test questions							Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f	g		
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	X	X	N	N	N	N	N	No	Present as remnant vegetation
Shale Gravel Transition Forest in the Sydney Basin Bioregion	E	X	X	N	N	N	N	N	No	Present as small remnant and revegetation (planted)
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	E	X	X	N	N	N	N	N	No	Present as remnant and revegetation (planted)
<b>Flora</b>										
Downy Wattle ( <i>Acacia pubescens</i> )	V	N	N	X	N	N	N	N	No	Present
<i>Dillwynia tenuifolia</i>	V	N	N	X	N	N	N	N	No	Present
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	V	N	N	X	N	N	N	N	No	Present
Juniper-leaf Grevillea ( <i>Grevillea juniperina</i> subsp. <i>juniperina</i> )	V	N	N	X	N	N	N	N	No	Present
<i>Marsdenia viridiflora</i> subsp. <i>viridiflora</i> (endangered population)	E2	X	N	X	N	N	N	N	No	Moderate
Nodding Geebung ( <i>Persoonia nutans</i> )	E	N	N	X	N	N	N	N	No	Present
Spiked-rice Flower ( <i>Pimelea spicata</i> )	E	N	N	X	N	N	N	N	No	Moderate
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	E	N	N	X	N	N	N	N	No	Present

Species	Status (TSC Act)	7-part test questions							Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f	g		
<b>Fauna</b>										
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	E	N	N	X	N	N	N	N	No	Moderate
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	V	N	N	X	N	N	N	N	No	Moderate
Glossy Black-Cockatoo ( <i>Calyptorhynchus latham</i> )	V	N	N	X	N	N	N	N	No	Moderate
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	N	N	X	N	N	N	N	No	Moderate
Little Eagle ( <i>Hieraaetus morphnoides</i> )		N	N	X	N	N	N	N	No	Moderate
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	V	N	N	X	N	N	N	N	No	Moderate
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	V	N	N	X	N	N	N	N	No	Moderate
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	V	N	N	X	N	N	N	N	No	Moderate
Swift Parrot ( <i>Lathamus discolor</i> )	E	N	N	X	N	N	N	N	No	Moderate
<b>Arboreal Mammals</b>										
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	V	N	N	X	N	N	N	N	No	Moderate
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	V	N	N	X	N	N	N	N	No	Moderate
Yellow-bellied Glider ( <i>Petaurus australis</i> )	V	N	N	X	N	N	N	N	No	Moderate
<b>Woodland birds</b>										
Flame Robin ( <i>Petroica phoenicea</i> )	V	N	N	X	N	N	N	N	No	Moderate

Species	Status (TSC Act)	7-part test questions							Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f	g		
Scarlet Robin ( <i>Petroica boodang</i> )	V	N	N	X	N	N	N	N	No	Moderate
Speckled Warbler ( <i>Chthonicola sagittatus</i> )	V	N	N	X	N	N	N	N	No	Moderate
Varied Sittella ( <i>Daphoenositta chrysoptera</i> )	V	N	N	X	N	N	N	N	No	Moderate
<b>Large Forest Owls</b>										
Barking Owl ( <i>Ninox connivens</i> )	V	N	N	X	N	N	N	N	No	Moderate
Masked Owl ( <i>Tyto novaehollandiae</i> )	V	N	N	X	N	N	N	N	No	Moderate
Powerful Owl ( <i>Ninox strenua</i> )	V	N	N	X	N	N	N	N	No	Moderate
<b>Cave roosting microchiropteran bats</b>										
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	N	N	X	N	N	N	N	No	Moderate
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii oceanensis</i> )	V									Present
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	V									Moderate
Southern Myotis ( <i>Myotis macropus</i> )	V									Present
<b>Tree roosting microchiropteran bats</b>										
Eastern Freetail-bat ( <i>Mormopterus norfolkensis</i> )	V	N	N	X	N	N	N	N	No	Moderate
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	V									Moderate
										Moderate

Species	Status (TSC Act)	7-part test questions							Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f	g		
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	V									Moderate
Yellow-bellied Sheathtail-bat ( <i>Saccolaimus flaviventris</i> )	V									Moderate
<p>* Y= Yes (negative impact), N = No (no or positive impact), X = not applicable,</p> <p>Significance assessment questions</p> <p>a In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction</p> <p>b In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction</p> <p>c In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:</p> <p>(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or</p> <p>(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction</p> <p>d In relation to the habitat of a threatened species, population or ecological community:</p> <p>(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed</p> <p>(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action</p> <p>(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality</p> <p>e Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)</p> <p>f Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan</p> <p>g Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.</p>										

## 6.2 Environment Protection and Biodiversity Conservation Act 1999

### 6.2.1 Threatened ecological communities

Full details of the assessment of significance for threatened species under the EPBC Act are presented in **Appendix D**. The conclusions of the EPBC Act assessment of significance are provided in **Table 6-2** which indicates that a significant impact is considered unlikely for any Matter of NES.

**Table 6-2 Summary of Commonwealth EPBC Act assessments of significance for threatened ecological communities**

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Likely Significant Impact	
	1	2	3	4	5	6	7	8	9		
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	N	N	N	N	N	N	N	N	N	N	No
Shale Sandstone Transition Forest	N	N	N	N	N	N	N	N	N	N	No

### 6.2.2 Threatened species

Full details of the assessment of significance for threatened species under the EPBC Act are presented in **Appendix D**. The conclusions of the EPBC Act assessment of significance are provided in **Table 6-3** which indicates that a significant impact is considered unlikely for any Matter of NES.

**Table 6-3 Summary of Commonwealth EPBC Act assessments of significance for threatened species**

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Likely Significant Impact	Important Population+ Impact
	1	2	3	4	5	6	7	8	9		
<b>Vulnerable flora</b>											
Downy Wattle ( <i>Acacia pubescens</i> )	N	N	N	N	N	N	N	N	N	No	No
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	N	N	N	N	N	N	N	N	N	No	No
<b>Endangered flora</b>											
Nodding Geebung ( <i>Persoonia nutans</i> )	N	N	N	N	N	N	N	N	N	No	No
Spiked-rice Flower ( <i>Pimelea spicata</i> )	N	N	N	N	N	N	N	N	N	No	No

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Likely Significant Impact	Important Population+ Impact
	1	2	3	4	5	6	7	8	9		
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	N	N	N	N	N	N	N	N	N	No	No
<b>Vulnerable fauna</b>											
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	N	N	N	N	N	N	N	N	N	No	Yes
Large-eared Pied Bat ( <i>Chalinobus dwyeri</i> )	N	N	N	N	N	N	N	N	N	No	Yes
<b>Endangered fauna</b>											
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	N	N	N	N	N	N	N	N	N	No	N/A
Swift Parrot ( <i>Lathamus discolor</i> )	N	N	N	N	N	N	N	N	N	No	N/A
<p>* Assessment of significance questions</p> <ol style="list-style-type: none"> <li>1) Lead to a long-term decrease in the size of a population</li> <li>2) Reduce the area of occupancy of the species</li> <li>3) Fragment an existing population into two or more populations</li> <li>4) Adversely affect habitat critical to the survival of a species</li> <li>5) Disrupt the breeding cycle of a population</li> <li>6) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline</li> <li>7) Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat</li> <li>8) Introduce disease that may cause the species to decline</li> <li>9) Interfere with the recovery of the species.</li> </ol> <p>+ Important population as determined by the EPBC Act is a population of a vulnerable species that:</p> <ul style="list-style-type: none"> <li>is likely to be key source populations either for breeding or dispersal</li> <li>is likely to be necessary for maintaining genetic diversity</li> <li>is at or near the limit of the species range</li> </ul>											

### 6.2.3 Migratory species

While migratory species of bird do use the study area and locality, the study area would not be classed as an 'important habitat' as defined under the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (Department of the Environment 2013), in that the study area does not contain:

- Habitat utilised by a migratory species occasionally or periodically within a

region that supports an ecologically significant proportion of the population of the species

- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

As such, it is unlikely that the planning proposal would significantly affect migratory species. Full details of the assessment of significance under the EPBC Act are presented in **Appendix D**. The conclusions of the assessments of significance on migratory species are provided in **Table 6-3** and indicate that the project is considered unlikely to significantly impact on migratory birds.

**Table 6-3 Summary of Commonwealth significance assessment for migratory species**

Migratory species	EPBC Act status	Important population* in project area	Likely significant impact
Black-faced Monarch ( <i>Monarcha melanopsis</i> )	Marine; Migratory (BONN)	No	No
Cattle Egret ( <i>Ardea ibis</i> )	Marine; Migratory (CAMBA, JAMBA)	No	No
Fork-tailed Swift ( <i>Apus pacificus</i> )	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Great Egret ( <i>Egretta alba</i> )	Marine; Migratory (CAMBA, JAMBA)	No	No
Latham's Snipe ( <i>Gallinago hardwickii</i> )	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Rainbow Bee-eater ( <i>Merops ornatus</i> )	Marine; Migratory (JAMBA)	No	No
Rufous Fantail ( <i>Rhipidura rufifrons</i> )	Marine; Migratory (BONN)	No	No
Satin Flycatcher ( <i>Myiagra cyanoleuca</i> )	Marine; Migratory (BONN)	No	No
Swift Parrot ( <i>Lathamus discolor</i> )	Marine	No	No
White-bellied Sea-Eagle ( <i>Haliaeetus leucogaster</i> )	Marine; Migratory (CAMBA)	No	No
White Throated Needletail ( <i>Hirundapus caudacutus</i> )	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No

Migratory species	EPBC Act status	Important population* in project area	Likely significant impact
-------------------	-----------------	---------------------------------------	---------------------------

\* Important population as determined by the Environment Protection and Biodiversity Conservation Act 1999, is one that for a vulnerable species:

- is likely to be key source populations either for breeding or dispersal
- is likely to be necessary for maintaining genetic diversity
- is at or near the limit of the species range.

## 7 References

---

Australian Museum Business Services (AMBS) 2003. Baseline Fauna Inventory of the Orchard Hills Defence Establishment. Report prepared for Parsons Brinkerhoff and Department of Defence.

Australasian Network for Plant Conservation (ANPC) 1997. Guidelines for the Translocation of Threatened Plants in Australia. Australasian Network for Plant Conservation Working Group, Canberra.

Birdlife Australia n.d.. Gang-gang Cockatoo Profile [Online]. Accessed 11 August 2015. Available from: <http://birdlife.org.au/bird-profile/gang-gang-cockatoo>.

Clark, S.A. 2009. A review of the land snail genus *Meridolum* (Gastropoda: Camaenidae) from central New South Wales, Australia. *Molluscan Research* 29(2):61-120

Cogger, H. 2014. Reptiles and amphibians of Australia. Seventh Edition. CSIRO PUBLISHING.

Debus, S.J.S. 1997. The Barking Owl in New South Wales. *Aust. Birds* 30: 53-80

Department of Environment and Climate Change (DECC) 2005. Regional Biodiversity Corridors in the Hawkesbury-Nepean Catchment Management Authority Area. GIS data layer.

Department of Environment and Climate Change (DECC) 2007. Threatened species assessment guidelines. The assessment of significance. Department of Environment and Climate Change, Hurstville.

Department of Environment and Conservation 2005 *Pimelea spicata* R. Br. Recovery Plan. Department of Environment and Conservation (NSW), Hurstville NSW.

Department of Environment and Resource Management. 2011. National recovery plan for the large-eared pied bat *Chalinolobus dwyeri*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Department of Environment Climate Change and Water (DECCW) 2008. BioBanking Assessment Methodology. BioBanking Methodology and Credit Calculator Operation Manual. Assessed online at <http://www.environment.nsw.gov.au/resources/biobanking/09181bioopsman.pdf>

Department of Environment, Climate Change and Water NSW. 2009. Draft National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus*. Prepared by Dr Peggy Eby. Department of Environment, Climate Change and Water NSW, Sydney.

Department of Environment Climate Change and Water (NSW) 2010. Cumberland Plain Recovery Plan, Department of Environment, Climate Change and Water (NSW), Sydney.

Department of Environment and Conservation (NSW) 2006. NSW Recovery Plan for the Large Forest Owls: Powerful Owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*) DEC, Sydney.

Department of the Environment 2013. Matters of National Environmental Significance: Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999. Department of the Environment, Canberra.

Department of Planning 2008. Biodiversity Restoration Strategy – South and Ropes Creeks. Department of Planning, Sydney

Department of Environments (DoE) 2014. Cumberland Plain Shale Woodlands and Higgins PJ, Peter JM, (Eds) 2002 'Handbook of Australian, New Zealand and Antarctic birds (vol. 6).' (Oxford University Press: Melbourne).

Shale-Gravel Transition Forest in Community and Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: <http://www.environment.gov.au/sprat>.

Dwyer, P.D 1995. Common bentwing-bat. In: The Mammals of Australia (ed. R. Strahan) pp. 494– 495. Reed Books: New South Wales.

Goldingay, R. L. (2009). Characteristics of tree hollows used by Australian birds and bats. *Wildlife Research*, 36(5), 394-409.

Hall, L.S. 1982. The effect of cave microclimate on winter roosting behaviour in the bat, *Miniopterus schreibersii blepotis*. *Australian Journal of Ecology* 7: 129-36.

Hall, L.S. and Richards, G. 2003. Flying around underground: Cave bats. In: *Beneath the Surface: A Natural History of Australian Caves*. (eds. B. Finlayson and E. Hamilton-Smith) pp. 111–126 University of New South Wales Press: Sydney.

Jones, M.E., M. Oakwood C.A. Belcher, K. Morris, A.J. Murray, P.A. Woolley, K.B. Firestone, B. Johnson & S. Burnett (2003). Carnivore Concerns: Problems, issues and solutions for conserving Australasia's marsupial carnivores. In: Jones, M., C. Dickman & M. Archer, eds. *Predators with Pouches: The biology of carnivorous marsupials*. Page(s) 422-434. Collingwood, Victoria: CSIRO Publishing.

Kavanagh R P, Debus S J S, Rose A B and Turner R J 1995. Notes on the diet and habitat of the Barking Owl *Ninox connivens* in New South Wales. *Aust. Bird Watcher* 16: 137-144.

Kuginis L., Byrne G., Serov P, Williams J.P., June 2012, Risk assessment guidelines for groundwater dependent ecosystems, Volume 3 – Identification of high probability groundwater dependent ecosystems on the coastal plains of NSW and their ecological value, NSW Department of Primary Industries, Office of Water, Sydney

Law, B.S. and Urquhart, C.A. 2000. Diet of the Large-footed Myotis *Myotis macropus* at a forest stream roost in northern New South Wales. *Australian Mammalogy* 22: 121-4.

Lerner HRL and Mindell DP 2005. Phylogeny of eagles, Old World vultures, and other accipitridae based on nuclear and mitochondrial DNA. *Molecular Phylogenetics and Evolution* 37, 327-346.

Marchant S and Higgins PJ (Eds) 1993. 'Handbook of Australian, New Zealand and Antarctic birds (vol. 2).' (Oxford University Press: Melbourne).

National Parks & Wildlife Service (NPWS) 2001. Environmental Impact Assessment Guideline – Red-crowned Toadlet. NSW National Parks and Wildlife Service, Sydney

- National Parks & Wildlife Service (NPWS) 2002. Native Vegetation of the Cumberland Plain - Final Edition. NSW National Parks and Wildlife Service, Sydney
- NSW Department of Environment and Conservation 2005. *Persoonia nutans*. R Br (Nodding Geebung) Recovery Plan. NSW Department of Environment and Conservation, Hurstville NSW
- New South Wales National Parks & Wildlife Service (NSW NPWS) 2001. Broad-headed Snake, *Hoplocephalus bungaroides*.
- NSW National Parks and Wildlife Service 2003. Downy Wattle (*Acacia pubescens*) Recovery Plan. NSW NPWS, Hurstville, NSW.
- Office of Environment and Heritage (OEH) 2012. Scientific Committee determinations. <http://www.environment.nsw.gov.au/determinations/index.htm>
- Office of Environment and Heritage (OEH) 2013. Atlas of NSW Wildlife. NSW OEH Hurstville, NSW (accessed March 2013).
- Office of Environment and Heritage (OEH) 2015. Threatened Species Profile Search. NSW Office of Environment and Heritage. Available from <http://www.environment.nsw.gov.au/threatenedSpeciesApp/>
- Pringle, R.M., J.K. Webb & R. Shine 2003. Canopy structure, microclimate, and habitat selection by a nocturnal snake, *Hoplocephalus bungaroides*. *Ecology*. 84(10):2668-2679.
- Saunders, D.L. and Tzaros, C.L. 2011. National Recovery Plan for the Swift Parrot *Lathamus discolor*, Birds Australia, Melbourne.
- Sharp A, Gibson L, Norton M, Ryan B, Marks A, Semeraro L 2002 The breeding season diet of the Wedge-tailed Eagle (*Aquila audax*) in western New South Wales and the influence of Rabbit Calicivirus Disease. *Wildlife Research* 29, 175-184.
- Strahan, R (Ed.) 1995. The mammals of Australia. New Holland Pub Pty Limited.
- Thumm, K., & Mahony, M. 1999. Loss and degradation of red-crowned toadlet habitat in the Sydney region. *Declines and Disappearances of Australian Frogs*, 99-108.
- Tozer, M., Turner, K., Simpson, C., Keith, D., Beukers, P., MacKenzie, B., Tindall, D. and Pennay, C 2010. Native vegetation of south-east NSW: a revised classification and map for the coast and eastern tablelands. Prepared for the NSW Department of Environment and Conservation and the NSW Department of Natural Resources.

## Appendix A Threatened subject species assessment

The following assessment identifies the list of threatened flora and fauna species recorded from a 10 kilometre radius of the project and compares the preferred habitat of these species with the habitats identified in the study area to make an assessment of the likelihood of the species being present in the project study area (i.e. subject species). The criteria used in the assessment are detailed below.

Likelihood of Occurrence	Criteria
Unlikely	<ul style="list-style-type: none"> <li>Species highly restricted to certain geographical areas not within the proposal footprint</li> <li>Specific habitat requirements are not present in the study area</li> </ul>
Low	<p>Species not recorded during field surveys and fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>Have not been recorded previously in the study area/surrounds and for which the study area is beyond the current distribution range</li> <li>Use specific habitats or resources not present in the study area</li> <li>Are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded</li> </ul>
Moderate	<p>Species not recorded during the field surveys that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>Have infrequently been recorded previously in the study area/surrounds</li> <li>Use specific habitats or resources present in the study area but in a poor or modified condition</li> <li>Are unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration</li> <li>Are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded</li> </ul>
High	<p>Species recorded during the field surveys or species not recorded that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> <li>Have frequently been recorded previously in the study area/surrounds</li> <li>Use habitat types or resources that are present in the study area that are abundance and/or in good condition within the study area</li> <li>Are known or likely to maintain resident populations surrounding the study area</li> <li>Are known or likely to visit the site during regular seasonal movements or migration</li> </ul>

**Table A-7-1 Known or potentially occurring threatened flora species**

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Bynoe's Wattles <i>Acacia bynoeana</i>	V	E	Found in central eastern NSW, from the Hunter District south to the Southern Highlands and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra. Occurs in heath or dry sclerophyll forest on sandy soils. 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 ( <i>Corymbia gummifera</i> ), Scribbly Gum ( <i>Eucalyptus haemastoma</i> ), Drooping Red Gum ( <i>E. parramattensis</i> ), Old Man Banksia ( <i>Banksia serrata</i> ) and Small-leaved Apple ( <i>Angophora bakeri</i> ).	18 PMST	Absent	Unlikely  No suitable habitat for this species is present
Gordon's Wattle <i>Acacia gordonii</i>	E	E	Restricted to north-west Sydney occurring in the lower Blue Mountains to Maroota/Glenorie area. 2000 individuals are thought to occur. Grows in dry sclerophyll forest and heathlands around sandstone rock outcrops.	1 PMST	Absent	Unlikely  No suitable habitat for this species is present
Gosford Wattle <i>Acacia prominens</i> (endangered population)	-	E 2	Occurs at a few sites along the railway line at Penshurst, at Carss Bush Park, Carss Park and there is an unconfirmed sighting at Oatley Park, Oatley. This population is disjunct from other populations (Hunter Valley to Gosford region) and at the southern limit of the range of the species. Grows in open situations on clayey or sandy soils. This population is only endangered in the Hurstville and Kogarah LGAs	1	Potential habitat widespread in study area	None  The proposal is not in the Hurstville LGA or Kogarah LGA
Downy Wattle <i>Acacia pubescens</i>	V	V	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/	4445 PMST	Map Unit 1 and 2	Present  Four individuals

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravelly soils, often with ironstone.			were recorded at one location in the study area to the west of the Ropers Road intersection on the southern side of the M4 Motorway.
Sunshine Wattle <i>Acacia terminalis</i> subsp. <i>terminalis</i>	E	E	Very limited distribution between Botany Bay to the northern foreshore of Port Jackson. Recent collections have only been made from the Quarantine Station, Clifton Gardens, Dover Heights, Parsely Bay, Nielson Park, Cooper Park, Chifley and Watsons Bays. Coastal scrub and dry sclerophyll woodland on sandy soils. Habitat is generally sparse and scattered. Most areas of habitat or potential habitat are small and isolated.	8 PMST	Absent	Unlikely  No suitable habitat for this species is present
<i>Allocasuarina glareicola</i>	E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil. Found in open woodland with <i>Eucalyptus parramattensis</i> , <i>Eucalyptus fibrosa</i> , <i>Angophora bakeri</i> , <i>Eucalyptus sclerophylla</i> and <i>Melaleuca decora</i> . Common associated understorey species include <i>Melaleuca nodosa</i> , <i>Hakea dactyloides</i> , <i>Hakea sericea</i> , <i>Dillwynia tenuifolia</i> , <i>Micromyrtus minutiflora</i> , <i>Acacia elongata</i> , <i>Acacia brownei</i> , <i>Themeda australis</i> and <i>Xanthorrhoea minor</i> .	2 PMST	Map Unit 1	Low  This species is restricted to Richmond and Voyager Point
<i>Asterolasia elegans</i>	E	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a	0 PMST	Absent	Unlikely  No suitable habitat for this

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			conservation reserve. Occurs on Hawkesbury sandstone. Found in sheltered forests on mid- to lower slopes and valleys, e.g. in or adjacent to gullies which support sheltered forest. The canopy at known sites includes Turpentine ( <i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i> ), Smooth-barked Apple ( <i>Angophora costata</i> ), Sydney Peppermint ( <i>Eucalyptus piperita</i> ), Forest Oak ( <i>Allocasuarina torulosa</i> ) and Christmas Bush ( <i>Ceratopetalum gummifera</i> ).			species is present
Thick Lip Spider Orchid <i>Caladenia tessellata</i>	V	E	Occurs in the Sydney area, Wyong, Ulladulla and Braidwood. Populations in Kiama and Queanbeyan are presumed extinct. Has been recorded in the Huskisson area in the 1930s. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, however the population near Braidwood is in low woodland with stony soil.	2 PMST	Map Unit 1 and 2	Low This species has not been recorded in the Sydney area since the 1950s
Netted Bottlebrush <i>Callistemon linearifolius</i>	-	V	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Was more widespread across its distribution in the past. Some populations are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve, and Spectacle Island Nature Reserve. Further north it has been recorded from Yengo National Park and Werakata National Park. Grows in dry sclerophyll forest on the coast and adjacent ranges.	11	Map Unit 1 and 2	Low This species is large and conspicuous and was not recorded during the survey
Leafless Tongue-orchid <i>Cryptostylis</i>	V	V	The Leafless Tongue Orchid has been recorded from as far north as Gibraltar Range National Park south into Victoria around the coast as far as Orbost. The larger populations typically occur in woodland dominated by Scribbly Gum ( <i>Eucalyptus</i>	0 PMST	Map Unit 1 and 2	Low This species has not been

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>hunteriana</i>			sclerophylla), Silvertop Ash ( <i>E. sieberi</i> ), Red Bloodwood ( <i>Corymbia gummifera</i> ) and Black Sheoak ( <i>Allocasuarina littoralis</i> ); appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid ( <i>C. subulata</i> ) and the Tartan Tongue Orchid ( <i>C. erecta</i> ).			recorded in the Sydney area
White-flowered Wax Plant <i>Cynanchum elegans</i>	E	E	Occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; Coastal Tea-tree ( <i>Leptospermum laevigatum</i> ) – Coastal Banksia ( <i>Banksia integrifolia</i> subsp. <i>integrifolia</i> ) coastal scrub; Forest Red Gum ( <i>Eucalyptus tereticornis</i> ) aligned open forest and woodland; Spotted Gum ( <i>Corymbia maculata</i> ) aligned open forest and woodland; and Bracelet Honeymyrtle ( <i>Melaleuca armillaris</i> ) scrub to open scrub.	1 PMST	Map Unit 2	Low  This species is not known from the study area and was not recorded during surveys
<i>Darwinia biflora</i>	V	V	Occurs at 129 sites in the northern and north-western suburbs of Sydney, in the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai Local Government Areas (LGAs). Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Associated overstorey species include <i>Eucalyptus haemastoma</i> , <i>Corymbia gummifera</i> and/or <i>E. squamosa</i> . The vegetation structure is usually woodland, open forest or scrub-heath.	17 PMST	Map Unit 11	Low. Habitat marginal
<i>Deyeuxia appressa</i>	E	E	A highly restricted NSW endemic known only from two pre-1942 records in the Sydney area. Was first collected in 1930 at Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown. Was then collected in 1941 from Killara, near Hornsby. Has not been collected since and may now be extinct in the wild due to the level of habitat loss and development that has occurred within these areas.	0 PMST	Map Unit 3	Low  Considered extinct, not seen since the 1940s
<i>Dillwynia tenuifolia</i>	V	V	Core distribution is the Cumberland Plain from Windsor to Penrith east to Deans Park. Other populations in Western Sydney are recorded at Voyager Point and Kemps Creek in	311	Map Unit 1	Present

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			the Liverpool LGA, Luddenham in the Penrith LGA and South Maroota in the Baulkham Hills Shire. Disjunct localities include the Bulga Mountains at Yengo in the north, and Kurrajong Heights and Woodford in the Lower Blue Mountains. In western Sydney, it may be locally abundant particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland. At Yengo, is reported to occur in disturbed escarpment woodland on Narrabeen sandstone.			135 individuals were directly counted in the study area, in three main clusters west of the Ropers Road interchange.
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	-	V	Recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Found in a range of habitat types, most of which have a strong shale soil influence.	94	Map Unit 11	Low. Habitat marginal
Camden White Gum <i>Eucalyptus benthamii</i>	V	V	Occurs on the alluvial flats of the Nepean River and its tributaries. There are two major subpopulations: in the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. A further 18 trees are scattered along the Nepean River, south to The Oaks. Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest. Associated species at the Bents Basin site include <i>Eucalyptus elata</i> , <i>E. bauerina</i> , <i>E. amplifolia</i> , <i>E. deanei</i> and <i>Angophora subvelutina</i> . Understorey species include <i>Bursaria spinosa</i> , <i>Pteridium esculentum</i> and a wide variety of agricultural weeds. The Kedumba Valley site lists <i>E. crebra</i> , <i>E. deanei</i> , <i>E. punctata</i> , <i>Leptospermum flavescens</i> , <i>Acacia filicifolia</i> and <i>Pteridium esculentum</i> among its associated species.	3 PMST	Absent	Low  This species was not recorded in the study area. Only suitable habitat is along the Nepean River
Narrow-leaved Black Peppermint <i>Eucalyptus nicholii</i>	V	V	This species is sparsely distributed but widespread on the New England Tablelands from Nundle to north of Tenterfield, being most common in central portions of its range. Found largely on private property and roadsides, and occasionally conservation reserves. Planted as urban trees, windbreaks and corridors. Typically grows in dry grassy	12	Natural habitat absent.	Present  A single individual was

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			<p>woodland, on shallow soils of slopes and ridges. Found primarily on infertile soils derived from granite or metasedimentary rock.</p> <p>This species has been planted in the locality.</p>		Planted in the study area	recorded on the northern side of the M4 Motorway corridor south of the major service centre and rest stop area, This species has been planted.
<p>Wallangarra White Gum</p> <p><i>Eucalyptus scoparia</i></p>	V	E	<p>In NSW it is known from only three locations near Tenterfield, including Bald Rock National Park. In Queensland it is equally rare, occurring at three sites of which only one has more than a dozen trees. In NSW it is known from only three locations near Tenterfield, including Bald Rock National Park. In Queensland it is equally rare, occurring at three sites of which only one has more than a dozen trees.</p> <p>This species has been planted in the locality.</p>	1	<p>Natural habitat absent.</p> <p>Potentially planted in the study area</p>	<p>Low</p> <p>This species was not recorded in the study area.</p>
<p>Bauer's Midge Orchid</p> <p><i>Genoplesium baueri</i></p>	-	V	<p>Recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahrenonga. No collections have been made from those sites in recent years. The species has been recorded at locations now likely to be within the several conservation reserves including Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. May occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments. Found in sparse sclerophyll forest and moss gardens over sandstone</p>	10	Absent	<p>Unlikely</p> <p>No suitable habitat for this species is present</p>

Species	Status	TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC					
Narrow-leaf Finger Fern <i>Grammitis stenophylla</i>	-	E	In NSW it has been found on the south, central and north coasts and as far west as Mount Kaputar National Park near Narrabri. Inhabits moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest.	1	Absent	Unlikely  No suitable habitat for this species is present
Juniper-leaf Grevillea <i>Grevillea juniperina</i> subsp. <i>juniperina</i>	-	V	Endemic to Western Sydney, centred on an area bounded by Blacktown, Erskine Park, Londonderry and Windsor with outlier populations at Kemps Creek and Pitt Town. Grows on reddish clay to sandy soils derived from Wianamatta Shale and Tertiary alluvium often with a shale influence, typically containing lateritic gravels. Recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition Forest. Associated canopy species within Cumberland Plain Woodland and Shale/Gravel Transition Forest include Forest Red Gum ( <i>Eucalyptus tereticornis</i> ), Grey Box ( <i>E. moluccana</i> ), Narrow-leaved Ironbark ( <i>E. crebra</i> ), Broad-leaved Ironbark ( <i>E. fibrosa</i> ) and Thin-leaved Stringybark ( <i>E. eugenioides</i> ). Understorey species include Sweet Bursaria ( <i>Bursaria spinosa</i> ), Prickly parrot pea ( <i>Dillwynia sieberi</i> ), White Dogwood ( <i>Ozothamnus diosmifolius</i> ), Gorse Bitter Pea ( <i>Daviesia ulicifolia</i> ), Sickie Wattle ( <i>Acacia falcata</i> ), Parramatta Wattle ( <i>Acacia parramattensis</i> ), Kangaroo Grass ( <i>Themeda australis</i> ), Purple Wiregrass ( <i>Aristida ramose</i> ), Barbwire Grass ( <i>Cymbopogon refractus</i> ), Brown's Lovegrass ( <i>Eragrostis brownie</i> ), Rock Fern ( <i>Cheilanthes sieberi</i> ), Blue Flax Lily ( <i>Dianella revolute</i> ) and Ivy Goodenia ( <i>Goodenia hederacea</i> ). In Castlereagh Woodland on more sandy soils the dominant canopy species are Broad-leaved Ironbark ( <i>Eucalyptus fibrosa</i> ), Scribbly Gum ( <i>E. sclerophylla</i> ), Small-leaved Apple ( <i>Angophora bakeri</i> ) and Honey Myrtle ( <i>Melaleuca decora</i> ). Understorey species include Prickly-leaved Paperbark ( <i>Melaleuca nodosa</i> ), Needlebush ( <i>Hakea sericea</i> ), <i>Cryptandra spinescens</i> , Slender Wattle ( <i>Acacia elongate</i> ), Forest Raspwort ( <i>Gonocarpus teucrioides</i> ), Spiny-headed Mat Rush ( <i>Lomandra longifolia</i> ) and the threatened species <i>Dillwynia tenuifolia</i> , Prickly-bush	1113	Map Unit 1, 2, 3 and 5	Present  Over 950 individuals were directly counted in the study area. Large populations of this species occur surrounding the Ropers Road interchange on both sides of the M4 Motorway. There are also several population clusters further

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			Pea ( <i>Pultenaea parviflora</i> ), <i>Micromyrtus minutiflora</i> and <i>Allocasuarina glareicola</i> .			west surrounding the Kent Road overpass.
Small-flower Grevillea <i>Grevillea parviflora</i> <i>subsp. parviflora</i>	V	V	Sporadically distributed throughout the Sydney Basin with the main occurrence centred on Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie on the Central Coast, and Cessnock and Kurri Kurri in the Lower Hunter. Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	3 PMST	Map Unit 11	Low. Habitat marginal
Square Raspwort <i>Haloragis exalata</i> <i>subsp. exalata</i>	V	V	Square Raspwort occurs in 4 widely scattered localities in eastern NSW. It is disjunctly distributed in the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW. Square Raspwort appears to require protected and shaded damp situations in riparian habitats. Flowering specimens in NSW are recorded from November to January.	0 PMST	Map Unit 3	Low. Habitat marginal
<i>Hibbertia puberula</i>	-	E	Has not been seen for over 40 years. Early records of this species are from the Hawkesbury River area and Frenchs Forest in northern Sydney, South Coogee in eastern Sydney, the Hacking River area in southern Sydney, and the Blue Mountains. Occurs on sandy soil often associated with sandstone.	2	Absent	Unlikely  No suitable habitat for this species is present
<i>Hibbertia</i> sp. <i>Bankstown</i>	C E	C E	Is currently known to occur in only one population at Bankstown Airport in Sydney's southern suburbs. The airport site is very heavily modified from the natural state, now largely lacks canopy species, and is currently a low grass/shrub association with many	0 PMST	Potential habitat widespread	Low  known to occur in only

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			pasture grasses and other introduced herbaceous weeds.			one population at Bankstown Airport
Julian's Hibbertia <i>Hibbertia sp.</i> <i>Turramurra</i>	-	C E	Endemic to NSW where it is restricted to a single population located in the northern Sydney suburb of Turramurra. Grows in forest with canopy species including <i>Eucalyptus pilularis</i> , <i>E. resinifera</i> , <i>Corymbia gummifera</i> and <i>Angophora costata</i> . The understorey is open with species of Poaceae, Orchidaceae, Fabaceae and Liliaceae.	1	Map Unit 11	Low. habitat marginal
<i>Hibbertia superans</i>	-	E	Occurs from Baulkham Hills to South Maroota in the northern outskirts of Sydney and at one locality at Mount Boss inland from Kempsey. Occurs in both open woodland and heathland, and appears to prefer open disturbed areas, such as tracksides.	44	Absent	Unlikely No suitable habitat for this species is present
<i>Hypsela sessiliflora</i> (syn. <i>Isotoma sessiliflora</i> )	X	E	Currently known from only two adjacent sites on a single private property at Erskine Park in the Penrith LGA. Previous sightings are all from western Sydney, at Homebush and at Agnes Banks. Known to grow in damp places, on the Cumberland Plain, including freshwater wetland, grassland/alluvial woodland and an alluvial woodland/shale plains woodland ecotone.	8	Map Unit 3 and 4	Low Restricted to two sites in Erskine Park.
<i>Leptospermum deanei</i>	V	V	Known from the Hornsby, Warringah, Ku-ring-gai and Ryde LGAs. Occurs in woodland on lower hill slopes or near creeks, sandy alluvial soil or sand over sandstone, riparian scrub woodland and open forest.	5 PMST	Absent	Unlikely No suitable habitat for this

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						species is present
<i>Leucopogon fletcheri</i> subsp. <i>fletcheri</i>	-	E	Restricted to north-western Sydney between St Albans in the north and Annangrove in the south, within the LGAs of Hawkesbury, Baulkham Hills and Blue Mountains. Occurs in dry eucalypt woodland or in shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs.	164	Absent	Unlikely No suitable habitat for this species is present
<i>Marsdenia viridiflora</i> subsp. <i>viridiflora</i> (endangered population)	-	E 2	Endangered population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas. Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Grows in vine thickets and open shale woodland.	374	Potential habitat widespread	Moderate Suitable habitat for this species exists in the vegetation in the study area
Biconvex Paperbark ( <i>Melaleuca biconvexa</i> )	V	V	Found only in NSW, with scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. Generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	0 PMST	Absent	Unlikely No suitable habitat for this species is present
Deane's Paperbark <i>Melaleuca deanei</i>	V	V	Deane's Paperbark occurs in two distinct areas, in the Ku-ring-gai, Berowra, Holsworthy and Wedderburn areas, and there are also more isolated occurrences at Springwood, Wollemi National Park, Yalwal and the Central Coast areas. The species grows in heath on sandstone.	23 PMST	Absent	Unlikely No suitable habitat for this species is

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						present
<i>Micromyrtus minutiflora</i>	V	E	Restricted between Richmond and Penrith of western Sydney. Grows in Castlereagh Scribbly Gum Woodland, Ironbark Forest, Shale/Gravel Transition Forest and open forest on tertiary alluvium.	17 PMST	Map Unit 1	Low Only found between Richmond and Penrith
Omeo Storksbill ( <i>Pelargonium</i> sp. G.W. Carr 10345)	E	E	Known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. A population at a fourth known site on the Monaro has not been seen in recent years. The only other known population is at Lake Omeo, Victoria. It occurs at altitudes between 680 to 1030 m. It is known to occur in the local government areas of Goulburn-Mulwaree, Cooma-Monaro, and Snowy River, but may occur in other areas with suitable habitat; these may include Bombala, Eurobodalla, Palerang, Tumbarumba, Tumut, Upper Lachlan, and Yass Valley local government areas. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities. It sometimes colonises exposed lake beds during dry periods.	0 PMST	Map Unit 4	Low This species is not known from Sydney
Needle Geebung <i>Persoonia acerosa</i>	V	V	The Needle Geebung has been recorded only on the central coast and in the Blue Mountains, from Mt Tomah in the north to as far south as Hill Top where it is now believed to be extinct. Mainly in the Katoomba, Wentworth Falls, Springwood area. Occurs in dry sclerophyll forest, scrubby low-woodland and heath on low fertility soils.	1	Absent	Unlikely No suitable habitat for this species is present
Hairy Geebung	E	E	The Hairy Geebung has been recorded in the Sydney coastal area, the Blue Mountains area and the Southern Highlands. Found in sandy soils in dry sclerophyll open forest,	13	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>Persoonia hirsuta</i>			woodland and heath on sandstone.	PMST		No suitable habitat for this species is present
Nodding Geebung <i>Persoonia nutans</i>	E	E	Restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south. Core distribution occurs within the Penrith, and to a lesser extent, Hawkesbury LGAs, with isolated and relatively small populations also occurring in the Liverpool, Campbelltown, Bankstown and Blacktown LGAs. Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	86 PMST	Map Unit 1	Present  A single individual of this species was recorded directly west of Ropers Road on the northern side of the M4 motorway.
Austral Pillwort <i>Pilularia novae-hollandiae</i>	-	E	In NSW, Austral Pillwort has been recorded from suburban Sydney, Khancoban, and the Riverina between Albury and Urana (including Henty, Walbundrie, Balldale and Howlong) and at Lake Cowal near West Wyalong. The population at Lake Cowal is the only known extant population in NSW. The species has also been recorded in the Australian Capital Territory, Victoria, Tasmania, South Australia and Western Australia. Austral Pillwort grows in shallow swamps and waterways, often among grasses and sedges. It is most often recorded in drying mud as this is when it is most conspicuous. Most of the records in the Albury-Urana area were from table drains on the sides of roads.	1	Map Unit 4	Low  The population at Lake Cowal is the only known extant population in NSW.
Slender Curved Rice Flowers	V	V	Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta River and Port	14	Absent	Unlikely  No suitable

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>Pimelea curviflora</i> <i>var. curviflora</i>			Jackson region including Five Dock, Bellevue Hill and Manly. Occurs on shaley/lateritic soils over sandstone and shale sandstone transition soils on ridgetops and upper slopes amongst woodlands.	PMST		habitat for this species is present
Spiked-rice Flower <i>Pimelea spicata</i>	E	E	Broad distribution in western Sydney, occurring on the Cumberland Plain (Narellan, Marayong, Prospect Reservoir areas). Another smaller population is recorded in districts (Landsdowne to Shellharbour to northern Kiama) Illawarra. It grows on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark. In the coastal Illawarra it occurs commonly in Coastal Banksia open woodland with a more well developed shrub and grass understorey.	4812 PMST	Map Unit 2	Moderate Suitable habitat is present within the study area
Brown Pomaderris <i>Pomaderris brunnea</i>	V	V	Found in a very limited area around the Nepean and Hawkesbury Rivers, including the Bargo area. It also occurs at Walcha on the New England tablelands and in far eastern Gippsland in Victoria. Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	0 PMST	Absent	Low No suitable habitat for this species is present
<i>Pomaderris prunifolia</i> (endangered population)	-	E 2	Endangered population in the Parramatta, Auburn, Strathfield and Bankstown Local Government Areas. Known from only three sites within the listed local government areas, at Rydalmere, within Rookwood Cemetery and at The Crest of Bankstown. At Rydalmere it occurs along a road reserve near a creek, among grass species on sandstone. At Rookwood Cemetery it occurs in a small gully of degraded Cooks River / Castlereagh Ironbark Forest on shale soils.	21	Absent	Unlikely No suitable habitat for this species is present
Seaforth Mintbush <i>Prostanthera marifolia</i>	E	E	<i>Prostanthera marifolia</i> is currently only known from the northern Sydney suburb of Seaforth and has a very highly restricted distribution within the Sydney Basin Bioregion. The single population is fragmented by urbanisation into three small sites. All known sites are within an area of 2x2 kilometres. Two of the sites are within the local government area	2 PMST	Absent	Unlikely No suitable habitat for this species is

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			of Manly and one site is in the LGA of Warringah. Occurs in localised patches in or in close proximity to the endangered Duffys Forest ecological community. Located on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses, a soil type which only occurs on ridge tops and has been extensively urbanised.			present
<i>Pterostylis chaetophora</i>	-	V	In NSW it is currently known from c. 18 scattered locations in a relatively small area. It occurs in an area between Taree and Kurri Kurri, extending to the south-east towards Tea Gardens and west into the Upper Hunter, with additional records near Denman and Wingen. The preferred habitat of <i>Pterostylis chaetophora</i> is seasonally moist, dry sclerophyll forest with a grass and shrub understorey.	1	Map Unit 1 and 2	Low. Marginal habitat present and the species is highly restricted
Illawarra Greenhood <i>Pterostylis gibbosa</i>	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803).  All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage. In the Hunter region, the species grows in open woodland dominated by Narrow-leaved Ironbark ( <i>Eucalyptus crebra</i> ), Forest Red Gum ( <i>Eucalyptus tereticornis</i> ) and Black Cypress Pine ( <i>Callitris endlicheri</i> ).	0 PMST	Map Unit 1 and 2	Low  It is apparently extinct in western Sydney
Sydney Plains Greenhood <i>Pterostylis saxicola</i>	E	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated. Only one population occurs within a conservation reserve at Georges River National Park. Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where it occurs are sclerophyll forest or woodland on shale sandstone transition soils or shale soils.	2 PMST	Absent	Unlikely  No suitable habitat for this species is present

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Smooth Bush-pea ( <i>Pultenaea glabra</i> )	V	V	Restricted to the higher Blue Mountains and has been recorded from the Katoomba-Hazelbrook and Mount Victoria areas, with unconfirmed sightings in the Mount Wilson and Mount Irvine areas. All known populations occur within the Blue Mountains Local Government Area. Grows in swamp margins, hillslopes, gullies and creekbanks and occurs within dry sclerophyll forest and tall damp heath on sandstone.	0 PMST	Absent	Unlikely  No suitable habitat for this species is present
Sydney-bush Pea <i>Pultenaea parviflora</i>	E	E	Endemic to the Cumberland Plain the core distribution is from Windsor to Penrith and east to Dean Park. Outlier populations are recorded from Kemps Creek and Wilberforce. May be locally abundant, particularly within scrubby/dry heath areas of Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland. <i>Eucalyptus fibrosa</i> is usually the dominant canopy species. <i>Eucalyptus globoidea</i> , <i>E. longifolia</i> , <i>E. parramattensis</i> , <i>E. sclerophylla</i> and <i>E. sideroxylon</i> may also be present or co-dominant, with <i>Melaleuca decora</i> frequently forming a secondary canopy layer. Associated species may include <i>Allocasuarina littoralis</i> , <i>Angophora bakeri</i> , <i>Aristida</i> spp. <i>Banksia spinulosa</i> , <i>Cryptandra</i> spp., <i>Daviesia ulicifolia</i> , <i>Entolasia stricta</i> , <i>Hakea sericea</i> , <i>Lissanthe strigosa</i> , <i>Melaleuca nodosa</i> , <i>Ozothamnus diosmifolius</i> and <i>Themeda australis</i> .	353 PMST	Map Unit 1	Present  29 individuals were counted in the study area to the west of the Ropers Road interchange on both sides of the M4 Motorway.
Matted Bush-pea <i>Pultenaea pedunculata</i>	-	V	Widespread in Victoria, Tasmania, and south-eastern South Australia, However in NSW it is represented by just three disjunct populations on the Cumberland Plains in Sydney, the coast between Tathra and Bermagui and the Windellama area south of Goulburn. NSW populations are generally among woodland vegetation but plants have also been found on road batters and coastal cliffs. It is largely confined to loamy soils in dry gullies in populations in the Windellama area.	13	Map Unit 1 and 2	Low  This species is not known from north of Guildford in Sydney
<i>Pultenaea villifera</i>	-	E	An endangered population in Blue Mountains LGA. Has a patchy distribution within NSW,	12	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
(endangered population)		2	occurring within the South and Central Coasts and Southern Tablelands. The population of <i>P. villifera</i> in the Blue Mountains Local Government Area is disjunct from other known populations and occurs only at a few small sites in the Springwood-Woodford Area. One of these populations occurs within Blue Mountains National Park. Grows in dry sclerophyll forest and woodlands on sandy soil and appears to favour sheltered spots.			Study area outside Blue Mountains LGA
Eastern Australian Underground Orchid <i>Rhizanthella slateri</i>	E	V	Occurs from south-east Queensland to south-east NSW. In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. Habitat requirements are poorly understood and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest.	0 PMST	Map Unit 1 and 2	Low This species is not known from the study area
Whalebone Tree <i>Streblus brunonianus</i> (syn. <i>Streblus pendulinus</i> )	E	-	In warmer rainforest, chiefly along watercourses, north from Milton.	0 PMST	Absent	Unlikely No suitable habitat for this species is present
Magenta Lilly Pilly <i>Syzygium paniculatum</i>	V	V	The Magenta Lilly Pilly is found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State Forest. On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	15	Natural habitat absent. Planted in the study area	Present Six individuals were recorded outside the M4 corridor at Leonray Park, Emu Plains.
Glandular-pink Bell	V	V	Endemic to NSW, with around about 150 populations from Yengo National Park to Lane	8	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>Tetratheca glandulosa</i>			Cove National Park. Associates in areas with shale cappings over sandstone. Occurs in heath, scrublands to woodlands and open forest. Common woodland tree species include: <i>Corymbia gummifera</i> , <i>C. eximia</i> , <i>Eucalyptus haemastoma</i> , <i>E. punctata</i> , <i>E. racemosa</i> , and/or <i>E. sparsifolia</i> , with an understorey dominated by species from the families Proteaceae, Fabaceae, and Ericaceae.	PMST		No suitable habitat for this species is present
Black-eyed Susan <i>Tetratheca juncea</i>	V	V	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. It is usually found in low open forest/woodland with a mixed shrub understorey and grassy groundcover. However, it has also been recorded in heathland and moist forest. The majority of populations occur on low nutrient soils associated with the Awaba Soil Landscape. While the species has a preference for cooler southerly aspects, it has been found on slopes with a variety of aspects. It generally prefers well-drained sites and occurs on ridges, although it has also been found on upper slopes, mid-slopes and occasionally in gullies.	17	Absent	Unlikely  No suitable habitat for this species is present
Kangaloon Sun Orchid <i>Thelymitra sp. Kangaloon</i>	C E	C E	Only known to occur on the southern tablelands of NSW in the Moss Vale / Kangaloon / Fitzroy Falls area at 550-700 m above sea level. It is known to occur at three swamps that are above the Kangaloon Aquifer. It is found in swamps in sedgeland over grey silty grey loam soils	0 PMST	Absent	Unlikely  No suitable habitat for this species is present
Austral Toad-flax ( <i>Thesium australe</i> )	V	V	Austral Toad-flax is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Occurs in grassland or grassy woodland. Often found in damp sites in association with Kangaroo Grass ( <i>Themeda australis</i> ). A root parasite that takes water and some nutrient from other plants, especially Kangaroo Grass.	0 PMST	Map Unit 1 and 2	Low  This species is not known from the study area

