



Figure 40 Cochlear Building frontage to University Avenue requires replacement planting.

5.4 Creek corridors and parklands

University Creek

A Landscape Rehabilitation plan has been prepared for University Creek. For management purposes the Creek has been divided into a number of reaches. The reaches are currently being rehabilitated in association with roadworks along University Avenue. For further maintenance issues relating to the creek, refer to the Plan prepared for Mars Creek (below) and also the Vegetation Management Plan 2015.

Mars Creek

A Mars Creek Environmental Plan prepared by Storm Consulting was commissioned in 2010/11 by the University. Habitat restoration has been an overwhelming success. Over time further sections of the highly modified creekline may be naturalised, changing the maintenance priorities in the zone. For further maintenance issues relating to the creek, refer to the Plan and also the Vegetation Management Plan 2015.

Culloden Creek

Culloden Creek corridor provides opportunities for the restoration of the Sydney Turpentine-Ironbark Forest and passive open space. Refer to the Vegetation Management Plan 2015.

5.5 Primary roads and pedestrian connections

Each of the universities internal roads and pedestrian connections are characterised by unique street tree planting. The length of the roads are not necessarily planted with a single species, making the most important aspect of landscape management the height to which each species is under-pruned of lower branches to make clearance for pedestrians and vehicles, but also to suit the species type and to achieve a relatively consistent canopy. For each road below the street tree under-pruned height has been noted.

University Avenue

University Avenue is changing to accommodate future uses. Parts of its length have been upgraded with formal street tree planting of *Pyrus* "Chanticleer" where adjacent to buildings, and *Tristaniopsis laurina* where alongside University Creek. The final section up to Herring Road is proposed to be planted with an avenue of Kauri Pines (*Agathis robusta*). Each of these trees has a distinctive form different from the next.

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Agathis robusta</i>	Kauri Pine	5
<i>Pyrus calleryana</i> "Chanticleer"	"Chanticleer"	3
<i>Tristaniopsis laurina</i>	Water Gum	3

Research Park Drive

Research Park Drive will terminate at University Creek where Water Gums make a connection with the creek landscape and Crow's Ash and Red Cedar will provide tall and imposing avenue from the Talavera Road.

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Flindersia australis</i>	Crow's Ash	5
<i>Toona ciliata</i>	Red Cedar	5
<i>Waterhousia floribunda</i> Cv.	"Green Avenue" Weeping Lilly Pilly	3

Innovation Drive

Innovation Drive street trees reinforce the University Creek Crossing with Weeping Lilly Pilly and Turpentine, and acknowledges the sandstone Geology at its interface with Herring Road with Smooth-Barked Apple and Grey Gum

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Angophora costata</i>	Smooth-Barked Apple	5
<i>Eucalyptus punctata</i>	Grey Gum	5
<i>Waterhousia floribunda</i>	Weeping Lilly Pilly	3

Eastern Road

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Eucalyptus paniculata</i>	Grey Ironbark	5
<i>Eucalyptus punctata</i>	Grey Gum	5
<i>Syncarpia glomulifera</i>	Turpentine	5

Western Avenue

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Angophora costata</i>	Smooth-Barked Apple	5
<i>Eucalyptus paniculata</i>	Grey Ironbark	5
<i>Eucalyptus punctata</i>	Grey Gum	5

West Precinct Road

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Cupaniopsis anacardioides</i>	Tuckeroo	3
<i>Tristaniopsis laurina</i> "Luscious"	Water Gum	3
<i>Waterhousia floribunda</i> Cv.	"Green Avenue"	3

Secondary East-West Pedestrian Connections

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Pistacia chinensis</i>	Chinese pistachio	3
<i>Pyrus ussuriensis</i>	Manchurian Pear	3
<i>Ulmus parvifolia</i>	Chinese Elm	3

Secondary North-South Pedestrian Connections

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
<i>Backhousia myrtifolia</i>	Grey Myrtle	3
<i>Elaeocarpus eumundii</i>	Blueberry Ash	3
<i>Flindersia pimenteliana</i>	Maple Silkwood	3

5.6 Sports field and facilities

Macquarie University sports fields

Macquarie University maintains approximately seven hectares of high quality specialist playing areas at high standard, suitable for a range of intended uses. Resource use in maintaining the sports fields should be environmentally sustainable due to their location in proximity to The Lane Cove River Catchment and sensitive bushland. Runoff from irrigation and excess fertiliser should be minimised and turf areas should be managed for minimum disease by providing good growing conditions. Chemical use should be discouraged. Amenity of spectators should be enhanced.

Sports ovals will continue to be maintained by a contractor who has expertise in this type of landscape management. This approach has worked well in recent years. To assist the contractor maintain the ovals to a high standard, the university should consider upgrading grounds maintenance equipment. An audit of the type and condition of existing equipment is needed to determine priorities for future.

One of the goals is to 'adopt further water sensitive urban design practices to minimise potable water consumption'. It recommends that current irrigation practices for the sports ovals are reviewed to identify water efficiency and drought proofing strategies.