Species	Status	TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC					
Creek Triplarina <i>Triplarina imbricata</i>	E	E	Found only in a few locations in the ranges south-west of Glenreagh and near Tabulam in north-east NSW. Along watercourses in low open forest with Water Gum ( <i>Tristaniopsis laurina</i> ).	4	Absent	Unlikely No suitable habitat for this species is present
Tadgell's Bluebell <i>Wahlenbergia multicaulis</i> (endangered population)	-	E 2	Endangered population in the in the local government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield LGAs. There are 13 known sites, two of which are in northern Sydney (i.e. Thornleigh and Mt Ku-Ring-Gai) with the remainder in western Sydney (e.g. at Rookwood, Chullora, Bass Hill, Bankstown, Georges Hall, Campsie, South Granville and Greenacre). In Western Sydney most sites are closely aligned with the Villawood Soil Series, which is a poorly drained, yellow podsolic extensively permeated with fine, concretionary ironstone (laterite). However, the sites in Hornsby LGA are on the 'Hawkesbury' soil landscape. Found in disturbed sites and grows in a variety of habitats including forest, woodland, scrub, grassland and the edges of watercourses and wetlands. Typically occurs in damp, disturbed sites (with natural or human disturbance of various forms), typically amongst other herbs rather than in the open. In Hornsby LGA it occurs in or adjacent to sandstone gully forest. In Western Sydney it is found in remnants of Cooks River/Castlereagh Ironbark Forest.	69	Absent	Unlikely No suitable Cooks River/Castlereagh Ironbark Forest is present.
Narrow-leaved Wilsonia <i>Wilsonia backhousei</i>	-	V	Found on the coast between Mimosa Rocks National Park and Wamberal north of Sydney. It grows in all southern states. This is a species of the margins of salt marshes and lakes, both coastal and inland.	96	Absent	Unlikely No suitable habitat for this species is present
<i>Zannichellia</i>	-	E	Known only from the lower Hunter, in NSW. Grows in fresh or slightly saline stationary or	4	Map Unit 4	Low. Habitat

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>palustris</i>			slowly flowing water.			marginal
<i>Zieria involuocrata</i>	V	E	Has a disjunct distribution north and west of Sydney, in the Baulkham Hills, Hawkesbury, Hornsby and Blue Mountains LGAs. Recent records for the species come from 22 populations in the catchments of the Macdonald, Colo and Hawkesbury Rivers—between Melon Creek and Mogo Creek in the north to Little Cattai Creek and Wheeny Creek in the south, and from a single population in the upper Blue Mountains north of Katoomba. Occurs primarily on Hawkesbury sandstone. Also occurs on Narrabeen Group sandstone and on Quaternary alluvium. Found primarily in sheltered forests on mid- to lower slopes and valleys, such as in or adjacent to gullies which support sheltered forest, however some populations extend upslope into drier vegetation. Also known from at least two atypical ridgetop locations. The canopy typically includes <i>Syncarpia glomulifera subsp. glomulifera</i> , <i>Angophora costata</i> , <i>Eucalyptus agglomerata</i> and <i>Allocasuarina torulosa</i> .	5	Map Unit 11	Low. habitat marginal
<p>* Distribution and habitat requirement information adapted from:</p> <ul style="list-style-type: none"> <li>Australian Government Department of Sustainability, Environment, Water, Populations and Community <a href="http://www.environment.gov.au/biodiversity/threatened/index.html">http://www.environment.gov.au/biodiversity/threatened/index.html</a></li> <li>NSW Office of Environment and Heritage <a href="http://www.environment.nsw.gov.au/threatenedspecies/">http://www.environment.nsw.gov.au/threatenedspecies/</a></li> <li>Department of Primary Industries – Threatened Fish and Marine Vegetation <a href="http://pas.dpi.nsw.gov.au/Species/All_Species.aspx">http://pas.dpi.nsw.gov.au/Species/All_Species.aspx</a></li> </ul> <p>+ Data source includes</p> <ul style="list-style-type: none"> <li>Number of records from the NSW Office of Environment and Heritage Wildlife Atlas record data (Accessed November 2012); and</li> <li>Identified from the Protected Matters Search Tool (PMST) Australian Government Department of Sustainability, Environment, Water, Populations and Community</li> </ul>						

Species	Status	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act			
<a href="http://www.environment.gov.au/epbc/pmst/index.html">http://www.environment.gov.au/epbc/pmst/index.html</a>					

**Table A-7-2 Known or potentially occurring threatened and migratory fauna species**

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<b>MAMMALS</b>						
Brush-tailed Rock Wallaby ( <i>Petrogale penicillata</i> )	E	E	Open forest habitats on steep terrain with exposed rocks, rock overhangs and platforms.	0 PMST	Map Unit 11	Low. habitat marginal
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii oceanensis</i> )	-	V	Occurs on east and north west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.	192	Potential habitat widespread	Present  A diurnal roost site was identified in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	-	V	Occurs in a variety of open forest and woodland habitats with hollow-bearing trees. Requires hollows for roosting. May forage in re-growth and modified environments.	25	Potential habitat widespread	Moderate  Likely to utilise all habitats in the study area
Eastern Freetail Bat ( <i>Mormopterus norfolkensis</i> )	-	V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in human-made	67	Potential habitat	Moderate  Likely to utilise

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			structures.		widespread	all habitats in the study area
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	-	V	Found in a broad range of habitats from rainforest through to wet and dry sclerophyll forest and woodland to heath, but in most areas woodlands and heath appear to be preferred.	3	Map Unit 11	Moderate Potentially utilises habitats on foothills west of Emu Plains
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	-	V	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings.	30	Potential habitat widespread	Moderate Likely to utilise all habitats in the study area
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	V	Forages on nectar and pollen in sclerophyll forests and on rainforest fruits and vines, orchards, gardens.	339 PMST	Potential habitat widespread	Moderate Likely to utilise all habitats in the study area
Koala ( <i>Phascolarctos cinereus</i> )	V	V	Open forests and woodlands with favoured food tree species.	29 PMST	Potential habitat present but no known populations	Low No known Koala populations exist in the study area and this species

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						was not recorded during surveys. Habitat for this species is poor quality.
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	V	Forages over a broad range of open forest and woodland habitats, this species is a cave roosting bat which favours sandstone escarpment habitats for roosting, in the form of shallow overhangs, crevices and caves.	7 PMST	Potential habitat mostly in west of study area	Moderate  Likely to utilise habitats on the Cumberland Plain including vegetation in the study area
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	-	V	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest	4	Potential habitat widespread	Moderate  Likely to utilise all habitats in the study area
Long-nosed Bandicoot ( <i>Perameles nasuta</i> ) – endangered population	-	E 2	An endangered population in inner western Sydney. The exact area occupied by the population is not clearly defined, and includes the local government areas (LGA) of Marrickville and Canada Bay, with the likelihood that it also includes Canterbury, Ashfield and Leichhardt LGAs. Future research may better define the population and possibly indicate a wider distribution. This population is disjunct from the nearest records of the Long-nosed Bandicoot, which occur north of the Parramatta River or much further south at Holsworthy	24	Potential habitat present	Unlikely  The study area occurs outside of the distribution of this population

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			<p>Military Reserve. Shelter mostly under older houses and buildings</p> <p>Forage in parkland and back-yards</p> <p>There are apparently no large blocks of suitable habitat, likely to support a large source population, on the Cooks River to the south, or along the southern foreshore of Parramatta River and Sydney Harbour to the north.</p>			which is the Marrickville and Canada Bay LGAs, with the likelihood that it also includes Canterbury, Ashfield and Leichhardt LGAs.
Long-nosed Potoroo ( <i>Potorous tridactylus</i> )	V	V	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	0 PMST	Potential habitat widespread	Unlikely This species is not known from the study area and habitat is disturbed
New Holland Mouse ( <i>Pseudomys novaehollandiae</i> )	V	-	Distribution is fragmented across all eastern states of Australia, where it inhabits open heath lands, open woodlands with heath understorey and vegetated sand dunes.	0 PMST	Absent	Unlikely No suitable habitat is present for this species
Southern Brown Bandicoot	E	E	Typically associated with coastal heaths or open forest habitats with a heathy	0	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>(Isoodon o. obesulus)</i>			understorey on sandy soils.	PMST		No suitable habitat is present for this species
Southern Myotis <i>(Myotis macropus)</i>	-	V	Generally roost in groups close to water in caves, mine shafts, hollow-bearing trees, and storm water channels, buildings, under bridges and in dense foliage. Forages over streams and pools catching insects and small fish.	55	Potential habitat widespread	Present A diurnal roost site was identified in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700
Spotted-tailed Quoll <i>(Dasyurus maculatus)</i>	E	V	Wet and dry sclerophyll forests and rainforests, and adjacent open agricultural areas. Generally associated with large expansive areas of habitat to sustain territory size. Requires hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	31 PMST	Potential habitat widespread	High Larger areas of high quality habitat west of Emu Plains
Squirrel Glider <i>(Petaurus norfolcensis)</i>	-	V	Forest and woodland habitats, particularly areas with a diversity of eucalypt species in the canopy and other suitable food resources (shrubs and small trees). Requires tree hollows for denning.	1	Map Unit 11	Moderate Potential habitat west of Emu Plains

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Yellow-bellied Glider ( <i>Petaurus australis</i> )	-	V	Tall open forest habitats, favours mature wet sclerophyll forest and dense gullies.	11	Map Unit 11	High Potential habitat west of Emu Plains
Yellow-bellied Sheathtail-bat ( <i>Saccolaimus flaviventris</i> )	-	V	Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. Roost in tree hollows and buildings.	9	Potential habitat widespread	Moderate Likely to utilise all habitats in the study area
<b>BIRDS</b>						
Australasian Bittern ( <i>Botaurus poiciloptilus</i> )	E	E	They are widespread but uncommon over south-eastern Australia. It extends mainly along the coasts of eastern Australia and is found all over NSW except for the far north west. It inhabits freshwater wetlands with tall dense vegetation where it feeds in shallow waters.	12 PMST	Map Unit 3 and 4	Low Wetland habitats generally in poor condition
Australian Fairy Tern ( <i>Sternula nereis nereis</i> )	V	-	Within Australia, the Fairy Tern occurs along the coasts of Victoria, Tasmania, South Australia and Western Australia; occurring as far north as the Dampier Archipelago near Karratha. The subspecies has been known from New South Wales (NSW) in the past, but it is unknown if it persists there. The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline. The bird roosts on beaches at night.	0 PMST	Absent	Unlikely No suitable habitat is present for this species

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Australian Painted Snipe ( <i>Rostratula benghalensis australis</i> )	V, M	E	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	2 PMST	Map Unit 3 and 4	Unlikely  Wetland habitats generally in poor condition
Barking Owl ( <i>Ninox connivens</i> )	-	V	Forest and woodland habitats, particularly drier western slopes and riverine areas, hunts for birds and small mammals.	9	Potential habitat widespread	Moderate  Potentially suitable habitat west of Emu Plains
Black Bittern ( <i>Ixobrychus flavicollis</i> )	-	V	Occurs from south NSW to Cape York, and extends to the Kimberley region. Inhabits terrestrial and estuarine wetlands, preferring permanent water and dense vegetation.	7	Map Unit 3 and 4	Low  Wetland habitats generally in poor condition
Black-chinned Honeyeater ( <i>Meliphreptus gularis</i> )	-	V	Woodland bird species, favour dry sclerophyll forests and woodlands, generally with a sparse understorey, grassy areas and logs.	1	Potential habitat widespread, particularly riparian zones	Low  While some potential habitat for this species is present it is rarely recorded east

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						of the Great Dividing Range and tends to occur in the largest woodland patches in the landscape.
Black-necked Stork ( <i>Ephippiorhynchus asiaticus</i> )	-	E	Open wetlands & adjoining agricultural areas.	4	Map Unit 3 and 4	Unlikely Wetland habitats generally in poor condition
Black-tailed Godwit ( <i>Limosa limosa</i> )	M	V	A migratory wading bird that breeds in Mongolia and Eastern Siberia and flies to Australia for the southern summer, arriving in August and leaving in March. In NSW, it is most frequently found at Kooragang Island (Hunter River estuary). Occurs in sheltered bays, estuaries and lagoons with large intertidal mudflats and sand flats. Also found at inland mudflats, swamps.	15	Absent	Unlikely No suitable habitat is present for this species
Broad-billed Sandpiper ( <i>Limicola falcinellus</i> )	-	V	Oceanic, marine and estuarine	2	Absent	Unlikely No suitable habitat is present for this species

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Bush-stone Curlew ( <i>Burhinus grallarius</i> )	V	E	Open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights. Feed on insects and small vertebrates, such as frogs, lizards and snakes. Nest on the ground in a scrape or small bare patch.	9	Map unit 1 and 2	Low No recent records of this species have been made in the study area. Habitat is disturbed
Cotton Pygmy-goose ( <i>Nettapus coromandelianus</i> )	-	E	Although once found from north Queensland to the Hunter River in NSW, the Cotton Pygmy-Goose is now only a rare visitor to NSW. Uncommon in Queensland. Occupies freshwater lakes, lagoons, swamps and dams, particularly those vegetated with waterlilies and other floating and submerged aquatic vegetation. The Cotton Pygmy-goose uses standing dead trees with hollows close to water for roosting and breeding.	3	Absent	Unlikely No suitable habitat is present for this species
Curlew Sandpiper ( <i>Calidris ferruginea</i> )	M	E	It is distributed along most of the Australian coastline. It occurs in littoral and estuarine habitats and intertidal mudflats and also non tidal lakes, swamps and lagoons. Sometimes found at inland freshwater wetlands.	356	Absent	Unlikely No suitable habitat is present for this species
Diamond Firetail ( <i>Stagonopleura guttata</i> )	-	V	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum ( <i>Eucalyptus pauciflora</i> ) Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.	4	Map Unit 1, 2 and 3	Low Needs high quality grassy woodland

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						habitat
Eastern Bristlebird ( <i>Dasyornis brachypterus</i> )	E	E	Habitat is characterised by dense, low vegetation including heath and open woodland with a heathy understorey; in northern NSW occurs in open forest with tussocky grass understorey; all of these vegetation types are fire prone.	0 PMST	Absent	Unlikely  No suitable habitat is present for this species
Eastern Curlew ( <i>Numenius madagascariensis</i> )	C E, M	-	Within Australia, the Eastern Curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass.	29 PMST	Absent	Unlikely  No suitable habitat is present for this species
Eastern Grass Owl ( <i>Tyto longimembris</i> )	-	V	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues. Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains.	1	Absent	Unlikely  No suitable habitat is present for this species
Eastern Osprey ( <i>Pandion haliaetus</i> )	-	V	Favour coastal areas, especially the mouths of large rivers, lagoons and lakes	2	Absent	Unlikely  No suitable habitat is present for this species

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Flame Robin ( <i>Petroica phoenicea</i> )	-	V	Breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes. Prefers clearings or areas with an open understorey.	7	Map Unit 1, 2, 3 and 11	Moderate  Dispersing non breeding birds may occur in habitats of study area mainly west of Emu Plains
Freckled Duck ( <i>Stictonetta naevosa</i> )	-	V	Open wetlands & adjoining agricultural areas.	3	Map unit 1 and 2	Unlikely  Wetland habitats generally in poor condition
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	-	V	Occurs within a variety of forest and woodland types. Usually frequents forested areas with old growth attributes required for nesting and roosting purposes.	294	Map Unit 111	High  Prefers forested areas with mature trees for foraging and roosting
Glossy Black-Cockatoo	-	V	Open forest habitats with She-oak species ( <i>Allocasuarina</i> spp.) required for food.	21	Map Unit 111	High  Feed trees

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>(Calyptorhynchus latham)</i>						observed with potential breeding habitat west of Emu Plains
Great Knot <i>(Calidris tenuirostris)</i>	M	V	Oceanic, marine and estuarine	2	Absent	Unlikely No suitable habitat is present for this species
Greater Sand Plover <i>(Charadrius leschenaultii)</i>	M	V	Oceanic, marine and estuarine	2	Absent	Unlikely No suitable habitat is present for this species
Hooded Robin <i>(Melanodryas c. cucullata)</i>	-	V	Woodland bird species, favour dry sclerophyll forests and woodlands, generally with a sparse understorey, grassy areas and logs.	1	Map Unit 1, 2 and 3	Low Needs high quality grassy woodland habitat. Study area lacks habitat structure

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Lesser Sand Plover ( <i>Charadrius mongolus</i> )	M	V	Oceanic, marine and estuarine		Absent	Unlikely No suitable habitat is present for this species
Little Eagle ( <i>Hieraaetus morphnoides</i> )	-	V	Occupies open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used.	26	Map Unit 1, 2, 3 and 11	Moderate This species may forage in the study area
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	-	V	Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in apples ( <i>angophora</i> sp.), paperbarks ( <i>melaleuca</i> sp.) and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open country (e.g. paddocks, roadside remnants) and urban trees also help sustain viable populations of the species.	15	Map Unit 1, 2, 3 and 11	Moderate This species may forage in the study area from time to time
Little Tern ( <i>Sterna albifrons</i> )	E	E	Oceanic, marine and estuarine	8	Absent	Unlikely No suitable habitat is present for this species
Masked Owl ( <i>Tyto novaehollandiae</i> )	-	V	Dry eucalypt forests and woodland, typically prefers open forest with low shrub density. Requires old trees for roosting and nesting	14	Map Unit 1, 2 and 3	Moderate Known from

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						Prospect Nature Reserve, this species may utilise habitat in the study area from time to time
Orange-bellied Parrot ( <i>Neophema chrysogaster</i> )	C E, M	C E	Coastal saltmarsh and strandline/foredune vegetation communities as well as pasture and weedy areas on the coast.	0 PMST	Absent	Unlikely  No suitable habitat is present for this species
Pied Oystercatcher ( <i>Haematopus longirostris</i> )	-	V	Oceanic, marine and estuarine	2	Absent	Unlikely  No suitable habitat is present for this species
Pink Robin ( <i>Petroica rodinogaster</i> )	-	V	The Pink Robin is found in Tasmania and the uplands of eastern Victoria and far south-eastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW. Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies.	1	Map Unit 1, 2 and 3	Low  Habitat is not optimal but vagrant individuals may utilise the

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						study area from time to time
Powerful Owl ( <i>Ninox strenua</i> )	-	V	Open forests with dense wet gullies and creek areas, requires large mature trees with hollows for breeding and dense areas of vegetation for prey and roosting	252	Map Unit 1, 2 and 3	Moderate Known from Prospect Nature Reserve, this species may utilise habitat in the study area from time to time
Red Goshawk ( <i>Erythrorichis radiatus</i> )	V	C E	This unique Australian endemic raptor is distributed sparsely through northern and eastern Australia, from the western Kimberley Division of northern Western Australia to north-eastern Queensland and south to far north-eastern NSW, and with scattered records in central Australia. The species is very rare in NSW, extending south to about 30°S, with most records north of this, in the Clarence River Catchment, and a few around the lower Richmond and Tweed Rivers. Formerly, it was at least occasionally reported as far south as Port Stephens. Red Goshawks inhabit open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water, and are often found in riparian habitats along or near watercourses or wetlands. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers.	0 PMST	Map Unit 3	Low In NSW, this species is restricted to the Hunter-Central Rivers and Northern Rivers regions. Does not occur in Sydney

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Regent Honeyeater ( <i>Anthochaera phrygia</i> )	E, M	E	A nomadic species typically associated with forest and woodland habitats with the presence of suitable foraging species such as Yellow Box ( <i>Eucalyptus melliodora</i> ) and Red Ironbark ( <i>Eucalyptus sideroxylon</i> ).	29	Map Unit 1, 2 and 3 and planted areas with feed trees	Low Dispersing individual non-breeding birds may visit the habitat in the study area from time to time when preferred foraging grounds are unproductive. Habitat is generally poor for this species
Sanderling ( <i>Calidris alba</i> )	-	V	A regular summer migrant from Siberia and other Arctic breeding grounds to most of the Australian coastline. It is uncommon to locally common, arriving from September and leaving by May (some may overwinter in Australia). Sanderlings occur along the NSW coast, with occasional inland sightings. Often found in coastal areas on low beaches of firm sand, near reefs and inlets, along tidal mudflats and bare open coastal lagoons; individuals are rarely recorded in near-coastal wetlands.	1	Absent	Unlikely No suitable habitat is present for this species
Scarlet Robin	-	V	The Scarlet Robin lives in dry eucalypt forests and woodlands. The	9	Map Unit 1,	Moderate

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>(Petroica boodang)</i>			understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and re-growth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps.		2, 3 and 11	Dispersing non breeding birds may occur in habitats of study area mainly west of Emu Plains
Sooty Owl <i>(Tyto tenebricosa)</i>	-	V	Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests.	4	Map Unit 1, 2 and 3	Unlikely No suitable rainforest or wet forest habitat is present
Sooty Oystercatcher <i>(Haematopus fuliginosus)</i>	-	V	Oceanic, marine and estuarine	1	Absent	Unlikely No suitable habitat is present for this species
Speckled Warbler <i>(Chthonicola sagittatus)</i>	-	V	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt re-growth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an	19	Map Unit 1, 2, 3 and 11	Moderate Dispersing non breeding birds may occur in habitats of

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
			area.			study area mainly west of Emu Plains
Spotted Harrier ( <i>Circus assimilis</i> )	-	V	Occurs throughout the Australian mainland and disperses into NSW as one single population. It occurs on grassy open woodland, inland riparian woodlands, grasslands and shrub steppe.	3	Absent	Low May fly over the study area from time to time but no suitable foraging, roosting or breeding habitat is present for this species
Square-tailed Kite ( <i>Lophoictinia isura</i> )	-	V	It is widely distributed to the coastal and sub-coastal area of Australia. Migrates to NSW in September for breeding. Occurs in dry woodlands and open forests, and timbered watercourses.	6	Map Unit 1 and 2	Low May fly over the study area from time to time but no suitable foraging, roosting or breeding

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						habitat is generally absent for this species
Superb Fruit-dove ( <i>Ptilinopus superbus</i> )	-	V	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms	7	Planted areas with fig trees	Low No rainforest habitat is present
Superb Parrot ( <i>Polytelis swainsonii</i> )	V	V	Occurs in eastern inland NSW. Inhabit Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest	2	Absent	Unlikely No suitable habitat is present for this species
Swift Parrot ( <i>Lathamus discolor</i> )	E, M	E	On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany ( <i>Eucalyptus robusta</i> ), Spotted Gum ( <i>Corymbia maculate</i> ), Red Bloodwood ( <i>C. Gummifera</i> ), Red Ironbark ( <i>E. sideroxylon</i> ), and White Box ( <i>E. albens</i> ).	46 PMST	Map Unit 1, 2 and 3 and planted areas with feed trees	Moderate Dispersing foraging individuals or small flocks may utilise the habitat in the study area in Winter
Terek Sandpiper	-	V	Oceanic, marine and estuarine	3	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>(Xenus cinereus)</i>						No suitable habitat is present for this species
Turquoise Parrot <i>(Neophema pulchella)</i>	-	V	Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	5	Map Unit 1, 2 and 3	Low Foraging and breeding habitat are absent from the study area
Varied Sittella <i>(Daphoenositta chrysoptera)</i>	-	V	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and acacia woodland.	53	Map Unit 1, 2 and 3	Moderate Likely to utilise habitat in the study area from time to time. Numerous recent records of this species exist near the study area
Wandering Albatross <i>(Diomedea exulans)</i>	V	E	Oceanic, marine and estuarine	1	Absent	Unlikely No suitable habitat is

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						present for this species
White-fronted Chat ( <i>Epthianura albifrons</i> ) – endangered population	-	E 2	An endangered population in the Sydney Metropolitan Catchment Management Area. Regularly observed in the saltmarsh of Newington Nature Reserve (with occasional sightings from other parts of Sydney Olympic Park and in grassland on the northern bank of the Parramatta River). Current estimates suggest this population consists of 8 individuals. Regularly observed in the saltmarsh and on the sandy shoreline of a small island of Towra Point Nature Reserve. This population is estimated to comprise 19-50 individuals.	211	Map Unit 4	Unlikely  In Sydney, restricted to a population at Newington Nature Reserve on the Parramatta River and a population at Towra Point Nature Reserve in Botany Bay.
<b>REPTILES</b>						
Broad-headed Snake ( <i>Hoplocephalus bungaroides</i> )	V	V	Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.	1 PMST	Map Unit 11	Moderate  May intermittently utilise habitats on foothills west of Emu Plains

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<b>AMPHIBIANS</b>						
Giant Barred Frog ( <i>Mixophyes iteratus</i> )	E	E	Forages and lives amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m. They breed around shallow, flowing rocky streams from late spring to summer.	0 PMST	Absent	Unlikely  No suitable habitat is present for this species
Giant Burrowing Frog ( <i>Heleioporus australiacus</i> )	V	V	Found in heath, woodland and open forest with sandy soils.	5 PMST	Absent	Unlikely  No suitable habitat is present for this species
Green and Golden Bell Frog ( <i>Litoria aurea</i> )	E	E	Ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by Typha and other aquatics, free from predatory fish.	12045 PMST	Map Unit 4	Low  Wetland habitats are generally unsuitable for this species and <i>Gambusia</i> is prevalent
Littlejohn's Tree Frog ( <i>Litoria littlejohni</i> )	V	V	It occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops.	0 PMST	Absent	Unlikely  No suitable habitat is

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						present for this species
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	-	V	It has restricted distribution from Pokolbin to Nowra and west to Mt Victoria. Occurs in open forests and wet drainage lines below sandstone ridges that often have shale lenses or cappings in the Hawkesbury and Narrabeen Sandstones.	61	Absent	Moderate May occur in foothills west of Emu Plains
Southern Bell Frog ( <i>Litoria raniformis</i> )	V	E	In NSW the species was once distributed along the Murray and Murrumbidgee Rivers and their tributaries, the southern slopes of the Monaro district and the central southern tablelands as far north as Tarana, near Bathurst. Currently, the species is known to exist only in isolated populations in the Coleambally Irrigation Area, the Lowbidgee floodplain and around Lake Victoria. A few yet unconfirmed records have also been made in the Murray Irrigation Area in recent years. The species is also found in Victoria, Tasmania and South Australia, where it has also become endangered. Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat.	0 PMST	Map Unit 3 and 4	Unlikely Not known from the Sydney area
Stuttering Frog ( <i>Mixophyes balbus</i> )	-	E	Permanent streams in moist and wet sclerophyll forests.	0 PMST	Map Unit 3 and 4	Unlikely No wet or rainforest habitat is present

Species	Status	Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area	
	EPBC TSC Act					
<b>INVERTEBRATE</b>						
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	-	E	Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	409	Map Unit 1 and 2	Present  Cumberland Plain Land Snails were confirmed at five locations in the study area
Giant Dragonfly ( <i>Petalura gigantea</i> )	-	E	Sedge swamps, freshwater wetlands and peat bogs.	1	Absent	Unlikely  No suitable habitat is present for this species
<b>FISH</b>						
Australian Grayling ( <i>Prototroctes maraena</i> )	V		The Australian Grayling has been recorded within the upper reaches of the Hawkesbury-Nepean River Catchment. It inhabits clear, flowing waters.	0 PMST	Map Unit 3 and 4	Unlikely  Not known from the study area. Habitat in waterways is degraded

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Black Cod ( <i>Epinephelus daemeli</i> )	V	V	In Australia, the distribution of black cod ranges from southern Queensland through NSW to northern Victoria. However, records from Queensland and Victoria are rare, and the NSW coastline forms the species' main range, both in Australia and internationally. The use of estuaries may be an important part of the ecology of juvenile black cod in NSW waters.	0 PMST	Map Unit 3 and 4	Unlikely  No suitable habitat is present in the study area. This species generally inhabit near-shore rocky and offshore coral reefs
Macquarie Perch ( <i>Macquaria australasica</i> )	E	E (F M Ac t)	Macquarie Perch has been recorded within the upper Reaches of the Hawkesbury –Nepean System.	0 PMST	Map Unit 3 and 4	Low  In NSW and they are now considered isolated to the upper reaches of the Lachlan and Murrumbidgee Rivers in southern NSW. A population exists in the Cataract Dam.

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<b>MIGRATORY MARINE SPECIES</b>						
Fork-tailed Swift ( <i>Apus pacificus</i> )	M	-	The species breeds in Asia and migrate to Australia in the summer from which they spend their entire life-cycle on the wing, hunting, resting and sleeping.	PMST	Potential habitat widespread	Moderate Likely to fly over the study area from October to March
Cattle Egret ( <i>Ardea ibis</i> )	M	-	Grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Often seen with cattle.	PMST	Potential habitat widespread	Moderate Likely to use open paddocks adjacent to the study area, No breeding habitat is present
<b>MIGRATORY TERRESTRIAL SPECIES</b>						
Black-faced Monarch ( <i>Monarcha melanopsis</i> )	M	-	Rainforests, moist eucalypt forests and coastal scrubs.	PMST	Map Unit 1, 2 and 3	Low No preferred habitat present. Mainly occurs in rainforest

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						ecosystems. Low chance of vagrant birds occurring in spring, summer and autumn
Rainbow Bee-eater ( <i>Merops ornatus</i> )	M	-	Predominantly woodland and timbered plains.	PMST	Map Unit 1, 2 and 3	Moderate May be present in the study area from August to early November. However, no breeding habitat is present
Rufous Fantail ( <i>Rhipidura rufifrons</i> )	M	-	Predominantly rainforests and wetter forests.	PMST	Map Unit 1, 2 and 3, and planted areas	Low No preferred habitat present. May pass through the study area on migration to and from

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						coastal lowlands and off-shore islands in south-east Queensland, north to Cape York Peninsula and Torres Strait Island.
Satin Flycatcher ( <i>Myiagra cyanoleuca</i> )	M	-	Predominantly forests, in particular thick vegetation in gullies.	PMST	Map Unit 1, 2 and 3	Low No preferred habitat present. May utilise the study area from time to time during migration
White-bellied Sea-eagle ( <i>Haliaeetus leucogaster</i> )	M	-	Predominantly ocean shores and estuaries, occasionally inland rivers and streams.	PMST	Map Unit 3	Moderate This species may fly over the study area from time to time. May

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						forage in Nepean River.
White-throated Needletail ( <i>Hirundapus caudacutus</i> )	M	-	An aerial foraging species which occupies a range of habitats from open modified landscapes to woodland and forest.	PMST	Potential habitat widespread	Moderate Likely to fly over the study area during October and November
<b>MIGRATORY WETLAND SPECIES</b>						
Great Egret ( <i>Ardea modesta</i> )	M	-	A wide range of wetland habitats including swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs.	PMST	Map Unit 3 and 4	Moderate May occasionally occur in wetlands in the study area
Bar-tailed Godwit ( <i>Limosa lapponica</i> )	M	-	Mudflats and beaches.	PMST	Absent	Unlikely No suitable habitat is present for this species
Double-banded Plover	M	-	Coastal beaches, mudflats, sewage farms, river banks, fields, dunes, upland	PMST	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
<i>(Charadrius bicinctus)</i>			tussock grasses and shingle.			No suitable habitat is present for this species
Eastern Curlew <i>(Numenius madagascariensis)</i>	M	-	Intertidal mudflats and sandflats, often with beds of seagrass, on sheltered coasts, especially estuaries, mangrove swamps, bays, harbours and lagoons.	PMST	Absent	Unlikely No suitable habitat is present for this species
Grey-tailed Tattler <i>(Heteroscelus brevipes)</i>	M	-	Sheltered coasts with reefs and rock platforms or with intertidal mudflats	PMST	Absent	Unlikely No suitable habitat is present for this species
Latham's Snipe <i>(Gallinago hardwickii)</i>	M	-	Wetlands, wet meadows, flooded grassy paddocks, open grassland and drainage areas.	PMST	Map Unit 3 and 4	Moderate May occur in wetlands from July to November
Little Curlew <i>(Numenius minutus)</i>	M	-	Coastal and inland grasslands and black soil plains in northern Australia near swamps and flooded areas. They also feed on playing fields, paddocks and urban lawns.	PMST	Absent	Unlikely No suitable habitat is present for this

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
						species
Marsh Sandpiper ( <i>Tringa stagnatilis</i> )	M	-	Fresh or brackish (slightly salty) wetlands such as rivers, water meadows, sewage farms, drains, lagoons and swamps.	PMST	Absent	Unlikely No suitable habitat is present for this species
Pacific Golden Plover ( <i>Pluvialis fulva</i> )	M	-	Fields, beaches and tidal flats.	PMST	Absent	Unlikely No suitable habitat is present for this species
Red Knot ( <i>Calidris canutus</i> )	M	-	Coastal mudflats.	PMST	Absent	Unlikely No suitable habitat is present for this species
Ruddy Turnstone ( <i>Arenaria interpres</i> )	M	-	Coastline and only occasionally inland. They are mainly found on exposed rocks or reefs, often with shallow pools, and on beaches.	PMST	Absent	Unlikely No suitable habitat is present for this species

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Sharp-tailed Sandpiper ( <i>Calidris acuminata</i> )	M	-	Grasslands and mudflats.	PMST	Absent	Unlikely No suitable habitat is present for this species
Whimbrel ( <i>Numenius phaeopus</i> )	M	-	Mudflats and beaches.	PMST	Absent	Unlikely No suitable habitat is present for this species
<p>* Distribution and habitat requirement information adapted from:</p> <ul style="list-style-type: none"> <li>Australian Government Department of the Environment <a href="http://www.environment.gov.au/biodiversity/threatened/index.html">http://www.environment.gov.au/biodiversity/threatened/index.html</a></li> <li>NSW Office of Environment and Heritage <a href="http://www.environment.nsw.gov.au/threatenedspecies/">http://www.environment.nsw.gov.au/threatenedspecies/</a></li> <li>Department of Primary Industries – Threatened Fish and Marine Vegetation <a href="http://pas.dpi.nsw.gov.au/Species/All_Species.aspx">http://pas.dpi.nsw.gov.au/Species/All_Species.aspx</a></li> </ul> <p>+ Data source includes</p> <ul style="list-style-type: none"> <li>Number of records from the NSW Office of Environment and Heritage Wildlife Atlas record data (Accessed November 2012); and</li> <li>Identified from the Protected Matters Search Tool (PMST) Australian Government Department of Sustainability, Environment, Water, Populations and Community <a href="http://www.environment.gov.au/epbc/pmst/index.html">http://www.environment.gov.au/epbc/pmst/index.html</a></li> </ul>						

Species	Status		Distribution and habitat requirements*	Number of records/ Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC	TSC Act				
Key						
E = endangered species						
E2 = endangered population						
V = vulnerable species						
M = migratory species						

■ **Table A-4 Threatened ecological communities known from the region and recorded in the study area**

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
Castlereagh Swamp Woodland Community (Endangered)	-	No. This community is not present in the study area. Restricted to the Castlereagh and Holsworthy areas (also in the Kemps Creek area) on deposits from ancient river systems (alluvium) along current intermittent creek lines. Often present in poorly drained depressions.
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	No. This community is not present in the study area. This community occurs in the intertidal zone along the NSW coast.
Cooks River/ Castlereagh Ironbark Forest in the Sydney Basin Bioregion (Endangered)	-	No. This community is not present in the study area. The most extensive stands of this community occur in the

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
		Castlereagh and Holsworthy areas. Smaller remnants occur in the Kemps Creek area. Mainly occurs on clay soils derived from the deposits of ancient river systems (alluvium), or on shale soils of the Wianamatta Shales.
Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered)	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered)	Present. Occurs on soils derived from Wianamatta Shale. Present throughout the study area as small remnants and predominantly in revegetation areas where this community has been planted after creation of the M4 motorway.
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	Present. Known from along the majority of the NSW coast. Associated with coastal areas subject to periodic flooding and in which standing fresh water persists for at least part of the year. Some wetlands in the study area are likely to have been created as drains and detention basins.
Moist Shale Woodland in the Sydney Basin Bioregion (Endangered)	-	No. This community is not present in the study area. While similar to Cumberland Plain Woodland, Moist Shale Woodland usually occurs on soils derived from Wianamatta Shale on high country in the southern half of the Cumberland Plain, and occurs mainly in Wollondilly local government area. Also occurs in smaller amounts further north in the Camden, Campbelltown, Fairfield, Liverpool and Penrith local government areas.
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner	-	Present.

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
Bioregions (Endangered)		Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. Present in the study area as remnant vegetation along drainage lines.
Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered)	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered)	Present. Mainly found in the northern section of the Cumberland Plain, western Sydney, in the Richmond, Marsden Park and Windsor districts. Occurs primarily where shallow deposits from ancient river systems overlay shale soils, but also associated with localised concentrations of iron-hardened gravel. Present in the study areas as revegetation where this community has been planted after creation of the M4 motorway. Natural remnants exist around the Roper Road interchange and support four threatened flora species <i>Grevillea juniperina</i> , <i>Dillwynia tenuifolia</i> , <i>Pultenaea parviflora</i> and <i>Acacia pubescens</i> , and the Cumberland Plain Land Snail.
Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Critically Endangered)	Shale Sandstone Transition Forest (Critically Endangered)	Present. Occurs at the edges of the Cumberland Plain, where clay soils from the shale rock intergrade with earthy and sandy soils from sandstone, or where shale caps overlay sandstone. Present in the study area as remnant vegetation west of Emu Plains on the foothills of the Blue Mountains and as revegetation where this community has been planted after creation of the M4 motorway. No threatened flora species were recorded in this community, however this community provides habitat for numerous threatened fauna species occurring as larger contiguous

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
		patches of habitat.
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	No. This community is not present in the study area. This community is found on the coastal floodplains of NSW. It has a dense to sparse tree layer in which <i>Casuarina glauca</i> (swamp oak) is the dominant species occurring on saline sub-soils.
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	-	No. This community is not present in the study area. A dry vine scrub community of the Cumberland Plain. Very restricted and occurs most commonly in the far southern section of the Cumberland Plain, in the Razorback Range near Picton.



Group	Family	Scientific name	Common name	Floristic plots																		
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	ADIANTACEAE	<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	Poison Rock Fern								1	1	1							1	1	
	ADIANTACEAE	<i>Pellaea falcata</i> var. <i>falcata</i>	Sickle Fern											1								
	DAVALLIACEAE	<i>Nephrolepis cordifolia</i>	Fishbone Fern	i																		
	DENNSTAEDTIACEAE	<i>Pteridium esculentum</i>	Bracken																			
	MARSILEACEAE	<i>Marsilea hirsuta</i>	Hairy Nardoo																			
<b>Dicotyledons</b>																						
	ACANTHACEAE	<i>Avicennia marina</i>	Grey Mangrove																			
	ACANTHACEAE	<i>Brunoniella australis</i>	Blue Trumpet																			
	ACANTHACEAE	<i>Pseuderanthemum variabile</i>	Pseuderanthemum				1										1					
	AIZOACEAE	<i>Aptenia cordifolia</i>	Baby Sun Rose	i																		
	AIZOACEAE	<i>Galenia pubescens</i>	Galenia	i																		
	AIZOACEAE	<i>Tetragonia tetragonioides</i>	New Zealand Spinach																1			
	ALTINGIACEAE	<i>Liquidambar styraciflua</i>	Liquid Amber	i																		







Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	ASTERACEAE	<i>Xerochrysum bracteatum</i>	Golden Everlasting																	
	BASELLACEAE	<i>Anredera cordifolia</i>	Madeira Vine	ix																
	BIGNONIACEAE	<i>Jacaranda mimosifolia</i>	Jacaranda	i	1															
	BIGNONIACEAE	<i>Tecoma capensis</i>	Cape Honeysuckle	i																
	BIGNONIACEAE	<i>Tecoma stans</i>	Yellow Bells	i																
	BRASSICACEAE	<i>Lepidium africanus</i>	Peppergrass	i																
	BRASSICACEAE	<i>Rorippa laciniata</i>	Watercress	i																
	CACTACEAE	<i>Opuntia ficus-indica</i>	Indian Fig	i	1	1						1		1						
	CAMPANULACEAE	<i>Wahlenbergia communis</i>	Tufted Bluebell				1													
	CAMPANULACEAE	<i>Wahlenbergia gracilis</i>	Sprawling Bluebell								1									
	CAMPANULACEAE	<i>Wahlenbergia spp.</i>	Bluebell																	
	CAMPANULACEAE	<i>Wahlenbergia stricta</i>	Tall Bluebell																	
	CAPRIFOLIACEAE	<i>Lonicera japonica</i>	Honeysuckle	i																
	CARYOPHYLLACEAE	<i>Polycarpon tetraphyllum</i>	Four-leaved Allseed																	
	CARYOPHYLLACEAE	<i>Stellaria media</i>	Common Chickweed	i																

Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	CASUARINACEAE	<i>Allocasuarina littoralis</i>	Black She-oak	1	1		1					1					1	1	1	
	CASUARINACEAE	<i>Allocasuarina torulosa</i>	Forest Oak																	
	CASUARINACEAE	<i>Casuarina cunninghamiana</i>	River Oak																	
	CASUARINACEAE	<i>Casuarina glauca</i>	Swamp Oak							1			1							
	CHENOPODIACEAE	<i>Atriplex semibaccata</i>	Creeping Saltbush																	
	CHENOPODIACEAE	<i>Chenopodium album</i>	Fat Hen	i																
	CHENOPODIACEAE	<i>Einadia hastata</i>	Shrubby Berry-saltbush		1				1								1			
	CHENOPODIACEAE	<i>Einadia nutans</i> subsp. <i>linifolia</i>	Narrow-leaf Berry-saltbush																	
	CHENOPODIACEAE	<i>Einadia nutans</i> subsp. <i>nutans</i>	Climbing Berry-saltbush																	
	CHENOPODIACEAE	<i>Einadia polygonoides</i>																		
	CHENOPODIACEAE	<i>Einadia trigonos</i>	Fishweed							1		1								
	CLUSIACEAE	<i>Hypericum gramineum</i>	Narrow-leaf St. Johns Wort																	
	CLUSIACEAE	<i>Hypericum perforatum</i>	St. Johns Wort	ix				1	1											
	CONVOLVULACEAE	<i>Convolvulus erubescens</i>	Blushing Blindweed							1										
	CONVOLVULACEAE	<i>Dichondra repens</i>	Kidney Weed		1		1	1		1	1	1		1		1	1		1	



Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	FABACEAE-FABOIDEAE	<i>Daviesia ulicifolia</i>	Gorse Bitter-pea				1				1	1						1		
	FABACEAE-FABOIDEAE	<i>Desmodium gunnii</i>	Slender Tick Trefoil																	
	FABACEAE-FABOIDEAE	<i>Desmodium rhytidophyllum</i>	Rusty Tick-trefoil																	
	FABACEAE-FABOIDEAE	<i>Desmodium varians</i>	Slender Tick-trefoil				1		1			1								
	FABACEAE-FABOIDEAE	<i>Dillwynia sieberi</i>	Prickly Parrot-pea								1				1					
	FABACEAE-FABOIDEAE	<i>Dillwynia tenuifolia</i>		t							1	1								
	FABACEAE-FABOIDEAE	<i>Genista momspessulana</i>	Montpellier Broom	i																
	FABACEAE-FABOIDEAE	<i>Glycine clandestina</i> agg.	Twining Glycine		1							1						1		
	FABACEAE-FABOIDEAE	<i>Glycine microphylla</i>	Small-leaf Glycine															1		
	FABACEAE-FABOIDEAE	<i>Glycine sp.</i>							1											
	FABACEAE-FABOIDEAE	<i>Glycine tabacina</i> agg.			1	1	1	1		1	1									
	FABACEAE-FABOIDEAE	<i>Glycine tomentella</i>	Wooly Glycine																	
	FABACEAE-FABOIDEAE	<i>Gompholobium pinnatum</i>	Pinnate Wedge-pea																	
	FABACEAE-FABOIDEAE	<i>Hardenbergia violacea</i>	Purple Twining-pea				1				1						1			
	FABACEAE-FABOIDEAE	<i>Hovea linearis</i>																1		







Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		<i>hederacea</i>																		
	GOODENIACEAE	<i>Goodenia ovata</i>	Ovate Goodenia																	
	GOODENIACEAE	<i>Goodenia paniculata</i>	Panicled Goodenia																	
	GOODENIACEAE	<i>Scaevola albida</i>	Pale Fan-flower																	
	HALORAGACEAE	<i>Halorgis heterophylla</i>	Variable Raspwort																	
	LAMIACEAE	<i>Ajuga australis</i>	Austral Bugle														1			
	LAMIACEAE	<i>Plectranthus parviflorus</i>	Cockspur Flower						1											
	LAMIACEAE	<i>Prostanthera scutellarioides</i>																		
	LAMIACEAE	<i>Stachys arvensis</i>	Stagger Weed	i																
	LAMIACEAE	<i>Westringia fruticosa</i>	Coast Rosemary	n																
	LAURACEAE	<i>Cassytha pubescens</i>	Devils Twine									1								
	LAURACEAE	<i>Cinnamomum camphora</i>	Camphor Laurel	i																
	LINACEAE	<i>Linum trigynum</i>	French Flax	i	1															
	LOBELIACEAE	<i>Lobelia alata</i>	Angled Lobelia																	
	LOBELIACEAE	<i>Pratia purpurescens</i>	White Root									1		1	1				1	1
	LORANTHACEAE	<i>Amyema gaudichaudii</i>	Paperbark Mistletoe																	





Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	MYRTACEAE	<i>Corymbia eximia</i>	Yellow Bloodwood																1	1
	MYRTACEAE	<i>Corymbia gummifera</i>	Red Bloodwood																	
	MYRTACEAE	<i>Corymbia maculata</i>	Spotted Gum						1											
	MYRTACEAE	<i>Eucalyptus amplifolia</i>	Cabbage Gum																	
	MYRTACEAE	<i>Eucalyptus baueriana</i>	Blue Box																	
	MYRTACEAE	<i>Eucalyptus bosistoana</i>	Coast Grey Box																	
	MYRTACEAE	<i>Eucalyptus botryoides</i>	Bangalay	n					1											
	MYRTACEAE	<i>Eucalyptus crebra</i>	Narrow-leaf Ironbark		1	1													1	1
	MYRTACEAE	<i>Eucalyptus eugenoides</i>	Thin-leaved Stringybark																1	1
	MYRTACEAE	<i>Eucalyptus fibrosa</i>	Broad-leaf Ironbark				1			1	1	1				1				
	MYRTACEAE	<i>Eucalyptus globoidea</i>	White Stringybark																	
	MYRTACEAE	<i>Eucalyptus globulus</i>	Tasmanian Blue Gum	n																
	MYRTACEAE	<i>Eucalyptus grandis</i>	Flooded Gum	n																
	MYRTACEAE	<i>Eucalyptus longifolia</i>	Woollybutt							1						1				
	MYRTACEAE	<i>Eucalyptus melliodora</i>	Yellow Box	n																



Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	MYRTACEAE	<i>Eucalyptus tereticornis</i>	Forest Red Gum		1	1	1	1		1	1	1					1			
	MYRTACEAE	<i>Kunzea ambigua</i>	Tick Bush				1													1
	MYRTACEAE	<i>Leptospermum pertersonii</i>	Lemon-scented Tea-tree	n																
	MYRTACEAE	<i>Leptospermum polygalifolium</i>	Yellow Tea-tree																	
	MYRTACEAE	<i>Lophostemon confertus</i>	Brush Box	n																
	MYRTACEAE	<i>Melaleuca armillaris</i>	Coast Paperbark	n																
	MYRTACEAE	<i>Melaleuca bracteata</i>	Black Tea-tree	n																
	MYRTACEAE	<i>Melaleuca decora</i>	White Feather Honey-myrtle									1	1				1	1		
	MYRTACEAE	<i>Melaleuca erubescens</i>																		
	MYRTACEAE	<i>Melaleuca lanceolata</i>		n																
	MYRTACEAE	<i>Melaleuca linariifolia</i>	Snow-in-Summer				1	1		1	1									
	MYRTACEAE	<i>Melaleuca nodosa</i>	Ball Honey-myrtle									1	1				1			
	MYRTACEAE	<i>Melaleuca parvistaminea</i>		n																
	MYRTACEAE	<i>Melaleuca quinquenervia</i>	Broad-leaved Paperbark																	
	MYRTACEAE	<i>Melaleuca styphelioides</i>	Prickly Paperbark			1				1										







Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	RANUNCULACEAE	<i>Clematis aristata</i>	Toothed Clematis							1					1					
	RANUNCULACEAE	<i>Ranunculus inundatus</i>	River Buttercup																	
	RHAMNACEAE	<i>Alphitonia excelsa</i>	Red Ash																	
	RHAMNACEAE	<i>Cryptandra amara</i> var. <i>Amara</i>										1								
	RHAMNACEAE	<i>Cryptandra spinescens</i>	Spiny Cryptandra																	
	ROSACEAE	<i>Photinia glabra</i>	Japanese Photinia	i																
	ROSACEAE	<i>Rubus fruticosus</i> agg.	Blackberry	ix					1				1	1				1		
	RUBIACEAE	<i>Asperula conferta</i>	Common Woodruff		1															
	RUBIACEAE	<i>Galium aparine</i>	Cleavers	i					1								1			
	RUBIACEAE	<i>Galium leiocarpum</i>	Bedstraw																	
	RUBIACEAE	<i>Opercularia diphylla</i>	Stinkweed					1				1			1					
	RUBIACEAE	<i>Pomax umbellata</i>	Pomax																1	1
	RUBIACEAE	<i>Richardia brasiliensis</i>	Mexican Clover	i																
	RUBIACEAE	<i>Richardia stellaris</i>		i				1	1											
	RUTACEAE	<i>Boronia polygalifolia</i>	Waxy Boronia																	

















Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	POACEAE	<i>Panicum simile</i>	Two-colour Panic									1						1		
	POACEAE	<i>Paspalidium distans</i>	Paspalidium				1			1		1	1	1		1			1	
	POACEAE	<i>Paspalum dilatatum</i>	Paspalum	i				1	1		1				1					
	POACEAE	<i>Paspalum urvillei</i>	Vasey Grass	i	1					1										
	POACEAE	<i>Pennisetum alopecuroides</i>	Swamp Foxtail Grass	n																
	POACEAE	<i>Pennisetum clandestinum</i>	Kikuyu	i																
	POACEAE	<i>Phragmites australis</i>	Common Reed																	
	POACEAE	<i>Rytidosperma pilosum</i>	Smooth-flower Wallaby Grass																	
	POACEAE	<i>Rytidosperma tenuius</i>	Wallby Grass		1							1				1				
	POACEAE	<i>Setaria gracilis</i>	Slender Pigeon Grass	i			1		1	1	1	1	1	1		1			1	
	POACEAE	<i>Setaria sphacelata</i>	South African Pigeon Grass	i				1												
	POACEAE	<i>Sorghum halepense</i>	Johnson Grass	ix																
	POACEAE	<i>Sporobolus africanus</i>	Parramatta Grass	i																
	POACEAE	<i>Sporobolus elongatus</i>	Slender Rats Tail Grass		1	1		1					1		1					
	POACEAE	<i>Stenotaphrum secundatum</i>	Buffalo Grass	i																

Group	Family	Scientific name	Common name	Floristic plots																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	POACEAE	<i>Themeda australis</i>	Kangaroo Grass	1	1	1	1	1		1		1	1			1			1	1
	POTAMOGETONACEAE	<i>Potamogeton tricarinatus</i>	Floating Pondweed																	
	TYPHACEAE	<i>Typha orientalis</i>	Broad-leaf Cumbungi																	
	XANTHORRHOEACEAE	<i>Xanthorrhoea minor subsp. minor</i>	A Grass Tree																	

## Appendix C Fauna species inventory

### NOTES ON SYMBOLS USED IN THE TABLE

Nomenclature follows Stanger et al (1997)

AMBS (2003): Results of a comprehensive seasonal fauna survey at the Defence Establishment Orchard Hills located to the south of the M4 along The Northern Road, in the remnant woodland habitat less than 1 kilometre from the current study area.

#### Fauna Habitats as per Section 3.3.1:

**A - Planted native landscape**

**B – Remnant or regrowth open forest/woodland**

**C – Riparian habitat**

**D – Aquatic habitat**

(E) endangered species

(V) vulnerable species

M migratory species listed in the EPBC Act

\* introduced species

FAMILY/Scientific Name	Common Name	Status		A	B	C	D	AMBS (2003)
		TSC Act	EPBC Act					
<b>MAMMALIA</b>								
PETAURIDAE								
<i>Petaurus breviceps</i>	Sugar Glider							•
PHALANGERIDAE								
<i>Trichosurus vulpecula</i>	Common Brushtail Possum							•
MACROPODIDAE								
<i>Macropus aiqanteus</i>	Eastern Grey Kangaroo			•				•
<i>Macropus rufogriseus</i>	Red-necked Wallaby							•
MURIDAE								
<i>Rattus rattus</i> *	Black Rat				•			
<i>Mus musculus</i> *	House Mouse							•
CANIDAE								
<i>Canis familiaris</i> *	Dog				•			•
<i>Vulpes vulpes</i> *	Fox				•			•
BOVIDAE								
<i>Capra hircus</i> *	Goat							•
SUIDAE								
<i>Sus scrofa</i> *	Pig							•

FAMILY/Scientific Name	Common Name	Status		A	B	C	D	AMBS (2003)
		TSC Act	EPBC Act					
<b>LEPORIDAE</b>								
<i>Lepus capensis</i> *	Brown Hare							•
<i>Oryctolagus cuniculus</i> *	Rabbit			•				•
<b>BOVIDAE</b>								
<i>Bos taurus</i> *	Cattle			•				•
<b>MOLOSSIDAE</b>								
<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat	V						•
<i>Nvctinomus australis</i>	White-striped Freetail-bat							•
<b>VESPERTILIONIDAE</b>								
<i>Miniopterus schreibersii</i>	Large Bent-wing Bat	V				•		
<i>Myotis macropus</i>	Southern Myotis	V				•		
<i>Chalinolobus aouldii</i>	Gould's Wattled Bat							•
<i>Chalinolobus morio</i>	Chocolate Wattled Bat							•
<i>Vespadelus vulturnus</i>	Little Forest Bat							•
<b>REPTILIA</b>								
<b>CHELIDAE</b>								
<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle							•
<b>AGAMIDAE</b>								
<i>Amphibolurus muricatus</i>	Jacky lizard				•			•
<i>Poocna barbata</i>	Bearded Dragon							•
<b>VARANIDAE</b>								
<i>Varanus varius</i>	Lace Monitor							•
<b>SCINCIDAE</b>								
<i>Cryptoblepharus virgatus</i>	Cream-striped Shinning-skink			•	•			•
<i>Ctenotus taeniolatus</i>	Copper-tailed Skink							•
<i>Eulamprus quoyii</i>	Eastern Water Skink							•
<i>Lampropholis delicata</i>	Delicate Skink				•			•
<i>Lampropholis quichenoti</i>	Grass Skink				•			•
<i>Tiliqua scincoides</i>	Eastern Blue-tongued Lizard			•				
<b>ELAPIDAE</b>								
<i>Demansia psammophis</i>	Yellow-faced Whip Snake			•				
<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake			•	•			•
<b>AMPHIBIA</b>								
<b>MYOBATRACHIDAE</b>								
<i>Crinia signifera</i>	Common Eastern Froglet			•	•			•
<i>Limnodynastes peronii</i>	Striped Marsh Frog							•
<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog				•			
<i>Pseudophryne bibronii</i>	Brown Toadlet			•	•			
<i>Uperoleia laevisata</i>	Smooth Toadlet			•				
<b>HYLIDAE</b>								
<i>Litoria fallax</i>	Eastern Dwarf Tree Frog							•
<i>Litoria latopalmata</i>	Broad-palmed Frog							•
<i>Litoria peronii</i>	Peron's Tree Frog							•
<b>AVES</b>								

FAMILY/Scientific Name	Common Name	Status		A	B	C	D	AMBS (2003)
		TSC Act	EPBC Act					
PHASIANIDAE								
<i>Coturnix australis</i>	Brown Quail							•
TURNICIDAE								
<i>Turnix varius</i>	Painted Button-quail							•
ANATIDAE								
<i>Chenonetta jubata</i>	Australian Wood Duck							•
<i>Anas superciliosa</i>	Pacific Black Duck							•
<i>Avthya australis</i>	Hardhead							•
PODICIPEDIDAE								
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe							•
PHALACROCORACIDAE								
<i>Phalacrocorax varius</i>	Pied Cormorant							•
<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant							•
ARDEIDAE								
<i>Ardea pacifica</i>	White-necked Heron							•
<i>Eareta novaehollandiae</i>	White-faced Heron							•
<i>Nvcticorax caledonicus</i>	Nankeen Night Heron							•
THRESKIORNITHIDAE								
<i>Threskiornis molucca</i>	Australian White Ibis							•
<i>Threskiornis spinicollis</i>	Straw-necked Ibis							•
<i>Platalea regia</i>	Royal Spoonbill							•
<i>Platalea flavipes</i>	Yellow-billed Spoonbill							•
ACCIPITRIDAE								
<i>Elanus notatus</i>	Black-shouldered Kite							•
<i>Haliastur sphenurus</i>	Whistling Kite				•			
<i>Aquila audax</i>	Wedge-tailed Eagle							•
FALCONIDAE								
<i>Falco cenchroides</i>	Nankeen Kestrel				•	•		
RALLIDAE								
<i>Porphyrion porphyrio</i>	Purple Swamphen							•
<i>Fulica atra</i>	Eurasian Coot							•
<i>Gallinago hardwickii</i>	Latham's Snipe		M					•
BURHINIDAE								
<i>Burhinus orallarius</i>	Bush Stone-curlew	E						•
CHARADRIIDAE								
<i>Vanellus miles</i>	Masked Lapwing							•
COLUMBIDAE								
<i>Streptopelia chinensis</i> *	Spotted Turtledove				•			•
<i>Geopelia striata</i>	Peaceful Dove							•
<i>Phaps chalcoptera</i>	Common Bronzewing							•
<i>Ocyphaps lophotes</i>	Crested Pigeon				•			•
CACATUIDAE								
<i>Cacatua roseicapilla</i>	Galah				•			•
<i>Cacatua alalerita</i>	Sulphur-crested Cockatoo				•			•
<i>Cacatua sanguinea</i>	Little Corella				•	•		•

FAMILY/Scientific Name	Common Name	Status				A	B	C	D	AMBS (2003)
		TSC Act	EPBC Act							
PSITTACIDAE										
<i>Tricholossus haematodus</i>	Rainbow Lorikeet					•				
<i>Platycercus eximius</i>	Eastern Rosella									•
<i>Psephotus haematonotus</i>	Red-rumped Parrot					•	•			•
CUCULIDAE										
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo						•			
<i>Cuculus pallidus</i>	Pallid Cuckoo									•
<i>Eudynamis scolopacea</i>	Common Koel									•
TYTONIDAE										
<i>Tyto alba</i>	Barn Owl									•
PODARGIDAE										
<i>Podargus striatoides</i>	Tawny Frogmouth									•
HALCYONIDAE										
<i>Dacelo novaeguineae</i>	Laughing Kookaburra									•
<i>Todiramphus sanctus</i>	Sacred Kingfisher									•
CORACIIDAE										
<i>Eurystomus orientalis</i>	Dollarbird									•
MALURIDAE										
<i>Malurus cyaneus</i>	Superb Fairy-wren					•	•	•		•
<i>Malurus lamberti</i>	Variiegated Fairy-wren						•			
PARDALOTIDAE										
<i>Pardalotus punctatus</i>	Spotted Pardalote						•			•
<i>Pardalotus striatus</i>	Striated Pardalote					•	•			
<i>Gerygone olivacea</i>	White-throated Gerygone					•				•
<i>Acanthiza pusilla</i>	Brown Thornbill					•				•
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill									•
<i>Acanthiza lineata</i>	Striated Thornbill						•			•
<i>Acanthiza nana</i>	Yellow Thornbill					•				
<i>Smicromis brevirostris</i>	Weebill									•
MELIPHAGIDAE										
<i>Anthochaera chrysoptera</i>	Little Wattlebird					•				
<i>Anthochaera carunculata</i>	Red Wattlebird						•			
<i>Philemon corniculatus</i>	Noisy Friarbird									•
<i>Manorina melanophrys</i>	Bell Miner						•	•		
<i>Manorina melanocephala</i>	Noisy Miner					•	•			•
<i>Meliphaga lewinii</i>	Lewin's Honeyeater						•			
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater						•			
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater					•				•
<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill					•	•			•
PETROICIDAE										
<i>Microeca leucophaea</i>	Jacky Winter									•
<i>Eopsaltria australis</i>	Eastern Yellow Robin						•			•
<i>Petroica rosea</i>	Rose Robin						•			
NEOSITTIDAE										
<i>Daophenositta chrysoptera</i>	Varied Sittella			V						•
PACHYCEPHALIDAE										

FAMILY/Scientific Name	Common Name	Status		A	B	C	D	AMBS (2003)
		TSC Act	EPBC Act					
<i>Pachycephala rufiventris</i>	Rufous Whistler				•	•		•
<i>Colluricincla harmonica</i>	Grey Shrike-thrush				•			•
DICRURIDAE								
<i>Rhipidura leucophrys</i>	Willie Wagtail			•	•			•
<i>Rhipidura rufifrons</i>	Rufous Fantail		M		•			
<i>Rhipidura fuliginosa</i>	Grey Fantail			•		•		•
<i>Grallina cyanoleuca</i>	Magpie-lark			•	•			•
CAMPEPHAGIDAE								
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike			•				
<i>Lalage sueurii</i>	White-winged Triller							•
ARTAMIDAE								
<i>Cracticus torquatus</i>	Grey Butcherbird				•			•
<i>Gymnorhina tibicen</i>	Australian Magpie			•	•			•
<i>Strepera araculina</i>	Pied Currawong							•
CORVIDAE								
<i>Corvus coronoides</i>	Australian Raven			•	•			•
CORCORACIDAE								
<i>Corcorax melanorhombos</i>	White-winged Chough							•
MOTACILLIDAE								
<i>Anthus novaeseelandiae</i>	Richard's Pipit							•
PASSERIDAE								
<i>Passer domesticus</i> *	House Sparrow							•
<i>Taeniopygia bichenovii</i>	Double-barred Finch			•	•			•
<i>Neochmia temporalis</i>	Red-browed Finch			•				•
<i>Lonchura castaneothorax</i> *	Chestnut-breasted Mannikin				•			
DICAIDAE								
<i>Dicaeum hirundinaceum</i>	Mistletoebird							•
HIRUNDINIDAE								
<i>Hirundo neoxena</i>	Welcome Swallow			•				•
<i>Hirundo niaricans</i>	Tree Martin							•
<i>Hirundo ariel</i>	Fairy Martin							•
ACROCEPHALIDAE								
<i>Acrocephalus stentoreus</i>	Clamorous Reed-Warbler							•
SYLVIIDAE								
<i>Megalura aramineus</i>	Little Grassbird							•
<i>Cisticola exilis</i>	Golden-headed Cisticola				•			•
PYCNONOTIDAE								
<i>Pycnonotus jocosus</i> *	Red-whiskered Bulbul			•		•		
MUSCICAPIDAE								
<i>Turdus merula</i> *	Eurasian Blackbird			•				
STURNIDAE								
<i>Sturnus vulgaris</i> *	Common Starling			•				•
<i>Acridotheres tristis</i> *	Common Myna				•			•
<b>GASTROPODA</b>								
CAMAENIDAE								

FAMILY/Scientific Name	Common Name	Status				AMBS (2003)	
		TSC Act	EPBC Act	A	B		C
<i>Meridolum corneovirens</i>	Cumberland Plain Land Snail				•		•
<i>Meridolum sp.</i>					•		
<b>ACTINOPTERYGI</b>							
<b>ANGUILLIDAE</b>							
<i>Anquilla sp.</i>	Eel						•
<b>CYPRINIDAE</b>							
<i>Cyprinus carpio*</i>	Carp						•
<b>POECILIIDAE</b>							
<i>Gambusia holbrooki*</i>	Plague Minnow						•

## Appendix D Assessment of significance

An Assessment of Significance has been conducted for species, populations and communities that were identified as having a moderate or high potential to occur in the study area. These species are listed in **Table 6-1** for TSC Act listed species, **Table 6-2** for EPBC Act listed species and **Table 6-3** for EPBC Act listed migratory species.

The project has been assessed under Part 5 of the EP&A Act. Section 5A of the EP&A Act requires that a '7 part test' is undertaken to assess the likelihood of significant impact upon threat-listed species, populations or ecological communities listed under the TSC Act.

For threatened biodiversity listed under the EPBC Act, an Assessment of Significance has been completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of the Environment 2013). Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is affected, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of the Environment 2013). Importantly, for a 'significant impact' to be 'likely', it is not necessary for a significant impact to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility (Department of the Environment 2013).

Species listed under both the TSC Act and the EPBC Act has been assessed using both assessment guidelines separately. Significance assessments have been divided into:

- State listed species (under the TSC Act or the FM Act (**Appendix D.1**))
- Commonwealth listed species (under the EPBC Act (**Appendix D.2**)).

Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats and cave-roosting microchiropteran bats.

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
<b>Threatened ecological communities</b>			
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE		1.77
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	CE		0.28
Cumberland Plain Woodland in the Sydney basin Bioregion		CE	10.99 (2.51 remnant, 8.48 planted)
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		E	0.15 (modified)
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		E	0.79
Shale Gravel Transition Forest in the Sydney Basin		E	0.87 (0.3 remnant,

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
Bioregion			0.57 planted)
Shale Sandstone Transition Forest in the Sydney Basin Bioregion		CE	0.68 (0.28 remnant, 0.4 planted)
<b>Flora</b>			
Downy Wattle ( <i>Acacia pubescens</i> )	V	V	Up to 11 - No individuals impacted
<i>Dillwynia tenuifolia</i>	-	V	0.3  1 plant at Roper Rd interchange
Narrow-leaved Black Peppermint ( <i>Eucalyptus nicholii</i> )	V	V	N/A (planted) cannot predict
Juniper-leaf Grevillea ( <i>Grevillea juniperina</i> subsp. <i>juniperina</i> )	-	V	Up to 11  55 plants in total
<i>Marsdenia viridiflora</i> subsp. <i>viridiflora</i> (endangered population)	-	E2	Up to 11 - No individuals impacted
Nodding Geebung ( <i>Persoonia nutans</i> )	E	E	0.3 - No individuals impacted
Spiked-rice Flower ( <i>Pimelea spicata</i> )	E	E	2.51 - No individuals impacted
Sydney-bush Pea ( <i>Pultenaea parviflora</i> )	E	E	0.3 - No individuals impacted
Magenta Lilly Pilly ( <i>Syzygium paniculatum</i> )	V	E	N/A (planted) cannot predict - No individuals impacted
<b>Fauna</b>			
<b>MAMMALS</b>			
Eastern Bent-wing Bat ( <i>Miniopterus schreibersii</i> <i>oceanensis</i> )	-	V	29.45
Eastern Pygmy Possum ( <i>Cercartetus nanus</i> )	-	V	0.68

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
Eastern False Pipistrelle ( <i>Falsistrellus tasmaniensis</i> )	-	V	29.45
Eastern Freetail Bat ( <i>Mormopterus norfolkensis</i> )	-	V	29.45
Greater Broad-nosed Bat ( <i>Scoteanax rueppellii</i> )	-	V	29.45
Grey-headed Flying-fox ( <i>Pteropus poliocephalus</i> )	V	V	24.89
Large-eared Pied Bat ( <i>Chalinolobus dwyeri</i> )	V	V	29.45
Little Bent-wing Bat ( <i>Miniopterus australis</i> )	-	V	29.45
Southern Myotis ( <i>Myotis macropus</i> )	-	V	29.45
Spotted-tailed Quoll ( <i>Dasyurus maculatus</i> )	E	V	0.68
Squirrel Glider ( <i>Petaurus norfolcensis</i> )	-	V	0.68
Yellow-bellied Glider ( <i>Petaurus australis</i> )	-	V	0.68
Yellow-bellied Sheath-tail-bat ( <i>Saccolaimus flaviventris</i> )	-	V	29.45
<b>BIRDS</b>			
Barking Owl ( <i>Ninox connivens</i> )	-	V	0.68
Flame Robin ( <i>Petroica phoenicea</i> )	-	V	0.68
Gang-gang Cockatoo ( <i>Callocephalon fimbriatum</i> )	-	V	0.68
Glossy Black-Cockatoo ( <i>Calyptorhynchus lathamii</i> )	-	V	0.68
Little Eagle ( <i>Hieraaetus morphnoides</i> )	-	V	13.48
Little Lorikeet ( <i>Glossopsitta pusilla</i> )	-	V	24.89
Masked Owl ( <i>Tyto novaehollandiae</i> )	-	V	0.68
Powerful Owl ( <i>Ninox strenua</i> )	-	V	0.68
Scarlet Robin ( <i>Petroica boodang</i> )	-	V	0.68
Speckled Warbler ( <i>Chthonicola sagittatus</i> )	-	V	0.68
Swift Parrot ( <i>Lathamus discolor</i> )	E, M	E	24.89
Varied Sittella ( <i>Daphoenositta chrysoptera</i> )	-	V	24.89
<b>REPTILES AND AMPHIBIANS</b>			
Broad-headed Snake ( <i>Hoplocephalus bungaroides</i> )	V	V	0.68

Species	Status		Predicted impact (habitat in ha)
	EPBC Act	TSC Act	
Red-crowned Toadlet ( <i>Pseudophryne australis</i> )	-	V	0.28
<b>INVERTEBRATES</b>			
Cumberland Plain Land Snail ( <i>Meridolum corneovirens</i> )	-	E	1.2 (0.1 high quality, 1.1 moderate quality)

# D.1 Environmental Planning & Assessment Act 1979

## Threatened ecological communities

The threatened ecological communities that are present in the study area and are subject to this assessment include:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
- Cumberland Plain Woodland in the Sydney basin Bioregion
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions
- Shale Gravel Transition Forest in the Sydney Basin Bioregion
- Shale Sandstone Transition Forest in the Sydney Basin Bioregion

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened ecological communities or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

In addressing this question, the local occurrence of these threatened ecological communities is taken to be the community that occurs within the study area. Risk of extinction is used here as the likelihood that the local occurrence of the ecological community will become extinct either in the short-term or in the long-term as a result of direct or indirect impacts on the threatened ecological community from the proposal. Composition refers to the assemblage of species and the physical structure of the community.

Cumberland Plain Woodland in the Sydney basin Bioregion is listed as a critically endangered ecological community and is considered to be facing an extremely high risk of extinction in New South Wales in the immediate future. The remainder of the threatened ecological communities subject to this assessment are considered likely to become extinct in nature in

New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate.

The threatened ecological communities subject to this assessment are already at risk of extinction. However, it is unlikely that the proposal will result in the extinction of the local occurrence of any of these threatened ecological communities. The proposal will reduce the local extent of these threatened ecological communities as outlined in **Table D-1**. However, the predicted removal of TECs is small and >85 per cent of the current extent of TECs will remain surrounding the study area after construction. The majority of threatened ecological communities within the study area occur as small isolated patches in a fragmented landscape.

The composition of threatened ecological communities may be modified as a result of the proposal through weed invasion and removal of some vegetation. However, the local occurrences of these threatened ecological communities are currently suffering from altered composition caused by a very large reduction in ecological function, as indicated by:

- Altered community structure (i.e. missing structural layers)
- Altered species composition (i.e. weed invasion, lack of native species)
- Disruption of ecological processes (i.e. altered drainage,
- Invasion and establishment of exotic species
- Degradation of habitat
- Fragmentation of habitat.

The proposal is not considered likely to further modify the composition of any of the threatened ecological communities within the study area such that its local occurrence is placed at risk of extinction. The composition of the threatened ecological communities within the study area is predicted to remain intact after the implementation of the proposal.

**Table D-1 Impact on the extent of each threatened ecological community**

Threatened ecological community	Status	Area (ha)			Proportion of habitat impacted adjoining and within the study area
		Extent within locality*	Extent within and adjoining study area	Extent to be removed	
Cumberland Plain Woodland in the Sydney basin Bioregion	Critically Endangered TSC act	8,740	151.93 (105.07 remnant, 46.86 planted)	10.99 (2.51 remnant, 8.48 planted)	7.23%
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC act	13	1.47	0.15	10.2%

Threatened ecological community	Status	Area (ha)			Proportion of habitat impacted adjoining and within the study area
		Extent within locality*	Extent within and adjoining study area	Extent to be removed	
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered TSC act	3,113	67.97 (remnant/modified)	0.79	1.16%
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered TSC act	1,079	15.95 (9.26 remnant, 6.7 planted)	0.87 (0.3 remnant, 0.57 planted)	5.45%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered TSC act	184	3.11 (planted only)	0.68 (0.28 remnant, 0.4 planted)	21.86%

Notes: \* = Predicted amount of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest within the locality based on Tozer (2003). Note this is likely to be an overestimate due to recent development.

Twenty-three separate larger patches of threatened ecological communities ( $\geq 1$  hectare in size) have been identified as having contiguous vegetation outside of the study area (refer to **Table D-2**). Proposed construction within these local occurrences is limited to the outer edges and works are unlikely to significantly reduce the size of remnant patches. The design phase has generally avoided direct impacts where possible and remaining indirect impacts such as edge effects (i.e. weed invasion) would be mitigated appropriately.

**Table D-2 Direct and indirect impacts to larger vegetation patches of threatened ecological community**

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
S1	Map Unit 1: Remnant Shale-Gravel Transition Forest	2.5	0.08	0.0	3.2%
S2		1.03	0.18	0.07	17.5%
S3		3.1	0	0.0	0%
S4		0.54	0.04	0.0	7.4%
S5		2.02	0	0.0	0%
S6	Map Unit 6: Planted Shale-Gravel Transition Forest	4.69	0.38	0.0	8.1%
C1	Map Unit 2: Remnant Shale	51.28	0.23	0.0	0.4%

Patch ID	Map Unit	Total patch size (ha)	Direct Impact (ha)	Indirect Impact (ha)	Proportion of patch directly impacted
C2	Plains Woodland	15.44	0.59	0.33	3.8%
C3		12.61	0.1	0.0	0.8%
C4		8.96	0.05	0.0	0.6%
C5		2.09	0	0.0	0%
C6		4.04	0.02	0.06	0.5%
C7		1.28	0.03	0.0	2.3%
C8		0.63	0.01	0.0	1.6%
C9		Map Unit 5: Planted Shale Plains Woodland	1.69	0.17	0.33
A1	Map Unit 3: Remnant Alluvial Woodland	14.92	0.05	0.0	0.3%
A2		11.83	0.03	0.0	0.3%
A3		10.26	0	0.0	0.0%
A4		10.08	0.04	0.0	0.4%
A5		7.83	0.1	0.0	1.3%
A6		4.9	0.13	0.2	2.7%
A7		3.2	0.07	0.0	2.2%
A8		2.61	0.02	0.0	0.7%
A9		0.69	0.04	0.0	5.8%
SS1		Map Unit 11: Remnant Shale Sandstone Transition Forest	8.92	0	0
SS2	11.2		0	0	0%
SS3	6.71		0.04	0	0.6%
SS4	40.41		0.24	0.4	0.6%

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

**iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The extent of each threatened ecological community to be removed as a result of the proposal is outlined in Table D-1. Overall, the proposal will have a small impact on the local extent of threatened ecological communities and small proportional impact (1-13 per cent of habitat impacted adjoining and within the study area) on the extent of each of these threatened ecological communities within the locality.

Importantly, the proposal will not result in the breaking apart of large blocks of high quality examples of threatened ecological communities. No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. However, installation of the ITS may cause some temporary local disturbance to components of these ecological communities including species such as reptiles and amphibians that cannot move large distances away from disturbance. Overall, habitat connectivity will remain in a similar state after construction of the proposal and a similar level of functional east west habitat connectivity will remain. There is unlikely to be declines in population density or species richness within vegetation patches as a result of the proposal. There is also unlikely to be a significant alteration to community composition, species interactions or ecosystem functioning in the locality due to the proposal. These factors are already highly impacted by historic land use. Therefore, habitat fragmentation is considered a minor impact of the proposal in regard to its context and intensity.

Due to the conservation significance of these threatened ecological communities (particularly Cumberland Plain Woodland in the Sydney basin Bioregion) the remaining patches of these threatened ecological communities within NSW are likely to be important for their survival. However, the patches within the study area are small, are largely degraded and in poor condition, and in many cases are the result of revegetation works associated with the construction of the original M4 motorway. As such, the threatened ecological community patches within the study area can be considered less important than larger high quality examples of these threatened ecological communities that retain high levels of ecological integrity and function.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the threatened ecological communities subject to this assessment.

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. The recovery objectives include:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands.
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.

- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

A targeted strategy for managing threatened ecological communities is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing ecological communities.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover threatened biodiversity on the Cumberland Plain are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs (**Table D-2**). Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, 11 are applicable to the threatened ecological communities subject to this assessment (refer **Table D-2**). However, hygiene and weed control measures will reduce or avoid the impact of most KTPs with the exception of clearing of native vegetation and removal of dead wood and dead trees.

**Table D-2 Key threatening processes that may result from the proposal that may impact on threatened ecological communities**

Key threatening process	Relevance to the proposal
Aggressive exclusion of birds by noisy miners ( <i>Manorina melanocephala</i> )	None
Alteration of habitat following subsidence due to longwall mining	None
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	None

Key threatening process	Relevance to the proposal
Anthropogenic climate change	None
Bushrock removal	None
Clearing of native vegetation	Yes. The proposal will result in clearing of native vegetation.
Competition and grazing by the feral European rabbit ( <i>Oryctolagus cuniculus</i> )	Minor. Impact of rabbits is unlikely to increase as this species is established in the study area and no new habitats will be created.
Competition and habitat degradation by feral goats ( <i>Capra hircus</i> )	None
Competition from feral honey bees ( <i>Apis mellifera</i> )	Minor. Impact of feral honey bees is unlikely to increase as this species is established in the study area.
Death or injury to marine species following capture in shark control programs on ocean beaches	None
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments	None
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	None
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	None
Herbivory and environmental degradation caused by feral deer	None
Importation of red imported fire ants ( <i>Solenopsis invicta</i> )	None
Infection by psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations	None
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Yes. The proposal may result in the introduction or spread of amphibian chytrid. However, hygiene measures will be followed to prevent spread of this fungus.
Infection of native plants by <i>Phytophthora cinnamomi</i>	Yes. The proposal may result in the introduction or spread of <i>Phytophthora cinnamomi</i> . However, hygiene measures will be followed to prevent spread of <i>Phytophthora cinnamomi</i> .
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Yes. The proposal may result in the introduction or spread of Exotic Rust Fungi. However, hygiene measures will be followed to prevent spread of Exotic Rust Fungi.

Key threatening process	Relevance to the proposal
Introduction of the large earth bumblebee ( <i>Bombus terrestris</i> )	None
Invasion and establishment of exotic vines and scramblers	Yes. The proposal may result in the invasion and establishment of exotic vines and scramblers. However, weed control measures will be followed to prevent invasion and establishment of exotic vines and scramblers.
Invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> )	Yes. The proposal may result in the invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ). However, weed control measures will be followed to prevent invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ).
Invasion and establishment of the cane toad ( <i>Bufo marinus</i> )	None.
Invasion of native plant communities by African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i>	Yes. The proposal may result in the invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i> . However, weed control measures will be followed to prevent invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>Cuspidata</i> .
Invasion, establishment and spread of <i>Lantana camara</i>	Yes. The proposal may result in the invasion and establishment of <i>Lantana camara</i> . However, weed control measures will be followed to prevent invasion and establishment of <i>Lantana camara</i> .
Invasion of native plant communities by <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed)	Yes. The proposal may result in the invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed). However, weed control measures will be followed to prevent invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed).
Invasion of native plant communities by exotic perennial grasses	Yes. The proposal may result in the invasion and establishment of exotic perennial grasses. However, weed control measures will be followed to prevent invasion and establishment of exotic perennial grasses.
Invasion of the yellow crazy ant ( <i>Anoplolepis gracilipes</i> (Fr. Smith)) into NSW	None
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	None
Loss of hollow-bearing trees	None
Loss or degradation (or both) of sites used for hill-topping by butterflies	None
Predation and hybridisation of feral dogs ( <i>Canis lupus familiaris</i> )	None

Key threatening process	Relevance to the proposal
Predation by the European red fox ( <i>Vulpes vulpes</i> )	Minor. Impact of European red fox is unlikely to increase as this species is established in the study area.
Predation by the feral cat ( <i>Felis catus</i> )	Minor. Impact of feral cats is unlikely to increase as this species is established in the study area.
Predation by <i>Gambusia holbrooki</i> Girard, 1859 (plague minnow or mosquito fish)	Minor. Impact of <i>Gambusia holbrooki</i> is unlikely to increase as this species is established in waterways of the study area.
Predation by the ship rat ( <i>Rattus rattus</i> ) on Lord Howe Island	None
Predation, habitat degradation, competition and disease transmission by feral pigs ( <i>Sus scrofa</i> )	None
Removal of dead wood and dead trees	Yes. Some dead wood and dead trees will be removed as part of the proposal.

### Conclusion

The threatened ecological communities that are present in the study area will be reduced by a small extent from the proposal. However, no change in composition is considered likely. No further habitat fragmentation or isolation on a landscape scale will occur. The local occurrence of these threatened ecological communities will persist after the proposal is built. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to threatened ecological communities.

### Endangered populations

One endangered population, the *Marsdenia viridiflora* R. Br. subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas is considered to have a moderate likelihood of occurrence within the study area. While it is unknown whether *Marsdenia viridiflora* subsp. *viridiflora* exists within the study area, suitable habitat for this species is present and records of this species have been made nearby the study area near Roper Road and Erskine Park Road.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened populations or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Demonstrating that a population is not viable would require considerable effort and study. As such, the presumed local population of *Marsdenia viridiflora* subsp. *viridiflora* within the study area is assumed to be viable for the purposes of this assessment.

The risk of extinction of the local *Marsdenia viridiflora* subsp. *viridiflora* population will increase if anything reduces its population size or reproductive success. The lifecycle of the local *Marsdenia viridiflora* subsp. *viridiflora* population (i.e. the population within the study area) is dependent on the habitat that is present within the study area. The potential habitat of the *Marsdenia viridiflora* subsp. *viridiflora* population within the study area includes 11 hectares comprising remnant and planted vegetation as this species is known to occur in disturbed habitats.

While it is unknown whether *Marsdenia viridiflora* subsp. *viridiflora* exists within the study area, the removal or modification of remnant Shale-Gravel Transition Forest and/or remnant Shale Plains Woodland may be detrimental to the survival of the species. However, due to the predicted small amount of habitat removal within the study area and the extent of these habitats that will remain within the study area after construction (i.e. >90 per cent), the local population is considered unlikely to be placed at further risk of extinction and the population (if present) would remain viable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the *Marsdenia viridiflora* subsp. *viridiflora* population within the study area includes planted and remnant vegetation of 11 hectares will be impacted. While it is unknown whether *Marsdenia viridiflora* subsp. *viridiflora* exists within the study area, targeted surveys were undertaken and no individuals were identified. The extent of potential habitat for this species will be altered by approximately 11 hectares. This is a small impact compared to the availability of these habitats in the study area.

Importantly, the proposal will not result in the breaking apart of large blocks of high quality habitat for *Marsdenia viridiflora* subsp. *viridiflora*. No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. Critical ecosystem processes such as pollination and seed dispersal will still function as per the current state after the proposal has been completed.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no

critical habitat has been listed for the *Marsdenia viridiflora* subsp. *viridiflora* population subject to this assessment.

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) has been prepared with the overall objective to provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. This multi species recovery plan applies to *Marsdenia viridiflora* subsp. *viridiflora*. The recovery objectives include:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands.
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

A targeted strategy for managing endangered populations is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened populations.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover threatened biodiversity on the Cumberland Plain are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs (**Table D-4**). Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, seven are applicable to the *Marsdenia viridiflora* subsp. *viridiflora* population subject to this assessment. (refer **Table D-4**). However, hygiene and weed control measures will reduce or avoid the impact of most KTPs with the exception of clearing of native vegetation.

**Table D-4 Key threatening processes that may result from the proposal that may impact on the endangered *Marsdenia viridiflora* subsp. *viridiflora* population**

Key threatening process	Relevance to the proposal
Aggressive exclusion of birds by noisy miners ( <i>Manorina melanocephala</i> )	None
Alteration of habitat following subsidence due to longwall mining	None
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	None
Anthropogenic climate change	None
Bushrock removal	None
Clearing of native vegetation	Yes. The proposal will result in clearing of native vegetation.
Competition and grazing by the feral European rabbit ( <i>Oryctolagus cuniculus</i> )	None
Competition and habitat degradation by feral goats ( <i>Capra hircus</i> )	None
Competition from feral honey bees ( <i>Apis mellifera</i> )	None
Death or injury to marine species following capture in shark control programs on ocean beaches	None
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments	None
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	None
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	None
Herbivory and environmental degradation caused by feral deer	None
Importation of red imported fire ants ( <i>Solenopsis invicta</i> )	None

Key threatening process	Relevance to the proposal
Infection by psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations	None
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	None
Infection of native plants by <i>Phytophthora cinnamomi</i>	None, not known to be affected by <i>Phytophthora cinnamomi</i> .
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	None
Introduction of the large earth bumblebee ( <i>Bombus terrestris</i> )	None
Invasion and establishment of exotic vines and scramblers	Yes. The proposal may result in the invasion and establishment of exotic vines and scramblers. However, weed control measures will be followed to prevent invasion and establishment of exotic vines and scramblers.
Invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> )	Yes. The proposal may result in the invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ). However, weed control measures will be followed to prevent invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ).
Invasion and establishment of the cane toad ( <i>Bufo marinus</i> )	None.
Invasion of native plant communities by African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i>	Yes. The proposal may result in the invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i> . However, weed control measures will be followed to prevent invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>Cuspidata</i> .
Invasion, establishment and spread of <i>Lantana camara</i>	Yes. The proposal may result in the invasion and establishment of <i>Lantana camara</i> . However, weed control measures will be followed to prevent invasion and establishment of <i>Lantana camara</i> .
Invasion of native plant communities by <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed)	Yes. The proposal may result in the invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed). However, weed control measures will be followed to prevent invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed).
Invasion of native plant communities by exotic perennial grasses	Yes. The proposal may result in the invasion and establishment of exotic perennial grasses. However, weed control measures will be followed to prevent invasion and establishment of exotic perennial grasses.

Key threatening process	Relevance to the proposal
Invasion of the yellow crazy ant ( <i>Anoplolepis gracilipes</i> (Fr. Smith)) into NSW	None
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	None
Loss of hollow-bearing trees	None
Loss or degradation (or both) of sites used for hill-topping by butterflies	None
Predation and hybridisation of feral dogs ( <i>Canis lupus familiaris</i> )	None
Predation by the European red fox ( <i>Vulpes vulpes</i> )	None
Predation by the feral cat ( <i>Felis catus</i> )	None
Predation by <i>Gambusia holbrooki</i> Girard, 1859 (plague minnow or mosquito fish)	None
Predation by the ship rat ( <i>Rattus rattus</i> ) on Lord Howe Island	None
Predation, habitat degradation, competition and disease transmission by feral pigs ( <i>Sus scrofa</i> )	None
Removal of dead wood and dead trees	None

## Conclusion

The *Marsdenia viridiflora* subsp. *viridiflora* population that may occur in the study area will suffer a small reduction in extent of suitable habitat from the proposal. No further habitat fragmentation or isolation on a landscape scale will occur. The local occurrence of the *Marsdenia viridiflora* subsp. *viridiflora* population will persist after the proposal is built. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the endangered *Marsdenia viridiflora* subsp. *viridiflora* population.

## Threatened plant species

The threatened plant species subject to this assessment include:

- Downy Wattle (*Acacia pubescens*)
- Dillwynia tenuifolia
- Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*)
- Nodding Geebung (*Persoonia nutans*)
- Sydney-bush Pea (*Pultenaea parviflora*)
- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*)

- Spiked-rice Flower (*Pimelea spicata*)

Of these species, the Downy Wattle (*Acacia pubescens*), *Dillwynia tenuifolia*, Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*), Nodding Geebung (*Persoonia nutans*), Sydney-bush Pea (*Pultenaea parviflora*), and Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) were recorded within the study area during the field survey. The distribution and abundance of these species within the study area is outlined in **Table D-5**.

The occurrence of the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) in the study area is the result of human intervention. This species has been planted in the corridor. The natural distribution of this species is on the New England Tablelands and this species has been widely planted throughout Sydney as an ornamental tree and street tree planting. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant.

The Spiked-rice Flower (*Pimelea spicata*) was not recorded within the study area during the survey. However, suitable habitat in the form of Map Unit 2: Remnant Shale Plains Woodland is present in the study area. This species is known from near the study area in the Prospect Nature Reserve and bushland near the M7 interchange. As such, this species is considered moderately likely to occur within the study area, particularly in the vegetation to the west of the Ropers Road interchange on both sides of the M4 Motorway with other threatened plant species (**Table D-5**).

**Table D-5 Distribution and abundance of threatened plant species within the study area (v = vulnerable; E = endangered)\_**

Threatened flora species	Status	Distribution and abundance
Downy Wattle <i>Acacia pubescens</i>	V, TSC Act V, EPBC Act	Four individuals were recorded at one location in the study area to the west of the Ropers Road intersection on the southern side of the M4 Motorway. These four individuals were growing in a small cluster consisting of two medium sized plants (1.2-1.7 metres high) and two small plants (c. 1 metre high). These individuals were growing in a disturbed remnant of Shale-Gravel Transition Forest (Map Unit 1) approximately four metres from the existing M4 motorway road pavement.
<i>Dillwynia tenuifolia</i>	V, TSC Act	<p>A total of 135 individuals were directly counted in the study area, in four main population clusters west of the Ropers Road interchange. These three clusters are associated with higher condition Shale-Gravel Transition Forest (Map Unit 1) and are greater than 150 metres apart and so are considered to be four separate local populations.</p> <p>Two clusters occur directly west of the Ropers Road interchange on the northern and southern side of the M4 Motorway approximately 200 metres apart within fenced remnants . There are approximately 91 individuals in these clusters.</p> <p>There is another cluster approximately 400 metres further west on the northern side of the M4 Motorway on top of an existing cutting on both sides of an existing sound wall. Some individuals in this cluster are approximately seven metres from the existing M4 Motorway road pavement. There are 42 individuals in this cluster. An additional 2 individuals occur approximately 300 metres west of this cluster.</p>

Threatened flora species	Status	Distribution and abundance
Narrow-leaved Black Peppermint <i>Eucalyptus nicholii</i>	V, TSC Act, V, EPBC Act	<p>A single individual of this species was recorded on the northern side of the M4 Motorway corridor south of the major service centre and rest stop area. This species has been planted in the corridor.</p> <p>The natural distribution of this species is on the New England Tablelands, typically growing in dry grassy woodland, on shallow soils of slopes and ridges, primarily on infertile soils derived from granite or metasedimentary rock.</p> <p>This species is widely planted as an ornamental tree.</p>
Juniper-leaf Grevillea <i>Grevillea juniperina</i> subsp. <i>juniperina</i>	V, TSC Act	<p>Over 1000 individuals were directly counted in the study area, however not all individuals were directly counted in high density areas that are remote from the existing M4 Motorway road pavement around the Ropers Road interchange.</p> <p>Large populations of this species occur in the study area surrounding the Ropers Road interchange on both sides of the M4 Motorway (&gt;800 individuals). There are also several population clusters further west surrounding the Kent Road overpass (c. 204 individuals). These two occurrences are considered to be two separate local populations.</p> <p>Another non-threatened subspecies of <i>Grevillea juniperina</i> has been planted in the corridor suspected to be <i>Grevillea juniperina</i> subsp. <i>allojohnsonii</i>. This species was possibly originally planted to compensate for impacts to <i>Grevillea juniperina</i> subsp. <i>juniperina</i>.</p>
Nodding Geebung <i>Persoonia nutans</i>	E, TSC Act E, EPBC Act	<p>Only a single individual of this species was recorded in high condition Shale-Gravel Transition Forest (Map Unit 1) directly west of Ropers Road on the northern side of the M4 motorway in a fenced off remnant. This individual is approximately 55 metres from the existing M4 Motorway road pavement.</p>
Sydney-bush Pea <i>Pultenaea parviflora</i>	E, TSC Act E, EPBC Act	<p>A total of 29 individuals were directly counted in the study area to the west of the Ropers Road interchange on both sides of the M4 Motorway in two main clusters that are greater than 150 metres apart and so are considered to be four separate local populations.</p> <p>One cluster occurs directly west of the Ropers Road interchange on the northern and southern side of the M4 Motorway within fenced remnants. There are approximately 26 individuals in this cluster</p> <p>The other cluster occurs further west on the northern side of the M4 Motorway on top of an existing cutting on the road side of an existing sound wall comprising four individuals. These individuals are approximately eight metres from the existing M4 Motorway road pavement.</p>

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The local populations of the Downy Wattle (*Acacia pubescens*), *Dillwynia tenuifolia*, Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*), Nodding Geebung (*Persoonia nutans*), and Sydney-bush Pea (*Pultenaea parviflora*) are persisting in the roadside environment and are considered viable local populations. The presumed local population of Spiked-rice Flower (*Pimelea spicata*) within the study area is assumed to be viable for the purposes of this assessment.

The risk of extinction of the local populations of threatened plant species will increase if anything reduces their population size or reproductive success. The lifecycle of the local populations is dependent on the habitat that is present within the study area. The habitat for these species within the study area is predominantly Map Unit 1: Remnant Shale-Gravel Transition Forest in the vicinity of Roper Road. Habitat for the Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*) is also present along the M4 motorway near the Kent Road overpass. Map Unit 2: Remnant Shale Plains Woodland provides suitable habitat for the Spiked-rice Flower (*Pimelea spicata*).

Removal or modification of habitat for these plant species may be detrimental to their survival in the study area. However, due to the predicted small amount of habitat removal within the study area (0.3 hectares of remnant Shale-Gravel Transition Forest and 2.51 hectares of remnant Shale Plains Woodland) and the extent of these habitats that will remain within the study area after construction (>95 per cent of present habitat will remain), the local population is considered unlikely to be placed at further risk of extinction and the population (if present) would remain viable.

The proposal will potentially result in the removal of the following local populations of threatened species:

- A single *Dillwynia tenuifolia* plant from a population of 87 individuals (1.1 per cent impacted).
- A total of 49 *Grevillea juniperina* subsp. *juniperina* plants from two separate local populations, comprising one population at Ropers Road interchange of which 40 plants from a large population of greater than 824 individuals will be impacted (maximum 4.9 per cent) and another population near the Kent Road overpass consisting of 204 individuals of which 9 individuals will be impacted (4.4 per cent).

Where possible removal of threatened flora will be avoided during construction through the implementation of exclusion zones and minor modification to the alignment of ancillary infrastructure. If these plants were to be removed, it is unlikely that the removal would result in an adverse effect on the life cycle of threatened flora such that a viable local population of the species is likely to be placed at risk of extinction considering the small number of plants to be affected and the abundance of these species remaining in the study area and locality. If supported by OEH, Roads and Maritime could consider propagation trials and translocation as an option to retain genetic material of these species. This process would be properly planned and managed so as to contribute to the recovery of the species.

The Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) tree in the study area is the result of human intervention and this species has been planted. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered**

population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

In relation to the habitat of a Threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The potential habitat of the threatened plant species within the study area includes:

- Map Unit 1: Remnant Shale-Gravel Transition Forest (6.2 ha).
- Map Unit 2: Remnant Shale Plains Woodland (12.5 ha).

The extent to which habitat for these species will be altered is outlined in **Table D-6**. The predicted impact to these species is small when compared to the availability of suitable habitats in the study area and the extent to remain after construction and outside of the area to be disturbed.

**Table D-6 Impact on the extent of habitat for each threatened plant species**

Species	% population impacted		
	Extent within and surrounding the study area (ha)	Extent to be removed (ha)	
<i>Acacia pubescens</i>	171	11	6.43%
<i>Dillwynia tenuifolia</i>	9.26	0.3	3.24%
<i>Eucalyptus nicholii</i>	N/A	N/A	N/A
<i>Grevillea juniperina</i> subsp. <i>juniperina</i>	171	11	6.43%
<i>Persoonia nutans</i>	9.26	0.3	3.24%

Species	% population impacted		
<i>Pultenaea parviflora</i>	9.26	0.32	3.24%
<i>Pimelea spicata</i>	114.33	2.51	2.2%

Importantly, the proposal will not result in the breaking apart of large blocks of high quality habitat for these species. No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. Critical ecosystem processes such as pollination and seed dispersal will still function as per the current state after the proposal has been completed.

Habitats in the study area are considered important for these threatened plant populations present as well as being a potential pollination 'stepping stone' between populations in the wider locality. The large majority (94-98 per cent) of potential habitat for these species in the study area will be retained following the proposal.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the threatened plants subject to this assessment.

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. This multi species recovery plan applies the threatened plants subject to this assessment. The recovery objectives include:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

An approved recovery plan exists for The Downy Wattle (*Acacia pubescens*) (NSW National Parks and Wildlife Service 2003) and the Nodding Geebung (*Persoonia nutans*) (NSW Department of Environment and Conservation 2005). The approved recovery plan for the Downy Wattle (*Acacia pubescens*) identifies 13 recovery actions including:

- Identify sites that are a high priority to protect
- Carry out negotiations with public authorities to increase protection of sites
- Liaise with private landholders to increase protection of sites

- Negotiate with public authorities to implement threat and habitat management programs on public lands
- Informed environmental assessment and planning decisions are made
- Undertake studies into the genetic variability of the species
- Investigate the cause of disease in the species
- Research other aspects of the species' biology, ecology and distribution
- Encourage community involvement
- Provide advice and assistance to private landholders
- Maintain a database on the species
- NPWS to be advised of any consents or approvals which affect *A. pubescens*
- Re-assess conservation status of species.

The approved recovery plan for the Nodding Geebung (*Persoonia nutans*) (NSW Department of Environment and Conservation 2005) identifies the following objectives:

- To minimise the loss and fragmentation of *P. nutans* habitat using land-use planning mechanisms.
- To identify and minimise the threats operating at sites where the species occurs.
- Develop & implement a survey & monitoring program that will provide information on the extent and viability of *P. nutans*.
- To provide public authorities with information that assists in conserving the species.
- To raise awareness of the species and involve the community in the recovery program.
- To promote research projects that will assist future management decisions.

The *Pimelea spicata* Recovery Plan (Department of Environment and Conservation 2005) consists of six specific recovery objectives as follows:

- Conserve *P. spicata* using land-use and conservation planning mechanisms
- Identify and minimise the operation of threats at sites where *P. spicata* occurs
- Implement a survey and monitoring program that will provide information on the extent and viability of *P. spicata*
- Provide the community with information that assists in conserving the species
- Raise awareness of the species and involve the community in the recovery program.
- Promote research questions that will assist future management decisions.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Downy Wattle (*Acacia pubescens*), Juniper-leaf Grevillea (*Grevillea juniperina* subsp. *juniperina*), Nodding Geebung (*Persoonia nutans*), Sydney-bush Pea (*Pultenaea parviflora*), Spiked-rice Flower (*Pimelea spicata*), and Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) have been assigned to the Site-managed species management stream under the OEH Saving our Species program. *Dillwynia tenuifolia* has been assigned to the Keep-watch species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover threatened biodiversity on the Cumberland Plain are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. However, through this impact assessment process, informed environmental assessment and planning decisions are being made which is consistent with the approved recovery plan for the Downy Wattle (*Acacia pubescens*) (NSW National Parks and Wildlife Service 2003) and the Nodding Geebung (*Persoonia nutans*) (NSW Department of Environment and Conservation 2005).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs (**Table D-4**). Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, seven are applicable to the threatened plant species subject to this assessment. (refer **Table D-7**). However, hygiene and weed control measures will reduce or avoid the impact of most KTPs with the exception of clearing of native vegetation.

**Table D-7 Key threatening processes that may result from the proposal that may impact on the threatened plant species within the study area**

Key threatening process	Relevance to the proposal
Aggressive exclusion of birds by noisy miners ( <i>Manorina melanocephala</i> )	None
Alteration of habitat following subsidence due to longwall mining	None
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	None
Anthropogenic climate change	None
Bushrock removal	None
Clearing of native vegetation	Yes. The proposal will result in clearing of native vegetation including habitat for these species.

Key threatening process	Relevance to the proposal
Competition and grazing by the feral European rabbit ( <i>Oryctolagus cuniculus</i> )	None
Competition and habitat degradation by feral goats ( <i>Capra hircus</i> )	None
Competition from feral honey bees ( <i>Apis mellifera</i> )	None
Death or injury to marine species following capture in shark control programs on ocean beaches	None
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments	None
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	None
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	None
Herbivory and environmental degradation caused by feral deer	None
Importation of red imported fire ants ( <i>Solenopsis invicta</i> )	None
Infection by psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations	None
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	None
Infection of native plants by <i>Phytophthora cinnamomi</i>	None, not known to be affected by <i>Phytophthora cinnamomi</i> .
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	None
Introduction of the large earth bumblebee ( <i>Bombus terrestris</i> )	None
Invasion and establishment of exotic vines and scramblers	Yes. The proposal may result in the invasion and establishment of exotic vines and scramblers. However, weed control measures will be followed to prevent invasion and establishment of exotic vines and scramblers.
Invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> )	Yes. The proposal may result in the invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ). However, weed control measures will be followed to prevent invasion and establishment of Scotch broom ( <i>Cytisus scoparius</i> ).

Key threatening process	Relevance to the proposal
Invasion and establishment of the cane toad ( <i>Bufo marinus</i> )	None.
Invasion of native plant communities by African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i>	Yes. The proposal may result in the invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i> . However, weed control measures will be followed to prevent invasion and establishment of African Olive <i>Olea europaea</i> L. subsp. <i>Cuspidata</i> .
Invasion, establishment and spread of <i>Lantana camara</i>	Yes. The proposal may result in the invasion and establishment of <i>Lantana camara</i> . However, weed control measures will be followed to prevent invasion and establishment of <i>Lantana camara</i> .
Invasion of native plant communities by <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed)	Yes. The proposal may result in the invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed). However, weed control measures will be followed to prevent invasion and establishment of <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed).
Invasion of native plant communities by exotic perennial grasses	Yes. The proposal may result in the invasion and establishment of exotic perennial grasses. However, weed control measures will be followed to prevent invasion and establishment of exotic perennial grasses.
Invasion of the yellow crazy ant ( <i>Anoplolepis gracilipes</i> (Fr. Smith)) into NSW	None
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	None
Loss of hollow-bearing trees	None
Loss or degradation (or both) of sites used for hill-topping by butterflies	None
Predation and hybridisation of feral dogs ( <i>Canis lupus familiaris</i> )	None
Predation by the European red fox ( <i>Vulpes vulpes</i> )	None
Predation by the feral cat ( <i>Felis catus</i> )	None
Predation by <i>Gambusia holbrooki</i> Girard, 1859 (plague minnow or mosquito fish)	None

Key threatening process	Relevance to the proposal
Predation by the ship rat ( <i>Rattus rattus</i> ) on Lord Howe Island	None
Predation, habitat degradation, competition and disease transmission by feral pigs ( <i>Sus scrofa</i> )	None
Removal of dead wood and dead trees	None

## Conclusion

The threatened plant species that occur and may occur in the study area will suffer a small reduction in extent of suitable habitat from the proposal. No further habitat fragmentation or isolation on a landscape scale will occur. The local populations of these species are likely to persist after the proposal is built, considering the absence of impacts or small proportion of the population being impacted (1.1 to 5.9 per cent). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these threatened plant species.

The Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) tree in the study area is the result of human intervention and this species has been planted. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant.

## Broad-headed Snake (*Hoplocephalus bungaroides*)

While the Broad-headed Snake (*Hoplocephalus bungaroides*) was not recorded in the study area during the field survey it is considered to potentially occur based on the presence of suitable habitat.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

### **In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Broad-headed Snake (*Hoplocephalus bungaroides*) is a habitat specialist being largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. The Broad-headed Snake is often found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger, 2014; NSW NPWS 2001). The most suitable sites occur in sandstone ridgetops (Cogger, 2014). Near Bathurst snakes occur in forest growing on shale or conglomerate slopes and bluffs (Cogger, 2014). Common canopy species include *Corymbia eximia*, *C. gummifera*, *Eucalyptus sieberi*, *E. punctata* and *E. piperita*. Snakes prefer sites with a west to north-west aspect (NSW NPWS 2001).

Potential habitat for this species was located in the west of the study area only around the exposed sandstone and surrounding vegetation in Lapstone. The proposal will result in the removal of 0.68 hectares of potential habitat. This area represents marginal habitat only for this species and surrounding sandstone habitat that may not be utilised due to its north east aspect (studies using radio-telemetry have never found individuals sheltering under rocks on easterly cliff tops (Pringle *et al.*, 2003)). Therefore disruption to the life cycle of this species is unlikely and it is unlikely to be placed at risk of extinction.

### **In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Broad-headed Snake (*Hoplocephalus bungaroides*) within the study area is limited to exposed sandstone and surrounding vegetation located in the west of the study area around Lapstone. The proposal will result in the removal of 0.68 hectares of potential habitat. This area represents marginal habitat for this species. Also, this amount of habitat removal is small when the amount of available habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Broad-headed Snake (*Hoplocephalus bungaroides*). The vegetation to be cleared is roadside (and in some cases plantings) and represents only marginal potential habitat. The proposal will not affect the movement of the Broad-headed Snake (*Hoplocephalus bungaroides*) between habitat patches.

The roadside vegetation presents low-quality potential habitat for the Broad-headed Snake (*Hoplocephalus bungaroides*). The current potential for the species to occur based on the presence of potential habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Broad-headed Snake (*Hoplocephalus bungaroides*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Broad-headed Snake (*Hoplocephalus bungaroides*). However, the following actions have been identified by the OEH for recovery of this species:

- Retain sandstone rock in bushland on escarpment areas; implement LEPs, DCPs with suitable restrictions on the removal of bushrock
- Limit vehicle and pedestrian access to and recreational use of sandstone escarpments where this species occurs

- Retain woodland adjacent to sandstone escarpments, particularly large hollow-bearing trees
- Restore rocky habitat to escarpments that have been disturbed
- Report suspected illegal reptile collection or sale
- Targeted survey of areas of secure potential habitat
- Advocate the use of quarried sandstone or alternatives in preference to sandstone sourced from bushland on escarpments; implement a community and industry bushrock education strategy
- Maintain colonies in captivity for future re-introduction to depleted sites or sites undergoing restoration
- Undertake feral goat control programs in sandstone escarpment areas.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Broad-headed Snake (*Hoplocephalus bungaroides*) has been assigned to the Site-managed species management stream under the OEH Saving our Species program. The OEH has identified three management sites where conservation activated need to take place to endure the conservation of this species (Royal National Park, Woronora Plateau and Morton National Park).

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Broad-headed Snake (*Hoplocephalus bungaroides*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Broad-headed Snake (*Hoplocephalus bungaroides*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Broad-headed Snake (*Hoplocephalus bungaroides*) that will be increased by the proposal is clearing of native vegetation and bushrock removal.

### **Conclusion**

The Broad-headed Snake (*Hoplocephalus bungaroides*) will suffer a small reduction in extent of low-quality habitat from the proposal. The proposal is unlikely to reduce the population size of the Broad-headed Snake (*Hoplocephalus bungaroides*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Broad-headed Snake (*Hoplocephalus bungaroides*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Broad-headed Snake (*Hoplocephalus bungaroides*).

## **Cumberland Plain Land Snail (*Meridolum corneovirens*)**

At each habitat assessment site (n=84) an A field-based assessment was made on the potential presence and condition of the habitat for the Cumberland Plain Land Snail (*Meridolum corneovirens*) at 84 sites across the study area. The condition of the habitat was assessed, using the criteria described below, to rank and map the value of the habitat for the

species in areas to be impacted by the project. Targeted searches for the species were also carried out all sites that scored a moderate to high condition rating (n=17). The Cumberland Plain Land Snail was confirmed at five locations

Condition	Sheltering habitat	Leaf litter	Naturalness	Patch size / Connectivity	Ground cover
High	Abundant logs and / or building refuse	Abundant	Remnant	Large patch or adjoins large remnant outside the road reserve	>10% open ground, low abundance of dense exotic grasses
Moderate	Low abundance of logs or building refuse	Moderate	Regrowth	Small patch in fragmented mosaic of woodland patches	<10% open ground, patchy mix of open ground and plant cover
Poor	Logs or building refuse absent	None	Planted	Small isolated patch	100% cover of tall exotic grasses, no open patches of leaf litter

Of the 84 sites surveyed, high quality habitat for the species was identified at five locations all associated with remnant Shale-Gravel Transition Forest or a mix of remnant and regrowth forest with a relatively lower density of exotic grasses in the understorey and an abundance of leaf litter and natural or artificial debris. Common Garden Snails (*Helix aspera*) were recorded in the lower quality habitats. Moderate condition habitat was identified at 12 sites also containing remnant woodland although three planted woodland sites were considered to provide moderate potential habitat on the basis of the connectivity to larger remnant woodland patches, the low abundance of weeds and presence of sheltering habitat for this species.

The Cumberland Plain Land Snail (*Meridolum corneovirens*) was confirmed as present at the following five locations:

1. Four live snails found on the south side of the M4 Motorway corridor and east of Archbold Road at **Chainage 27350**. Remnant vegetation is present in the road corridor and part of a larger fragment of moderate to high quality woodland extending both sides of Archbold Road and on land occupied by the quarry.
2. Three snails and snail shells found south west side of Erskine Park Road at a number of locations in a large fragment of remnant Shale-Gravel Transition Forest between **Chainage 28800 and 29100**.
3. One live snail and snail shells found on the North west side of Erskine Park Road in a small remnant area of Shale-Gravel Transition Forest between **Chainage 28800 and 29100**.
4. Snail shells found to the west of Kent Road on south side of the M4 at **Chainage 34450** in a very small patch of remnant Shale Plains Woodland surrounded by planted vegetation.
5. Snail shells found to the west of Kent Road and on the northern side of the M4 at **Chainage 34700** in remnant Shale Plains Woodland and part of a larger patch of high quality woodland extending across private land to the north of the road corridor.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Cumberland Plain Land Snail (*Meridolum corneovirens*) primarily inhabits Cumberland Plain Woodland, Shale Gravel Transition Forests, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest. It lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish. Where conditions are suitable it will bury into loose soil especially under logs and around the bases of large trees (Clark 2009). The Cumberland Plain Land Snail (*Meridolum corneovirens*) is a fungus specialist.

The population of Cumberland Plain Land Snail (*Meridolum corneovirens*) that is known from the study area is assumed to be viable. Breeding is assumed to occur within the habitats. The Cumberland Plain Land Snail (*Meridolum corneovirens*) is known to inhabit patches of vegetation in the study area including Map Unit 1: Remnant Shale-Gravel Transition Forest (6.2 ha) and Map Unit 2: Remnant Shale Plains Woodland (12.5 ha). This species may also be present at the edges of Map Unit 3: Remnant Alluvial Woodland. There is potential that in the future this species may also utilise the remaining revegetated lands including Map Unit 5: Planted Shale Plains Woodland and Map Unit 6: Planted Shale-Gravel Transition Forest.

The loss of vegetation where the Cumberland Plain Land Snail (*Meridolum corneovirens*) is known to occur will directly affect the lifecycle of this species. The proposal would remove approximately 0.1 hectares of high quality habitat and 1.1 hectares of moderate quality habitat for the Cumberland Plain land Snail. However, removal of vegetation will be avoided where possible and mitigation measures including translocation of individuals before habitat removal will ensure that direct mortality is limited during construction. . The habitat within the study area where the Cumberland Plain Land Snail (*Meridolum corneovirens*) occurs is likely to be important for this species. This species is sedentary and does not move far. The Cumberland Plain Land Snail (*Meridolum corneovirens*) is likely to remain in the study area after the completion of the project and it is likely that in areas that are undisturbed by the proposal that foraging, movement and other life-cycle attributes would not be impacted.

Given the identified populations of Cumberland Plain Land Snail within the study area and potential impacts to suitable habitat associated with the proposal, it is recommended that a translocation management strategy be implemented for the species. The objective of the strategy would be to capture snails found within the construction corridor and relocate them outside of the corridor into suitable recipient sites (refer to Section 5.2.5). By capturing snails and translocating to a recipient site sufficiently close to the impact site, individuals will be saved from almost certain mortality during clearing works. Rescuing individual snails and translocating them to nearby sites is important not only for retaining population numbers but also to ensure that genetic variation is well represented across the subpopulations.

The proposal is unlikely to significantly reduce the population size of the Cumberland Plain Land Snail (*Meridolum corneovirens*) or decrease the reproductive success of this species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The extent of habitat for the Cumberland Plain Land Snail (*Meridolum corneovirens*) will be reduced by approximately 0.1 hectares of high quality habitat and 1.1 hectares of moderate quality habitat. The criteria for classifying habitat quality in the field is described above and considered patch-size, connectivity and presence of sheltering habitat (refer Figure 3-4). Live snails were recorded in both moderate quality and high quality habitat. This amount of habitat removal comprises a small percentage of the potential habitat available to this species observed outside the project corridor within the study area which includes several adjacent and larger remnant patches not impacted by the proposal.

In all remnants where the snail was observed the impact of the project will remove habitat from a narrow linear strip located along the edge of the habitat patch associated with widening of the road (refer Figure 3-4). This removal of habitat will therefore be a small percentage (averaging <5-10 %) of the extent of habitat present within the patch. The exception is a small remnant on the northwest side of Erskine Park Road (Chainage 28900 to 29100) which would be reduced by around 40-45 % of its current size. This patch is completely isolated by roads and residential development and was rated as moderate although a live snail was found here indicating the species persistence in smaller remnants (i.e 2-3 ha). None of the remnants impacted would be reduced to less than 1-2 hectares in area and this species is expected to persist in these smaller remnant based on recent movement studies for this species (Ridgeway *et al* 2014) which indicate their persistence in smaller remnants.

Of the five locations where snails were confirmed, all of these are already isolated patches of suitable habitat, with varying patch-sizes from <2 ha up to 10 ha. As the proposed clearing is along the existing M4 road corridor the clearing would not further isolate the habitat for this species and it is likely that the original M4 construction was responsible for fragmenting habitat, as snails were located on opposite sides of the road in two locations and there are no opportunities to cross the road. Importantly, the proposed widening will not result in fragmentation of habitat or further isolate habitat as the clearing will be limited to the road p

The loss of habitat for the Cumberland Plain Land Snail will involve a total of 0.1 hectares of high quality habitat will be removed which features remnant Shale-Gravel Transition Forest or a mix of remnant and regrowth forest with a relatively lower density of exotic grasses in the understorey and an abundance of leaf litter and natural or artificial debris. A total of 1.1 hectares of moderate condition habitat will be removed containing remnant woodland and connectivity to larger remnant woodland patches, with a low abundance of weeds and presence of sheltering habitat. Both habitats are considered locally important as they were

found to comprise live snails. However the project will impact small portion of the edge of the habitat and not completely remove or isolate and the species could be reasonably expect to persist in this location following the upgrade.

A translocation strategy should be implemented to capture snails found within the construction corridor and relocate them outside of the corridor into the adjoining areas of habitat to remain.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Cumberland Plain Land Snail (*Meridolum corneovirens*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Cumberland Plain Land Snail (*Meridolum corneovirens*). However, the following recovery actions have been identified by the OEH for the recovery of this species:

- Preserve remaining pockets of habitat from further urban development.
- Controlling weed invasion of habitat is considered an important activity in managing the species at the sites it occupies.
- Ensuring the community are aware of the implications of 'tidying up' and removing habitat for the species in sites that are occupied will be important for persistence of the species.
- Undertake research on the ecology of the species and determine characteristics of habitats that support the species and map potential habitat.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Cumberland Plain Land Snail (*Meridolum corneovirens*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Cumberland Plain Land Snail (*Meridolum corneovirens*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal is not consistent with objective 1 in that it will involve removal of habitat for urban development.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals

- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, there are eight KTPs relevant to the Cumberland Plain Land Snail (*Meridolum corneovirens*) that will be increased by the proposal. However, hygiene and weed control measures will reduce or avoid the impact of most KTPs with the exception of clearing of native vegetation and removal of dead wood and dead trees.

### Conclusion

The Cumberland Plain Land Snail (*Meridolum corneovirens*) will suffer a small reduction in extent of available habitat from the proposal. The proposal is unlikely to significantly reduce the population size of this species or decrease its reproductive success. Mitigation including translocation of individuals before habitat removal will ensure that no direct mortality occurs as a result of the proposal. Translocating individual snails to nearby sites is important not only for retaining population numbers but also to ensure that genetic variation is well represented across the subpopulations. The proposal will not interfere with the recovery of the Cumberland Plain Land Snail (*Meridolum corneovirens*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Cumberland Plain Land Snail (*Meridolum corneovirens*).

### Gang Gang Cockatoo (*Callocephalon fimbriatum*) and Glossy Black-cockatoo (*Calyptorhynchus lathamii*)

While the Gang Gang Cockatoo (*Callocephalon fimbriatum*) and Glossy Black-cockatoo (*Calyptorhynchus lathamii*) were not recorded in the study area during the field survey, they are considered likely to occur based on the presence of suitable foraging habitat, hollow trees for nesting and recent records in larger habitat patches on the foothills west of Emu Plains.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

#### Gang Gang Cockatoo

The Gang-gang Cockatoo is distributed from southern Victoria through south- and central-eastern New South Wales. In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. It occurs regularly in the Australian Capital Territory. It is rare at the extremities of its range, with isolated records known from as far north as Coffs Harbour and as far west as Mudgee (OEH 2012). In summer this species is generally found in tall mountain forests and woodlands, and may occur at lower altitudes in winter in drier more open eucalypt forests and woodlands, with old growth habitats being favoured for nesting and roosting (OEH 2012). Gang-gang Cockatoos feed mainly on seeds of native and introduced trees and shrubs, with a preference for eucalypts, wattles and introduced hawthorns. They will also eat berries, fruits, nuts and insects and their larvae. They are mainly arboreal (found in trees), coming to the ground only to drink and to forage among fallen fruits or pine cones (Birdlife Australia, n.d.).

#### Glossy Black Cockatoo

Glossy Black-cockatoos require suitable hollows in large, old eucalypt trees (living or dead) for nesting. Glossy Black-cockatoos are highly specialised, feeding almost exclusively on the

seeds extracted from the cones of species of *Allocasuarina*. The cockatoos are highly selective with respect to both the trees and the cones on which they choose to forage, often showing fidelity to particular trees. Glossy Black-cockatoos prefer trees carrying a large number of cones (Pepper et al. 2000), in part because they appear to select feeding trees primarily on the basis of optimizing kernel intake (Crowley and Garnett, 2006).

The feed-tree species for the threatened Glossy Black-cockatoo, namely Black She-oak (*Allocasuarina littoralis*) was observed at several locations in the study area including planted vegetation. The species was not confirmed during the survey either through direct observation or evidence of feeding (i.e. chewed She-oak cones). Suitable habitat is generally restricted to larger habitat patches on the foothills west of Emu Plains where Black She-oak stands are common and hollows potential suitable for nesting are present.

The proposal would result in the removal of about 0.68 hectares of potential foraging habitat for Gang-gang Cockatoo (*Callocephalon fimbriatum*) and the Glossy Black-cockatoo (*Calyptorhynchus lathamii*). A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Many of these are insufficient size for these two species to nest in. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Shelter and food resources in the study area are likely to be important for the life cycle of this species, however there is a low potential that the proposal would adversely affect the life-cycle of the species to be impacted given the widespread occurrence of suitable foraging habitat.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The extent of foraging habitat for the Gang-gang Cockatoo (*Callocephalon fimbriatum*) and the Glossy Black-cockatoo (*Calyptorhynchus lathamii*) will be reduced by approximately 0.68 hectares. Hollow-bearing trees are scarce within the proposed ITS cabling footprint and will

be avoided during construction where possible through minor adjustments to the cabling alignment. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Gang-gang Cockatoo (*Callocephalon fimbriatum*) and the Glossy Black-cockatoo (*Calyptorhynchus lathamii*). No large blocks of high quality habitat for this species will be broken apart by the proposal. These species are mobile species that occupy a large home range and are able to persist in areas where small scale disturbances occur. The proposal will not affect the movement of these between habitat patches.

The proposal would remove foraging habitat containing *Allocasuarina littoralis* (foraging habitat for Glossy Black-cockatoo). The proposal would also remove a range of Eucalypt and Acacia species (potential foraging habitat for Gang-gang Cockatoo). Large areas of foraging habitat are present within the locality. No important large hollow-bearing trees will be impacted by the proposal. Given the high mobility of these species and the proximity of large areas of native vegetation in the locality (e.g. Blue Mountains National Park (to the west) and Wollemi National Park (to the north)), the removal of a small area of foraging habitat would be very unlikely to have a significant effect on the long-term survival of a local population of these species.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Gang-gang Cockatoo (*Callocephalon fimbriatum*) or the Glossy Black-cockatoo (*Calyptorhynchus lathamii*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

There is no recovery plan for the Gang-gang Cockatoo (*Callocephalon fimbriatum*) or the Glossy Black-cockatoo (*Calyptorhynchus lathamii*). There are 11 priority action statements for this species related to scientific research, community awareness, habitat restoration and protection of this species.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. These species have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Gang-gang Cockatoo (*Callocephalon fimbriatum*) or the Glossy Black-cockatoo (*Calyptorhynchus lathamii*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will avoid removing roadside vegetation where possible. The proposal will not interfere with the recovery of these threatened bird species.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Gang Gang Cockatoo (*Callocephalon fimbriatum*) and Glossy Black-cockatoo

(*Calyptorhynchus lathamii*) that will be increased by the proposal are clearing of native vegetation and removal of dead wood and dead trees.

## Conclusion

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) or the Glossy Black-cockatoo (*Calyptorhynchus lathamii*) will suffer a small reduction in extent of foraging habitat from the proposal. No important large hollow-bearing trees will be impacted by the proposal. The proposal is unlikely to reduce the population size of these species or decrease its reproductive success. The proposal will not interfere with the recovery of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Gang-gang Cockatoo (*Callocephalon fimbriatum*) or the Glossy Black-cockatoo (*Calyptorhynchus lathamii*).

## Grey-headed Flying-fox (*Pteropus poliocephalus*)

While the Grey-headed Flying-fox (*Pteropus poliocephalus*) was not recorded in the study area during the field survey due to the diurnal nature of the surveys, it is considered likely to occur based on the presence of suitable foraging habitat and the nearby location of roosting camps at Parramatta Park, Clyde (Duck River), Wetherill Park, Ropes Creek, and Emu Plains.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Grey-headed Flying-fox (*Pteropus poliocephalus*) occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 kilometres of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Annual mating commences in January and conception occurs in April or May; a single young is born in October or November.

There are no roost camps located in the study area and at the time of this assessment the proposal would not directly impact on any known breeding / maternity site. The closest camp is at Clyde on the Duck River approximately 800 metres south of the proposal. As such, the impacts of the proposal to the Grey-headed Flying-fox (*Pteropus poliocephalus*) will be limited to loss of feeding habitat caused by direct clearing or damage to native vegetation during the construction phase.

The proposal would remove approximately 24.89 hectares of potential foraging habitat (although not all of this habitat is likely to be used due to limited foraging resources) however removal of vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within the locality. The study area is not considered a critical habitat for these species and much of it is made up of planted roadside vegetation. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of the camps located near the study area, the project is not expected to significantly affect the life cycle of the species.

The draft recovery plan for the Grey-headed Flying-fox (DECCW 2009) identifies critical foraging habitat for this species. One of the criteria is if the area is known to support populations of greater than 30,000 individuals within a 50 kilometre radius of the site.

Considering the presence of numerous camps within a 50 kilometre radius, habitats in the study area are likely to be classed as critical foraging habitat. Additionally Forest Red Gum (*Eucalyptus tereticornis*) is relatively common and is a known food source during winter and spring. The large majority of foraging habitat for this species will be retained within the study area.

Considering the above factors the proposal is unlikely to reduce the population size of the Grey-headed Flying-fox (*Pteropus poliocephalus*) or decrease the reproductive success of this species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Grey-headed Flying-fox (*Pteropus poliocephalus*) within the study area is limited to foraging habitat and includes all Map Units where fruiting and flowering trees and shrubs are present. The extent of habitat for the Grey-headed Flying-fox (*Pteropus poliocephalus*) will be reduced by approximately 24.89 hectares. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Grey-headed Flying-fox (*Pteropus poliocephalus*). This species is highly mobile and will freely fly long distances (up to 50 kilometres) over open areas including urbanised city centres to move between roost camps and foraging sites. The proposal will not affect the movement of the Grey-headed Flying-fox (*Pteropus poliocephalus*) between habitat patches.

Importantly, the proposal will not impact on the most important habitats for Grey-headed Flying-fox (*Pteropus poliocephalus*) within the locality. The most important habitats for the local Grey-headed Flying-fox (*Pteropus poliocephalus*) sub-populations are the roosting camps at Parramatta Park, Clyde (Duck River), Wetherill Park, Ropes Creek, and Emu Plains. These camps will not be affected by the proposal. Foraging habitat within the study area is classed as critical foraging habitat considering the close proximity of several roost camps and is likely to form part of an overall foraging range of these sub-populations.

However, much of the vegetation to be affected is planted roadside vegetation and would only form a small proportion of available habitat for this species. The foraging habitat within the study area is unlikely to be of critical importance for the survival of the Grey-headed Flying-fox (*Pteropus poliocephalus*) within the locality, although these habitats do meet the definition of foraging habitat critical to the survival of the species.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Grey-headed Flying-fox (*Pteropus poliocephalus*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The *Draft National Recovery Plan for the Grey-headed Flying-fox (Pteropus poliocephalus)* (Department of Environment, Climate Change and Water NSW. 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes
- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture
- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Grey-headed Flying-fox (*Pteropus poliocephalus*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Grey-headed Flying-fox (*Pteropus poliocephalus*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Grey-headed Flying-fox (*Pteropus poliocephalus*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Grey-headed Flying-fox (*Pteropus poliocephalus*) that will be increased by the proposal is clearing of native vegetation. The main threats to the Grey-headed Flying-fox (*Pteropus poliocephalus*) include:

- Loss and disturbance of roosting sites.
- Unregulated shooting.
- Electrocution on powerlines, entanglement in netting and on barbed-wire.
- Competition with Black Flying-foxes.
- Negative public attitudes and conflict with humans.
- Impacts from climate change.
- Disease.

The proposal will not increase any of the above threats.

### **Conclusion**

The Grey-headed Flying-fox (*Pteropus poliocephalus*) will suffer a small reduction in extent of critical foraging habitat from the proposal. No camps will be impacted. The proposal is unlikely to reduce the population size of the Grey-headed Flying-fox (*Pteropus poliocephalus*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Grey-headed Flying-fox (*Pteropus poliocephalus*) and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Grey-headed Flying-fox (*Pteropus poliocephalus*).

### **Little Eagle (*Hieraaetus morphnoides*)**

While the Little Eagle (*Hieraaetus morphnoides*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging habitat.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Little Eagle (*Hieraaetus morphnoides*) is distributed throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment (Marchant and Higgins 1993). It occurs as a single population throughout NSW. The population in New Guinea is now classified as a separate species, the Papuan Booted Eagle *Hieraaetus weiskei* (Lerner and Mindell 2005). The Little Eagle occupies habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used (Marchant and Higgins 1993). For nest sites, the Little Eagle requires a tall living tree within a remnant patch, where pairs build a large stick nest (one of the largest of all Australian raptors) in winter and lay in early spring. It eats birds, reptiles and mammals, occasionally adding large insects and carrion (Marchant and Higgins 1993). It was formerly heavily dependent on rabbits, but following the spread of rabbit calicivirus disease, and consequent decline in rabbit numbers by 65-85% in the arid and semi-arid zones (Sharp et al. 2002), the Little Eagle is increasingly dependent on native prey.

While the Little Eagle (*Hieraaetus morphnoides*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging habitat. The study area contains potential foraging habitat for the Little Eagle (*Hieraaetus morphnoides*), however the disturbed nature of the roadside vegetation means it is of lesser quality than preferred pre-rich vegetation. The proposal will also potentially result in the loss of a small number of mature nesting trees, however, these trees are unlikely to be used for nesting as they are too close to the edge of the vegetation patch. The proposal would remove approximately 13.48 hectares of potential foraging habitat (although not this entire habitat is likely to be used). However much of this area is planted vegetation and its removal will be avoided where possible. Some mature trees will be removed; however these are unlikely to be used as nesting trees due to their close proximity to the edge of the patch. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of the Little Eagle (*Hieraaetus morphnoides*) or decrease the reproductive success of this species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

**iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

While the Little Eagle (*Hieraaetus morphnoides*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging habitat. The potential habitat of the Little Eagle (*Hieraaetus morphnoides*) within the study area is limited to foraging habitat, however there are potential nesting trees that may be utilised. The extent of foraging habitat for this species will be reduced by approximately 13.48 hectares. Some mature trees will be removed; however these are unlikely to be used as nesting trees due to their close proximity to the edge of the patch. Much of this is planted vegetation and this amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Little Eagle (*Hieraaetus morphnoides*). This species is highly mobile and will freely fly long distances over open areas to move between habitats. The proposal will not affect the movement of the Little Eagle (*Hieraaetus morphnoides*) between habitat patches.

The study area would most likely constitute low quality non-breeding habitat for the Little Eagle (*Hieraaetus morphnoides*). The loss of foraging habitat and some potentially used nest trees would directly affect the species in the area; however, the study area is not considered a critical area for the Little Eagle (*Hieraaetus morphnoides*). This species is likely to utilise vegetation in the study area for foraging intermittently when no other suitable resources are available. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Little Eagle (*Hieraaetus morphnoides*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Little Eagle (*Hieraaetus morphnoides*). However, the following actions have been identified by the OEH for recovery of this species:

- Buffer habitat areas from the impacts of other activities.
- Protect known populations and areas of potential habitat from clearing, fragmentation or disturbance.
- Rehabilitate known and potential habitat.
- Retain and protect nesting and foraging habitat

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Little Eagle (*Hieraaetus morphnoides*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Little Eagle (*Hieraaetus morphnoides*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Little Eagle (*Hieraaetus morphnoides*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Little Eagle (*Hieraaetus morphnoides*) that will be increased by the proposal is clearing of native vegetation and removal of dead wood and dead trees.

**Conclusion**

The Little Eagle (*Hieraaetus morphnoides*) will suffer a small reduction in extent of potential low quality foraging habitat and a small number of potential mature nesting trees from the proposal. The proposal is unlikely to reduce the population size of these species or decrease its reproductive success. The proposal will not interfere with the recovery of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Little Eagle (*Hieraaetus morphnoides*).

### Little Lorikeet (*Glossopsitta pusilla*)

While the Little Lorikeet (*Glossopsitta pusilla*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging habitat.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

Little Lorikeets (*Glossopsitta pusilla*) are known to occupy a diversity of forest and woodland habitats, including old-growth and logged forests, and remnant woodland patches and roadside vegetation. The species is generally considered to be nomadic, with irregular large or small influxes of individuals occurring at any time of year, apparently related to food availability. However, they do exhibit some site fidelity, with breeding pairs resident from April to December, and even during their non-resident period some individuals will return to the nest area for short periods if there is some tree-flowering in the vicinity.

The Little Lorikeet (*Glossopsitta pusilla*) feeds in small flocks, often with other species of lorikeet, primarily on nectar and pollen in the tree canopy. They prefer profusely flowering eucalypts but will also feed in other species such as melaleucas and mistletoes. The species breeds in tree hollows in living trees, during May to September, raising clutches of three to five eggs. They likely start breeding at one year, and live for around 10 years in the wild.

The study area contains foraging habitat for the Little Lorikeet (*Glossopsitta pusilla*) including a wide range of flowering trees and shrubs, and there is no breeding habitat for the species present (i.e. there are very few trees supporting suitable hollows). The loss of feed trees would directly affect the species opportunity to feed and breed in the area; however, the study area is not considered a critical area for the Little Lorikeet. The Little Lorikeet (*Glossopsitta pusilla*) is likely to utilise trees in the study area for foraging intermittently when no other

suitable resources are available. The proposal would remove approximately 24.89 hectares of potential foraging habitat (although not this entire habitat is likely to be used). Much of this is planted vegetation and its removal will be avoided where possible. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of the Little Lorikeet (*Glossopsitta pusilla*) or decrease the reproductive success of this species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Little Lorikeet (*Glossopsitta pusilla*) within the study area is limited to foraging habitat and includes all Map Units where flowering trees and shrubs are present. The extent of habitat for the Little Lorikeet (*Glossopsitta pusilla*) will be reduced by approximately 24.89 hectares of potential foraging habitat (although not this entire habitat is likely to be used). Much of this is planted vegetation and its removal will be avoided where possible. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. Hollow-bearing trees located in the proposed ITS cabling footprint will be avoided during construction through minor adjustments to the cabling alignment.

Importantly, the proposal will not result in fragmentation of habitat for the Little Lorikeet (*Glossopsitta pusilla*). This species is highly mobile and will freely fly long distances over open areas to move between habitats. The proposal will not affect the movement of the Little Lorikeet (*Glossopsitta pusilla*) between habitat patches.

The study area would constitute non-breeding habitat for the Little Lorikeet (*Glossopsitta pusilla*) as no trees supporting suitable hollows will be impacted. The loss of feed trees would directly affect the species opportunity to feed in the area; however, the study area is not considered a critical area for the Little Lorikeet (*Glossopsitta pusilla*). The Little Lorikeet (*Glossopsitta pusilla*) is likely to utilise trees in the study area for foraging intermittently when no other suitable resources are available. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Little Lorikeet (*Glossopsitta pusilla*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Little Lorikeet (*Glossopsitta pusilla*). However, the following actions have been identified by the OEH for recovery of this species:

- Retain large old trees, especially those that are hollow-bearing
- Ensure recruitment of trees into the mature age class so that there is not a lag period of decades between the death of old trees and hollow formation in younger trees
- Protect large flowering Eucalyptus trees throughout the habitats frequented by this species
- Manage remnant woodlands and forest for recovery of old-growth characteristics
- Where natural tree recruitment is inadequate, replant local species to maintain foraging habitat and breeding sites
- Reduce the abundance of feral Honeybees and limit the exploitation of nectar by domestic bees where resources are spatially or temporally sparse (e.g. in years of drought)
- Document nest sites and ensure their protection.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Little Lorikeet (*Glossopsitta pusilla*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Little Lorikeet (*Glossopsitta pusilla*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Little Lorikeet (*Glossopsitta pusilla*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Little Lorikeet (*Glossopsitta pusilla*) that will be increased by the proposal is clearing of native vegetation.

The major threats to the Little Lorikeet (*Glossopsitta pusilla*) are loss of breeding sites and food resources from ongoing land clearing. Loss of nest trees from road-side verges, often associated with road works, remains an ongoing threat. The proposal will not result in the loss of roadside nest trees and the foraging habitat that will be removed is marginal.

**Conclusion**

The Little Lorikeet (*Glossopsitta pusilla*) will suffer a small reduction in extent of foraging habitat from the proposal. No important nesting trees will be impacted. The proposal is unlikely to reduce the population size of the Little Lorikeet (*Glossopsitta pusilla*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Little Lorikeet (*Glossopsitta pusilla*) and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Little Lorikeet (*Glossopsitta pusilla*).

**Red-crowned Toadlet (*Pseudophryne australis*)**

While the Red-crowned Toadlet (*Pseudophryne australis*) was not recorded in the study area during the field survey it is considered to have some potential to occur based on the presence of suitable habitat. There are records approximately 700 metres from the western end of the impact area.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Red-crowned Toadlet (*Pseudophryne australis*) is a habitat specialist occurring only on sandstone formations of the Sydney Basin, generally within 100m of ridge tops. The species prefers ephemeral 'feeder creeks', permanently moist soaks and seepage zones (Thumm and Mahony, 1999). When not breeding, individuals are still largely restricted to the vicinity of breeding areas, dispersing only in the order of tens of metres. Breeding may occur year-round depending on weather conditions. Eggs are laid in nests of decomposing leaf matter and are flushed by rainfall events into transient pools where tadpoles complete their development

(National Parks and Wildlife Service 2001). Water quality is particularly important for this species.

Potential habitat for this species was located in the west of the study area near the Knapsack Viaduct in the form of constructed drainage lines. The proposal will result in the removal of 0.28 hectares of this habitat. These areas represent very poor quality habitat for this species, due to the limited presence sandstone formations and moist depressions, and there is potential for fluctuations in water quality with runoff from the existing motorway (this species has not been recorded breeding neither in sites that are even mildly polluted nor in permanently flowing watercourses). Therefore disruption to the life cycle of this species is unlikely and would not be placed at risk of extinction.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Red-crowned Toadlet (*Pseudophryne australis*) within the study area is limited to constructed drainage lines located in the west of the study area near the Knapsack Viaduct. The proposal will result in the removal of 0.28 hectares of this habitat. These areas represent very poor quality habitat for this species, due to the absence of sandstone formations and potential water pollution. Also, this amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Red-crowned Toadlet (*Pseudophryne australis*). Most of this species' life is spent under some form of cover, such as rocks, deep leaf-litter, or in rock crevices. The vegetation is roadside and the drainage line is low-quality habitat.

The drainage line presents low-quality habitat for the Red-crowned Toadlet (*Pseudophryne australis*). The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Red-crowned Toadlet (*Pseudophryne australis*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Red-crowned Toadlet (*Pseudophryne australis*). However, the following actions have been identified by the OEH for recovery of this species:

- Apply mosaic pattern hazard reduction techniques.
- Retain and protect habitat and buffers around habitat, particularly vegetation on upper slopes and ridges.
- Protect water quality and maintain natural water flows in drainage lines below developed ridges.
- Do not remove sandstone rock from bushland in escarpment areas.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Red-crowned Toadlet (*Pseudophryne australis*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Red-crowned Toadlet (*Pseudophryne australis*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Red-crowned Toadlet (*Pseudophryne australis*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Red-crowned Toadlet (*Pseudophryne australis*) that will be increased by the proposal is clearing of native vegetation and Infection of frogs by amphibian chytrid causing the disease chytridiomycosis

**Conclusion**

If present, the Red-crowned Toadlet (*Pseudophryne australis*) will suffer a small reduction in extent of low-quality habitat from the proposal. The proposal is unlikely to reduce the population size of the Red-crowned Toadlet (*Pseudophryne australis*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Red-crowned Toadlet (*Pseudophryne australis*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Red-crowned Toadlet (*Pseudophryne australis*).

**Spotted-tail Quoll (*Dasyurus maculatus*)**

While the Spotted-tail Quoll (*Dasyurus maculatus*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging

habitat. There are several more recent records (post 2000) within 1 kilometre of the western end of the study area.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Spotted-tail Quoll (*Dasyurus maculatus*) typically has a large home range and occupies a diversity of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. The Spotted-tail Quoll (*Dasyurus maculatus*) is predominantly nocturnal and rests during the day in dens, such as hollow logs, tree hollows, rock outcrops or caves (Jones *et al.*, 2001). Preferred habitat includes dry and moist sclerophyll forests and may include adjacent modified patches of forest on farmland. Suitable habitat is well represented in the large forest reserves in the locality (i.e. National Parks north and west of the study area). Suitable habitat in the study area includes the larger vegetation patches in the foothills west of Emu Plains including patches of Shale Sandstone Transition Forest and adjoining planted vegetation within the road reserve. The project would remove a small area of habitat for the species which is limited to the edges of larger patches of forest habitats west of Emu Plains. The overall reduction of habitat as a result of the proposal represents a small proportion of the available area of suitable habitat.

The proposal will result in the loss of approximately 0.68 hectares of habitat for the Spotted-tail Quoll (*Dasyurus maculatus*) comprising larger patches of remnant vegetation (Map Unit 11) and adjoining planted areas (Map Unit 7). The study area also contains some rock outcrops at the western end. The proposal is unlikely to displace or disturb any individuals with impacts limited to foraging habitat from cabling for ITS infrastructure.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Spotted-tail Quoll (*Dasyurus maculatus*) within the study area is limited to the western end, which is separate to, but borders onto the foothills of the Blue Mountains. The extent of habitat for the Spotted-tail Quoll (*Dasyurus maculatus*) will be reduced by approximately 0.68 hectares. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Spotted-tail Quoll (*Dasyurus maculatus*). The vegetation to be removed is roadside vegetation and already subject to edge effects and the majority is in a moderate condition. The proposal will not affect the movement of the Spotted-tail Quoll (*Dasyurus maculatus*) between habitat patches.

The Spotted-tail Quoll (*Dasyurus maculatus*) occupies a wide range of habitats and requires dens for daytime nest sites. Vegetation in the impact area is not considered to be important for this species. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Spotted-tail Quoll (*Dasyurus maculatus*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Spotted-tail Quoll (*Dasyurus maculatus*). However, the following actions have been identified by the OEH for recovery of this species:

- Consult with OEH/NPWS if Spotted-tailed Quolls are raiding poultry, rather than taking direct action
- Consult with OEH/NPWS if poison baiting is planned in or near areas where Spotted-tailed Quolls are known or likely to occur
- Undertake cat and fox control using poison-baiting techniques least likely to affect quolls
- Retain and protect large, forested areas with hollow logs and rocky outcrops, particularly areas with thick understorey or dense vegetation along drainage lines.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Spotted-tail Quoll (*Dasyurus maculatus*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Spotted-tail Quoll (*Dasyurus maculatus*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Spotted-tail Quoll (*Dasyurus maculatus*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological

community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Spotted-tailed Quoll that will be increased by the proposal is clearing of native vegetation.

### **Conclusion**

The Spotted-tail Quoll (*Dasyurus maculatus*) will suffer a small reduction in extent of marginal foraging habitat from the proposal. The proposal is unlikely to reduce the population size of the Spotted-tail Quoll (*Dasyurus maculatus*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Spotted-tail Quoll (*Dasyurus maculatus*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Spotted-tail Quoll (*Dasyurus maculatus*).

### **Swift Parrot (*Lathamus discolor*)**

While the Swift Parrot (*Lathamus discolor*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable winter foraging habitat.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

#### **In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Swift Parrot (*Lathamus discolor*) is endemic to south-eastern Australia and breeds only in Tasmania, and migrates to mainland Australia in autumn. This species is semi-nomadic during winter, foraging in dry woodlands mainly in Victoria and New South Wales.

Key habitats for the species on the coast and coastal plains of New South Wales include Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*E. robusta*), Red Bloodwood (*Corymbia gummifera*) and Forest Red Gum (*E. tereticornis*) forests. These tree species provide foraging and roosting habitat for the species. The Swift Parrot feeds mostly on nectar, mainly from eucalypts, but also eats psyllid insects and lerps, seeds and fruit. Coastal Grey Box (*Eucalyptus moluccana*) and Red Bloodwood (*Corymbia gummifera*) are important nectar sources in coastal parts of the non-breeding range. As a specialist nectarivore, dependent on flowering eucalypts in both breeding and non-breeding parts of its range, Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat, but continued habitat loss and disturbance processes threaten the Swift Parrot's survival

The study area contains some marginal foraging habitat for the Swift Parrot (*Lathamus discolor*). While the habitat in the study area is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the study area is not considered a critical area for the Swift Parrot (*Lathamus discolor*). The Swift Parrot (*Lathamus discolor*) may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The proposal would remove approximately 24.89 hectares of potential foraging habitat (although not this entire habitat is likely to be used). Much of this is planted vegetation and its removal will be avoided where possible. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be

avoided during construction through minor adjustments to the cabling alignment. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of the Swift Parrot (*Lathamus discolor*) or decrease the reproductive success of this species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Swift Parrot (*Lathamus discolor*) within the study area is limited to foraging habitat and includes all Map Units where flowering trees are present. The extent of habitat for the Swift Parrot (*Lathamus discolor*) will be reduced by approximately 24.89 hectares of potential foraging habitat (although not this entire habitat is likely to be used). Much of this is planted vegetation and its removal will be avoided where possible. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. Hollow-bearing trees located in the proposed ITS cabling footprint will be avoided during construction through minor adjustments to the cabling alignment.

Importantly, the proposal will not result in fragmentation of habitat for the Swift Parrot (*Lathamus discolor*). This species is highly mobile and will freely fly long distances over open areas to move between habitats. The proposal will not affect the movement of the Swift Parrot (*Lathamus discolor*) between habitat patches.

The loss of feed trees would directly affect the species opportunity to feed in the area; however, the study area is not considered a critical area for this species. The Swift Parrot (*Lathamus discolor*) is likely to utilise trees in the study area for foraging intermittently when no other suitable resources are available. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around

the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for the Swift Parrot (*Lathamus discolor*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The *National Recovery Plan for the Swift Parrot* (Saunders & Tzaros 2011) identifies the following actions for recovery of this species:

- Identify the extent and quality of habitat
- Manage and protect Swift Parrot habitat at the landscape scale
- Monitor and manage the impact of collisions, competition and disease
- Monitor population and habitat.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Swift Parrot (*Lathamus discolor*) has been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Swift Parrot (*Lathamus discolor*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Swift Parrot (*Lathamus discolor*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Swift Parrot (*Lathamus discolor*) that will be increased by the proposal is clearing of native vegetation.

### **Conclusion**

The Swift Parrot (*Lathamus discolor*) will suffer a small reduction in extent of marginal foraging habitat from the proposal. No important nesting trees will be impacted. The proposal is unlikely to reduce the population size of the Swift Parrot (*Lathamus discolor*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Swift Parrot (*Lathamus discolor*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Swift Parrot (*Lathamus discolor*).

### **Arboreal mammals**

While no threatened arboreal mammals were directly observed in the study area due to the diurnal nature of the surveys, they are considered likely to occur based on the presence of suitable foraging habitat. Suitable habitat for threatened arboreal mammals is generally restricted to large remnant habitat patches west of Emu Plains. The arboreal mammal species considered comprise:

- Eastern Pygmy Possum (*Cercartetus nanus*)
- Squirrel Glider (*Petaurus norfolcensis*)
- Yellow-bellied Glider (*Petaurus australis*)

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

#### **Eastern Pygmy Possum**

The Eastern Pygmy Possum (*Cercartetus nanus*) occurs in a range of habitats from rainforest through sclerophyll forests and woodlands to heath, though heath and woodland habitats are preferred through most of its range. It feeds on nectar and pollen from eucalypts, banksias and bottlebrushes and occasionally on insects (DEC 2005). It is known to nest in hollows in trees but its small size also allows it to nest in a variety of places, including under the bark of eucalypts, forks of tea-trees, and in abandoned bird nests (Turner and Ward 1995). It shelters during the day in tree hollows, rotten stumps, and holes in the ground, abandoned bird nests, possum dreys or thickets of vegetation, including the bases of grasstrees or waratahs. Males have non-exclusive home-ranges of about 0.68 hectares and females about 0.35 hectares. There are records approximately 700 metres from the western end of the impact area.

#### **Squirrel Glider**

The Squirrel Glider (*Petaurus norfolcensis*) inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey. The Squirrel Glider feeds on insects, the gum produced by Acacia species, the sap of certain eucalypts, nectar and pollen (Strahan, 1995). The Squirrel Glider (*Petaurus norfolcensis*) requires abundant tree hollows for refuge and nest sites, with family groups utilising a number of hollows within their home range. Hollows used by Squirrel Glider (*Petaurus norfolcensis*) are small (about 5 cm diameter). There are records approximately 9.5 kilometres from the western end of the impact area.

#### **Yellow-bellied Glider**

Yellow-bellied Gliders (*Petaurus australis*) have a patchy distribution and is known to occur in a variety of habitats, Yellow-bellied Gliders are usually associated with tall, mature wet

eucalypt forest in high rainfall areas. They are present at low densities, even in areas of preferred habitat, probably as a result of the low food availability and their territorial nature. The low nutritional value of the major food of this species (sap) requires individuals to spend large amounts of time foraging within extensive home ranges. The diet of this species includes plant exudates (sap, nectar, honeydew and manna) as well as insects. Sap is tapped from the trunks of trees via chewed "V" shaped incisions or in some cases extended vertical incisions (Goldingay & Kavanagh 1991). Tree species used varies according to locations and habitats, and although none of the species in the study area have been identified as food trees, some of these species may potentially be utilised by the species. The shedding of bark by tree species is considered important for the gathering of invertebrates and honeydew. Hollows for nest sites are essential, as are suitable food trees. Den sites are often, but not always, located in mature, living smooth-barked eucalypts with large hollows. The Yellow-bellied Glider (*Petaurus australis*) is known to have a large home range of more than 35 hectares and may travel in excess of 2 kilometres from the den to forage in a single night. There are records approximately one kilometre from the western end of the impact area.

Shrubby woodland habitats at the western end of the study area contain potential habitat for the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*). The proposal would involve the removal of about 0.68 hectares of potential foraging habitat. This may also present potential nesting habitat for the Eastern Pygmy Possum (*Cercartetus nanus*) as it is known to shelter in a variety of sites due to its small body size. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Hollows represent potential nesting habitat for the Eastern Pygmy Possum (*Cercartetus nanus*) and Squirrel Glider (*Petaurus norfolcensis*), however hollows are likely not large enough for the Yellow-bellied Glider (*Petaurus australis*). Habitats at the site would represent only a minor proportion of the habitat available to any resident individuals in the locality. Potential habitat occurs as intact dry sclerophyll forest where there is a mid-storey nectar resource. Tree hollows likely occur in moderate densities throughout the surrounding landscapes, and habitat for this species is particularly well represented within the adjoining National Parks. The removal of 0.68 hectares of remnant vegetation and existing edge areas is not expected to significantly impact on the life-cycle of local populations, if they occur.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

Potential foraging and nesting habitat of the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) is located in the western end of the study area. The extent of habitat for these species will be reduced by approximately 0.68 hectares. This impact area represents foraging habitat for all three species, though only nesting habitat for the Eastern Pygmy Possum (*Cercartetus nanus*) as it is known to nest in a variety of tree hollows, rotten stumps, and holes in the ground, abandoned bird nests, possum dreys or thickets of vegetation. Hollow-bearing trees located in the project footprint are potential habitat for the Squirrel Glider (*Petaurus norfolcensis*), however many may be too small for the Yellow-bellied Glider (*Petaurus australis*). Hollow-bearing trees located in the proposed ITS cabling footprint will be avoided during construction through minor adjustments to the cabling alignment. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*). No large blocks of high quality habitat for these species will be broken apart by the proposal. The proposal will not affect the movement of the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) between habitat patches.

The loss of foraging habitat trees would directly affect the opportunity for these three species to feed in the area; however, the impact area is not considered to be an important area of habitat for these species. The Eastern Pygmy Possum (*Cercartetus nanus*) may utilise the area for nesting as it is known to nest in a variety of sites including tree hollows, rotten stumps, and holes in the ground, abandoned bird nests, possum dreys or thickets of vegetation. The Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) may utilise the habitat in the study area intermittently for foraging, though they require hollow-bearing trees for nesting. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Many of these are likely not large enough for the Yellow-bellied Glider (*Petaurus australis*), which are often, but not always, found in mature, living smooth-barked eucalypts with large hollows. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains) and the current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project. It is unlikely that the proposal will impact on foraging, movement and other life-cycle attributes of the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*).

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The *NSW Recovery Plan for Yellow-bellied Glider (Petaurus australis)* (NPWS, 2003) identifies the following objectives:

- To co-ordinate the recovery of the Yellow-bellied Glider in NSW
- To encourage and assist in improving the protection and management of the Yellow-bellied Glider and its habitat
- To identify and monitor significant populations of the species
- To facilitate strategic research into the ecology of the Yellow-bellied Glider that is relevant to its conservation
- To increase community awareness of the Yellow-bellied Glider and encourage community involvement in its conservation.

A recovery plan does not exist for the Eastern Pygmy Possum (*Cercartetus nanus*) or Squirrel Glider (*Petaurus norfolcensis*). A targeted strategy for managing threatened species is being developed under the OEH Saving Our Species program for these three species. The Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTP relevant to the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) that will be increased by the proposal is clearing of native vegetation and predation by the feral cat (*Felis catus*).

**Conclusion**

The Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*) will suffer a small reduction (0.68 hectares) in extent of marginal foraging habitat from the proposal. This impact area represents foraging habitat for all three species, though only nesting habitat for the Eastern Pygmy Possum

(*Cercartetus nanus*) as it known to nest in a variety tree hollows, rotten stumps, and holes in the ground, abandoned bird nests, possum dreys or thickets of vegetation. As such, there are extensive areas of suitable nesting habitat for this species in the locality. Hollow-bearing trees located in the project footprint are potential habitat for the Squirrel Glider (*Petaurus norfolcensis*), however many may be too small for the Yellow-bellied Glider (*Petaurus australis*). Only several hollow-bearing trees are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. The proposal is unlikely to reduce the population size of these species' or decrease their reproductive success. The proposal will not interfere with the recovery of these species'. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Eastern Pygmy Possum (*Cercartetus nanus*), Squirrel Glider (*Petaurus norfolcensis*) and the Yellow-bellied Glider (*Petaurus australis*).

## Large Forest Owls

While no threatened large forest owl species were recorded in the study area during the field survey, they are considered moderately likely to occur based on the presence of suitable foraging habitat and nearby records. This assessment concerns three species comprising:

- Masked Owl (*Tyto novaehollandiae*)
- Powerful Owl (*Ninox strenua*)
- Barking Owl (*Ninox connivens*).

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

### Masked Owl

Optimal habitat for the Masked Owl (*Tyto novaehollandiae*) includes an open understorey and a mosaic of sparse (grassy) and dense (shrubby) groundcover on gentle terrain (Department of Environment and Conservation 2006). Roosts in hollows in live or occasionally dead eucalypts; dense foliage in gullies; and caves or recesses in cliffs (Department of Environment and Conservation 2006). Nests in old hollow eucalypts, live or dead but commonly live, in a variety of topographic positions from gully to upper slope, with hollows greater than 40 cm wide and greater than 100 cm deep; there is no relationship with distance to streams (Department of Environment and Conservation 2006). There is a record of this species at Prospect Reservoir approximately 700 metres from the study area and there are also numerous records 1.5-3 kilometres to the south of the western end of the study area.

### Powerful Owl

Optimal habitat for the Powerful Owl (*Ninox strenua*) includes a tall shrub layer and abundant hollows supporting high densities of arboreal marsupials (Department of Environment and Conservation 2006). For roosting, this species prefers groves of dense mid-canopy trees or tall shrubs in sheltered gullies, typically on wide creek flats and at the heads of minor drainage lines (Department of Environment and Conservation 2006). Nests in old hollow eucalypts in unlogged, unburnt gullies and lower slopes within 100 m of streams or minor drainage lines, with hollows greater than 45 cm diameter and greater than 100 cm deep; surrounded by canopy trees and subcanopy or understorey trees or tall shrubs (Department of Environment and Conservation 2006). There are several records of this species within one kilometre of the study area at St Clair and at the western end of the study area at Lapstone.

## Barking Owl

The Barking Owl (*Ninox connivens*) lives in forests and woodlands of tropical, temperate and semi-arid zones. The habitat is typically dominated by eucalypts, often red gum species and, in the tropics, paperbarks *Melaleuca* species. It usually roosts in or under dense foliage in large trees including rainforest species of streamside gallery forests, River She-oak (*Casuarina cunninghamiana*), other *Casuarina* and *Allocasuarina* species, eucalypts, *Angophora* or *Acacia* species. Roost sites are often near watercourses or wetlands. It typically breeds in hollows of large eucalypts or paperbarks, usually near watercourses or wetlands (Kavanagh et al., 1995; Debus, 1997; Higgins and Peter, 2002). Mean hollow diameter is reported to be 27.8 cm (14 cm – 76 cm) and hollow depth as 104 cm (Goldingay, 2009). There are records 2-3 kilometres from the impact area.

The study area contains some marginal foraging habitat for the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*). These three species have very similar nesting habitat requirements, which include mature trees bearing large hollows (30 cm to 40 cm diameter). A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Many of these are insufficient size for these species to nest in. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. While the habitat in the study area is not optimal, individuals that live nearby in vegetation remnants such as the Prospect Nature Reserve or vegetation at the foot of the Blue Mountains may utilise the vegetation in the study area as part of a home range. The loss of vegetation within the study area would directly affect the opportunity for these species to feed in the area. However, the impact area is not considered to be an important area of habitat for the Masked Owl (*Tyto novaehollandiae*), Barking Owl (*Ninox connivens*) or Powerful Owl (*Ninox strenua*). The proposal would remove approximately 0.68 hectares of potential foraging habitat however removal of vegetation will be avoided where possible. The proposal will not result in the removal of any large hollow bearing trees. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted. The proposal is unlikely to reduce the population size of the Masked Owl (*Tyto novaehollandiae*), or Powerful Owl (*Ninox strenua*) or Barking Owl (*Ninox connivens*) or decrease the reproductive success of these species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The potential habitat of the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*) within the study area is limited to some marginal foraging habitat and includes all Map Units where prey species are likely to be present such as arboreal mammals (possums and gliders), rodents (rabbits, rats and mice) and birds. The extent of habitat for the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*) will be reduced by approximately 0.68 hectares. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. Hollow-bearing trees located in the proposed ITS cabling footprint will be avoided during construction through minor adjustments to the cabling alignment.

Importantly, the proposal will not result in fragmentation of habitat for the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) or Barking owl (*Ninox connivens*). No large blocks of high quality habitat for these two species will be broken apart by the proposal. The Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*) are mobile species that occupy large home ranges and are able to persist in areas where small scale disturbances occur. The proposal will not affect the movement of the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) or Barking owl (*Ninox connivens*) between habitat patches.

The loss of foraging habitat trees would directly affect the species opportunity to feed in the area; however, the impact area is not considered to be an important area of habitat for these species. The Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*) may utilise the habitat in the study area intermittently for foraging. Vegetation in the western end on the study area represents potential foraging habitat for these species. Some open grassy areas proposed as compound sites are also potential foraging habitat. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Many of these are insufficient size for these species to nest in. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains) and the current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project. It is unlikely that the proposal will impact on foraging, movement and other life-cycle attributes of the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) or Barking owl (*Ninox connivens*).

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*).

### **Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The *NSW Recovery Plan for the Large Forest Owls* (Department of Environment and Conservation 2006) identifies the following objectives for recovery of the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*).

- Model and map owl habitat and validate with surveys
- Monitor owl population parameters
- Audit forestry prescriptions
- Manage and protect habitat off reserves and state forests
- Undertake research
- Increase community awareness and involvement in owl conservation
- Provide organisational support and integration.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. The Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*) have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*).

### **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking Owl (*Ninox connivens*) that will be increased by the proposal is clearing of native vegetation and potentially removal of hollow bearing trees. However, clearing in this case is of marginal foraging habitat only, potentially including removal of hollow-bearing trees suitable for prey species.

### **Conclusion**

The Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*) will suffer a small reduction (0.68 hectares) in extent of marginal foraging habitat from the proposal. These three species have very similar nesting habitat requirements, which include mature trees bearing large hollows (30 cm to 40 cm diameter). No important large hollow-bearing trees will be impacted by the proposal suitable for nesting and roosting. There is potential for removal of a small number of hollow bearing trees potentially suitable for prey species. The proposal is unlikely to reduce the population size of these species' or decrease their reproductive success. The proposal will not interfere with the recovery of these species'. After consideration of the factors above, an overall conclusion has

been made that the proposal is unlikely to result in a significant impact to the Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and Barking owl (*Ninox connivens*).

## Woodland birds

Four woodland bird species have suitable habitat in the study area and are likely to periodically utilise these habitats, comprising the following species:

- Flame Robin (*Petroica phoenicea*)
- Scarlet Robin (*Petroica boodang*)
- Speckled Warbler (*Chthonicola sagittatus*)
- Varied Sittella (*Daphoenositta chrysoptera*)

While these species were not recorded in the study area during the field survey, they are considered moderately likely to occur based on the presence of suitable habitat and nearby records. The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

### Flame Robin

The Flame Robin (*Petroica phoenicea*) is found in a broad coastal band from Queensland border to Tasmania and South Australia. In NSW, it breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. In winter many individuals migrate to more open lowland habitats on the inland slopes and plains. Individuals forage from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris. The open cup nest of plant fibres and cobweb is built near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank (OEH 2013b).

The Flame Robin was not recorded during current surveys. The species may forage and breed in woodland throughout much of the study area. The best habitats for the Flame Robin (*Petroica phoenicea*) within the study area include the remnant patches of vegetation such as Unit 11: Remnant Shale Sandstone Transition Forest (6.1 hectares), however this species may also utilise planted vegetation.

### Scarlet Robin

In NSW, the Scarlet Robin (*Petroica boodang*) occurs in open forests and woodlands from the coast to the inland slopes. It breeds in drier eucalypt forests and temperate woodlands, often on ridges and slopes, within an open understorey of shrubs and grasses and sometimes in open areas. Abundant logs and coarse woody debris are important structural components of its habitat. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. The Scarlet Robin was not recorded from the targeted surveys however the species may forage and breed in woodland throughout much of the study area. The Scarlet Robin was not recorded during current surveys. The species may forage and breed in woodland throughout much of the study area. The best habitats for the Scarlet Robin (*Petroica boodang*) within the study area include the remnant patches of vegetation such as Unit 11: Remnant Shale Sandstone Transition Forest (6.1 hectares), however this species may also utilise planted vegetation.

### Speckled Warbler

The Speckled Warbler (*Chthonicola sagittata*) has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians.

The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. The Speckled Warbler (*Chthonicola sagittata*) lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area. The diet consists of seeds and insects, with most foraging taking place on the ground around tussocks and under bushes and trees. Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding. The rounded, domed, roughly built nest of dry grass and strips of bark is located in a slight hollow in the ground or the base of a low dense plant, often among fallen branches and other litter. A side entrance allows the bird to walk directly inside. The best habitats for the Speckled Warbler (*Chthonicola sagittata*) within the study area include the remnant patches of vegetation such as Unit 11: Remnant Shale Sandstone Transition Forest (6.1 hectares), however this species may also utilise planted vegetation.

### **Varied Sittella**

The Varied Sittella (*Daphoenositta chrysoptera*) is sedentary and within the locality inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches. This species feeds on arthropods gleaned from crevices in rough or decorticated bark, dead branches, standing dead trees and small branches and twigs in the tree canopy. The Varied Sittella (*Daphoenositta chrysoptera*) builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years. Generation length is estimated to be 5 years.

The best habitats for the Varied Sittella (*Daphoenositta chrysoptera*) within the study area include the remnant patches of vegetation including Map Unit 1: Remnant Shale-Gravel Transition Forest (6.2 hectares), Map Unit 2: Remnant Shale Plains Woodland (12.5 hectares), Map Unit 3: Remnant Alluvial Woodland (7.8 hectares) and Map Unit 11: Remnant Shale Sandstone Transition Forest (6.1 hectares). However, this species may also utilise the remaining revegetated lands including:

- Map Unit 5: Planted Shale Plains Woodland (46.9 hectares)
- Map Unit 6: Planted Shale-Gravel Transition Forest (3.7 hectares)
- Map Unit 7: Planted Shale Sandstone Transition Forest (3.1 hectares).

Suitable foraging habitat for the habitat for the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) is present within the study area where there are rough-barked tree species and mature smooth-barked gums with dead branches. Breeding habitat may also be present; however, breeding habitat is more likely to occur in the larger less disturbed vegetation remnants in the locality.

The loss of vegetation within the study area would directly affect the opportunity for Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) to feed in the area. The proposal would remove approximately 0.68 hectares of potential foraging habitat for the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*) and Speckled Warbler, and 24.89 hectares of potential foraging habitat for the Varied Sittella (*Daphoenositta chrysoptera*). However, much of this vegetation is planted roadside vegetation and is not considered important habitat and removal of vegetation will be avoided where possible. These four species are nest-builders and are more likely to utilise the larger less disturbed vegetation remnants in the locality for breeding, therefore the proposal will not impact on

important breeding habitat. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of the Flame Robin (*Petroica phoenicea*), Scarlet, Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) or decrease the reproductive success of these species as no important breeding habitat will be removed.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The extent of habitat for the Flame Robin (*Petroica phoenicea*), Scarlet, Robin (*Petroica boodang*) and Speckled Warbler (*Chthonicola sagittatus*) will be reduced by 0.68 hectares and habitat for the Varied Sittella (*Daphoenositta chrysoptera*) will be reduced by approximately 24.89 hectares (although the species are unlikely to utilise this entire habitat). This is likely to be utilised a primarily foraging habitat as breeding is more likely to be undertaken in larger less disturbed vegetation remnants in the locality. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal will not result in fragmentation of habitat for the Flame Robin (*Petroica phoenicea*), Scarlet, Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*). No large blocks of high quality habitat for this species will be broken apart by the proposal. While the Varied Sittella (*Daphoenositta chrysoptera*) is a sedentary species and resides in a home range, the proposal is unlikely to influence the ability of this species to move between habitat patches.

The loss of foraging habitat would directly affect the opportunity for the Flame Robin (*Petroica phoenicea*), Scarlet, Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) to feed in the area; however, the study area is not considered an important area for these species as much of it is made up of planted roadside vegetation. Breeding is more likely to be undertaken in larger less disturbed

vegetation remnants in the locality. Extensive areas of higher quality habitat for the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains) and the current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). No critical habitat has been listed for the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) or Varied Sittella (*Daphoenositta chrysoptera*).

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) or Varied Sittella (*Daphoenositta chrysoptera*). However, the OEH has identified a number of activities to assist in the recovery of these species (OEH, 2015).

A targeted strategy for managing these threatened species is also being developed under the OEH Saving Our Species program. The Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will avoid removing roadside vegetation where possible. The proposal will not interfere with the recovery of the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*).

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) that will be increased by the proposal are clearing of native vegetation and removal of dead wood and dead trees.

**Conclusion**

The Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*) will suffer a small reduction in extent of foraging habitat from the proposal. These species are nest builders and are more likely to breed in larger less disturbed vegetation remnants in the locality. The

proposal is unlikely to reduce the population size of this species or decrease its reproductive success as no important breeding habitat will be removed. The proposal will not interfere with the recovery of the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Flame Robin (*Petroica phoenicea*), Scarlet Robin (*Petroica boodang*), Speckled Warbler (*Chthonicola sagittatus*) and Varied Sittella (*Daphoenositta chrysoptera*).

## Cave Roosting Microchiropteran Bats

This assessment concerns the following microchiropteran bat species which are known to roost in caves, derelict mines, storm-water tunnels, culverts, bridges, buildings and other man-made structures:

- Large-eared Pied Bat (*Chalinolobus dwyeri*)
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)
- Little Bent-wing Bat (*Miniopterus australis*)
- Southern Myotis (*Myotis macropus*).

The Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*) were recorded in the study area during the survey. A diurnal roost site for these two species was identified in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700. The roost site was dominated by Eastern Bentwing-bats (*Miniopterus schreibersii oceanensis*), with only a small number of Southern Myotis (*Myotis macropus*). Bats were found roosting in all three culverts and utilising holes located in the ceiling of the culverts. The culvert was approximately 50 metres in length and spanned the width of the M4 corridor.

The Little Bent-wing Bat (*Miniopterus australis*) is considered moderately likely to occur within the study area based on the presence of suitable foraging habitat and nearby records near South Creek and Ropes Creek. While the Little Bent-wing Bat (*Miniopterus australis*) is also known to roost in tree hollows, it is often found roosting with the larger Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) so these species are assessed here together.

The Large-eared Pied Bat (*Chalinolobus dwyeri*) is considered moderately likely to occur within the study area (predominantly at the western end from the Nepean River to the Blue Mountains) based on the presence of suitable foraging habitat in proximity to sandstone escarpments of the Blue Mountains and nearby records.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) primarily roosts in caves, but will also use derelict mines, storm-water tunnels, buildings and other man-made structures. The Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) forms populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. At other times of the year, populations disperse within about 300 kilometres range of maternity caves. The Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) hunts in forested areas.

The Southern Myotis (*Myotis macropus*) generally roosts in groups of 10 - 15 close to water in

caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage. The Southern Myotis (*Myotis macropus*) forages over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW, females have one young each year usually in November or December.

The Little Bent-wing Bat (*Miniopterus australis*) is generally found in well-timbered areas where they roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and occasionally buildings. They often share roosting sites with the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*). In NSW the largest maternity colony is in close association with a large maternity colony of Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*). Maternity colonies form in spring and birthing occurs in early summer. Males and juveniles disperse in summer. Only five nursery sites /maternity colonies are known in Australia.

The Large-eared Pied Bat (*Chalinolobus dwyeri*) roosts in caves, crevices in cliffs, old mine workings and in the disused mud nests of the Fairy Martin (*Petrochelidon ariel*) and inhabits low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts from November through to January in roof domes in sandstone caves and overhangs.

The study area contains a roost site for the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*) in a series of box culverts (3 x 3.0 x 3.0 m) under the M4 Motorway at Chainage 35700. This roost is not a maternity site for the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*); it is a roost that is used in winter when this species has dispersed from maternity cave. It is unknown whether the Southern Myotis (*Myotis macropus*) uses the culverts for breeding however there is potential for the site to be used for this purpose. The populations of the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*) that utilise the box culverts are considered to be viable. It is unknown whether the culverts also support a local population of the Little Bent-wing Bat (*Miniopterus australis*) but it is possible that this species may utilise the culverts occasionally. The Large-eared Pied Bat (*Chalinolobus dwyeri*) is unlikely to utilise the culverts as a roost site.

All vegetation within the study area is likely to provide foraging habitat for these four microchiropteran bat species. The Southern Myotis (*Myotis macropus*) will preferentially forage in the riparian zones and open water surface of South Creek, Ropes Creek and Eastern Creek and perhaps the smaller drainage lines within the study area. Riparian zones are also likely to be a focal point for foraging of the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and also the Little Bent-wing Bat (*Miniopterus australis*) if this species is present in the study area. The Large-eared Pied Bat (*Chalinolobus dwyeri*) may enter the study area to forage, and the vegetation at western end of the study area west from the Nepean River may support this species.

The proposal will not result in damage to the culverts used as a roost by the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*). The culvert will remain intact throughout the works and will remain in its current condition after construction of the proposal. The proposal will remove approximately 29.45 hectares of potential foraging habitat for microchiropteran bat species. Much of this area is planted vegetation and is not considered high quality habitat. The current potential for these species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project. Foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of these four cave roosting microchiropteran bat species or decrease the reproductive success of these species'.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The proposal will remove approximately 29.45 hectares of potential foraging habitat for microchiropteran bat species. Much of this area is planted vegetation and is not considered high quality habitat. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. Importantly, the proposal will not remove or damage the culvert roost site. There may be some impacts to bats utilising the culvert by way of noise and vibration caused by construction works. However, these are not likely to have a large impact on the use of the culvert as the resident bats are consistently exposed to a constant level of noise and vibration from the general motorway traffic. Construction works will need to be sensitive to the use of the culvert as roosting habitat.

Importantly, the proposal will not result in fragmentation of habitat for these species. These bats are highly mobile and will freely fly long distances over open areas to move between habitats, as is indicated by their presence in the study area. The proposal will not affect the movement of these species between habitat patches.

The vegetation in the study area would be important foraging habitat for these species. Riparian vegetation is likely to be a focal point of foraging activity as are the edges of vegetation patches. The loss of native vegetation from the study area will reduce the amount of foraging habitat available for these species. However, when compared to the larger and higher quality vegetation remnants in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains), the vegetation within the study area is not as important for the long-term survival of these species in the locality.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for these microchiropteran bat species.

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

The *National Recovery Plan for the Large-eared Pied Bat* (Department of Environment and Resource Management 2011) identifies the following objectives for recovery of this species:

- Identify priority roost and maternity sites for protection
- Implement conservation and management strategies for priority sites
- Educate the community and industry to understand and participate in the conservation of the large-eared pied bat
- Research the large-eared pied bat to augment biological and ecological data to enable conservation management
- Determine the meta-population dynamics throughout the distribution of the large-eared pied bat.

The proposal will not interfere with any of the objectives identified in the *National Recovery Plan for the Large-eared Pied Bat*.

A recovery plan does not exist for the other microchiropteran bat species subject to this assessment. However, the following actions have been identified by the OEH for recovery of these species:

- Protect known roosting and nursery sites and surrounding forest from disturbance by restricting and/or monitoring access
- Retain stands of native vegetation, particularly within 10 kilometres of roosts
- Reduce use of pesticides within breeding and foraging habitat
- Undertake non-chemical weed control to prevent obstruction of maternity caves and other roost entrances
- Exclude fire from 100m of maternity caves, winter roost or other significant roost entrances and ensure smoke/flames do not enter these roosts
- Control foxes, feral cats and goats around maternity caves, winter roosts and other significant roost sites
- Retain native vegetation along streams and rivers and around other waterbodies
- Ensure any fencing and gating of roosts is done in a bat friendly manner allowing adequate entrance and exit space for all species using the roost
- Check with OEH before undertaking recreational caving activities
- Ensure adequate foraging habitat is retained when undertaking hazard reduction activities, particularly during the breeding/reproduction season
- Ensure appropriate hygiene protocols are implemented when undertaking research and survey work.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing

threatened species. These species have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover threatened microchiropteran bat species are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. However, through avoidance of the culvert roost and retention of native vegetation, the management actions identified for threatened microchiropteran bat species will not be interfered with by the proposal. The proposal will not interfere with the recovery of threatened microchiropteran bat species.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the threatened microchiropteran bat species that will be increased by the proposal is clearing of native vegetation, and removal of hollow bearing trees, woody debris and dead-standing trees.

**Conclusion**

The threatened microchiropteran bats subject to this assessment will suffer a small reduction in extent of foraging habitat from the proposal. The culvert roost will not be impacted. . There may be some impacts to bats utilising the culvert by way of noise and vibration caused by construction works. However, these are not likely to have a large impact on the use of the culvert as the resident bats are consistently exposed to a constant level of noise and vibration from the general motorway traffic. Construction works will need to be sensitive to the use of the culvert as roosting habitat. The proposal is unlikely to reduce the population size of threatened microchiropteran bats or decrease the reproductive success of this species. The proposal will not interfere with the recovery of threatened microchiropteran bats and will not contribute to the key threats to these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to threatened cave roosting microchiropteran bats.

## Tree Hollow Roosting Microchiropteran Bats

This assessment concerns the following microchiropteran bat species which are known to roost in tree hollows, under bark, in the foliage of trees, and occasionally in buildings:

- Eastern Freetail-bat (*Mormopterus norfolkensis*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)

- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*).

The Eastern Freetail-bat (*Mormopterus norfolkensis*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), Greater Broad-nosed Bat (*Scoteanax rueppellii*), and Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) are considered moderately likely to occur within the study area based on the presence of suitable habitat (particularly vegetated riparian zones) and nearby records. These species are widespread on the Cumberland Plain and are powerful flyers capable of fast long distance travel for foraging.

The factors to be considered when determining whether an action, development or activity is likely to significantly affect threatened species or their habitats are outlined below:

**In the case of a Threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**

The Eastern Freetail-bat (*Mormopterus norfolkensis*), inhabits dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in man-made structures.

The Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) prefers to inhabit moist habitats with mature trees taller than 20 m. This species generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings. The Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) hibernates in winter and females are pregnant in late spring to early summer.

The Greater Broad-nosed Bat (*Scoteanax rueppellii*) utilises a variety of habitats from woodland through to moist and dry open eucalypt forest and rainforest. This species usually roosts in tree hollows but has also been found in buildings. Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of young.

The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) forages in most habitats including forested areas and open paddocks. Breeding has been recorded from December to mid-March, when a single young is born. The seasonal movements of this species are unknown but there is speculation about a migration to southern Australia in late summer and autumn.

The study area is likely to provide foraging habitat for these threatened microchiropteran bat species. Suitable foraging habitat is present throughout the study area where vegetation is present. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment. The Riparian zones are likely to be a focal point for foraging due to the higher productivity of these areas (i.e. more insect prey available around creek lines). These species, particularly the Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) are large and fast flyers and will exploit the edges of vegetation and open treeless areas for foraging. As such, foraging habitat for these species is widespread in the study area. It is unknown whether the study area contains a roost site for any of these species. However, the hollow bearing trees that were recorded may provide some suitable roosting habitat for these threatened microchiropteran bat species. Breeding may potentially occur in these trees or

these trees may form part of the range of breeding bats and may be used intermittently as shelters. Other trees and vegetation in the study area may also be suitable for roosting under loose bark or in foliage.

The proposal will potentially result in damage to the identified hollow bearing trees, however during detailed design and construction of the ITS infrastructure and other project components these trees will be avoided where possible. As such, tree hollow habitats will not be affected by the proposal. The proposal will remove approximately 29.45 hectares of potential foraging habitat for microchiropteran bat species in the form of native vegetation. Much of this area is planted vegetation and is not considered high quality habitat. However, the current potential for these species to occur in the study area is expected to remain after completion of the project as suitable habitats for these species will remain. Foraging, movement and other life-cycle attributes would not be impacted.

The proposal is unlikely to reduce the population size of these four tree hollow roosting microchiropteran bat species or decrease the reproductive success of these species.

**In the case of an Endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the Endangered population such that a viable local population of the species is likely to be placed at risk of extinction**

Not applicable.

**In the case of an Endangered ecological community or Critically Endangered ecological community, whether the action proposed:**

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

**In relation to the habitat of a Threatened species, population or ecological community:**

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**
- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**
- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The proposal will remove approximately 29.45 hectares of potential foraging habitat for microchiropteran bat species in the form of native vegetation. Much of this area is planted vegetation and is not considered high quality habitat. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered. Importantly, the proposal will not remove or damage any potential hollow-bearing roost trees. Hollow-bearing trees located in the proposed ITS cabling footprint will be avoided during construction through minor adjustments to the cabling alignment.

Importantly, the proposal will not result in fragmentation of habitat for these species. These three bats are relatively large for microchiropteran bats and are fast and highly mobile flyers. These species will freely fly long distances over open areas to move between habitats. In the case of the Yellow-bellied Sheath-tail-bat (*Saccolaimus flaviventris*), this species often forages

over treeless areas. The proposal will not affect the movement of these species between habitat patches.

The vegetation in the study area would be important foraging habitat for these species. Riparian vegetation is likely to be a focal point of foraging activity as are the edges of vegetation patches. The loss of native vegetation from the study area will reduce the amount of foraging habitat available for these species. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of these are located around the proposed ITS cabling footprint and will be avoided during detailed design and construction where possible through minor adjustments to the cabling alignment. When compared to the larger and higher quality vegetation remnants in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains), the vegetation within the study area is not as important for the long-term survival of these species in the locality.

**Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers only to those areas of land listed in the Register of Critical Habitat kept by the NSW Office of Environment and Heritage (OEH). This question is not applicable as no critical habitat has been listed for these microchiropteran bat species.

**Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan**

A recovery plan does not exist for the three microchiropteran bat species subject to this assessment. However, the following actions have been identified by the OEH for recovery of these species:

- Raise landowners' awareness about the presence of the species and provide information on how their management actions will affect the species' survival.
- Conduct searches for the species in suitable habitat in proposed development areas.
- DEC should be consulted when planning development/s to minimise impact/s on populations.
- Actively encourage the conservation of the riparian vegetation and water quality of streams and rivers.
- Retain stands of native vegetation, especially those with hollow-bearing trees (including dead trees), and retain other structures containing bats.
- Retain native vegetation that is floristically and structurally diverse.
- Retain a buffer of vegetation around roost sites in vegetated areas.
- Protect roost sites from disturbance.
- Protect hollow-bearing trees for breeding sites, including those on farmland; younger mature trees should also be retained to provide replacements for the older trees as they die and fall over.
- Mark known sites and potential habitat onto maps used for planned poison-spraying activities.
- Minimise the use of pesticides within or adjacent to areas where insectivorous bats occur.

- Encourage regeneration and replanting of local flora species to maintain bat foraging habitat.
- Assess the site's importance to the species' survival, including linkages provided between ecological resources across the broader landscape.

A targeted strategy for managing threatened species is also being developed under the OEH Saving Our Species program. OEH is currently developing a targeted approach for managing threatened species. These species have been assigned to the Landscape species management stream under the OEH Saving our Species program.

The recovery actions listed above, and those identified in the Saving Our Species program, that have been identified by the OEH to help recover threatened microchiropteran bat species are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. However, through avoidance of hollow-bearing trees and retention of native vegetation where possible, the management actions identified for threatened microchiropteran bat species will not be interfered with by the proposal. The proposal will not interfere with the recovery of threatened microchiropteran bat species.

**Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the TSC Act and at the present there are currently 38 listed KTPs. Broadly, the KTPs include threats to threatened species and other plants and animals in NSW including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.
- Habitat loss or change (e.g. through large-scale land clearing).

Of the 38 listed KTPs under the TSC Act, the only KTPs relevant to the threatened microchiropteran bat species that will be increased by the proposal are the clearing of native vegetation and removal of dead wood and dead trees.

**Conclusion**

The threatened microchiropteran bats subject to this assessment will suffer a small reduction in extent of foraging habitat from the proposal. Hollow-bearing trees that may be utilised as roosts will not be impacted. The proposal is unlikely to reduce the population size of threatened microchiropteran bats or decrease the reproductive success of this species. The proposal will not interfere with the recovery of threatened microchiropteran bats and will not contribute to the key threats to these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to threatened tree hollow roosting microchiropteran bats.

## D.2 Environment Protection and Biodiversity Conservation Act 1999 assessment

### Threatened ecological communities

The threatened ecological communities that are present in the study area and are subject to this assessment include:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
- Shale Sandstone Transition Forest

An action is likely to have a significant impact on a Critically Endangered or Endangered ecological community if there is a real chance or possibility that it will:

#### Reduce the extent of an ecological community

The extent of each threatened ecological community to be removed as a result of the proposal is outlined in Table D-8. Overall, the proposal will have a small impact on the local extent of threatened ecological communities and small proportional impact on the extent of each of these threatened ecological communities within the locality.

**Table D-8 Impact on the extent of each threatened ecological community**

Threatened ecological community	Status	Area (ha)			Proportion of habitat impacted adjoining and within the study area
		Extent within locality	Extent within and adjoining study area	Extent to be removed	
<b>EPBC Act</b>					
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered, EPBC Act	9,819*	110.06	1.77	1.61%
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered EPBC Act	184	3.11 (planted only)	0.28 (planted only)	9% (planted only)

#### Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines

Under the EPBC Act, a patch is defined as a discrete and continuous area of the ecological community. However, a patch may include small-scale disturbances, such as tracks or breaks or small-scale variations in vegetation that do not significantly alter its overall functionality (for instance the movement of wildlife or dispersal of plant propagules). The proposal may result in some small-scale disturbances but no large scale alteration to overall functionality of vegetation will occur.

Importantly, the proposal will not result in the breaking apart of large blocks of high quality examples of threatened ecological communities. No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. However, installation of the ITS may cause some temporary local disturbance to components of these ecological communities (i.e. sessile species such as reptiles and

amphibians) that cannot move large distances. Overall, habitat connectivity will remain in a similar state after construction of the proposal and a similar level of functional east west habitat connectivity will remain. There is unlikely to be declines in population density or species richness within vegetation patches as a result of the proposal. There is also unlikely to be a significant alteration to community composition, species interactions or ecosystem functioning in the locality due to the proposal. These factors are already highly impacted by historic land use. Therefore, habitat fragmentation is considered a minor impact of the proposal in regard to its context and intensity.

**Adversely affect habitat critical to the survival of an ecological community**

Due to the conservation significance of these threatened ecological communities (particularly the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest) the remaining patches of these threatened ecological communities within NSW are likely to be important for their survival. However, some patches of these communities are more important than others.

The patches of these communities within the study area are small and modified by human disturbance. As such, the threatened ecological community patches within the study area can be considered less important than larger high quality examples of these threatened ecological communities that retain high levels of ecological integrity and function. The habitats in the study area are not considered a critical. Higher quality patches of these communities occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant) and these patches are likely to be critical for the survival of these ecological communities as opposed to the vegetation within the study area.

**Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns**

Where these communities will be removed by the proposal, all abiotic factors (i.e. water, nutrients and soil) will be modified and/or destroyed through vegetation removal and construction of infrastructure. The extent of this modification will be limited to the areas of construction and immediate adjacent area which may suffer from increased runoff.

**Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting**

The composition of threatened ecological communities may be modified as a result of the proposal through weed invasion and removal of some vegetation. However, the local occurrences of these threatened ecological communities are currently suffering from altered composition caused by a very large reduction in ecological function, as indicated by:

- Altered community structure (i.e. missing structural layers)
- Altered species composition (i.e. weed invasion, lack of native species)
- Disruption of ecological processes (i.e. altered drainage,
- Invasion and establishment of exotic species
- Degradation of habitat
- Fragmentation of habitat.

The proposal is not considered likely to further modify the composition of any of the threatened ecological communities within the study area. The composition of the threatened

ecological communities within the study area is predicted to remain intact after the implementation of the proposal.

**Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:**

- b) assisting invasive species, that are harmful to the listed ecological community, to become established**
- c) causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community**

Weed introduction and spread and the Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. *Phytophthora* infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to introduce and transmit weed propagules and *Phytophthora* to remaining native vegetation remnants of the species. This is a potential indirect impact to the ecological communities through the spread and transmission of weeds and pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of weeds and pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of weeds and disease causing agents such as bacteria and fungi.

No regular mobilisation of fertilisers, herbicides or other chemicals will occur as a result of the project.

#### **Interfere with the recovery of an ecological community.**

The Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. The recovery objectives include:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

#### **Conclusion**

The threatened ecological communities that are present in the study area will be reduced by a small extent from the proposal comprising around 2.05 hectares of impacts along the edges of larger vegetation patches. The required vegetation clearing is minimal. However, no large change in composition is considered likely. No further habitat fragmentation or isolation on a landscape scale will occur. The local occurrence of these threatened ecological communities

will persist after the proposal is built. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to threatened ecological communities.

## Vulnerable plant species

The vulnerable plant species subject to this assessment include:

- Downy Wattle (*Acacia pubescens*)
- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*).

The Downy Wattle (*Acacia pubescens*) and the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) were recorded within the study area during the field survey. The distribution and abundance of these species within the study area is outlined in **Table D-9**. The occurrence of the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) in the study area is the result of human intervention. This species has been planted in the corridor. The natural distribution of this species is on the New England Tablelands and this species has been widely planted throughout Sydney as an ornamental tree and street tree planting. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant.

**Table D-9 Distribution and abundance of vulnerable plant species within the study area**

Threatened flora species	Status	Distribution and abundance
Downy Wattle <i>Acacia pubescens</i>	Vulnerable	Four individuals were recorded at one location in the study area to the west of the Ropers Road intersection on the southern side of the M4 Motorway. These four individuals were growing in a small cluster consisting of two medium sized plants (1.2-1.7 metres high) and two small plants (c. 1 metre high). These individuals were growing in a disturbed remnant of Shale-Gravel Transition Forest (Map Unit 1) approximately four metres from the existing M4 motorway road pavement.
Narrow-leaved Black Peppermint <i>Eucalyptus nicholii</i>	Vulnerable	A single individual of this species was recorded on the northern side of the M4 Motorway corridor south of the major service centre and rest stop area, This species has been planted in the corridor.  The natural distribution of this species is on the New England Tablelands. This species is widely planted as an ornamental tree.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

### Lead to a long-term decrease in the size of an important population of a species

The risk of extinction of the local populations of threatened plant species will increase if anything reduces their population size or reproductive success. The lifecycle of the local populations of the Downy Wattle (*Acacia pubescens*) is dependent on the habitat that is present within the study area. The habitat for The Downy Wattle (*Acacia pubescens*) within the study area is predominantly Map Unit 1: Remnant Shale-Gravel Transition Forest in the vicinity of Roper Road.

Removal or modification of habitat for the Downy Wattle (*Acacia pubescens*) may be detrimental to its survival in the study area. However, due to the predicted small amount of habitat removal within the study area (0.87 hectares of Shale-Gravel Transition Forest) and the extent of these habitats that will remain within the study area after construction, the local

population is considered unlikely to be placed at further risk of extinction. The population will remain viable and the proposal is unlikely to lead to a long-term decrease in the size of a population of this species.

The Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) tree in the study area is the result of human intervention and this species has been planted. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant

#### **Reduce the area of occupancy of an important population**

The Downy Wattle (*Acacia pubescens*) is confined to the Sydney district with most occurrences on the Cumberland Plain. The proposal will reduce the area of potential habitat for this species by up to approximately 11 hectares. The proposal will not significantly reduce the area of occupancy of this species as it will still exist throughout its range.

The proposal will not affect the area of occupancy for the natural occurrences of the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*).

#### **Fragment an existing important population into two or more populations**

Importantly, the proposal will not result in the breaking apart of large blocks of high quality habitat or populations of the Downy Wattle (*Acacia pubescens*). No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. Dispersal of plant propagules will still occur and pollinators will still be able to access the plants. Therefore, habitat fragmentation is considered a minor impact of the proposal in regard to its context and intensity.

The proposal will not affect the natural occurrences of the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*).

#### **Adversely affect habitat critical to the survival of a species**

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The Downy Wattle (*Acacia pubescens*) is currently known from 116 populations at 151 sites across the Cumberland Plain. The populations in Scheyville NP and Windsor Downs Nature Reserve and the sites at Mountain Lagoon, Pleasure Point, Campbell Hill Pioneer Park and Duck River Reserve are likely to be critical for this species. The habitats within the study area are not as important when compared to these sites.

Habitat critical for the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) is restricted to the northern NSW tablelands where it occurs naturally.

#### **Disrupt the breeding cycle of an important population**

The proposal is unlikely to disrupt the breeding cycle of these species. Dispersal of plant propagules will still occur and pollinators will still be able to access the plants.

#### **Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

The proposal will result in a very small decrease in the availability of habitat for the Downy Wattle (*Acacia pubescens*). Removal of part of the habitat along the M4 will not be so detrimental as to cause this species to decline. The Downy Wattle (*Acacia pubescens*) will remain in the higher quality vegetation patches such as Scheyville NP and Windsor Downs Nature Reserve and the sites at Mountain Lagoon, Pleasure Point, Campbell Hill Pioneer Park and Duck River Reserve.

No impact to the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) is expected to occur from the proposal.

**Result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat**

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

**Introduce disease that may cause the species to decline, or**

There are no diseases that are known to affect *Acacia pubescens*. Furthermore, the project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi. The proposal will not impact on the Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) nor will the proposal result in the introduction and establishment of exotic Rust Fungi of the order Pucciniales.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

**Interfere substantially with the recovery of the species.**

An approved recovery plan exists for The Downy Wattle (*Acacia pubescens*) (NSW National Parks and Wildlife Service 2003) and the Nodding Geebung (*Persoonia nutans*) (NSW Department of Environment and Conservation 2005). The approved recovery plan for the Downy Wattle (*Acacia pubescens*) identifies 13 recovery actions including:

- Identify sites that are a high priority to protect
- Carry out negotiations with public authorities to increase protection of sites
- Liaise with private landholders to increase protection of sites
- Negotiate with public authorities to implement threat and habitat management programs on public lands
- Informed environmental assessment and planning decisions are made
- Undertake studies into the genetic variability of the species
- Investigate the cause of disease in the species
- Research other aspects of the species' biology, ecology and distribution
- Encourage community involvement
- Provide advice and assistance to private landholders
- Maintain a database on the species
- NPWS to be advised of any consents or approvals which affect *A. pubescens*

- Re-assess conservation status of species.

Through this impact assessment process, informed environmental assessment and planning decisions are being made which is consistent with the approved recovery plan for the Downy Wattle (*Acacia pubescens*).

### Conclusion

The threatened plant species that occur and may occur in the study area will suffer a small reduction in extent of suitable habitat from the proposal. No further habitat fragmentation or isolation on a landscape scale will occur. The local occurrence of these species will persist after the proposal is built. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these threatened plant species.

The Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) tree in the study area is the result of human intervention and this species has been planted. The tree within the study area is a horticultural specimen and as such, impacts to this species will not be significant.

### Endangered plant species

The endangered plant species subject to this assessment include:

- Nodding Geebung (*Persoonia nutans*)
- Sydney-bush Pea (*Pultenaea parviflora*)
- Spiked-rice Flower (*Pimelea spicata*).

The Nodding Geebung (*Persoonia nutans*) and Sydney-bush Pea (*Pultenaea parviflora*) were recorded within the study area during the field survey. The distribution and abundance of these species within the study area is outlined in **Table D-5**.

The Spiked-rice Flower (*Pimelea spicata*) was not recorded within the study area during the survey. However, suitable habitat in the form of Map Unit 2: Remnant Shale Plains Woodland is present in the study area. This species is known from near the study area in the Prospect Nature Reserve and bushland near the M7 interchange. As such, this species is considered moderately likely to occur within the study area, particularly in the vegetation to the west of the Ropers Road interchange on both sides of the M4 Motorway with other threatened plant species (**Table D-5**).

**Table D-5 Distribution and abundance of threatened plant species within the study area**

Threatened flora species	Status	Distribution and abundance
Nodding Geebung <i>Persoonia nutans</i>	Endangered	A single individual was recorded in high condition Shale-Gravel Transition Forest (Map Unit 1) directly west of Ropers Road on the northern side of the M4 motorway in a fenced off remnant. This individual is approximately 55 metres from the existing M4 Motorway road pavement.
Sydney-bush Pea <i>Pultenaea parviflora</i>	Endangered	A total of 29 individuals were directly counted in the study area to the west of the Ropers Road interchange on both sides of the M4 Motorway in two main clusters that are greater than 150 metres apart and so are considered to be four separate local populations.  One cluster occurs directly west of the Ropers Road interchange on the northern and southern side of the M4 Motorway within

Threatened species	flora	Status	Distribution and abundance
			fenced remnants. There are approximately 26 individuals in this cluster  The other cluster occurs further west on the northern side of the M4 Motorway on top of an existing cutting on the road side of an existing sound wall comprising four individuals. These individuals are approximately eight metres from the existing M4 Motorway road pavement.
Spiked-rice Flower <i>Pimelea spicata</i>		Endangered	Not recorded during the field survey but suitable habitat for this species is considered to be present within Map Unit 2: Remnant Shale Plains Woodland in the study area. This species is known from near the study area in the Prospect Nature Reserve and bushland near the M7 interchange. This species may occur in the study area in vegetation to the west of the Ropers Road interchange on both sides of the M4 Motorway with other threatened plant species.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

**Lead to a long-term decrease in the size of a population**

There are at least 27 populations of Nodding Geebung (*Persoonia nutans*) and at least 5,500 individuals in total. The Sydney-bush Pea (*Pultenaea parviflora*) may be locally abundant in areas where it occurs, and populations have been recorded as containing between 10 and 5000+ individuals. The total number of mature *Pimelea spicata* individuals is approximately 4,300 and there are 30 known extant populations of *P. spicata*, including 25 within the Cumberland Plain.

The proposal would remove potential habitat for these species (**Table D-6**). However removal of vegetation will be avoided where possible. One *Pultenaea parviflora* plant may require removal but the proposal will be designed to avoid removing threatened plant species. Translocation will be considered as an option if avoidance is not possible.

**Table D-6 Impact on the extent of habitat for each threatened plant species**

Species	% impacted		
	Extent within and surrounding the study area	Extent to be removed	be
<i>Persoonia nutans</i>	9.26	0.3	3.23%
<i>Pultenaea parviflora</i>	9.26	0.3	3.23%
<i>Pimelea spicata</i>	114.33	2.51	2.19%

Removal or modification of habitat for these plant species may be detrimental to their survival in the study area. However, due to the predicted small amount of habitat removal within the study and the extent of these habitats that will remain within the study area after construction,

it is unlikely that the project will lead to a long-term decrease in the size of a population of these species.

### **Reduce the area of occupancy of the species**

The Nodding Geebung (*Persoonia nutans*) is restricted to the Cumberland Plains region of western Sydney, NSW. It is known from an area between Richmond and Macquarie Fields, particularly near the Nepean and Georges Rivers. The range of the species is fragmented, with approximately 99 per cent of the known populations occurring in the north of the distribution at Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs.

The Sydney-bush Pea (*Pultenaea parviflora*) is confined to the Cumberland Plain and is mainly found between Penrith and Windsor.

The Spiked-rice Flower (*Pimelea spicata*) has a relatively scattered distribution in two disjunct areas: the Cumberland Plain area of western Sydney; and the Illawarra Region near Wollongong. In Western Sydney, the distribution extends from Camden in the south to Maraylya in the north and from Horsley Park east to Bankstown. This species possesses a restricted area of occupancy of less than 17 hectares.

The proposal will not significantly reduce the area of occupancy of these species as they will still exist throughout their range after the proposal has been implemented.

### **Fragment an existing population into two or more populations**

Importantly, the proposal will not result in the breaking apart of large blocks of high quality habitat or populations of the Nodding Geebung (*Persoonia nutans*), Sydney-bush Pea (*Pultenaea parviflora*), or Spiked-rice Flower (*Pimelea spicata*). No further habitat fragmentation on a landscape scale will occur as a result of the proposal. Isolation of habitats is also unlikely to increase substantially as existing habitat fragments will not be totally removed from the landscape. Dispersal of plant propagules will still occur and pollinators will still be able to access the plants. Therefore, habitat fragmentation is considered a minor impact of the proposal in regard to its context and intensity.

### **Adversely affect habitat critical to the survival of a species**

Critical habitats for the Nodding Geebung (*Persoonia nutans*) include the Agnes Bank Nature Reserve, Windsor Downs Nature Reserve, Castlereagh Nature Reserve, Wianamatta Regional Park, and the Castlereagh-Londonderry Crown Lands. Critical habitats for the Sydney-bush Pea (*Pultenaea parviflora*) include Scheyville National Park, Windsor Downs Nature Reserve, Castlereagh Nature Reserve, and the ADI Regional Park. Critical habitats for the Spiked-rice Flower (*Pimelea spicata*) include Sydney Regional Park, Prospect Reservoir catchment, and the Mount Annan Botanic Garden. Collectively, these areas form habitat that is critical to the survival of these three species as a whole.

The study area is not habitat that is critical to the survival of these three species.

### **Disrupt the breeding cycle of a population**

The proposal is unlikely to disrupt the breeding cycle of these species. Dispersal of plant propagules will still occur and pollinators will still be able to access the plants.

### **Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

The proposal will result in a very small decrease in the availability of habitat for these three species. Removal of part of the habitat along the M4 will not be so detrimental as to cause these species to decline. High quality habitats for these species will still remain in the locality.

**Result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat**

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

**Introduce disease that may cause the species to decline, or**

The Nodding Geebung (*Persoonia nutans*) is known to be affected by *Phytophthora cinnamomi*. Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

**Interfere with the recovery of the species.**

The approved recovery plan for the Nodding Geebung (*Persoonia nutans*) (NSW Department of Environment and Conservation 2005) identifies the following objectives:

- To minimise the loss and fragmentation of *P. nutans* habitat using land-use planning mechanisms
- To identify and minimise the threats operating at sites where the species occurs
- Develop & implement a survey & monitoring program that will provide information on the extent and viability of *P. nutans*
- To provide public authorities with information that assists in conserving the species
- To raise awareness of the species and involve the community in the recovery program
- To promote research projects that will assist future management decisions.

The *Pimelea spicata* Recovery Plan (Department of Environment and Conservation 2005) consists of six specific recovery objectives as follows:

- Conserve *P. spicata* using land-use and conservation planning mechanisms
- Identify and minimise the operation of threats at sites where *P. spicata* occurs
- Implement a survey and monitoring program that will provide information on the extent and viability of *P. spicata*
- Provide the community with information that assists in conserving the species
- Raise awareness of the species and involve the community in the recovery program
- Promote research questions that will assist future management decisions.

Through this impact assessment process, informed environmental assessment and planning decisions are being made which is consistent with the approved recovery plan for the Nodding Geebung (*Persoonia nutans*) and the Spiked-rice Flower (*Pimelea spicata*).

## Conclusion

The endangered plant species that occur and may occur in the study area will suffer a small reduction in extent of suitable habitat from the proposal. No further habitat fragmentation or isolation on a landscape scale will occur. The local occurrence of these species will persist after the proposal is built. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these threatened plant species.

## Vulnerable fauna species

### **Broad-headed Snake (*Hoplocephalus bungaroides*)**

While the Broad-headed Snake (*Hoplocephalus bungaroides*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable foraging habitat.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

#### **Lead to a long-term decrease in the size of an important population of a species**

The following information regarding 'important populations' is taken from the Significant Impact Guidelines 1.1 (DoE 2013).

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity, and/or
- Populations that are near the limit of the species range.

The Broad-headed Snake (*Hoplocephalus bungaroides*) is a habitat specialist being largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. The Broad-headed Snake (*Hoplocephalus bungaroides*) is often found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger, 2014; NSW NPWS 2001). The most suitable sites occur in sandstone ridgetops (Cogger, 2014). Near Bathurst snakes occur in forest growing on shale or conglomerate slopes and bluffs (Cogger, 2014). Common canopy species include *Corymbia eximia*, *C. gummifera*, *Eucalyptus sieberi*, *E. punctata* and *E. piperita*. Snakes prefer sites with a west to north-west aspect (NSW NPWS 2001).

Potential habitat for this species was located in the west of the study area around the exposed sandstone and surrounding vegetation. The proposal will result in the removal of 0.68 hectares of foraging habitat. This area represents marginal foraging habitat only for this species and surrounds sandstone habitat that may not be utilised due to its north east aspect (studies using radio-telemetry have never found individuals sheltering under rocks on easterly cliff tops (Pringle *et al.*, 2003)). This area of marginal habitat is unlikely to support an important population of the Broad-headed Snake (*Hoplocephalus bungaroides*). Therefore, the project is not expected to lead to a long-term decrease in the size of an important population.

#### **Reduce the area of occupancy of an important population**

The proposal will result in the removal of 0.68 hectares of foraging habitat. This area represents marginal foraging habitat only for this species and surrounds sandstone habitat that may not be utilised due to its north east aspect (studies using radio-telemetry have never found individuals sheltering under rocks on easterly cliff tops (Pringle *et al.*, 2003)). This area

of marginal habitat is unlikely to support an important population of the Broad-headed Snake (*Hoplocephalus bungaroides*). Therefore, the project is not expected to reduce the area of occupancy of an important population.

### **Fragment an existing important population into two or more populations**

The proposal will result in the removal of 0.68 hectares of foraging habitat. Importantly, the proposal will not result in fragmentation of habitat for the Broad-headed Snake (*Hoplocephalus bungaroides*). The vegetation to be cleared is roadside (and in some cases plantings) and represents only marginal foraging habitat. This area represents marginal foraging habitat only for this species and surrounds sandstone habitat that may not be utilised due to its north east aspect (studies using radio-telemetry have never found individuals sheltering under rocks on easterly cliff tops (Pringle *et al.*, 2003)). This area of marginal habitat is unlikely to support an important population of the Broad-headed Snake (*Hoplocephalus bungaroides*). Therefore, the project is not expected to fragment an existing important population into two or more populations,

### **Adversely affect habitat critical to the survival of a species**

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The Broad-headed Snake (*Hoplocephalus bungaroides*) is a habitat specialist being largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. The Broad-headed Snake (*Hoplocephalus bungaroides*) is often found in rocky outcrops and adjacent sclerophyll forest and woodland (Cogger, 2014; NSW NPWS 2001). The most suitable sites occur in sandstone ridgetops (Cogger, 2014). Near Bathurst snakes occur in forest growing on shale or conglomerate slopes and bluffs (Cogger, 2014). Common canopy species include Yellow Bloodwood (*Corymbia eximia*), Red Bloodwood (*Corymbia gummifera*), Silvertop Ash (*Eucalyptus sieberi*), Grey Gum (*Eucalyptus punctata*) and Sydney Peppermint (*Eucalyptus piperita*). Snakes prefer sites with a west to north-west aspect (NSW NPWS 2001). Many of these attributes are present in the Shale Sandstone Transition Forest at the western end of the study area which is dominated by Yellow Bloodwood and Grey Gum with sandstone outcrops and small escarpments, and the occasional hollow bearing tree.

The project would directly remove up to 0.68 hectares of foraging habitat however vegetation will be avoided where possible. This area represents marginal foraging habitat only for this species and surrounding sandstone habitat that may not be utilised due to its north east aspect (studies using radio-telemetry have never found individuals sheltering under rocks on easterly cliff tops (Pringle *et al.*, 2003)). Disturbance and removal of rocks used as retreat sites is one of the greatest threats to this species. The sandstone slopes will not be impacted by the proposal. The surrounding vegetation area does not represent habitat critical to the survival of the Broad-headed Snake (*Hoplocephalus bungaroides*). The project is not expected to adversely affect habitat critical to the survival of a species.

### **Disrupt the breeding cycle of an important population**

The Broad-headed Snake (*Hoplocephalus bungaroides*) breeds in retreat sites such as under rocks or in crevices. Gravid females and young remain in retreat sites for much of the time. The exposed sandstone in the western end of the study area is likely not ideal due to its eastern aspect. Regardless, the sandstone slopes will not be impacted by the proposal. The marginal foraging habitat that will be impacted by the proposal is unlikely to support an important population of the Broad-headed Snake (*Hoplocephalus bungaroides*). The proposal is unlikely to disrupt the breeding cycle of an important population.

### **Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

The potential habitat of the Broad-headed Snake (*Hoplocephalus bungaroides*) within the study area is limited to exposed sandstone and surrounding vegetation located in the west of the study area. The proposal will result in the removal of 0.68 hectares of foraging habitat. This area is mostly planted vegetation and represents only marginal foraging habitat for this species. The proposal will not result in fragmentation of habitat for the Broad-headed Snake (*Hoplocephalus bungaroides*). The proposal will reduce and may modify the area of marginal foraging habitat. The proposal will not change the availability of habitat to the extent that this species is likely to decline.

### **Result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat**

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

### **Introduce disease that may cause the species to decline, or**

There are no known disease issues affecting Broad-headed Snake (*Hoplocephalus bungaroides*) in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

### **Interfere substantially with the recovery of the species.**

A recovery plan does not exist for the Broad-headed Snake (*Hoplocephalus bungaroides*). However, the following actions have been identified by the OEH for recovery of this species:

- Retain sandstone rock in bushland on escarpment areas; implement LEPs, DCPs with suitable restrictions on the removal of bushrock
- Limit vehicle and pedestrian access to and recreational use of sandstone escarpments where this species occurs
- Retain woodland adjacent to sandstone escarpments, particularly large hollow-bearing trees
- Restore rocky habitat to escarpments that have been disturbed
- Report suspected illegal reptile collection or sale
- Targeted survey of areas of secure potential habitat
- Advocate the use of quarried sandstone or alternatives in preference to sandstone sourced from bushland on escarpments; implement a community and industry bushrock education strategy

- Maintain colonies in captivity for future re-introduction to depleted sites or sites undergoing restoration
- Undertake feral goat control programs in sandstone escarpment areas.

### **Conclusion**

If present, the Broad-headed Snake (*Hoplocephalus bungaroides*) will suffer a small reduction in extent of low-quality habitat from the proposal. The proposal is unlikely to reduce the population size of the Broad-headed Snake (*Hoplocephalus bungaroides*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Broad-headed Snake (*Hoplocephalus bungaroides*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Broad-headed Snake (*Hoplocephalus bungaroides*).

### **Grey-headed Flying-fox (*Pteropus poliocephalus*)**

While the Grey-headed Flying-fox (*Pteropus poliocephalus*) was not recorded in the study area during the field survey due to the diurnal nature of the surveys, it is considered likely to occur based on the presence of suitable foraging habitat and the nearby location of roosting camps at Parramatta Park, Clyde (Duck River), Wetherill Park, Ropes Creek, and Emu Plains.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

#### **Lead to a long-term decrease in the size of an important population of a species**

There have been no roost camps identified in the project boundary to date and at the time of the REF the project would not directly impact on any known breeding / maternity sites. Therefore it is likely that the impacts of construction and operation of the project would be confined to loss of foraging habitat caused by direct clearing or damage to native vegetation during the construction phase.

The project would directly remove up to 24.89 hectares of potential foraging habitat however vegetation will be avoided where possible. Much of this area comprises of planted vegetation. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to lead to a long-term decrease in the size of an important population.

#### **Reduce the area of occupancy of an important population**

The project would directly remove up to 24.89 hectares of remnant and planted vegetation which contains known foraging habitat for this species in the form of flowering plants. Much of this area comprises of planted vegetation. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The project will reduce the area of habitat available to the species; however, the area occupied by this species will remain the same.

### **Fragment an existing important population into two or more populations**

There is currently a high degree of habitat fragmentation across the study area. Highly mobile species such as bats are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom. The project would not fragment an important population of the Grey-headed Flying-fox.

### **Adversely affect habitat critical to the survival of a species**

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The proposed area of habitat loss represents a small percentage of the potential foraging habitat for the Grey-headed Flying-fox within a 50 kilometre radius of the project boundary and known roost camps in the region. This species typically exhibits very large home ranges and Grey-headed Flying-fox are known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources (Eby 1996). No evidence of a camp site has been identified from the footprint of the project.

The draft recovery plan for the Grey-headed Flying-fox (DECCW 2009) identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50 kilometre radius
- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

The project would directly remove up to 24.89 hectares of foraging habitat however vegetation will be avoided where possible. Considering the close proximity of several roost camps and presence of important feed trees the habitats are consistent with the classification for critical foraging habitat (DECCW 2009). The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to adversely affect habitat critical to the survival of the species.

### **Disrupt the breeding cycle of an important population**

As stated above there would be a minor impact on foraging habitat identified as important during the breeding cycle of the species. The project would not directly impact on a known roost camp / breeding or maternity site.

**Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

No evidence of a roost camp has been identified from the study area. Further, there would be a relatively minor impact on critical foraging habitat. This impact is not expected to lead to a decline in the species in this region.

**Result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat**

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

**Introduce disease that may cause the species to decline, or**

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

**Interfere substantially with the recovery of the species.**

The *Draft National Recovery Plan for the Grey-headed Flying-fox (Pteropus poliocephalus)* (Department of Environment, Climate Change and Water NSW. 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes
- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture
- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan.

The recovery actions listed above are largely not applicable to the proposal as they focus on priority conservation lands which are outside of the study area.

Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to interfere substantially with the recovery of the species.

### **Conclusion**

The Grey-headed Flying-fox (*Pteropus poliocephalus*) will suffer a small reduction in extent of suitable foraging habitat from the proposal. No breeding camps or other important habitat will be impacted. The proposal is unlikely to reduce the population size of the Grey-headed Flying-fox (*Pteropus poliocephalus*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Grey-headed Flying-fox (*Pteropus poliocephalus*) and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Grey-headed Flying-fox (*Pteropus poliocephalus*).

### **Large-eared Pied Bat (*Chalinolobus dwyeri*)**

The Large-eared Pied Bat (*Chalinolobus dwyeri*) is considered moderately likely to occur within the study area (predominantly at the western end from the Nepean River to the Blue Mountains) based on the presence of suitable foraging habitat in proximity to sandstone escarpments of the Blue Mountains and nearby records.

An action is likely to have a significant impact on a Vulnerable species if there is a real chance or possibility that it will:

#### **Lead to a long-term decrease in the size of an important population of a species**

The proposal will remove approximately 29.45 hectares of potential foraging habitat for the Large-eared Pied Bat (*Chalinolobus dwyeri*). Much of this area is planted vegetation.

The size of local population is not known, although expected to not to be considerably large considering the highly urbanised and modified habitats in the locality and absence of caves. Potential foraging habitat in the study area is generally widespread in the western end of the study area. Impacts to these habitats would impact on the potential breeding habitat for prey species (invertebrates), however any potential overall reductions to the abundance of prey species is likely to be minimal, considering the widespread nature of these habitats in the locality.

As no breeding habitat will be impacted, and considering the abundance of suitable foraging habitat in the locality, the proposal is considered unlikely to lead to a long-term decrease in the size of an important population of this species.

#### **Reduce the area of occupancy of an important population**

The proposal will remove approximately 29.45 hectares of potential foraging habitat for the Large-eared Pied Bat (*Chalinolobus dwyeri*). Much of this area is planted vegetation. No breeding habitat will be impacted. As such, the Large-eared Pied Bat (*Chalinolobus dwyeri*) can be expected to remain in the locality after completion of the proposal. The proposal is considered unlikely to reduce the area of occupancy of an important population of this species. The area of occupancy for this species will remain at approximately 9,120 square kilometres.

#### **Fragment an existing important population into two or more populations**

There is currently a high degree of habitat fragmentation across the study area. Highly mobile species such as bats are expected to be less impacted by fragmentation. The project would not fragment an important population of this species.

### **Adversely affect habitat critical to the survival of a species**

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The project would have some level of impact to up to 29.45 hectares of foraging habitat. The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the Large-eared Pied-bat. Impacts to areas of roosting habitat are not anticipated. As such, the project is unlikely to impact habitat critical to the survival of the species.

### **Disrupt the breeding cycle of an important population**

The proposed area of disturbance represents a very small fraction of the potential foraging habitat available in the locality for the Large-eared Pied-bat. Additionally the area of habitat to be impacted in comprised mainly of planted vegetation. The proposal would not directly impact on a known roost or maternity site and such as unlikely to disrupt the breeding cycle of this species.

### **Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

The project would have an impact of up to 29.45 hectares of foraging habitat for the Large-eared Pied-bat. Much of this habitat is comprised of planted vegetation. The proposed area of disturbance represents a very small fraction of the potential foraging habitat available in the locality for this species. This species is expected to continue using the habitats in the study area and the proposal is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

### **Result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat**

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

### **Introduce disease that may cause the species to decline, or**

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and

plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

#### **Interfere substantially with the recovery of the species.**

The *National Recovery Plan for the Large-eared Pied Bat* (Department of Environment and Resource Management 2011) identifies the following objectives for recovery of this species:

- Identify priority roost and maternity sites for protection
- Implement conservation and management strategies for priority sites
- Educate the community and industry to understand and participate in the conservation of the Large-eared Pied bat
- Research the large-eared pied bat to augment biological and ecological data to enable conservation management
- Determine the meta-population dynamics throughout the distribution of the large-eared pied bat.

The proposal will not interfere with any of the objectives identified in the *National Recovery Plan for the Large-eared Pied Bat*.

#### **Conclusion**

The Large-eared Pied Bat (*Chalinolobus dwyeri*) will suffer a small reduction in extent of foraging habitat from the proposal. No breeding habitat will be impacted. The proposal is unlikely to reduce the population size of this species or decrease its reproductive success. The proposal will not interfere with the recovery of this species and will not contribute to the key threats to these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Large-eared Pied Bat (*Chalinolobus dwyeri*)

### **Endangered fauna species**

#### **Swift Parrot (*Lathamus discolor*)**

While the Swift Parrot (*Lathamus discolor*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable winter foraging habitat.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

#### **Lead to a long-term decrease in the size of a population**

The study area contains some marginal foraging habitat for the Swift Parrot (*Lathamus discolor*). While the habitat in the study area is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the study area is not considered a critical area for the Swift Parrot (*Lathamus discolor*). The Swift Parrot (*Lathamus discolor*) may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The proposal would remove approximately 24.89 hectares of potential foraging habitat however removal of vegetation will be avoided where possible. Much of this habitat is comprised of planted vegetation. A total of 22 hollow-bearing trees were located in the study area during the field survey with eight of these identified in larger patches of habitat west of Emu Plains many comprising dead-standing trees with smaller hollows and the remaining are scattered throughout the study area. Only several of

these are located around the proposed ITS cabling footprint and will be avoided during construction through minor adjustments to the cabling alignment.

The Swift Parrot (*Lathamus discolor*) does not breed in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation, such that the project is unlikely to lead to a long-term decrease in the size of a population.

#### **Reduce the area of occupancy of the species**

As a specialist nectarivore dependent on flowering eucalypts, Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available.

The project would contribute to the loss of potential foraging habitat which would reduce the area of habitat available. However, the proposal will not reduce the area of occupancy of this species which is estimated at 4,000 square kilometres. No important nesting trees will be impacted.

#### **Fragment an existing population into two or more populations**

Importantly, the proposal will not result in fragmentation of habitat for the Swift Parrot (*Lathamus discolor*). This species is highly mobile and will freely fly long distances over open areas to move between habitats. The proposal will not affect the movement of the Swift Parrot (*Lathamus discolor*) between habitat patches. No important nesting trees will be impacted.

#### **Adversely affect habitat critical to the survival of a species**

Key habitats for this species on the coast and coastal plains of New South Wales include large stands of Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*E. robusta*), Red Bloodwood (*Eucalyptus gummifera*) and Forest Red Gum (*E. tereticornis*) forests. These habitats do not exist within the study area. No important nesting trees will be impacted, due to the species nesting in Tasmania only. As such the study area is not considered to be critical foraging habitat for this species.

#### **Disrupt the breeding cycle of a population**

The Swift Parrot (*Lathamus discolor*) is endemic to south-eastern Australia and breeds only in Tasmania, and migrates to mainland Australia in autumn. As such, the proposal will not impact on breeding habitat for this species.

#### **Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

Foraging habitat of marginal quality for this species will be reduced by approximately 24.89 hectares. This is a small amount of habitat loss. Much of this habitat is comprised of planted vegetation. The proposal will not result in the removal of any hollow trees. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The proposal is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

### **Result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat**

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats. The management of invasive species would be managed under the construction environmental management plan and during operation of the motorway.

### **Introduce disease that may cause the species to decline, or**

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

### **Interfere with the recovery of the species.**

The *National Recovery Plan for the Swift Parrot* (Saunders & Tzaros 2011) identifies the following actions for recovery of this species:

- Identify the extent and quality of habitat
- Manage and protect Swift Parrot habitat at the landscape scale
- Monitor and manage the impact of collisions, competition and disease
- Monitor population and habitat.

The recovery actions listed above to help recover the Swift Parrot (*Lathamus discolor*) are largely not applicable to the proposal as they are actions for the OEH to complete and focus on priority conservation lands which are outside of the study area. The proposal will not interfere with the recovery of the Swift Parrot (*Lathamus discolor*).

### **Conclusion**

The Swift Parrot (*Lathamus discolor*) will suffer a small reduction in extent of marginal foraging habitat from the proposal. The proposal is unlikely to reduce the population size of the Swift Parrot (*Lathamus discolor*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Swift Parrot (*Lathamus discolor*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Swift Parrot (*Lathamus discolor*).

## **Spotted-tail Quoll (*Dasyurus maculatus*)**

While the Spotted-tail Quoll (*Dasyurus maculatus*) was not recorded in the study area during the field survey it is considered likely to occur based on the presence of suitable winter foraging habitat.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

### **Lead to a long-term decrease in the size of a population**

The Spotted-tail Quoll (*Dasyurus maculatus*) typically has a large home range and occupies a diversity of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. The Spotted-tailed Quoll (*Dasyurus maculatus*) is predominantly nocturnal and rests during the day in dens, such as hollow logs, tree hollows, rock outcrops or caves (Jones *et al.*, 2001). The project would remove potential habitat for the species however the overall reduction of habitat is a small proportion of the available potential habitat.

The proposal will result in the loss of approximately 0.68 hectares of potential habitat for the Spotted-tail Quoll (*Dasyurus maculatus*). The study area also contains some small areas of rock outcrops to the west. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The proposal may displace or disturb a small number of individuals but would only be a temporary and short duration impact that is unlikely to lead to a long term decrease in the size of the local population.

### **Reduce the area of occupancy of the species**

The Spotted-tail Quoll (*Dasyurus maculatus*) typically has a large home range and occupies a diversity of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. The Spot-tailed Quoll (*Dasyurus maculatus*) is predominantly nocturnal and rests during the day in dens, such as hollow logs, tree hollows, rock outcrops or caves (Jones *et al.*, 2001). It is therefore difficult to identify the area of occupancy. Theoretically, quolls could occur in any of the larger forest fragments of the study area. Preferred habitat includes dry and moist sclerophyll forests and may include adjacent modified patches of forest on farmland. Suitable habitat is well represented in the large forest reserves in the locality (i.e. National Parks north and west of the study area). The project would remove potential habitat for the species however the overall reduction of habitat is a small proportion of the available potential habitat.

The proposal will result in the loss of approximately 0.68 hectares of potential habitat for the Spotted-tail Quoll (*Dasyurus maculatus*). The study area also contains some small areas of rock outcrops to the west. The proposal is unlikely to reduce the area of occupancy of the Spotted-tail Quoll (*Dasyurus maculatus*).

### **Fragment an existing population into two or more populations**

The proposal will result in the loss of approximately 0.68 hectares of potential habitat for the Spotted-tail Quoll (*Dasyurus maculatus*). The study area also contains some small areas of rock outcrops to the west. Extensive areas of suitable habitat occur elsewhere in the locality (i.e. The Orchard Hills Defence site, the Prospect Nature Reserve, Wianamatta Nature reserve, Wianamatta Regional Park, the Shanes Park bushland remnant, Blue Mountains). The vegetation to be cleared as part of the proposal is roadside and planted vegetation. Its removal will not fragment an existing population into two or more populations.

### **Adversely affect habitat critical to the survival of a species**

The Spotted-tail Quoll (*Dasyurus maculatus*) typically has a large home range and occupies a diversity of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. The planted roadside vegetation to be impacted by the proposal is not considered to be critical habitat for this species.

### **Disrupt the breeding cycle of a population**

Breeding habitat for the Spotted-tail Quoll (*Dasyurus maculatus*) includes daytime den sites such as hollow logs, tree hollows, rock outcrops or caves. There are no suitable den sites in the clearing footprint. The proposal is unlikely to disrupt the breeding cycle of the Spotted-tail Quoll (*Dasyurus maculatus*).

### **Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline**

The potential habitat of the Spotted-tail Quoll (*Dasyurus maculatus*) within the study area is limited to the western end, which is separate to but borders onto the foothills of the Blue Mountains. The proposal will result in the removal of 0.68 hectares of foraging habitat. This area is mostly planted vegetation. The proposal will not result in fragmentation of habitat for the Spotted-tail Quoll (*Dasyurus maculatus*). The proposal will reduce and may modify the area of marginal foraging habitat. The proposal will not change the availability of habitat to the extent that this species is likely to decline.

### **Result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat**

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. The Spotted-tail Quoll (*Dasyurus maculatus*) is also predated upon by Red Foxes, Dingos (*Canis lupus dingo*) and Domestic Dogs (*Canis lupus familiaris*), which may utilise disturbed areas caused by the proposal. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats. The management of invasive species would be managed under the construction environmental management plan and during operation of the motorway.

### **Introduce disease that may cause the species to decline, or**

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

#### **Interfere with the recovery of the species.**

A recovery plan does not exist for the Spotted-tail Quoll (*Dasyurus maculatus*). However, the following actions have been identified by the OEH for recovery of this species:

- Consult with OEH/NPWS if Spotted-tailed Quolls are raiding poultry, rather than taking direct action.
- Consult with OEH/NPWS if poison baiting is planned in or near areas where Spotted-tailed Quolls are known or likely to occur.
- Undertake cat and fox control using poison-baiting techniques least likely to affect quolls.
- Retain and protect large, forested areas with hollow logs and rocky outcrops, particularly areas with thick understorey or dense vegetation along drainage lines.

#### **Conclusion**

The Spotted-tail Quoll (*Dasyurus maculatus*) will suffer a small reduction in extent of marginal foraging habitat from the proposal. The proposal is unlikely to reduce the population size of the Spotted-tail Quoll (*Dasyurus maculatus*) or decrease the reproductive success of this species. The proposal will not interfere with the recovery of the Spotted-tail Quoll (*Dasyurus maculatus*). After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Spotted-tail Quoll (*Dasyurus maculatus*).

### **Migratory species**

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

1. Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a Migratory species
2. Result in an invasive species that is harmful to the Migratory species becoming established in an area of important habitat for the Migratory species, or
3. Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a Migratory species.

An area of 'important habitat' for a migratory species is defined as:

- Habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- Habitat that is of critical importance to the species at particular life-cycle stages, and/or
- Habitat used by a migratory species which is at the limit of the species range, and/or
- Habitat within an area where the species is declining.

While migratory species of bird do use the study area and locality, the study area would not be classed as an 'important habitat' as defined under the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (Department of the Environment 2013), in that the study area does not contain:

- A region that supports an ecologically significant proportion of a population of migratory species

- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

As such, it is unlikely that the proposal would significantly affect migratory species.

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species. Some factors that would be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (for example, site fidelity and dispersal rates).

There is no evidence to suggest that an ecologically significant proportion of the population of any identified migratory species exists within the study area.

The potential for weed invasion has been considered highly likely with a proposal of this nature and appropriate controls have been provided during the construction and operation of the motorway to reduce this threat as it may have long term implications. The management of invasive species would be managed under the construction environmental management plan.

 [rms.nsw.gov.au/projects/sydney-west/m4](https://rms.nsw.gov.au/projects/sydney-west/m4)

 13 22 13

 Customer feedback  
Roads and Maritime  
Locked Bag 928,  
North Sydney NSW 2059

**October 2015**

RMS 15.564

ISBN: 978-1-925421-23-1

# Appendix C

## Revised Cultural Heritage Assessment Report



**M4 MANAGED MOTORWAY  
FROM LAPSTONE (WESTERN END) TO CHURCH STREET, PARRAMATTA (EASTERN END)  
REVIEW OF ENVIRONMENTAL FACTORS**

**Cultural Heritage Assessment Report**

Prepared for Sinclair Knight Merz Pty Ltd  
on behalf of Roads and Maritime Services

Holroyd, Blacktown, Penrith and Blue Mountains Local Government Areas

August 2015

Ref. 1214

**KELLEHER NIGHTINGALE CONSULTING PTY LTD**  
**Archaeological and Heritage Management**

ACN 120 187 671

Level 10  
25 Bligh Street  
SYDNEY NSW 2000  
Phone 02 9232 5373

## Document Information

Project Name	M4 Managed Motorway, from Lapstone (western end) to Church Street Parramatta (eastern end) REF: Cultural heritage assessment report
Project Number	1214
Status	Draft
Revision	0.5
Client Name	Sinclair Knight Merz Pty Ltd
Recipient	Matthew Faust, Project Manager; Jonas Ball, Senior Environmental Scientist; John McManus Senior Environmental Scientist
Issue Date	3 August 2015
Prepared by	Dr Matthew Kelleher; Stirling Smith; Alison Nightingale; Ben Anderson
Approved by	Dr Matthew Kelleher; Alison Nightingale

## Executive Summary

Roads and Maritime Services (RMS) proposes various upgrade activities to the M4 Motorway as part of the M4 Managed Motorway project. Sinclair Knight Merz (SKM) engaged Kelleher Nightingale Consulting Pty Ltd (KNC) on behalf of RMS to provide a Cultural Heritage Assessment Report (CHAR) to assist in the production of a Review of Environmental Factors (REF) for the project. The M4 Managed Motorway (M4MM) project area extends from Lapstone to Church Street, Parramatta.

A comprehensive survey of the M4MM project area undertaken by KNC in 2013 identified 32 Aboriginal archaeological sites within the M4 corridor. Twenty nine of the sites were highly disturbed and exhibited low archaeological significance, while three of the sites exhibited intact archaeological deposit and moderate or better archaeological significance.

Twenty nine of the sites were substantially disturbed due to erosion and existing development within the project area with no A horizon soils. No intact archaeological deposits remain at these sites. Due to high levels of disturbance, the 29 remnant sites have been assessed as exhibiting low archaeological significance.

Three sites contained intact archaeological deposit and exhibited moderate or better archaeological significance:

- Location 8 South Creek 1 AHIMS 45-5-1070
- Location 9 South Creek 2 AHIMS 45-5-1071
- Location 20A Clyburn Avenue AHIMS 45-5-1074

The M4MM project will result in an extensive range of impacts extending over the M4 corridor between Lapstone and Church Street, Parramatta related to motorway upgrades and trenching for services. The proposed M4MM project will impact on all 32 of the identified Aboriginal archaeological sites located within the existing M4 corridor. An Aboriginal heritage impact permit (AHIP) is required for the land within the project area.

An application for an AHIP should be made under section 90A of the *National Parks and Wildlife Act 1974* and is sought for the land and associated objects within the boundaries of the M4 Motorway between Lapstone and Church Street, Parramatta and specified Aboriginal sites and objects contained within these sites.

This CHAR has been prepared to support the application for an AHIP. It builds on the results of previous investigations and consultation regarding the proposal.

## Contents

<b>CONTENTS</b> .....	<b>IV</b>
<b>1 INTRODUCTION</b> .....	<b>1</b>
1.1 PROPONENTS AND CONSULTANTS .....	1
1.2 LOCATION AND SCOPE OF ACTIVITY .....	1
1.3 CHAR AND AHIP PROJECT AREA .....	1
1.4 STATUTORY CONTROLS AND DEVELOPMENT CONTEXT .....	4
1.5 NATIONAL PARKS AND WILDLIFE ACT 1974 .....	4
1.6 OBJECTIVES OF THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT REPORT (CHAR) .....	4
<b>2 DESCRIPTION OF THE AREA</b> .....	<b>5</b>
2.1 LANDFORM, GEOLOGY AND SOILS .....	5
2.2 ETHNOHISTORIC CONTEXT .....	7
<b>3 PREVIOUS ARCHAEOLOGICAL ASSESSMENT</b> .....	<b>8</b>
3.1 ARCHAEOLOGICAL INVESTIGATION OUTSIDE THE PROJECT AREA.....	8
3.2 ARCHAEOLOGICAL INVESTIGATIONS WITHIN THE PROJECT AREA.....	9
3.3 ABORIGINAL SITES WITHIN THE PROJECT AREA – SITE DESCRIPTIONS .....	13
<b>4 ABORIGINAL COMMUNITY CONSULTATION</b> .....	<b>22</b>
4.1 STAKEHOLDER IDENTIFICATION AND CONSULTATION .....	22
4.2 RESPONSE TO STAKEHOLDER SUBMISSIONS .....	22
4.3 ABORIGINAL CULTURAL VALUES .....	23
<b>5 SUMMARY AND ANALYSIS OF BACKGROUND INFORMATION</b> .....	<b>24</b>
<b>6 CULTURAL HERITAGE VALUES AND STATEMENT OF SIGNIFICANCE</b> .....	<b>25</b>
<b>7 AVOIDING AND/OR MITIGATING HARM</b> .....	<b>26</b>
7.1 PROPOSED ACTIVITY.....	26
7.2 PRACTICAL MEASURES TAKEN TO PROTECT, CONSERVE AND AVOID HARM TO ABORIGINAL OBJECTS.....	26
7.3 MITIGATING HARM.....	26
<b>8 RECOMMENDATIONS</b> .....	<b>27</b>
<b>REFERENCES</b> .....	<b>32</b>
<b>APPENDIX A ADVERTISEMENT FOR STAKEHOLDERS</b> .....	<b>34</b>
<b>APPENDIX B ABORIGINAL STAKEHOLDER COMMENTS</b> .....	<b>35</b>
<b>APPENDIX C AFG MINUTES</b> .....	<b>38</b>
<b>APPENDIX D RESEARCH DESIGN</b> .....	<b>44</b>

**FIGURES**

Figure 1. M4 Managed Motorway project area .....	2
Figure 2. Project area showing 11 individual study areas .....	3
Figure 3. Digital elevation model showing low lying flood prone land, major creek systems and archaeological sites within the project area .....	6
Figure 4. Aboriginal site locations in the project area (see detail maps Figures 5-8) .....	12
Figure 5. Aboriginal archaeological site detail section A and B (see Figure 4) .....	18
Figure 6. Aboriginal archaeological site detail section C and D (see Figure 4) .....	19
Figure 7. Aboriginal archaeological site detail section E and F (see Figure 4) .....	20
Figure 8. Aboriginal archaeological site detail section G (see Figure 4) .....	21
Figure 9. GPS coordinates of AHIP application boundary from Lapstone to Kent Road .....	28
Figure 10. GPS coordinates of AHIP application boundary from Kent Road to Eastern Creek .....	29
Figure 11. GPS coordinates of AHIP application boundary from Eastern Creek to Ettalong Road .....	30
Figure 12. GPS coordinates of AHIP application boundary from Ettalong Road to Church Street Parramatta .....	31
Figure 13. Excavation areas within Location 8 South Creek 1 and Location 9 South Creek 2 .....	48
Figure 14. Excavation areas within Location 20 A Clyburn Avenue .....	49

# 1 Introduction

## 1.1 Proponents and consultants

Roads and Maritime Services (RMS) proposes various upgrade activities to the M4 Motorway as part of the M4 Managed Motorway (M4MM) project. Sinclair Knight Merz (SKM) engaged Kelleher Nightingale Consulting Pty Ltd (KNC) on behalf of RMS to provide an Aboriginal Cultural Heritage Assessment Report (CHAR) to assist in the production of a Review of Environmental Factors (REF) for the project. The proposed upgrade project boundary, containing the future road corridor and ancillary areas, is shown in Figure 1 and hereafter referred to as the 'project area'.

This assessment was written in accordance with the Office of Environment and Heritage (OEH) Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW 2010). The CHAR complies with the RMS Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI) (RMS 2012).

## 1.2 Location and scope of activity

RMS proposes to install traffic management and on-road information systems and upgrade entry and exit ramps for the existing M4 Motorway between the Church Street intersection at Parramatta and the connection to the great Western Highway at Lapstone.

The project area encompasses virtually the entire length of the M4 Motorway, including all existing/proposed entry and exit ramps, arterial road approaches, intersections adjacent to the ramps, extensive trenching along the length of the corridor, ancillary areas as well as an area either side of the motorway to allow for construction. This area incorporates:

1. Approximately 30m either side of the centreline or 15m wider than the formation (whichever is greater) of any existing or proposed ramp footprint.
2. Approximately 100m longer than any existing or proposed ramp footprint.
3. From the centreline of the motorway interchange, approximately 500m along the arterial road and 15m behind the back of existing kerb.
4. The M4 Motorway median (if median is available) approximately 1km either side of the on-ramp/motorway main alignment interface (i.e. gore area) to allow potential motorway main carriageway realignment to improve motorway merge conditions.
5. The M4 Motorway between Roper Rd and Wallgrove Rd – possible additional lane each direction within existing motorway formation.
6. Approximately 50m longitudinally at proposed electronic signage locations and 15m either side of any trenching required to service the sign, or the access/maintenance bay required to access the sign on the M4 Motorway.
7. Approximately 50m longitudinally at proposed electronic signage locations and 15m either side of any trenching required to service the sign on the arterial roads.
8. Options for site compounds and stockpile sites on motorway reserve and RMS owned land parcels that adjoin the proposed works.

To assist with the field assessment work, the larger project area was divided into 11 individual study areas (Figure 2) referred to by cross roads:

1. Russell Street Study Area
2. Mulgoa Road Study Area
3. The Northern Road Study Area
4. Mamre Road Study Area
5. Roper Road Study Area
6. M7 Study Area
7. Reservoir Road Study Area
8. Prospect Highway Study Area
9. Cumberland Highway Study Area
10. Coleman Street Study Area
11. Burnett Street Study Area

## 1.3 CHAR and AHIP Project Area

For the purposes of the CHAR and AHIP application, the archaeological assessment and Aboriginal community consultation relates to the entire project area (M4 corridor between Lapstone and Church Street, Parramatta).

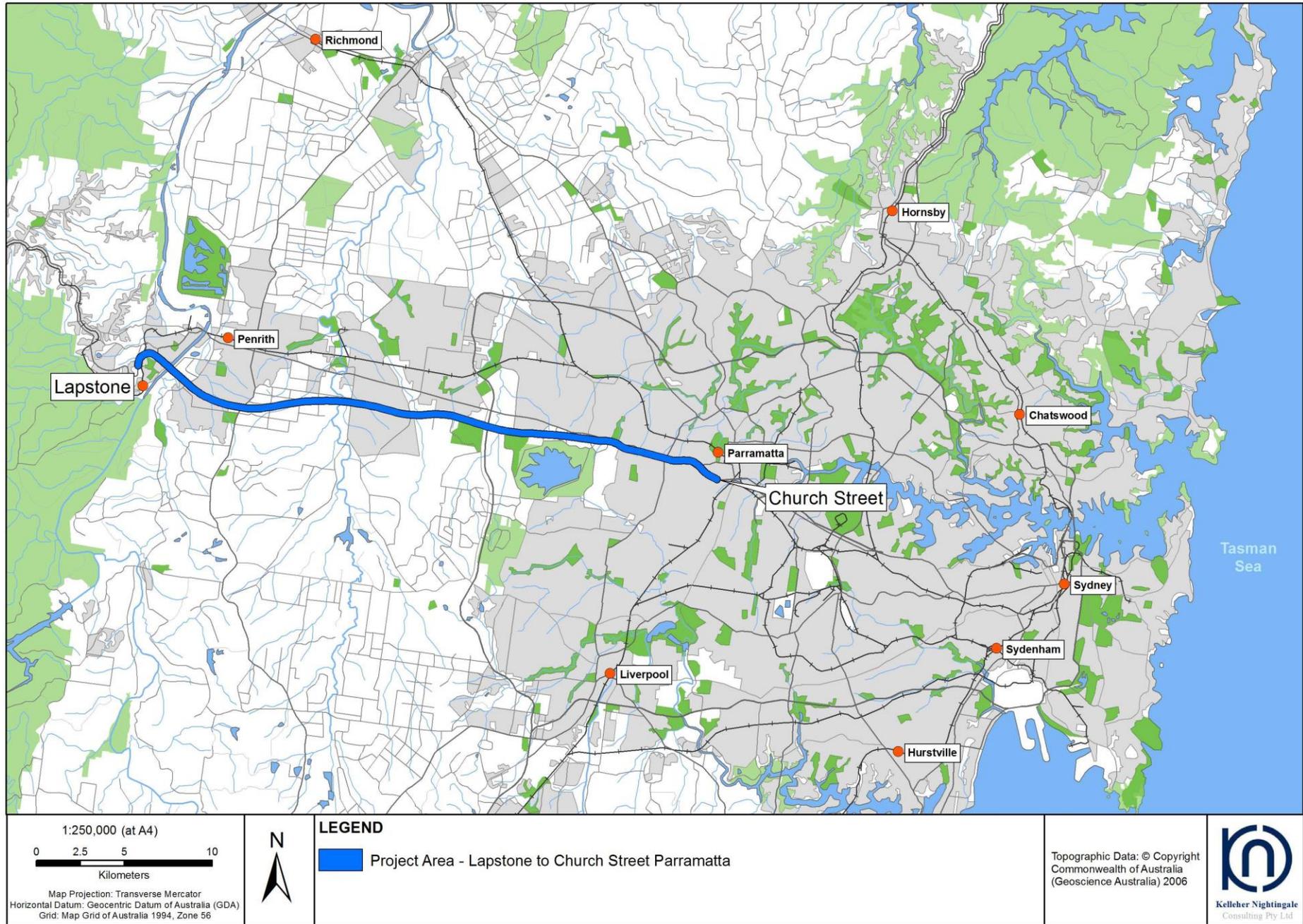


Figure 1. M4 Managed Motorway project area

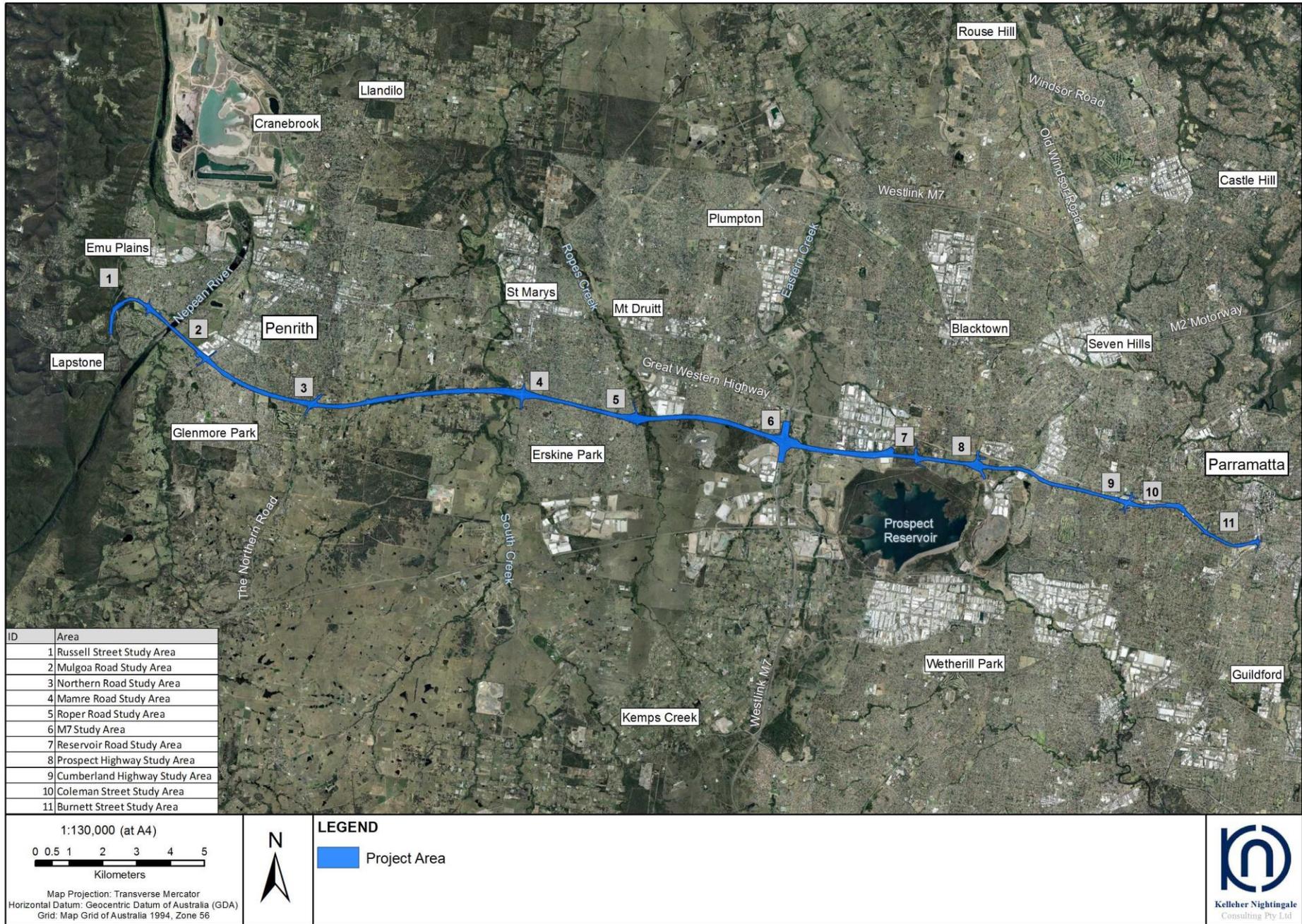


Figure 2. Project area showing 11 individual study areas

## 1.4 Statutory controls and development context

The proposal is for road infrastructure carried out by RMS, it will be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*.

## 1.5 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* is the primary statutory control for the protection and regulation of Aboriginal heritage in New South Wales.

An "Aboriginal object" is defined under the Act as "any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains". As such, Aboriginal objects are confined to physical evidence and are commonly referred to as Aboriginal sites.

Aboriginal objects and declared Aboriginal places are protected under section 86 of the Act. It is an offence to harm or desecrate an Aboriginal object, either knowingly [section 86 (1)] or unknowingly [section 86 (2)]. Harm includes to destroy, deface, damage or move.

Under section 87 (1) it is a defence to a prosecution for an offence under section 86 (1), (2) or (4) if "(a) the harm or desecration concerned was authorised by an Aboriginal heritage impact permit, and (b) the conditions to which that Aboriginal heritage impact permit was subject were not contravened".

Section 87 (2) of the Act provides a defence against prosecution under section 86 (2) if "the defendant exercised due diligence to determine whether the act or omission constituting the alleged offence would harm an Aboriginal object and reasonably determined that no Aboriginal object would be harmed". This defence appears to specifically relate to Aboriginal objects.

Section 89A of the Act relates to the notification of sites of Aboriginal objects, under which it is an offence if the location of an Aboriginal object is not notified to the Director-General in the prescribed manner within a reasonable time.

Under section 90 (1) of the Act "the Director-General may issue an Aboriginal heritage impact permit". The regulation of Aboriginal heritage impact permits is provided in Part 6 Division 2 of the Act (sections 90 to 90R), including regulations relating to consultation (section 90N).

An Aboriginal heritage impact permit (AHIP) is required for any activity which will harm an Aboriginal object or Aboriginal place.

## 1.6 Objectives of the Aboriginal cultural heritage assessment report (CHAR)

The M4MM boundary contains Aboriginal objects (sites) which will be impacted by proposed activities. Approval obtained under the *National Parks and Wildlife Act 1974* is required for these Aboriginal objects prior to any impact or harm. The proponent is applying for an AHIP under section 90A of the Act.

Clause 80D of the *National Parks and Wildlife Regulation 2009* requires that an application for an AHIP is accompanied by a CHAR. The CHAR is to provide information on:

- the significance of the Aboriginal places that are the subject of the application;
- the actual or likely harm to those Aboriginal objects or Aboriginal places from the proposed activity that is the subject of the application;
- any practical measures that may be taken to protect and conserve those Aboriginal objects or Aboriginal places; and
- any practical measures that may be taken to avoid or mitigate any actual or likely harm to those Aboriginal objects or Aboriginal places.

The OEH *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, April 2011) provides further guidance on the preparation of a CHAR. This report has been prepared in accordance with the requirement of the Regulation and the OEH guidelines.

This CHAR has been prepared to support an application for an AHIP by RMS for Aboriginal objects within the proposed road upgrade corridor.

## 2 Description of the Area

### 2.1 Landform, geology and soils

The project area traverses a variety of landforms along the M4 corridor. These landforms include: flat, open depression-flat, simple slope-crest-simple slope, ridge crest/ridge, floodplain/flat, undulating mid slope, foot slope and steep slope. The eastern part of the project area is highly developed by urbanisation and much of the landscape has been significantly modified. The landforms in the eastern end of the project area are mainly flat with several small crests and some open depressions. Landforms along the central section from Prospect to Regentville consist of a variety of simple slope, ridge crest/ridge landforms. Floodplain/flat landforms are predominantly along the watercourses including the Nepean River, Eastern Creek, South Creek and Ropes Creek. The western extent of the project area is dominated by the Nepean River floodplains and the steep slope leading from Leonay at the base of the Blue Mountains to Lapstone.

The project area traverses predominantly shale country with some alluvium along the streams and rivers. The landscape is bisected by watercourses with moderate flood margins. The main watercourses include Eastern Creek, Ropes Creek, South Creek and the Nepean River. Eastern Creek is a major drainage line of the Cumberland Plain with a length of approximately 35km draining northward to the Hawkesbury River. This waterway is located between Roper Road and Archibald Roads within the Roper Road Study Area. South Creek flows in a northerly direction bisecting the western side of the project area between Mamre Road and the Kent Road. The Nepean River is a large perennial river located in the western sector of the project area.

Soils are predominately from the Blacktown Landscape, with South Creek soil profiles along the central section of the project area. The western extent of the project area around the Nepean River also includes sections of Richmond and Freemans Reach soil profiles. Blacktown soils are characterised as red podzolic soils on a siltstone/mudstone substrate. These soils are strongly acidic, hard setting and comprised of loam overlying clay/silty clay soils with moderate erosion susceptibility. The South Creek soil profile is comprised of alluvial sediment, loams and clays, with high erodibility. The Richmond and Freemans Reach soils are typically fine-grained dark-brown and red-brown alluvial loams.

Only the alluvial South Creek soils contain the potential for archaeological stratification. The podzolic soils all suffer from aggrading-deflationary cycles resulting in a temporal-matrix collapse, where the objects within the soils end up mixed into a single A horizon. Alluvial soils by their nature are re-deposited and interpretations of stratigraphy must take into account flood modelling.

The primary archaeological implications from the landscape are flooding and soil aggradation. Much of the area is prone to flooding which removes archaeological material but also reveals important raw material and offers a paramount resource: water availability from the creek system. Project area soils generally allow erosion but accumulate sufficiently to assist artefact survivability outside of erosion prone areas. In summary the project area would have been a draw for Aboriginal people in the past due to its raw material availability and water, however flooding and erosion will have removed much of the archaeology. Archaeology will exist on the margins of the flood zones where the landforms offer some protection from erosive energy.

A digital elevation model (Figure 3) was constructed to highlight the margins and the majority of the identified archaeological sites were found on the margins of the major creek/river systems, on drainage channels or along minor tributaries. No archaeological material was found on high gradients or within the primary flood channels.

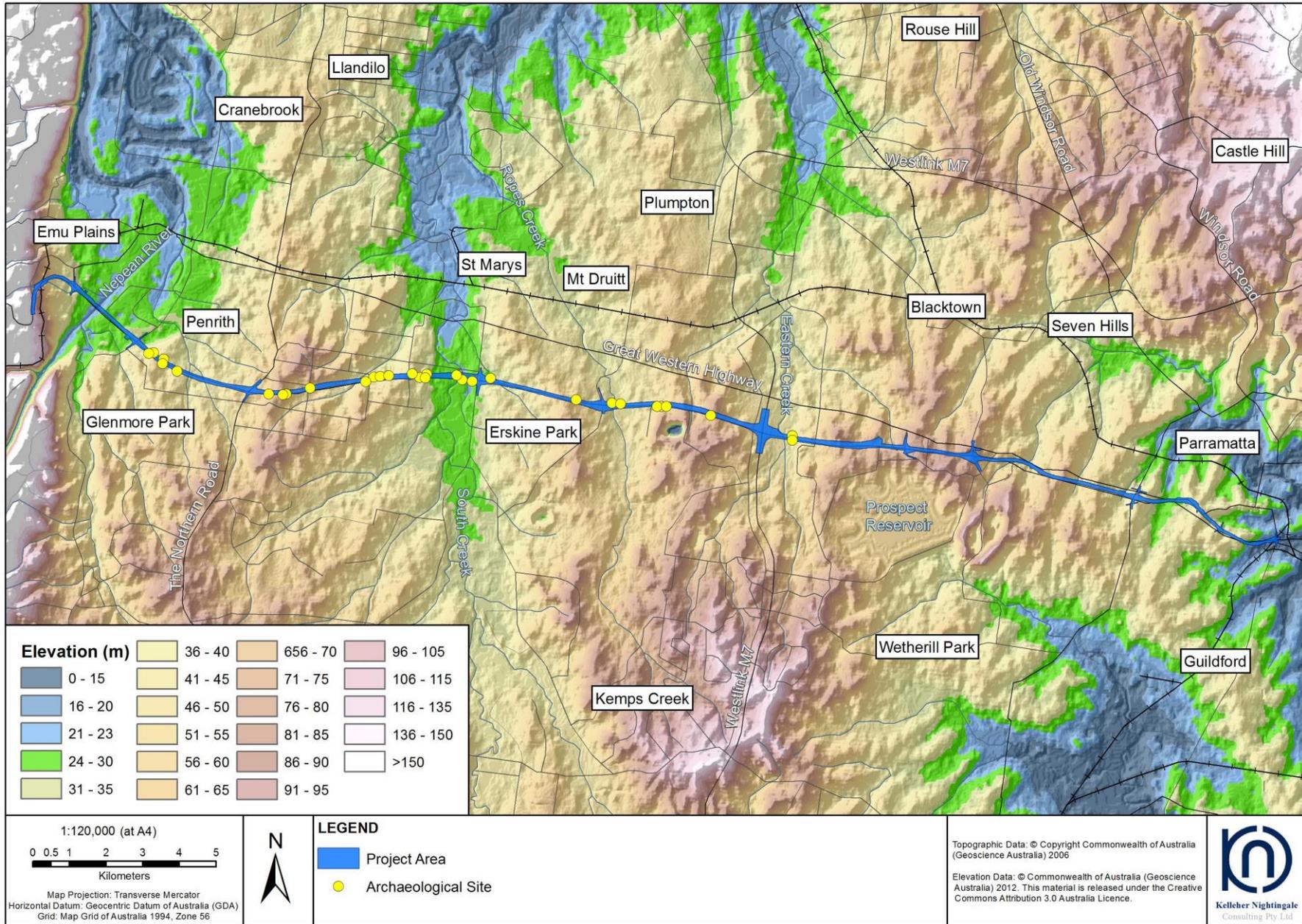


Figure 3. Digital elevation model showing low lying flood prone land, major creek systems and archaeological sites within the project area

## 2.2 Ethnohistoric context

Although the specific project area is not recorded directly in any ethnographical accounts, it lies in a landscape which was important to and intensively used by Aboriginal people in the past.

Kohen (1986a:77) records that Aboriginal people living between Parramatta and the Blue Mountains relied on small animals and plant foods in addition to seasonally available freshwater mullet and eels. Tench (1793:230) observed that 'they depend but little on fish, as the river yields only mullets, and that their principal support is derived from small animals which they kill, and some roots (a species of wild yam chiefly) which they dig out of the earth'. These wild yams were found in considerable quantities along the banks of the Nepean and Hawkesbury Rivers. Berries, Banksia flowers and wild honey were also recorded as foods of the local inhabitants (Collins 1798 [Kohen 1985:9]). A particularly important plant food was the Burrawong (*Macrozamia communis*), which provided a nutritious nut that was pounded and soaked in running water to leach out toxins before the flour-like extract was made into small cakes and baked over a fire (Kohen 1993:8).

Small animals provided the protein component of the Aboriginal diet on the Cumberland Plain, with hunting comprising a major economic role of the men. Along the river, traps and snares were set for bandicoots and wallabies, while decoys for snaring birds were also a commonly employed technique, 'these are formed of underwood and reeds, long and narrow, shaped like a mound raised over a grave, with a small aperture at one end for the admission of the prey' (Tench 1793 [Kohen 1985:9]). Possums and gliders were particularly common in the open woodland across the Cumberland Plain and probably formed the main sources of animal food. These were hunted in a number of ways, including smoking out the animal by lighting a fire in the base of a hollow tree, burning large tracts of land and gathering the stranded animals, as well as cutting toe-holds in trees mentioned above (Kohen 1993:10; Tench 1793:82).

The Cumberland Plain was actively used by Aboriginal people according to historic accounts. Aboriginal people have a long settlement history with the Plain, the pertinent questions to explore are the nuances of this settlement life as informed through material culture. The proposed archaeology program will assist in acquiring information to work towards a better understanding of the Aboriginal past on the Cumberland Plain.

### 3 Previous Archaeological Assessment

Several archaeological investigations have been conducted within a kilometre of the project area. A summary of the pertinent studies is presented in the first part of this section. A summary of previous archaeological studies within the M4 project area is presented in the second part of this section.

#### 3.1 Archaeological investigation outside the project area

Numerous surveys and archaeological studies were undertaken in the surrounding landscapes along the route of the M4 Motorway. In general these studies identified disturbed deposits on the rolling landscape with moderate concentrations of Aboriginal objects occurring in proximity to waterways.

In 1980 Haglund undertook a survey of land north and south of the M4 Motorway between Wallgrove Road and Chatsworth Road. A single site containing six artefacts of red silcrete was recorded on an eastern slope above Eastern Creek (AHIMS 45-5-0249). In 1982 Haglund returned to the area and undertook a series of surveys around the former Minchinbury Winery at Minchinbury and Eastern Creek and incorporated sections of the Great Western Highway and M4 Motorway. Two pieces of flaked chert and several fragments of quartz were noted but it was concluded that there was little chance of extensive undisturbed subsurface deposits to remain in these areas due to disturbance (Haglund 1983).

In 1981 Dallas undertook a survey of approximately 800 hectares on the south side of the M4 near Penrith. Twenty artefact scatters and seven isolated finds were identified. The majority of sites were located on hilltops or on crests in close proximity to creek lines or water sources. Artefact materials included chert, silcrete, mudstone, quartz and basalt while artefact types included cores, backed blades and a number of other modified pieces as well as debitage (waste material). The survey showed that intact archaeological deposit existed where remnant soils were unaffected by severe erosion.

In 1983 an extensive survey was made of a 200 hectare area south of the M4 and west of Wallgrove Road (Hagland, Conyers and McIntyre 1984). Six sites (AHIMS 45-5-0435 to 45-5-0440) and one isolated artefact were recorded. The majority of artefacts were silcrete with some quartz also present. A subsurface testing program was undertaken by Dallas in 1983. No artefacts were located from spade probes and many of the surface artefacts could not be relocated. The conclusion from the test program was that sheet erosion had removed the archaeological material.

In 1985 a number of sites were identified on the eastern side of Ropes Creek north of the M4 (Kohen 1985). A surface collection of artefacts was undertaken at AHIMS 45-5-0482, 45-5-0483 and Consent to Destroy (AHIP) was recommended for sites 45-5-0481 and 45-5-0484. Several other sites on the southern side of the M4, east of Ropes Creek, were also recorded (Kohen 1986). At site 45-5-0564 Kohen recorded 65 artefacts on a bend of the creek only 300 metres south of the road reserve. Artefacts consisted of five cores and a scraper and were mainly silcrete, although chert and quartz were also present. Kohen found that many of the open scatters were disturbed with the best deposit located near creek lines.

In 1989 three sites were recorded during the construction of a road deviation (Rich 1989). One of the sites (45-5-0750) contained nine artefacts of silcrete, one of indurated mudstone and one of quartzite and one artefact with possible usewear. Rich also recorded 45-5-0751 which contained ten artefacts including a silcrete and indurated mudstone artefacts. Site 45-5-0752 contained three artefacts of silcrete, indurated mudstone and quartzite. All of these sites were located in close proximity of drainage lines leading from gentle slopes.

Corkhill and Edgar in 1992 surveyed the area south from Park Hill Road to the M4 and west from Archbold (Chatsworth) Road to Ropes Creek. Over fifty artefacts were recorded at site 45-5-0206 with some considered to be in situ. Corkhill and Edgar suggested this site may be a continuation of site 45-5-0482 previously recorded by Kohen in 1985 and recommended a testing program. Corkhill and Edgar also recorded a site (45-5-0205), consisting of seven flaked stone artefacts 120 metres west of Archbold Road and 80 metres north of the M4. Subsequently a subsurface testing program was undertaken by Corkhill in 1993. Only six artefacts were located, three on the surface and three subsurface. The context was found to have been extremely disturbed by topsoil removal.

In 1995 Byrne recorded sites 45-5-0281 and 45-5-0282 at Park Hill Minchinbury. Site 45-5-0281 was assessed as being highly disturbed however 45-5-0282 was assessed as potentially containing intact subsurface archaeological deposits. Accordingly, Byrne undertook an excavation program in 1986 and recovered 25 artefacts from 13 spade probe pits and 102 surface artefacts. The majority of artefacts were silcrete with only four being indurated mudstone and two of chert. Byrne's excavation did not locate any archaeological features (such as hearths) or stratified archaeological deposits. The area was found to be disturbed. The normal A1 unit [humic loam] of the Cumberland Plain duplex soils was missing, while the A2 unit was of variable depth and in some areas also missing (cf. Brayshaw and Haglund 1996). The lack of A unit soils meant no archaeological deposit was present.

Excavations carried out at the Regentville substation, 2.5 kilometres south of the M4 in Mulgoa Creek Valley, found occupation between 2,500 and 7,500 years ago based on thermoluminescence dating of soils in a geomorphologically complex context (Koettig and Hughes 1995). Further investigations carried out at the site (McDonald, Mitchell and Rich 1996) found the location to be a low density site at which, consistent with other investigations of sites close to the Nepean (e.g. Shaws Creel II and Jamisons Creek), indurated mudstone/chert was the dominant raw material. The artefact assemblage was generally small and found to be consistent with a Bondaian classification, but site soils exhibited some structure supportive of an intact matrix. While the assemblage was small it showed that information can be obtained from localised stable deposits.

West of the Nepean and close to Russell Street, was 45-5-0222 (Kohen 1997). The site was an open campsite on an alluvial terrace. The deposit continued to a depth of 1.5 metres, unusually deep for open sites in the region. Two cultural phases were identified at the site, the older being dated to between about 7,000 – 14,000 years ago and the younger to about 1,600 years ago. Raw material present included chert, basalt and quartz from the Nepean gravels, as well as some silcrete and silicified wood. The site had mostly been destroyed as a result of construction of sporting facilities. The site was important as it demonstrated that significant archaeological deposit may exist on the margins of the Nepean River.

An Aboriginal heritage assessment was undertaken in 2003 at Claremont Meadows (ERM 2003). The assessment covered an area north of the M4 project area near Kent Road. Nine sites were identified. Test and then salvage excavation was carried out at site OAD1 (AHIMS 45-5-3013), which formed part of site 45-5-2898 (ERM 2006). The site was located on an interface between crest, slope and floodplain. Excavation recovered around 2,000 artefacts (density of 14/m<sup>2</sup>) and suggested complex activity zones within the site. It appeared to have been subject to very little historical disturbance. The site was interpreted as representing seasonal land use of an interface resource zone between the South Creek floodplain and low hills to the west. None of the Claremont Meadows archaeological sites are within the current project area, however the investigation showed that significant archaeological information exists along the margins of South Creek.

A further Aboriginal heritage assessment at Claremont Meadows was conducted in 2006 covering Lots 8, 9, 10 DP27107 and Lot 19 DP239091 on Caddens Road (ERM 2006a). This area was located on a floodplain approximately 500 metres west of Kent Road. Six Aboriginal sites were identified during the survey. One archaeological site, artefact scatter CMSW1 (AHIMS 45-5-3393) was identified as being of high archaeological significance. A test and salvage excavation of site CMSW1 was subsequently completed (ERM 2010). Lower artefact density (8.4/m<sup>2</sup>) at this site was contrasted with results from OAD1 (described above) suggesting either less intensive site use at locations where there was no interface between different landforms or perhaps more low energy fluvial disturbance.

### 3.2 Archaeological investigations within the project area

When the M4 Motorway was originally constructed in the late 1960's there were no archaeological surveys undertaken. It was not until 1984 that the first surveys directly relating to the freeway were completed, however none of the early assessments identified any archaeological objects.

#### Brayshaw and Haglund 1996 Assessment

In 1996 the first comprehensive archaeological survey was undertaken within the M4 Motorway corridor. The archaeological survey for Aboriginal sites for M4 Motorway upgrade was conducted by Helen Brayshaw and Laila Haglund prior to upgrade works on the M4 Motorway from Church Street, Parramatta to Coleman Street Mays Hill and Prospect to Emu Plains (Brayshaw and Haglund 1996). During their assessment, 29 locations containing Aboriginal objects were recorded. All sites recorded were either isolated finds or artefact scatters.

No Aboriginal objects were identified in the eastern portion of the corridor, between Parramatta and Mays Hill. This section of the road corridor had been completely modified and assessed to not have any potential to retain intact archaeological deposit.

All sites of Aboriginal objects were identified in the western section of the road corridor, restricted between the Eastern Creek service centres and The Northern Road. Most of the sites were low density artefact scatters or isolated finds. Much of the road corridor was heavily disturbed, resulting in an archaeological record that was not considered to be reflective or representative of past Aboriginal occupation and use of this area. In most instances, artefacts were recorded as separate find locations given the level of disturbance between locations and as they were not thought to have been originally discarded at some locations. Outside of the site locations, the remainder of the corridor was considered to not have any potential for intact archaeological deposit.

Two locations were identified as being less disturbed than others, with artefact movement likely to have been restricted to within the A horizon or deflated or where portions of the site remain which were fairly intact. Overall, the recorded sites were assessed as being reflective of a model of sparse artefact scatters across the landscape with occasional locations of greater concentration.

Silcrete artefacts dominated the recorded assemblage, with lower numbers of indurated mudstone, quartz, quartzite and igneous materials also being observed. Artefacts derived from knapping events, with around 30% of artefacts recorded as cores or core fragments and the remaining 70% being flakes and flake fragments. While this was consistent with assemblage characteristics at other sites in the area, a high proportion of the recorded M4 assemblage was considered to be broken or damaged as a result of disturbance rather than manufacture. One site, Location 8 South Creek 1, was considered to contain a large enough assemblage to provide an indication of reduction strategies.

As a result, it was recommended that appropriate section 90 consent (AHIP) should be sought for 27 of the 29 recorded locations. The locations all exhibited stripped or eroded deposits with no remaining intact A horizons. For the remaining two locations (Location 8 South Creek 1, AHIMS 45-5-1070 and Location 9 South Creek 2, 45-5-1071) it was determined both locations exhibited intact deposits with at least moderate artefact densities.

#### **Kelleher Nightingale Consulting 2013 Assessment**

The next comprehensive Aboriginal archaeological survey and assessment of the M4 Motorway was undertaken by KNC in 2013 as part of Stage 2 PACHCI investigation for the M4MM. The investigation included a review of background information, including identification of previously recorded Aboriginal sites registered on the Aboriginal Heritage Information Management System (AHIMS), sites known to the local Aboriginal community or others and any archaeologically sensitive landforms or areas or potential archaeological deposit in the project area.

The PACHCI Stage 2 investigation identified 31 Aboriginal archaeological sites within the project area (Figure 4). Twenty nine of these sites were originally recorded by Brayshaw and Haglund (1996) as part of the M4 archaeological survey for Aboriginal sites. As part of the 2013 survey each of Brayshaw and Haglund sites was revisited and recorded. One duplicate recording of Brayshaw and Haglund (1996), Location 10 South Creek 3 was identified as SC7 (AHIMS 45-5-3565). Areas outside of the existing recordings were also closely inspected for additional objects. One new Aboriginal site, Monfarville (M1) was recorded as part of the 2013 survey.

#### **Kelleher Nightingale Consulting 2015 Assessment**

Following the findings of the 2013 assessment, design modifications and ancillary site placement required an expansion of the project area to encompass additional areas outside the original project extent. A comprehensive Aboriginal archaeological survey and assessment of these areas was undertaken by KNC in 2015. One new Aboriginal site, South Creek 5 (SC 5) was recorded as part of the 2015 survey.

Each of the archaeological sites within the M4MM project area was reassessed during the 2013 and 2015 assessments. Of the now 32 archaeological sites, it was determined that 29 exhibited no intact archaeological deposit (consistent with the Brayshaw and Haglund 1996 assessment) and only a few artefacts were found resting on hard set clays, while three sites were found to exhibit intact archaeological deposit and numerous artefacts.

#### **Highly Disturbed Locations**

The KNC assessment of the 29 sites was consistent with the 1996 findings from Brayshaw and Haglund. In general the M4 corridor is highly disturbed with no possibility for in situ archaeological material. The ground has been modified by construction, which removed the upper layers of soil. Subsequent erosion has revealed remnant Aboriginal objects or transported objects from nearby surfaces (outside of the M4 corridor). Site descriptions are found in section 3.3.

#### **Intact Archaeological Deposits**

The two sites identified by Brayshaw and Haglund (1996) as exhibiting moderate to high significance were also confirmed as retaining intact archaeological deposit (Location 8 South Creek 1, AHIMS 45-5-1070 and Location 9 South Creek 2, 45-5-1071). Both of these locations are level rises above the primary South Creek flood zone with only limited evidence of sheet or rill erosion. Site descriptions are found in section 3.3.

In addition, a third site 20A Clyburn Avenue (AHIMS 45-5-1074) was found to contain intact deposit. Recent erosion along the road cutting, not visible during the 1996 study, revealed in situ artefacts emanating from a thin A horizon characteristic of the hilltop setting. A range of objects was identified at the site including a hammerstone and backed artefacts suggesting the site was a focus of activity as opposed to mere transitory site. A description of Location 20A Clyburn Avenue is found in section 3.3.

Locations of identified Aboriginal objects within the M4MM project area are shown on Figures 5-8 following site descriptions.

**Table 1. Summary of Aboriginal sites in the project area**

Site Name	AHIMS Site ID	Site Type	GDA94 Zone 56		Intact Deposit
			Easting	Northing	
Location 1 Eastern Creek 1	45-5-1066	Artefact scatter	302157	6257912	
Location 2 Eastern Creek 2	45-5-4583	Isolated find	302152	6258029	
Location 3 Minchinbury Hill	45-5-4584	Isolated find	299928	6258578	
Location 4A Chatsworth Road	45-5-4580	Isolated find	298726	6258823	
Location 4B Chatsworth Road	45-5-4581	Isolated find	298578	6258823	
Location 4C Chatsworth Road	45-5-4582	Isolated find	298470	6258825	
Location 5 Ropes Creek	45-5-1067	Artefact scatter	297476	6258891	
Location 6 Roper Road	45-5-1068	Artefact scatter	297242	6258910	
Location 7 Hewitt Street	45-5-1069	Artefact scatter	296264	6259010	
Location 8 South Creek 1	45-5-1070	Artefact scatter	293425	6259504	Yes
Location 9 South Creek 2	45-5-1071	Artefact scatter	293152	6259540	Yes
Location 10 South Creek 3	45-5-1072	Artefact scatter	292998	6259662	
Location 11 South Creek 4	45-5-4477	Artefact scatter	292190	6259699	
Location 12A Kent Road South	45-5-4430	Artefact scatter	292147	6259596	
Location 12B Kent Road South	45-5-4431	Isolated find	291996	6259603	
Location 13 Kent Road North	45-5-4424	Isolated find	291794	6259711	
Location 14A Claremont Creek 1	45-5-4578	Isolated find	290740	6259618	
Location 14B Claremont Creek 1	45-5-4579	Isolated find	290919	6259635	
Location 14C Claremont Creek 1	45-5-4575	Isolated find	291151	6259659	
Location 15 Claremont Creek 2	45-5-4576	Isolated find	290518	6259496	
Location 16 Kingswood Road	45-5-4572	Isolated find	289002	6259324	
Location 17A Northern Road East	45-5-4573	Artefact scatter	288360	6259155	
Location 17B Northern Road East	45-5-4574	Isolated find	288260	6259140	
Location 17C Northern Road East	45-5-4571	Isolated find	287881	6259154	
Location 18 Surveyors Creek	45-5-1073	Artefact scatter	285376	6259774	
Location 19A Regentville	45-5-4577	Isolated find	284979	6259986	
Location 19B Regentville	45-5-4569	Artefact scatter	284607	6260253	
Location 20A Clyburn Avenue	45-5-1074	Artefact scatter	284739	6260274	Yes
Location 20B Clyburn Avenue	45-5-4570	Artefact scatter	285012	6260099	
SC7 (South Creek) (Duplicate recording of Location 10 South Creek 3)	45-5-3565 (45-5-1072)	Duplicate recording	292998	6259662	
Monfarville (M1)	45-5-4585	Artefact scatter	293920	6259580	
South Creek 5 (SC 5)	tbc	Artefact scatter	293380	6259720	

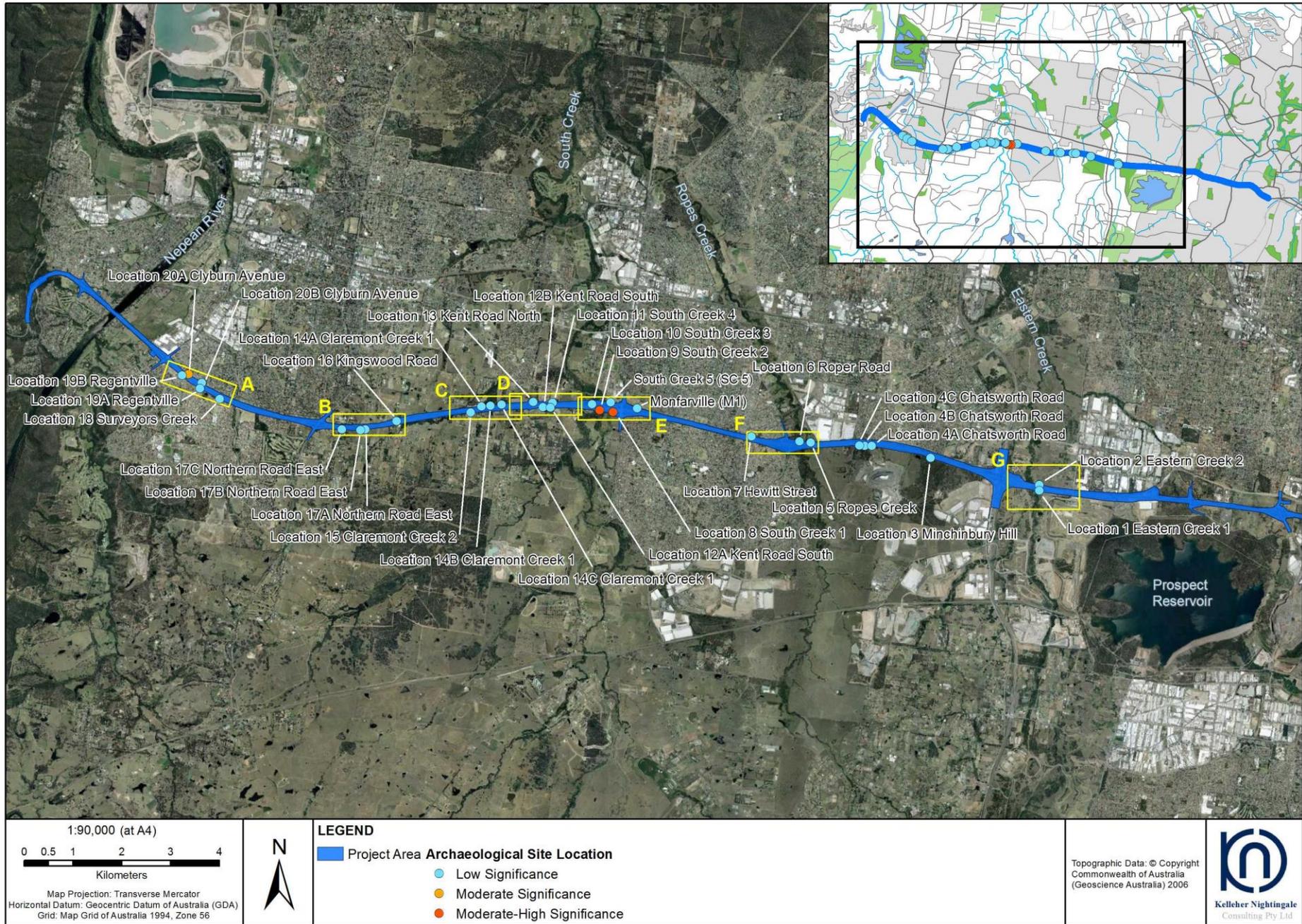


Figure 4. Aboriginal site locations in the project area (see detail maps Figures 5-8)

### 3.3 Aboriginal sites within the project area – site descriptions

#### Location 1 Eastern Creek 1

AHIMS Site ID: 45-5-1066

Coordinates: GDA 302157E 6257912N

Location 1 Eastern Creek 1 was located on a small south facing slope approximately 80 metres north of South Creek. Eleven artefacts were recorded at the site, including nine silcrete, one chert and one indurated mudstone artefact (Brayshaw and Haglund 1996). The location had shallow to non-existent A unit soils and parts of the site area were disturbed by past land use. It was considered unlikely that any significant undisturbed cultural material would remain at this location within the M4 corridor. No artefacts were observed at this location for the M4MM project assessment. The portion of the site within the project boundary was highly disturbed and parts affected by construction of an exit ramp and modified verge. The portion of the site within the project boundary was assessed as having no intact archaeological deposit. Consistent with the original recording of the site, the site area likely extends beyond the M4 corridor.

#### Location 2 Eastern Creek 2

AHIMS Site ID: 45-5-4583

Coordinates: GDA 302152E 6258029N

Location 2 Eastern Creek 2 was located on a gentle north facing slope approximately 150 metres east of Eastern Creek on the southern side of the M4 Motorway. A single broken red silcrete flake was recorded at this site (Brayshaw and Haglund 1996). Parts of the site within the road corridor had been disturbed. A thick cover of grass reduced ground visibility at the site location. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### Location 3 Minchinbury Hill

AHIMS Site ID: 45-5-4584

Coordinates: GDA 299928E 6258578N

Location 3 Minchinbury Hill was located on the upper western slope of a small hill on the south side of the M4 Motorway. A coarse grained silcrete core was recorded at this site (Brayshaw and Haglund 1996). The site location was originally recorded as having been bulldozed. Much of the top of the slope had been levelled off to create a vehicle access track resulting in localised erosion and good ground surface visibility at the site area. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### Location 4A Chatsworth Road

AHIMS Site ID: 45-5-4580

Coordinates: GDA 298726E 6258823N

Location 4A Chatsworth Road was located in a low depression adjacent to the RMS easement track on the southern side of the M4 Motorway. One silcrete flake was recorded at this site, on a firebreak track with good visibility and considered to be disturbed by erosion and development (Brayshaw and Haglund 1996). The site area had become heavily overgrown with exotic grasses, generally limiting ground surface visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### Location 4B Chatsworth Road

AHIMS Site ID: 45-5-4581

Coordinates: GDA 298578E 6258823N

Location 4B Chatsworth Road was located in a low lying depression along an RMS easement on the southern side of the M4 Motorway. One silcrete artefact was recorded at this site (Brayshaw and Haglund 1996). An informal vehicle access track through the site area has caused the ground surface to become eroded in parts. Ground surface visibility at the time of the 2013 survey was good, however no artefacts were observed at this location for the M4MM proposal assessment. The site exhibited no A horizon and was assessed as having no intact archaeological deposit.

#### Location 4C Chatsworth Road

AHIMS Site ID: 45-5-4582

Coordinates: GDA 298470E 6258825N

Location 4C Chatsworth Road was located in a shallow depression within the M4 easement on the southern side of the motorway. A single silcrete flake was recorded at this location, on a firebreak track with good visibility (Brayshaw and Haglund 1996). It was assessed that artefacts in the area would be few and sparse due to the eroded deposit. A vehicle track through the site area had caused considerable erosion to the ground surface. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 5 Ropes Creek**

AHIMS Site ID: 45-5-1067

Coordinates: GDA 297476E 6258891N

Location 5 Ropes Creek was located on a flood plain approximately 50 metres east of Ropes Creek on the northern side of the M4 Motorway. Three silcrete artefacts and one quartz artefact were recorded at this site (Brayshaw and Haglund 1996). The site had been disturbed, with parts bulldozed, and considered unlikely to retain undisturbed archaeological deposit. Much of the site had become heavily overgrown with grass and exotic trees reducing ground visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 6 Roper Road**

AHIMS Site ID: 45-5-1068

Coordinates: GDA 297242E 6258910N

Location 6 Roper Road was located on a flood plain approximately 140 metres west of Ropes Creek on the northern side of the M4 Motorway. One flake fragment of igneous material, one silcrete and two indurated mudstone artefacts recorded at this site (Brayshaw and Haglund 1996). The area was disturbed, with no A unit present in the artefact exposure. The site area had become heavily overgrown with grass, limiting ground visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 7 Hewitt Street**

AHIMS Site ID: 45-5-1069

Coordinates: GDA 296264E 6259010N

Location 7 Hewitt Street was located on an east facing slope within the M4 easement on the northern side of the motorway. Three silcrete artefacts were recorded at this site (Brayshaw and Haglund 1996). Artefacts comprised a core with usewear, a blade and a flake fragment. Ground surface visibility was good along the firebreak track on which the artefacts were recorded and the surrounding area was considered to be extensively disturbed. The site had become heavily overgrown with grass and trees and ground visibility was low. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 8 South Creek 1**

AHIMS Site ID: 45-5-1070

Coordinates: GDA 293425E 6259504N

Location 8 South Creek 1 was located on the eastern bank of a small tributary of Eastern Creek. The site covered an area of approximately 7500m<sup>2</sup> with residual A sediments over most of the site area. Around 150 artefacts were originally estimated to be visible at this site location, with a sample of 41 artefacts recorded including 39 specifically recorded within a 9x9 metre area and two from another part of the site (Brayshaw and Haglund 1996). Part of the site area is now in poor condition, being contained within the road easement on the southern side of the M4 and extending to within two metres of the motorway safety barriers. No artefacts were observed at this location for the M4MM project assessment. The site retained undisturbed subsurface deposits. The site was assessed to have moderate to high archaeological significance based on its geographical location next to South Creek, its situation on a low terrace landform, the large number of surface artefacts recorded and the presence of A unit sediments.

**Location 9 South Creek 2**

AHIMS Site ID: 45-5-1071

Coordinates: GDA 293152E 6259540N

Location 9 South Creek 2 was located on the eastern bank of South Creek near the junction of a small tributary on the southern side of the M4 Motorway. Seven artefacts were recorded at this site from a range of raw materials including chert, silcrete, quartz and quartzite (Brayshaw and Haglund 1996). The site area was heavily overgrown with grass and trees, with an access track on the northern side of the site providing reasonable ground surface visibility. No artefacts were observed at this location for the M4MM project assessment, however the site retained A unit sediments up to 20cm deep in exposed sections and relatively undisturbed where old growth trees and remnant natural vegetation was present. The site was assessed to have moderate to high archaeological significance based on its geographical location next to South Creek, situation on a low terrace landform, presence of surface artefacts and A unit sediments.

**Location 10 South Creek 3 (includes duplicate recording SC 7)**

AHIMS Site ID: 45-5-1072 (45-5-3565)

Coordinates: GDA 292998E 6259662N

Location 10 South Creek 3 was located within the M4 easement on the northern side of the motorway approximately 50 metres west of South Creek. Five silcrete and one chert artefacts were recorded at this site (Brayshaw and Haglund 1996). The site had been disturbed by past land uses and considered to have no archaeological potential. An informal vehicle track and pedestrian access path to the creek had caused localised soil erosion and disturbance to the site area. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 11 South Creek 4**

AHIMS Site ID: 45-5-4477

Coordinates: GDA 292190E 6259699N

Location 11 South Creek 4 was located on the crest of a hill approximately 700 metres west of South Creek. A quartz flake and a chert flake were recorded at this site (Brayshaw and Haglund 1996). The area had been disturbed by past land use practices and construction of an adjacent concrete noise barrier and access track. Ground visibility was good at the time of the survey. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 12A Kent Road South**

AHIMS Site ID: 45-5-4430

Coordinates: GDA 292147E 6259596N

Location 12A Kent Road South was located on a ridge spur sloping east within the M4 easement on the southern side of the motorway. Two silcrete artefacts were recorded at this site (Brayshaw and Haglund 1996). The site area was heavily overgrown with grass, limiting ground surface visibility, but surface disturbance was evident. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 12B Kent Road South**

AHIMS Site ID: 45-5-4431

Coordinates: GDA 291996E 6259603N

Location 12B Kent Road South was located on a ridge spur sloping east towards South Creek on the south side of the M4 Motorway. One silcrete artefact was recorded at this site (Brayshaw and Haglund 1996). The site was situated above a low swampy area in an area that had been severely disturbed. The site had become heavily overgrown with exotic grass and ground visibility was low. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 13 Kent Road North**

AHIMS Site ID: 45-5-4424

Coordinates: GDA 291794E 6259711N

Location 13 Kent Road North was located on a ridge crest with South Creek to the east and Claremont Creek to the west. The site was located along an easement on the northern side of the M4 Motorway approximately 50 metres east of Kent Road. A single silcrete blade core was recorded at this site (Brayshaw and Haglund 1996). The site was on a firebreak track with good ground surface visibility, but the ground was eroded with only a thin veneer of topsoil. Given the site location one kilometre from Eastern Creek, the artefact was considered to represent an isolated discard event. Location 13 Kent Road North was assessed as being a remnant outer part of a larger site area east of the road corridor, named G505, as part of the Werrington Road archaeological assessment (KNC 2012). No artefacts were observed within the M4 corridor at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit within the M4 corridor due to the lack of A unit soils.

**Location 14A Claremont Creek 1**

AHIMS Site ID: 45-5-4578

Coordinates: GDA 290740E 6259618N

Location 14A Claremont Creek 1 was located in a poorly drained depression approximately 200 metres south of Claremont Creek on the northern side of the M4 Motorway. One silcrete flake fragment was recorded at this site (Brayshaw and Haglund 1996). The site location was described as being severely disturbed with good exposure and visibility. Much of the site had become covered in thick exotic grass reducing ground visibility, but soil disturbance was evident. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 14B Claremont Creek 1**

AHIMS Site ID: 45-5-4579

Coordinates: GDA 290919E 6259635N

Location 14B Claremont Creek 1 was located in a small depression 250 metres south of Claremont Creek on the northern side of the M4 Motorway. One silcrete flake fragment was recorded at this site (Brayshaw and Haglund 1996). The site location was described as being severely disturbed with good exposure and visibility. The site had become vegetated reducing ground visibility, but soil disturbance was evident. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 14C Claremont Creek 1**

AHIMS Site ID: 45-5-4575

Coordinates: GDA 291151E 6259659N

Location 14C Claremont Creek 1 was located in a small depression 300 metres south of Claremont Creek on the northern side of the M4 Motorway. One silcrete flake fragment was recorded at this site (Brayshaw and Haglund 1996). The site location was described as being severely disturbed. Adjacent construction of a noise barrier and nearby

housing estate had substantially disturbed the surrounding landscape. No artefacts were observed at this location for the M4MM project assessment and soils were visible disturbed. The site was assessed as having no intact archaeological deposit.

#### **Location 15 Claremont Creek 2**

AHIMS Site ID: 45-5-4576

Coordinates: GDA 290518E 6259496N

Location 15 Claremont Creek 2 was located on a broad spur approximately 120 metres south of Claremont Creek on the southern side of the M4 Motorway. A silcrete flake fragment was recorded at this site (Brayshaw and Haglund 1996). The site was located on an exposed firebreak track with good visibility, although extensively disturbed. The site had become heavily overgrown with exotic grasses, limiting ground visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### **Location 16 Kingswood Road**

AHIMS Site ID: 45-5-4572

Coordinates: GDA 289002E 6259324N

Location 16 Kingswood Road was located against the western embankment of the Kingswood Road overpass bridge on the northern side of the M4 Motorway. A single flake of indurated mudstone was recorded at this site (Brayshaw and Haglund 1996). The area had been stripped and disturbed during construction of the overpass. The site had become overgrown with grass reducing ground visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### **Location 17A Northern Road East**

AHIMS Site ID: 45-5-4573

Coordinates: GDA 288360E 6259155N

Location 17A Northern Road East was located on an east facing upper slope on the southern side of the M4 Motorway. Two chert artefacts, one a core, were recorded at this site (Brayshaw and Haglund 1996). Artefacts were found on an exposed firebreak track with the ground surface having been disturbed and stripped of topsoil. The site had become heavily overgrown with grass reducing ground visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### **Location 17B Northern Road East**

AHIMS Site ID: 45-5-4574

Coordinates: GDA 288260E 6259140N

Location 17B Northern Road East was located on the crest of a small ridge that overlooks the M4 Motorway. A single damaged chert flake was recorded at this site (Brayshaw and Haglund 1996). The location was described as being very disturbed. A number of erosion channels had formed across the surface of the site and much of the topsoil has been removed by water runoff. The remaining topsoil was covered with exotic grasses. Overall ground visibility was good at the time of the survey however no artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### **Location 17C Northern Road East**

AHIMS Site ID: 45-5-4571

Coordinates: GDA 287881E 6259154N

Location 17C Northern Road East was located on a west facing slope on the southern side of the M4 Motorway. A single indurated mudstone bipolar pebble core was recorded at this site (Brayshaw and Haglund 1996). The ground surface was described as disturbed and the artefact was found among gravel lag deposit. The site was covered in remnant native vegetation with good ground surface visibility. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

#### **Location 18 Surveyors Creek**

AHIMS Site ID: 45-5-1073

Coordinates: GDA 285376E 6259774N

Location 18 Surveyors Creek was located on a broad spur 260 metres east of Surveyors Creek on the southern side of the M4 Motorway. Four artefacts were recorded over two exposures at this site (Brayshaw and Haglund 1996). The site location was described as having been scraped and altered, resulting in no archaeological potential remaining within this part of the road corridor. The north, east and west sides of the site had been enclosed behind a concrete noise barrier and the southern side by a wire fence. The site location was heavily overgrown with grass with limited ground surface visibility. No artefacts were observed at this location for the M4MM project assessment and the soils were highly disturbed. The site was assessed as having no intact archaeological deposit.

**Location 19A Regentville**

AHIMS Site ID: 45-5-4577

Coordinates: GDA 284979E 6259986N

Location 19A Regentville was located on an upper east facing slope on the southern side of the M4 Motorway. The site consisted of a white quartz core (Brayshaw and Haglund 1996). The area around Location 19A was heavily disturbed by construction of a concrete noise barrier, the base of which was ballasted by construction of a rock armour wall. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 19B Regentville**

AHIMS Site ID: 45-5-4569

Coordinates: GDA 284607E 6260253N

Location 19B Regentville was located on the western slope of a small ridge overlooking the M4 Motorway. Two indurated mudstone flakes were recorded at this site (Brayshaw and Haglund 1996). The site location was described as being disturbed and predominantly gravel lag, with no archaeological potential. The area had been disturbed by construction of a concrete noise barrier. No artefacts were observed at this location for the M4MM project assessment. The site was assessed as having no intact archaeological deposit.

**Location 20A Clyburn Avenue**

AHIMS Site ID: 45-5-1074

Coordinates: GDA 284739E 6260274N

Location 20A Clyburn Avenue was located on a west facing hillslope on the northern side of the M4 Motorway. Nine artefacts were originally recorded at this site, including four quartz, four silcrete and one chert (Brayshaw and Haglund 1996). A steep motorway embankment on the southern side of the site has caused erosion to encroach into the site area and artefacts were found eroding downslope. The remainder of the site was relatively stable and considered to retain intact archaeological deposit, being overgrown with grasses and retaining a stand of old growth gum trees along its southern side. Resulting ground visibility at the time of the 2013 survey was limited away from the eroded area and artefacts were identified at this location for the M4MM project assessment, including a small hammerstone.

This site and Location 19B Regentville were situated on the same small ridge, geographically linking the two sites prior to motorway construction. Ridgetop locations have proven valuable to understanding how past Aboriginal people operated in a landscape. The identified artefacts suggest that this elevated location was used for selective activities. Such locations are not expected to contain high artefact frequencies but should contain quality information. In this regard location 20A Clyburn Avenue was assessed as exhibiting moderate archaeological significance based on its geographic location, identified artefacts and residual intact soils.

**Location 20B Clyburn Avenue**

AHIMS Site ID: 45-5-4570

Coordinates: GDA 285012E 6260099N

Location 20B Clyburn Avenue was located on an east facing hillslope on the northern side of the M4 Motorway. Two quartz artefacts were recorded at this site (Brayshaw and Haglund 1996). The location was described as being disturbed with no archaeological potential. The surface of the site had been affected by runoff associated with an access track and adjacent park. Artefacts were observed on the clay access track. The site was assessed as having no intact archaeological deposit.

**Monfarville (M1)**

AHIMS Site ID: 45-5-4585

Coordinates: GDA 293920E 6259580N

Artefact scatter Monfarville (M1) was located on the northern side of the M4 Motorway approximately 250 metres east of Mamre Road. The scatter covered an area of approximately 5x5 metres within the M4 corridor. Two red silcrete artefacts were identified at the site (KNC 2013). Both artefacts were on exposed ground at the base of two small eucalypt trees. Apart from the exposed ground beneath the trees the area around site M1 was covered in thick grass limiting ground surface visibility. The landscape around site M1 was considerably disturbed and much of the area was revegetated with eucalypt saplings following re-contouring of the land. The site was assessed as having no intact archaeological deposit.

**South Creek 5 (SC 5)**

AHIMS Site ID: tbc

Coordinates: GDA 293380E 6259706N

South Creek 5 was located on the northern side of the M4 Motorway approximately 200 metres west of Mamre Road. Two silcrete flake fragments were identified a disturbed context associated with a drainage cut adjacent to the northern boundary of M4 project area. The identified artefacts were assessed as forming part of a larger artefact that extended across a raised landform north of the M4 project area. The portion of the site within the M4 project area had been considerably disturbed by the construction of the drainage channel and was assessed as having no intact archaeological deposit.



Figure 5. Aboriginal archaeological site detail section A and B (see Figure 4)



Figure 6. Aboriginal archaeological site detail section C and D (see Figure 4)



Figure 7. Aboriginal archaeological site detail section E and F (see Figure 4)



Figure 8. Aboriginal archaeological site detail section G (see Figure 4)

## 4 Aboriginal Community Consultation

The RMS *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI) provides a consistent means of effective consultation with Aboriginal communities regarding activities which may impact on Aboriginal cultural heritage and a consistent assessment process for RMS activities across NSW. The RMS PACHCI complies with all relevant OEH requirements.

### 4.1 Stakeholder identification and consultation

RMS advertised (Appendix A) for Aboriginal stakeholders in compliance with the Office of Environment and Heritage (OEH) *Aboriginal cultural heritage consultation requirements for proponents 2010*. RMS also contacted potential Aboriginal stakeholders identified from government agency notification responses. All consultation is consistent with the 2010 OEH requirements.

Registered stakeholders for the M4MM project are listed in the table below.

**Table 2. Registered Aboriginal stakeholders**

Group / Individual	Representative / Contact
Deerubbin Local Aboriginal Land Council	Kevin Cavanagh
Darug Tribal Aboriginal Corporation	John Riley
Darug Custodian Aboriginal Corporation	Leanne Watson
Darug Aboriginal Cultural Heritage Assessments	Gordon Morton
Darug Land Observations	Gordon Workman
Tocomwall	Scott Franks
Darug Aboriginal Land Care	Des Dyer
Gunjeewong Cultural Heritage Aboriginal Corporation	Cherie Carroll Turrise
Parramatta City Council Aboriginal Advisory Committee	Maggie Kyle
Gundungara Aboriginal Heritage Association	Meryl Williams
Gundangara Tribal Council Aboriginal Corporation	Sharon Brown
Individual	Trevor Robinson
Amanda Hickey Cultural Services	Amanda Hickey
Individual	Steven Hickey

The formal consultation process has included:

- advertising for registered stakeholders in local and Indigenous media, includes closing date (Appendix A);
- government agency notification letters;
- notification of assessment methodology (28 day review)
- ongoing compilation of registrants list, through continuing to register individuals and groups for consultation on the project;
- Aboriginal Focus Group (AFG) meeting was held on the 29 August 2013 at RMS offices Argyle Street, at which the results of the preliminary archaeological and Aboriginal cultural heritage assessments and methodologies for a further archaeological and Aboriginal cultural assessment were presented and discussed (minutes Appendix C);
- provision of draft CHAR for 28 day review; and
- ongoing consultation with the local Aboriginal community, including project updates every six months.

### 4.2 Response to stakeholder submissions

The draft CHAR was provided to Aboriginal stakeholders for review and comment. Comments were received from Darug Custodian Aboriginal Corporation (DCAC) and Darug Land Observations (DLO) (Appendix B). DCAC accepted the need for motorway and impacts on Aboriginal heritage. DLO requested the project area be enlarged to encompass the land up to Mamre House (to capture the connections between the identified cultural heritage in the M4 corridor - Location 8-9 South Creek 1-2 - and Mamre House. Post AFG discussions between Barry Gunther (RMS) and Gordon Workman (DLO) were held were it was explained and accepted by Gordon that the project area would not be expanded up to Mamre House.

### 4.3 Aboriginal cultural values

As part of the cultural assessment, registered Aboriginal stakeholders were invited to identify individuals they regarded as knowledge holders for the area. Identified knowledge holders were invited to participate in the cultural assessment process. To date no specific knowledge holders have been identified for the study area although the Aboriginal community has identified general cultural heritage values for the study area.

Aboriginal stakeholders have indicated that the study area exhibits general cultural heritage value. Some of the Aboriginal cultural heritage values expressed by stakeholders include:

- strong association with the land;
- responsibility to look after the land, including the heritage sites, plants and animals, creeks and the land itself;
- scarred trees;
- artefact sites and landscape features;
- creek lines;
- Indigenous plants and animals; and
- general concern for burials, as their locations are not always known and they can be found anywhere.

## 5 Summary and Analysis of Background Information

The archaeological and cultural heritage values of the project area have been previously assessed as part of the PACHCI Stage 2 archaeological assessment (KNC 2013) and outlined in this CHAR. The PACHCI Stage 2 survey and assessment found the project area displayed considerable disturbance with only three locations containing undisturbed soils. In general the PACHCI Stage 2 findings were consistent with the previous Brayshaw and Haglund survey of the M4 corridor finding the majority of the M4 corridor was heavily disturbed.

Thirty two Aboriginal archaeological sites were identified within the project area (Figures 4-8). Twenty nine of these were highly disturbed, low significance archaeological deposits. In most instances, artefacts were found on deflated or eroded clay profiles with no potential for further archaeological deposit. Aboriginal objects identified at the 29 disturbed site locations offer no archaeological value because the context was extremely poor as was concluded by both the Brayshaw and Haglund 1996 and KNC 2013 heritage assessments.

Three sites contained visible soil profiles and quantities of Aboriginal objects. Two of the sites on the margin of South Creek appear comparable with significant deposits excavated within Claremont Meadows (ERM 2003, 2006a). The South Creek sites within the project area offer an opportunity to further our understanding of the relationship between artefact densities-past activities-and fluvial disturbance. The Claremont Meadows findings suggested lower artefact densities within the South Creek floodplain related to variations in activities resultant from complex activity zones. A comparison between Location 8 South Creek 1 and Location 9 South Creek 2 should be able to either support the Claremont Meadows findings or describe the features of re-deposition. Location 20 Clyburn Ave is the opposite end of the elevation spectrum, located on top of a high ridge. This remnant site has the potential to show differences in activity areas based on comparison of artefact types and ratios.

**Table 3. Summary table of all Aboriginal archaeological sites within the project area**

Site Name	AHIMS	Site Type
Location 1 Eastern Creek 1	45-5-1066	Artefact scatter
Location 2 Eastern Creek 2	45-5-4583	Isolated find
Location 3 Minchinbury Hill	45-5-4584	Isolated find
Location 4A Chatsworth Road	45-5-4580	Isolated find
Location 4B Chatsworth Road	45-5-4581	Isolated find
Location 4C Chatsworth Road	45-5-4582	Isolated find
Location 5 Ropes Creek	45-5-1067	Artefact scatter
Location 6 Roper Road	45-5-1068	Artefact scatter
Location 7 Hewitt Street	45-5-1069	Artefact scatter
Location 8 South Creek 1	45-5-1070	Artefact scatter
Location 9 South Creek 2	45-5-1071	Artefact scatter
Location 10 South Creek 3	45-5-1072	Artefact scatter
Location 11 South Creek 4	45-5-4477	Artefact scatter
Location 12A Kent Road South	45-5-4430	Artefact scatter
Location 12B Kent Road South	45-5-4431	Isolated find
Location 13 Kent Road North	45-5-4424	Isolated find
Location 14A Claremont Creek 1	45-5-4578	Isolated find
Location 14B Claremont Creek 1	45-5-4579	Isolated find
Location 14C Claremont Creek 1	45-5-4575	Isolated find
Location 15 Claremont Creek 2	45-5-4576	Isolated find
Location 16 Kingswood Road	45-5-4572	Isolated find
Location 17A Northern Road East	45-5-4573	Artefact scatter
Location 17B Northern Road East	45-5-4574	Isolated find
Location 17C Northern Road East	45-5-4571	Isolated find
Location 18 Surveyors Creek	45-5-1073	Artefact scatter
Location 19A Regentville	45-5-4577	Isolated find
Location 19B Regentville	45-5-4569	Artefact scatter
Location 20A Clyburn Avenue	45-5-1074	Artefact scatter
Location 20B Clyburn Avenue	45-5-4570	Artefact scatter
Monfarville (M1)	45-5-4585	Artefact scatter
SC7 (South Creek) (Duplicate recording of Location 10 South Creek 3)	45-5-3565 (45-5-1072)	Duplicate recording
South Creek 5 (SC 5)	tbc	Artefact scatter

## 6 Cultural Heritage Values and Statement of Significance

The project area has cultural value for the local Aboriginal community. The identified cultural value is a feeling of attachment and responsibility for the land. These values become tangible when tied to identified Aboriginal objects found at the archaeological sites. In this way, the Aboriginal objects can be seen as exhibiting both scientific information and cultural meaning, knowledge about the past tied with social values and belief systems.

Thirty two Aboriginal archaeological sites exist within the M4 corridor.

Twenty nine of the Aboriginal archaeological sites exhibit low archaeological value largely due to high levels of disturbance and virtual absence of archaeological deposit. The ground surface associated with these sites has been altered thereby removing any archaeological potential. Even the identified objects at each location display evidence of artefact movement, with single objects occurring within rill gravels or on hard clays surfaces. For these reasons all 29 sites were assessed as exhibiting low significance.

Two Aboriginal archaeological sites exhibit a moderate to high degree of archaeological value (Location 8 South Creek 1, AHIMS 45-5-1070 and Location 9 South Creek 2, 45-5-1071) and one Aboriginal archaeological site (Location 20A Clyburn Avenue, AHIMS 45-5-1074) exhibited a moderate degree of archaeological value.

### Location 8 South Creek 1 (45-5-1070)

Location 8 South Creek 1 covered an area of approximately 7500m<sup>2</sup> and was located on the margin of the South Creek floodplain. Brayshaw and Haglund (1996) visually sampled a 9 x 9 metre area and recorded 39 surface artefacts. An estimated total of over 150 artefacts were visible at the time of the 1996 survey. Residual A horizon sediments were found to exist over most of the site area. At the time of the 2013 survey much of the site was covered by exotic grass and few artefacts were observed. However, several areas appeared to retain undisturbed subsurface deposits. The site was assessed to have moderate to high archaeological significance based on: geographical location next to South Creek, situated on a low terrace landform, large number of surface artefacts and the presence of A unit sediments.

### Location 9 South Creek 2 (45-5-1071)

Location 9 South Creek 2 was an artefact scatter of approximately 3000m<sup>2</sup> located on the eastern bank of South Creek near the junction of a small tributary. Brayshaw and Haglund (1996) recorded seven artefacts at this site from a range of materials including chert, silcrete, quartz and quartzite. The site retained A horizon sediments up to 20cm deep in exposed sections. During the 2013 survey no artefacts were identified, however, it was noted that in the western side of the site close to South Creek soils appeared relatively intact and consistent with the 1996 assessment. The site was assessed to have moderate to high archaeological significance based on: geographical location next to South Creek, situated on a low terrace landform, presence of surface artefacts, intact A horizon sediments and a range of artefactual raw materials.

### Location 20A Clyburn Avenue (45-5-1074)

Location 20A Clyburn Avenue was an artefact scatter located on a west facing hill slope overlooking a large cutting constructed for the motorway. Both this site and location 19B Regentville would have originally been located on the same small ridge (now bisected by the motorway) and were once part of a large archaeological site prior to the construction of the motorway. Location 20A Clyburn Avenue has suffered from disturbance as noted by Brayshaw and Haglund, primarily from the terraced cutting, however the remnant soils between the top of the cutting and the M4 boundary appear intact (albeit shallow). Aboriginal objects were identified within a 1500m<sup>2</sup> area during the 2013 survey and included a small hammerstone and a geometric backed artefact. Ridgetop locations have proven valuable to understanding how past Aboriginal people operated in a landscape as the ratios between tools-flakes-fragments show an increased for tools suggesting a different activity for the distinctly elevated sites. Such locations are not expected to contain high artefact frequencies but should contain quality information from relatively few artefacts. In this regard Location 20A Clyburn Avenue was assessed as exhibiting moderate archaeological significance based on: geographic location, identified artefacts and residual intact soils.

## 7 Avoiding and/or Mitigating Harm

### 7.1 Proposed activity

RMS proposes to install traffic management and on-road information systems and upgrade entry and exit ramps for the existing M4 Motorway between the Church Street intersection at Parramatta and the connection to the great Western Highway at Lapstone. The proposed impact area includes virtually the entire width of the M4 corridor over this length, including all existing/proposed entry and exit ramps, arterial road approaches, intersections adjacent to the entry and exit ramps, identified ancillary areas as well as an area either side of the route to allow for construction. Impact within the M4 corridor will result from upgrade construction, including extensive trenching and ongoing maintenance activities.

### 7.2 Practical measures taken to protect, conserve and avoid harm to Aboriginal objects

The proposal took into consideration the location of known Aboriginal cultural heritage sites and values. Thirty two Aboriginal archaeological sites are located within the footprint of the M4MM, however only three of the 32 sites exhibit any archaeological value with moderate or better levels of significance. This CHAR evaluated the potential harm of the development on Aboriginal archaeological heritage in terms of Ecologically Sustainable Development (ESD). The ESD assessment of Aboriginal heritage evaluated: long-term and short-term considerations, precautionary environmental impacts, maintenance and enhancement for future generations and impact assessment. In this regard, alternative designs and conservation principles have been considered by RMS to limit the cumulative harm of Aboriginal heritage. Where significant sites were identified, where possible the design has been modified to limit the impact to the identified cultural places and archaeological sites. For example all impact to the three moderately significant sites was limited to the existing M4 corridor.

### 7.3 Mitigating harm

Due to the number and distribution of the thirty two Aboriginal archaeological sites within the M4MM project area a corridor wide AHIP will be required. A map outlining the coordinates of the AHIP boundary has been developed (Figures 9-12). As twenty nine of the Aboriginal sites have been significantly disturbed and assessed as being of low significance they will not require salvage excavation (Table 4). However, three sites (Location 8 South Creek 1, Location 9 South Creek 2 and Location 20A Clyburn Avenue) have been assessed as being of at least moderate significance and will require mitigation in the form of salvage excavation. The salvage excavation of Location 8 South Creek 1, Location 9 South Creek 2 and Location 20A Clyburn Avenue will obtain representative samples of the impacted sites and will assist in mitigating the loss of archaeological and cultural information (Table 5).

**Table 4. Disturbed/low significance Aboriginal sites - no mitigation required**

Disturbed- Low Significance Aboriginal Archaeological Sites		
No archaeological value No mitigation required	Location 1 Eastern Creek 1; Location 2 Eastern Creek 2; Location 3 Minchinbury Hill; Location 4A Chatsworth Road; Location 4B Chatsworth Road; Location 4C Chatsworth Road; Location 5 Ropes Creek; Location 6 Roper Road; Location 7 Hewitt Street; Location 10 South Creek 3 (including duplicate SC 7); Location 11 South Creek 4; Location 12A Kent Road South; Location 12B Kent Road South; Location 13 Kent Road North;	Location 14A Claremont Creek 1; Location 14B Claremont Creek 1; Location 14C Claremont Creek 1; Location 15 Claremont Creek 2 ; Location 16 Kingswood Road; Location 17A Northern Road East; Location 17B Northern Road East; Location 17C Northern Road East; Location 18 Surveyors Creek; Location 19A Regentville; Location 19B Regentville; Location 20B Clyburn Avenue; Monfarville (M1); South Creek 5 (SC 5)

**Table 5. Moderate to high significance sites – salvage mitigation required**

Salvage Excavation of Aboriginal Archaeological Site	
Salvage mitigation required	Location 8 South Creek 1; Location 9 South Creek 2; Location 20A Clyburn Avenue

## 8 Recommendations

### AHIP application

An application for an AHIP should be made under section 90A of the *National Parks and Wildlife Act 1974*, for:

- the land and associated Aboriginal objects within the boundaries of the M4 Managed Motorway project area, as shown on Figures 9-12;
- including specified Aboriginal sites listed in Tables 4 and 5.

### Salvage Excavation

The AHIP would include mitigation through an archaeological salvage excavation at three sites:

- Location 8 South Creek 1 (AHIMS 45-5-1070)
- Location 9 South Creek 2 (AHIMS 45-5-1071)
- Location 20A Clyburn Avenue (AHIMS 45-5-1074).

Archaeological salvage should be completed prior to any activities which may harm Aboriginal objects at these site locations.

The archaeological salvage activities should be undertaken in accordance with the methodology developed in consultation with Aboriginal stakeholders attached as Appendix D.

### Collected Aboriginal Objects

The short term management of collected Aboriginal objects is as follows:

1. All collected Aboriginal objects will be held in a secure temporary storage location (KNC offices, Level 10, 25 Bligh St, Sydney 2000) pending any agreement reached as to the long term management of salvaged objects.

The long term management of collected Aboriginal objects is as follows:

2. Aboriginal objects will be transferred to the Australian Museum in accordance with legislative requirements, *Australian Museum Archaeological Collection Deposition Policy v1.0 January 2012*;
3. In the event the Australian Museum is unable to accept the objects, the objects will be transferred in accordance with a Care Agreement or similar agreement to an Aboriginal community;
4. In the event that neither the Australian Museum nor the Aboriginal community are able to accept the archaeological objects, KNC will seek a Care Agreement or similar agreement to curate the objects;
5. If long term storage is not possible, the objects will be reburied in accordance with OEH policy.

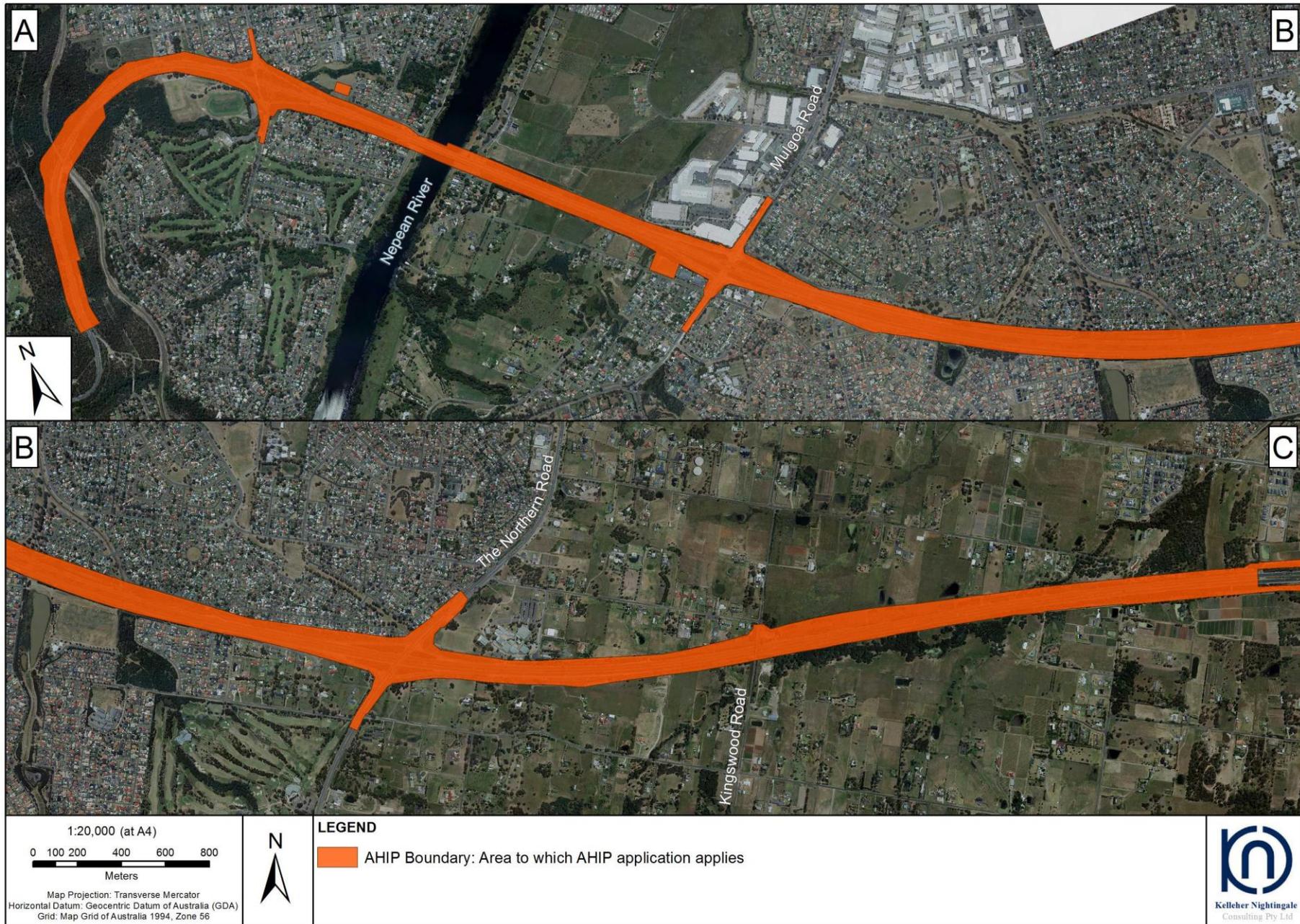


Figure 9. GPS coordinates of AHIP application boundary from Lapstone to Kent Road



Figure 10. GPS coordinates of AHIP application boundary from Kent Road to Eastern Creek



Figure 11. GPS coordinates of AHIP application boundary from Eastern Creek to Ettalong Road

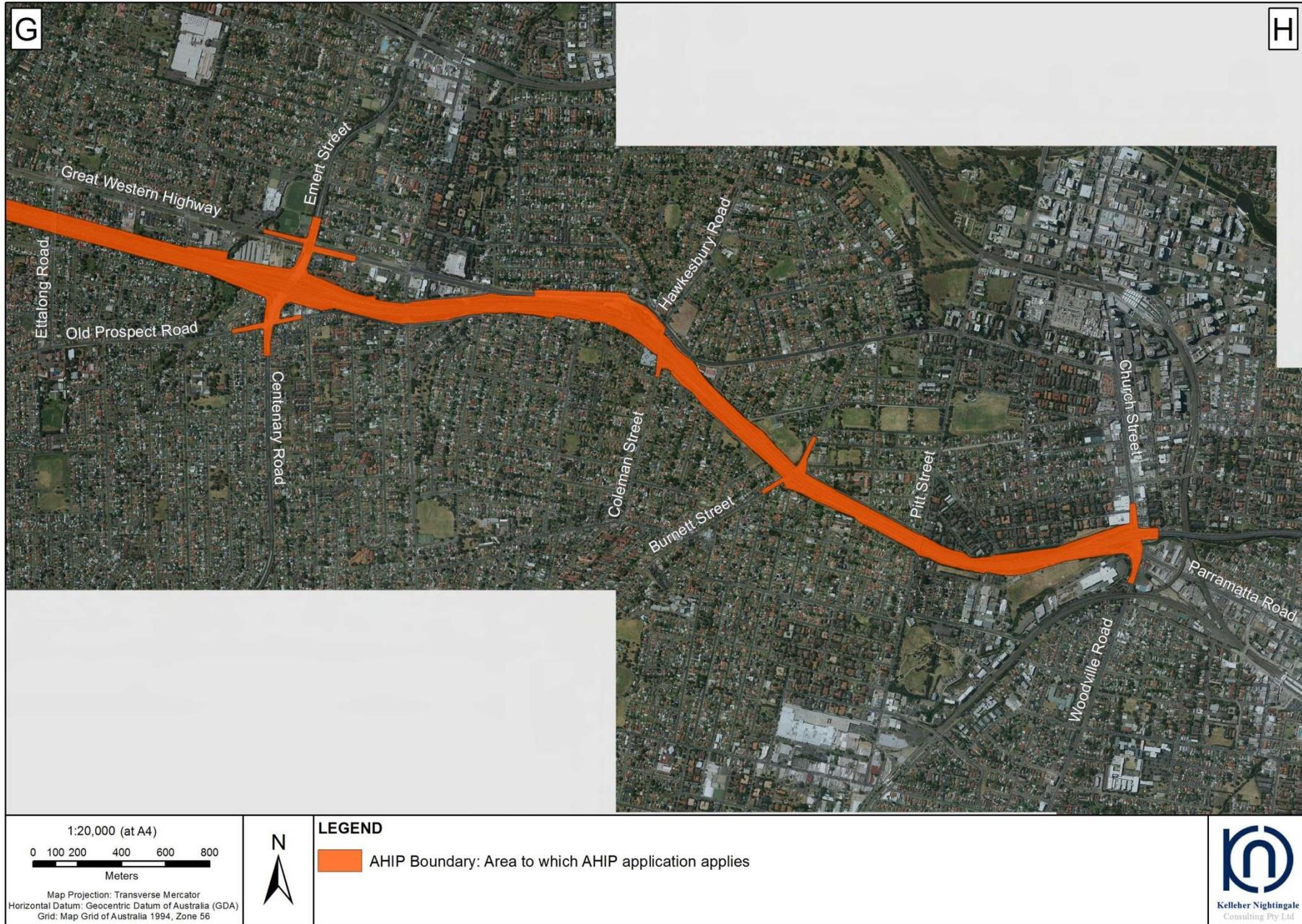


Figure 12. GPS coordinates of AHIP application boundary from Ettalong Road to Church Street Parramatta

## References

- Archaeological and Heritage Management Solutions (AHMS), 2012. Aboriginal Archaeological Survey Report: Werrington Arterial Road, Claremont Meadows, NSW. Unpublished Report for Aurecon Australia.
- Archaeological & Heritage Management Solutions (AHMS), 2011. Water related services for the North West Growth Centre – Second Release Precincts: Aboriginal heritage impact assessment. Report to Sydney Water.
- Attenbrow, V. 2002. *Sydney's Aboriginal Past: Investigating the Archaeological and Historical Records*. UNSW Press, Sydney.
- Brayshaw, H.C., and Haglund, L., 1996. M4 Upgrade, Archaeological Survey for Aboriginal Sites for Proposal to Upgrade the M4 Motorway from Church Street Parramatta to Coleman Street Mays Hill and Prospect to Emu Plains. Unpublished Report for SWR Constructors Pty Ltd through Environmental Planning Pty Ltd.
- Brayshaw, H.C., and Rich, E., 1995. Western Sydney Orbital Prestons to Cecil Park EIS Aboriginal Archaeology. Report to the RTA through Rust PPK PTY LTD.
- Byrne, D., 1996. Archaeological investigation of site 45-5-482 at Park Hill Road, Minchinbury, NSW. Report to Sargents Pies PTY LTD.
- Corkill, T., 1993. Subsurface testing at archaeological site RC2 [NPWS 45-4-205] Minchinbury, NSW. Report to Sargents Pies PTY LTD.
- Corkill, T., and Edgar j 1992. Survey for Aboriginal archaeological sites between Archbold Road, Park Hill Road and Western Motorway, Minchinbury, NSW Report to Sargents Pies PTY LTD.
- Dallas, M., 1981. An archaeological survey of the South Penrith development site. Report to NSW Housing Commission Roads.
- Dallas, M., 1983. Report on an investigation of three open sites at Wallgrove. Report to the TAFT Entertainment Company PTY LTD through Hirst Consulting Services.
- Dallas, M., 1984. An archaeological study of the F4 Western Freeway extension between May's Hill and Prospect. Report to the Department of Main Roads.
- Dallas, M., 1986. Archaeological survey of the F4 Western Freeway extension between May's Hill and Prospect. Report to Main Roads.
- DECCW, 24 September 2010. *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales: Part 6 National Parks and Wildlife Act 1974*. Department of Environment, Climate Change and Water NSW, Sydney.
- DECCW, April 2010. *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010: Part 6 National Parks and Wildlife Act 1974*. Department of Environment, Climate Change and Water NSW, Sydney.
- ERM, 2006. Aboriginal Archaeological Salvage Excavation Report of Aboriginal Site OAD1 at Claremont Meadows, New South Wales Unpublished Report for Landcom.
- ERM, 2006a. Lots 8, 9, 10 (DP27107) and Lot 19 (DP239091), Caddens Road, Claremont Meadows, Heritage Assessment. Unpublished Report for Landcom.
- ERM, 2010. Claremont Meadows South West 1, Section 90 Excavation, Aboriginal Heritage Excavation Report. Unpublished Report for Investa Property Group.
- Haglund, L., 1983. Report on archaeological survey in the Blacktown City area. Report to Blacktown City Council.
- Jo McDonald Cultural Heritage Management (JMCD CHM), 2006. Archaeological salvage excavation of the Colebee Release Area, Schofields, NSW. Report to Medallist Golf Holdings Pty Ltd.
- Kelleher Nightingale Consulting Pty Ltd (KNC), 2009. Marsden Park Industrial Precinct Aboriginal heritage assessment. Report to the NSW Department of Planning.

Kelleher Nightingale Consulting Pty Ltd (KNC), 2011. Schofields Road Upgrade Tallawong Road to Railway Terrace: Aboriginal archaeological survey report. Report to GHD Pty Ltd on behalf of NSW Transport Roads and Traffic Authority (RTA).

Kelleher Nightingale Consulting Pty Ltd (KNC), 2011a. Quakers Hill to Vineyard Rail Duplication Project: Stage 1 Quakers Hill to Schofields. Archaeological Excavation Program. Report to NSW Transport Construction Authority.

Kelleher Nightingale Consulting Pty Ltd (KNC), 2012. Werrington Arterial Road M4 Motorway to Great Western Highway Cultural Heritage Assessment Report. Prepared for Roads and Maritime Services

Kohen, J.L., 1986. Prehistoric Settlement in the Western Cumberland Plain: Resources, Environment and Technology. PhD Thesis, School of Earth Sciences, Macquarie University, Sydney.

Kohen, J.L., 1993. *The Darug and Their Neighbours. The Traditional Aboriginal Owners of the Sydney Region*. Darug Link in association with Blacktown and District Historical Society, Sydney.

Roads and Traffic Authority (RTA) Heritage Survey Unit, 1998. Aboriginal Heritage Sites adjacent to the Western Freeway (M4) Between Cumberland Highway and Mulgoa Road.

#### Electronic Sources

Office of Environment and Heritage, State Heritage Register Item # 2260228 Mamre House  
<http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=2260228> Accessed 27/6/2013

The University of Sydney, Department of History, Faculty of Arts A History of Aboriginal Sydney  
<http://www.historyofaboriginalsydney.edu.au/west/south-creek-people> Accessed 27/6/2013

## Appendix A Advertisement for Stakeholders

## Appendix B Aboriginal Stakeholder Comments



DARUG CUSTODIAN  
ABORIGINAL  
CORPORATION

PO BOX 81 WINDSOR 2756  
PHONE: 0245775181 FAX: 0245775098  
MOBILE: 0415770163  
EMAIL: mulgokiwi@bigpond.com

---

Attention: Clive Freeman,

Subject: M4 Managed motorway from Lapstone (western end) to Pitt St, Parramatta (eastern end) review of environmental factors.

Dear Clive,

The Darug Custodian Aboriginal Corporation have received and reviewed the Cultural heritage assessment draft report for the M4 managed motorway.

Our group understands that road construction impacts on our sites, as an Aboriginal group sites that are disturbed but still have potential to have Aboriginal objects, evidence and materials from thousands of years prior to contact, are significant to us. The main aim of our group is to care for and preserve all Aboriginal sites, and to promote awareness to the wider community about Darug people, their history and presence.

We support the Archaeological findings and recommendations set out within this report however the Aboriginal cultural heritage significance should be considered and mitigated, if artefacts are present in a archaeologically disturbed context within eroding areas, these materials need to be collected and relocated.

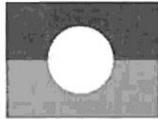
The cultural values have been included within this report and we are pleased that this has been included, we recommend that all sites where artefacts are evident, relocation is needed if further disturbance is evident.

Please contact us with all further enquiries on the above contacts.

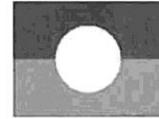
Regards

Leanne Watson

# DARUG - LAND - OBSERVATIONS



ABN: 87239202455  
E-MAIL: [gordow51@bigpond.net.au](mailto:gordow51@bigpond.net.au)  
PO BOX: 571 Plumpton, NSW 2761  
Phone: 029831 8868 or 0415 663 763



23-9-2013

**Clive Freeman**  
Aboriginal Cultural Heritage Officer– Sydney

**Re: M4 managed Motorways**

D.L.O has concerns with this area we would like to open the site to cover the whole area from edge of freeway to Mamre House to the south.

Yours faithfully

Uncle  
Gordon Workman  
Darug Elder

Sites Officer

## Appendix C    AFG Minutes

## Minutes



Purpose of Meeting	Aboriginal Focus Group - Presentation of CHAR		
Project	M4 Managed Motorways	Project No	
Prepared By	Jonas Ball	Phone No	02 9928 2225
Place of Meeting	RMS - Argyle Street Parramatta	Date/Time	29 August 2013
Present	Clive Freeman – RMS (CF) Barry Gunter – RMS (BG) Paul Nicholls – RMS (PN) Matt Smith – RMS (MS) Matthew Kelleher – KNC (MK) Jonas Ball – SKM (JB) Ben Staples – DLO (BS) Gordon Workman – DLO (GW) Carolyn Hickey – AHCS (CH) Steven Hickey – WIG (SH)		
Apologies	Sarah Barker - RMS	Leona Wade - RMS	
Distribution			

Item	Action By/Date
1) <b>Welcome to Country – Gordon Workman</b>	NA
2) <b>Objectives of Meeting</b>	NA
CF went through the objectives of the meeting, namely:	
<ul style="list-style-type: none"> <li>• To provide an overview of the project.</li> <li>• To present the draft CHAR to the AFG.</li> <li>• To allow AFG participants to ask any questions about the project or draft CHAR</li> <li>• To allow AFG participants to provide any additional cultural or archaeological information</li> <li>• To discuss a site visit</li> <li>• To describe the process for the finalisation of the CHAR</li> <li>• To discuss the process and requirements for site officer's for any archaeological investigations</li> <li>• To discuss preferences for the care and control of any items found during archaeological investigations</li> </ul>	

## Minutes



Item	Action By/Date
<ul style="list-style-type: none"> <li>Other matters as required.</li> </ul>	
<p>3) Description of M4 Managed Motorway Project</p> <p>PN presented a summary of the objectives and elements of the M4 Managed Motorway Project. There were a number of comments about the areas of traffic congestion including Erskine Park.</p>	NA
<p>4) Presentation of Draft CHAR</p> <p>MK gave a detailed presentation of the Draft CHAR. Issues covered in the presentation included:</p> <ul style="list-style-type: none"> <li>M4 corridor heavily disturbed and modified by road construction and maintenance activities.</li> <li>Many sections of the M4 constructed before protection of Aboriginal items and sites became legislated.</li> <li>First survey of the M4 Motorway corridor undertaken in 1993 - about 29 low-moderate value sites were identified – all sites were west of Eastern Creek; generally either around waterways or on ridgelines; often contained very few artefacts due to loss of top soil, erosion and disturbance; in some cases were protected by fencing (which generally was in disrepair); some sites extended outside the M4 Motorway corridor; only 4-5 sites were registered in AHIMS.</li> <li>A site inspection was undertaken with a representative of the LALC. The objectives of the site inspection were to relocate previously identified sites and identify any additional sites.</li> <li>GW suggested that the LALC should not be the only organisation involved in the site inspection. Local knowledge holders from other organisations should also undertake site inspections. BG explained that because of the current legislation and regulations, that RMS were obliged to engage the LALC for site inspections.</li> <li>All original sites were located and an additional site (M1) was identified. MK presented information on the current condition and archaeological potential of each of the sites.</li> <li>Of the 30 sites, 27 were considered not to have an intact archaeological profile and therefore were considered to have a low archaeological value.</li> <li>Three sites - Location 8 South Creek 1, Location 9 South Creek 2 and Location 20A Clyburn Avenue had an intact archaeological profile.</li> <li>Because of the impacts from the M4 Managed Motorway Project and specifically the trenching for ITS; maintenance activities and potential future development the whole corridor of the M4 Motorway had the potential to be disturbed. Therefore mitigation measures had be considered for all sites as they were all</li> </ul>	

Filename: Meeting minutes - AFG - Presentation of CHAR 29Aug13 Ver 1.docx

PAGE 2

Document no.:

## Minutes



Item	Action By/Date
<p>potentially impacted by the project.</p> <ul style="list-style-type: none"> <li>• As 27 sites had low archaeological significance and were generally already significantly impacted, no mitigation measures are proposed and these sites would no longer be considered Aboriginal sites.</li> <li>• For the 3 sites that had an intact archaeological profile salvage via archaeological excavation is proposed.</li> <li>• SH suggested that fencing the sites might be an alternative mitigation measure – and one commonly used in the area he was from.</li> <li>• MK explained that this had been done in the past in the M4 Motorway corridor with little success due to vandalism and maintenance activities. Also maintenance activities for the ITS backbone would be likely to disturb many areas. Also it was not worth fencing an area where there were very few low value artefacts. GW agreed that fencing and signposting sites generally encourage vandalism in the Sydney region, rather than protecting them.</li> <li>• There was general agreement that the mitigation measures proposed were appropriate given the potential impacts and archaeological value of the sites.</li> <li>• GW asked about the salvage program specifically the number of pits etc. MK gave a brief description of the methodology and referred back to the Draft CHAR.</li> <li>• GW also suggested that there were some high value ecological resources in the corridor especially around South Creek including Threatened Species.</li> <li>• JB gave a brief outline of the ecological studies for the project.</li> <li>• CF then asked if there were any further questions – which there were none at this stage.</li> <li>• CF then went on to explain the timetable for finalisation of the CHAR, namely comments on the Draft CHAR need to be provided by 13 September 2013.</li> <li>• BG &amp; CF reiterated that written comments were preferred to verbal comments, and if any comments could be accompanied by a general statement saying they either support or don't support the CHAR. If there were any questions about the CHAR MK can be contacted for further information.</li> </ul>	
5) Community and cultural knowledge	
<ul style="list-style-type: none"> <li>• CF asked if there was any specific community or cultural knowledge of the areas impacted by the M4 Motorway or that may</li> </ul>	

## Minutes



Item	Action By/Date
<p>be relevant for the CHAR.</p> <ul style="list-style-type: none"> <li>Aboriginal participants did not have any community or cultural knowledge of sites or other matters in the study area.</li> <li>GW said he needed to undertake a site inspection before he was prepared to conclusively say there were no cultural issues.</li> </ul>	
<p>6) Site Inspection</p> <ul style="list-style-type: none"> <li>CF asked if a site inspection was required before comments on the CHAR could be finalised.</li> <li>GW and SH indicated that they would like to have a site inspection of the 3 sites listed for salvage.</li> <li>CF &amp; BG outlined the conditions around the site inspection namely, it was voluntary, participants were not paid, the objective was not to identify additional sites, all registered knowledge holders would be invited and RMS would organise transport.</li> </ul>	<p>CF to organise site inspection including inviting other knowledge holders and organising transport. Tentatively week starting 9 September</p>
<p>7) PACHCI – Site officer nominations forms, Contracts, OHS and insurance</p> <ul style="list-style-type: none"> <li>CF asked if everyone had received the site officer nomination forms and if they have could they returned completed.</li> <li>CF &amp; BG outlined the conditions around the site officer positions including: <ul style="list-style-type: none"> <li>All site officers must public liability insurance and workers compensation.</li> <li>All site officers must have a "white card".</li> <li>RMS would select site officers based upon their experience and other minimum requirements and would also develop the roster for the site officers works. RMS makes no judgement on applicants' indigenous background.</li> </ul> </li> <li>There was some general discussion around the potential conflicts which can arise between non-indigenous and indigenous site officers and how they are resolved.</li> </ul>	
<p>8) OEH Care and Control Permit</p> <ul style="list-style-type: none"> <li>CF explained the OEH Care and Control Permit process in regard to the fate of any artefacts or items discovered during the site excavations.</li> <li>BG and MK explained the potential options for artefacts fate. BG asked that stakeholders state a preference now – however this was not binding and further feedback would be sought.</li> </ul>	

## Minutes



Item	Action By/Date
<ul style="list-style-type: none"><li>• GW suggested that the preference was Australian Museum followed by RMS (either for display or educational purposes) with the final option reburial.</li><li>• MK stated that reburial in the M4 Motorway corridor would be not be appropriate however reburial somewhere else would be OK.</li><li>• BG explained that RMS has a display cabinet which is used to display artefacts and in some cases copies of the artefacts are made and then used as educational resources for schools of RMS workers.</li><li>• No further comments were provided.</li></ul>	
9) General Business and summary	
<ul style="list-style-type: none"><li>• CF summarised what had been covered in the meeting including the project description and draft CHAR</li><li>• BG again reiterated the timetable for comments on the Draft CHAR and the preference for written comments and either support or non-support</li><li>• CF asked if there were any other matters that anyone wanted to bring up at this stage</li><li>• There were no more matters raised and the meeting was closed at about 1:30pm.</li></ul>	

## Appendix D    Research Design

## Methodology

### Research Aims

The main aims of the proposed salvage excavation program are:

- To salvage a representative sample of the identified archaeological sites (Location 8 South Creek 1, AHIMS 45-5-1070; Location 9 South Creek 2, 45-5-1071 and Location 20A Clyburn Avenue, AHIMS 45-51074) prior to impact.
- Analysis of the salvaged archaeological material to gain and conserve knowledge and understanding of the scientific and cultural information exhibited by the activities associated with the South Creek terrace associated with Location 8 South Creek 1 and Location 9 South Creek 2 as well as the ridgetop at Location 20A Clyburn Avenue.

The further scientific aim of the salvage excavation program will be to determine the subsurface integrity, extent, spatial distribution and nature of the cultural deposit and the specific types of associated archaeological/cultural activities:

- Determining the integrity of the deposit involves assessing the degree of disturbance which is present.
- Determining the statistical extent of the sites and/or activity areas involves identifying the boundaries associated with the identified archaeological deposit.
- Assessing the spatial distribution involves identifying the spread of archaeological material across the identified archaeological sites.
- The nature of the sites refers to the type of activities indicated by the artefactual material (e.g. primary production, domestic knapping, hunting camps). The goal would be to retrieve entire assemblages from specific activities if such activities were present.
- Retrieved assemblages would be compared with the results from other relevant archaeological projects such as Claremont Meadows (OAD 1, CMSW1) in order to assess significance.

Three archaeological sites are the focus of the proposed salvage excavation program: Location 8 South Creek 1; Location 9 South Creek 2; Location 20A Clyburn Avenue. The two South Creek sites are located on the margins of the 100 year flood zone indicating possible intact soil structure. South Creek 2 exhibits some fluvial sands and structured clayish loams, while the slightly higher South Creek 1 contains a residual soil. Both sites have the ability to curate archaeological objects, with the fluvial sands and basal residual deposits offering chronological potential. Chronologic results enhance our comparative analysis by identifying contemporary deposits (Contemporary archaeological sites extend our ability to interpret a cultural landscape, because they offer a wider snapshot of a specific time as opposed an amalgamation of cultural events through time.)

In contrast to the flood margin assessment, the elevated deposit at Location 20 Clyburn Avenue offers a low density deposit but with high yields in information. A comparison between statically random results between elevated sites and high density sites closer to waterways (such as South Creek 1 and 2) will yield information about the distribution of archaeological activities on the Cumberland Plain.

### Research Question

We know the upper South Creek catchment contain quantities of Aboriginal objects, the pertinent question is:

Are archaeological deposits on the margins of South Creek representing activity areas or are they the result of long term low energy fluvial forces.

Archaeological investigations in the Cumberland Plain associated with major and secondary river/creek systems (e.g. Nepean River, Eastern Creek, South Creek, Narellan Creek) have often encountered quantities of archaeological objects but generally not placed these objects into a geomorphic context. Specifically the geomorphic integrity of archaeological deposit needs to be further investigated in such potentially fluctuating environments especially where artefacts are retrieved using bulk excavation techniques. An ongoing research study by Dr. Anthony Barham and Dr. Matthew Kelleher suggests that the archaeological significance is degraded in these fluctuating environments because poor depositional integrity undermines the potential cultural information (Kelleher and Barham 2006, KNC 2011).

We now know that the Cumberland Plain, like much of south east Australia, would have been subject to dramatic fluctuations in aridity and rainfall, river discharge (including a long-term trend of declining river flows) and associated episodes of vegetation and soil regolith instability over the last 120,000 years (ka). These oscillations would have caused substantial changes in sediment storage both on hillslopes and in floodplains. Cycles of soil stripping on hillslopes, alternating with episodes of stability and soil development, were first identified in Eastern Australia over 50 years ago at sites on the Cumberland Plain. In floodplains, periods of sediment storage and alluvial sediment accumulation have probably alternated with incision and evacuation of previous floodplain sediments, especially in the mid-upper reaches of South Creek. These cycles, and their frequency, may have had profound effects on the present spatial distribution, visibility and nature of open landscape archaeological sites. Sites such as South Creek 1 and 2 have the potential to begin addressing these questions. When interpreting the depositional record archaeologists need to take on board these important controlling factors on site age, site preservation and site patterning across the landscape.

At present the archaeological methods being used for mitigation have become over preoccupied with recovering lithic artefact assemblages, and analysing these important sources of evidence independently of the environmental and stratigraphic contexts from which the lithic artefacts derive. Many research questions asked of lithic assemblages, cannot be answered without ancillary data and evidence e.g. the effects of past geomorphic and soil process on the taphonomy of artefact scatters, and the age of the deposits from which they derive.

In this light, salvage excavation will aim to establish the relationship between object and deposit. A crucial and basic part of any excavation, but in this case more attention will be paid towards assessing the potential geomorphic impact (both large and small scale). Excavation technique, as described below, will be modified where necessary to assist this aim. The result of the salvage of South Creek 1 and 2 will offer a comparison to other excavated sites on South Creek such as Claremont Meadows (OAD 1, CMSW1).

In contrast to flood margin archaeological sites is the isolated ridgetop open scatter of Location 20A Clyburn Ave. The pertinent question is deceptively simple: What artefacts occur at this location?

The range of objects at Clyburn Avenue will offer insight into past activities at elevated locations, but the most important aspect of this straight forward question come about when we compare the results to other archaeological sites. The range of objects will be contrast with other assemblages to look for trends related to elevated sites. We can expect the range of lithics to reflect at least in part the activity they were derived from. Outright variations in the tool kit are not an expected outcome of the salvage program. It is very unlikely that new tool types will be identified. So how will we see change? The answer: change will be identified by intersite spatial variation. Intersite variations will be defined by the comparative ratios of artefact types. For example, does Clyburn Avenue display higher percentages of tools or specific raw materials when compared to other sites?

#### **Field Methods**

The goal of the field excavation program is to recover significant assemblages of artefacts and to investigate the geomorphic context intrinsic to the archaeological deposit. The field methods reflect these goals.

#### **Salvage Program**

##### **Phase 1**

In order to achieve the most robust and comparable result, KNC advocates an open area salvage excavation. The first step in open area salvage is to establish the statistical boundaries of the previously identified archaeological deposit. This approach is designed to salvage the spatial properties of the site as shown in the lithic continuum. In other words, we are recording the spread of activities across the site/landscape. In practice a series of 1m<sup>2</sup> squares are excavated on a grid overlain on the site to mark the spread of lithics and related geomorphic activity. The grid is comprised of transects spaced at 10-15m intervals with squares every 10-15m. Each site will require approximately 25 x 1m<sup>2</sup> squares. The Geocentric Datum of Australia (GDA) coordinate system coordinates will be recorded for each square to enable three dimensional modelling. Statistical salvage following this method is highly beneficial because it creates a robust intersite sample, sufficiently random, critical for regional comparative analysis. No other method is as efficient or effective.

##### **Phase 2**

Next open area salvage will be undertaken where one or more of the following indicators of potential information bearing deposits: significant quantities of artefacts, variations in raw material, unusual artefacts, chronologic material and/or taphonomic indicators. Open area salvage of significant deposit will expand to encompass entire activity areas (Figures 13 and 14).

#### **Total Salvage Requirement**

It is anticipated that 350m<sup>2</sup> will be excavated during the salvage program for both Phase 1 and Phase 2 (c.150m<sup>2</sup> at Location 8 South Creek 1, c.150m<sup>2</sup> at Location 9 South Creek 2 and c.50m<sup>2</sup> at Location 20A Clyburn Avenue). The 350m<sup>2</sup> sample size will enable comparative assessment will other archaeological excavations along South Creek.

A map showing indicative locations of transects for Location 8 South Creek 1 and Location 9 South Creek 2 is provided in Figure 13 and for Location 9 South Creek 2 in Figure 14.

Individual excavation squares will be hand excavated in stratigraphic units. Squares will be excavated until the basal layer or culturally sterile deposit is reached (usually 25-35cm for remnant/podzolic soils and 50cm or more for fluvial/solodic soils). Excavation will make detailed recording the soil matrix as related to stratigraphy.

The location of each excavated square will be identified on a surveyed plan of the site. Stratigraphic sections detailing the stratigraphy and features within the excavated deposit would be drawn and all squares would be photographed. Soil samples as well as thin section profiles (where feasible) would also be collected. The stratigraphy of all excavated areas will be fully documented and appropriate records will be archived.

Carbon or other samples for dating would be collected and analysed with allowance for six radio carbon and two OSL samples. Soil samples will be collected and analysed for material relating to both the archaeology and geomorphology. Where appropriate cosmogenic and radiometric dating of soils and rock surfaces will be applied (Nishiizumi et al. 1986, 1993).

Wet sieving of all deposit is required with *three* nested sieve sizes: 5mm, 2.5mm and 1mm. The use of the 1mm sieve mesh is important to capture micro debitage necessary for assessing depositional movement (flooding, deflation and colluvial activity). The use of 1mm sieve mesh was found to contribute significant information about site integrity and artefact reduction at VR1 (Eastern Creek) and Mungerie Park (NWRL-Schofields and Windsor Roads).\

Core samples measuring at least 1m deep will be collected and archived using a 50mm hand corer to describe a cross section of the project area (South Creek and Clyburn ridgeline colluvial pattern) (around 15 sample will be required or 5 per site). In addition, thin section profiles (where feasible) would also be collected from open areas. The stratigraphy of all areas would be fully documented and appropriate records would be archived.

#### **Surface Collection**

Prior to commencing construction activities the surface artefacts from sites Location 8 South Creek 1; Location 9 South Creek 2; Location 20A Clyburn Avenue would be collected using defined grids. These artefacts would be labelled and bagged with location information. The artefacts would be documented in the salvage excavation report.



Figure 13. Excavation areas within Location 8 South Creek 1 and Location 9 South Creek 2



Figure 14. Excavation areas within Location 20 A Clyburn Avenue

## Analysis

Artefacts would be analysed on a comparable level with previous analyses of excavated assemblages (KNC 2008, KNC 2011, ERM 2003, Jo McDonald Cultural Heritage Management 2004, 2006; Attenbrow 1981). Information derived from this analysis, in particular the identification of specific artefact types and their distributions and associations, will be used to put together interpretations about how sites were used, where sites were located across the landscape, the age of sites and to assess cultural heritage values. By comparing different areas it will be possible to determine whether there were differences in the kinds of activities carried out and if different activities were related to different landforms.

The geoarchaeological assessment will focus on the integrity of the deposit and the ramifications of geomorphic change for: artefact survivability, interspatial assessments and scientific significance.

A range of stone artefacts may be present across the salvage areas and the analysis would expand accordingly to account for artefact variability. All information would be recorded in database form (MS Excel). Various types of evidence would be used to determine the kinds of activities that were carried out. A short description of the proposed analysis is outlined below.

- Field analysis would record basic data, such as material type, number and any significant technological characteristics, such as backing or bipolar techniques; added to this would be any provenance data such as pit ID and spit number. The purpose of the field recording is twofold: 1) establish a basic recording of artefacts retrieved and 2) to allow ongoing assessment of the excavation regime (e.g. whether higher stratigraphic resolution is required while digging).
- Detailed (laboratory) analysis would entail recording a larger number of characteristics for each individual artefact. These details would be recorded in matrices suitable for comparative analysis (e.g. multivariate and univariate) of the excavated assemblage on a local and regional basis.
- Lithic characteristics to be recorded cover a range of basic information but are not limited to these categories (see example below). For transparency, terms and category types would in large part be derived from Holdaway and Stern (2004).

Sample Categories						
Record number	Count	Quality	Width	Modification	Termination type	Scar type (core)
Pit ID	Raw material	% Cortex	Thickness	Reduction type	Core type	Shape of flake
Spit number	Colour	Length	Weight	Flake type	Number of scars (core)	Platform type

- A detailed explanation and glossary would be provided with the final excavation report.
- Minimum Number of Flake (MNF) calculations formulated by Hiscock (2000, 2002) will be undertaken where applicable (although past experience indicates MNF calculations will not be required for this excavation program).

The analysis of artefacts recovered during the excavation program would be undertaken in a transparent and replicable fashion so as to permit the comparison of the entire excavated assemblage with data from other areas. This would also allow for an interpretation of the project area's archaeological significance.

## Field Team

KNC directors, Dr Matthew Kelleher and Alison Nightingale, would be responsible for the salvage excavation program. Dr Matthew Kelleher would direct the excavation component of the Aboriginal archaeological assessment. Matthew has extensive experience in managing archaeological excavations and research projects, especially on the Cumberland Plain. The geoarchaeological assessment will be undertaken by a suitably qualified geomorphologist and Dr Matthew Kelleher.

## Salvage Excavation Requirements Summary

- Approximately 350m<sup>2</sup> total excavation (Phase 1 and Phase 2)
- Hand excavation of all squares
- Wet sieving of all deposit
- Sieve size must be nested in three layers: 5mm, 2.5mm and 1mm to capture micro debitage
- Allowance for six radio carbon dates
- Allowance for two OSL core sample dates
- 15 1m deep 50mm wide core samples, analysis and archive
- Thin section collection, analysis and archive
- Surface collection using defined grids
- Archaeological excavation report
- Geomorphological assessment report

 [rms.nsw.gov.au/projects/sydney-west/m4](https://rms.nsw.gov.au/projects/sydney-west/m4)

 13 22 13

 Customer feedback  
Roads and Maritime  
Locked Bag 928,  
North Sydney NSW 2059

**October 2015**

RMS 15.563

ISBN: 978-1-925421-22-4