Sporting Fields – Suggested Replacement Tree Schedule - species from the broader Sydney Sandstone Ridge-top Woodland community to provide shade for spectators at the perimeter of fields where space is available:

BOTANICAL NAME	COMMON NAME	MATURE SIZE
----------------	-------------	-------------

		(H X W)
<i>Angophora costata</i>	Smooth-Barked Apple	15 x 10 m
<i>Corymbia gummifera</i>	Red Bloodwood	25 x 10 m
<i>Eucalyptus haemastoma</i>	Broad-leaved Scribbly Gum	15 x 10 m
<i>Eucalyptus piperita</i>	Sydney Peppermint	20 x 10 m
<i>Eucalyptus sclerophylla</i>	Hard-leaved Scribbly Gum	20 x 10 m
<i>Eucalyptus squamosa</i>	Scaly Bark	7 m

6.0 Protective Measures

6.1 Protection of Existing Vegetation

Existing vegetation and newly planted areas need protection during construction and establishment. During construction and establishment periods, temporary fencing should be placed at the extent of area to be protected, preferably beyond the drip-line of trees to be protected.

The fencing methods should include flagging tape, stakes and temporary fencing, clearly identifying the area to be protected and restricting pedestrian and vehicular access to the protected zone.

Following completion of the construction period (including establishment), all temporary works should be removed when they are no longer required.

6.2 Tree Protection

Tree protection on all development sites within the City of Ryde must comply with *Australian Standard 4970 – 2009 Protection of trees on development sites*. Refer also to the *City of Ryde DCP 2010 Part 9.6 Tree Preservation* and the *City of Ryde Urban Forest Technical Manual and Application Guide*.

The relevant Australian Standards are:

- *AS 4970 Protection of trees on development sites.*
- *AS 4687 Temporary fencing and hoardings*

6.3 Erosion, Contamination and Sedimentation Control

During construction, all precautions necessary should be undertaken to prevent erosion, contamination, and sedimentation of the site, surrounding areas and drainage systems, including but not limited to the following:

- Progressive restoration of the riparian corridor (refer to Landscape Restoration Plan incorporating Vegetation Management Plan)

- Construction of temporary drains and catch drains
- Diversion and dispersal of concentrated flows to points where the water can pass through the site without detrimental impacts
- Construction and maintenance of silt traps to prevent discharge of scoured material to downstream areas
- Stabilisation of exposed soil surfaces (e.g. through sterile grass seeding, erosion control meshing, or mulching using vegetative material removed from the study area)
- Use of erosion and sediment control measures to collect sediment and to reduce flow velocities
- Construction of temporary fencing
- Regular monitoring and maintenance of all erosion and sediment control structures throughout the construction and operational phases of the development to ensure their effective function.

6.4 Tree Removal and Disposal of Vegetation on Site

All significant trees removed as a result of construction works are to be replaced by the same species and planted in a suitable location corresponding with the relevant vegetation community within the riparian corridor. Refer to the Landscape Rehabilitation Plan incorporating Vegetation Management Plan for University Creek.

For any significant trees removed for construction works, consideration should be given to retaining the woody parts whole or in sections, and placed on the ground in the riparian corridors of Mars Creek and University Creek to provide habitat for native fauna.

All other native vegetation that is identified for removal should be chipped for use as mulch. All weed material is to be separated and removed from the cleared material prior to chipping. Mulch should be stockpiled at approved locations around the site and be used in locations from where it was derived to ensure any seed stock located within the mulch will be located in appropriate site conditions.

Any vegetation, topsoil or other materials not identified for re-use shall be either disposal of off-site or in an area where the material will not wash into existing vegetation, Mars Creek or University Creek.

7.0 Monitoring and Reporting

Regular inspections of all landscape areas should be undertaken by the Campus Assets Team to ensure that maintenance is carried out according to the plan. The inspections should not be less frequent than three (3) monthly (or immediately after high rainfall/wind/heat events) with the objective that all areas are visited at least once within that period and an inspection checklist prepared and filled out during each inspection and a Three Monthly Maintenance Audit Form Submitted. (Refer to Appendix F). As well as open space currently in use, the inspection should include the ongoing protection of all existing vegetation and new revegetation works during its establishment period.

Maintenance staff should receive the audit form and carry out any remediation work required.

Appendix A – Illustrative Masterplan



Appendix C – Reference Documents

The following Australian Standards are referred to in this report:

- AS 1319 Safety signs for the occupational environment
- AS 4373 Pruning of amenity trees
- AS 4454 Composts, soil conditioners and mulches
- AS 4687 Temporary fencing and hoardings
- AS 4970 Protection of trees on development sites
- AS 1428 Access and Mobility Design

The following documents are referred to in this report:

- Macquarie University Campus Masterplan 2014 (Cox Richardson Architects and Planners 2014)
- Design Excellence Strategy and Urban Design Guidelines, prepared by Cox Richardson Architects and Planners in conjunction with CONTEXT
- Vegetation Management Plan (VMP) for Macquarie University, prepared by Lesryk Environmental Consultants 2015 in conjunction with this LMP.
- Precinct E Landscape Management Plan, prepared by CONTEXT 2010.
- University Creek Landscape Rehabilitation Plan (Incorporating Vegetation Management Plan) prepared by CONTEXT 2010.
- Mars Creek Environmental Plan (Storm Consulting 2011)
- Noxious and environmental weed control handbook. a guide to weed control in non-crop, aquatic and bushland situations. NSW Department of Primary Industry Management Guide, Sixth Edition.
- Soils for Landscape Development. Selection, Specification and Validation. Simon Leake and ELke Haege. CSIRO Publishing 2014.
- the City of Ryde DCP 2010 Part 9.6 Tree Preservation
- City of Ryde Urban Forest Technical Manual and Application Guide 30th September 2014
- Coffey Geotechnics, 2009, Geomorphological Assessment of University Creek, North Ryde.
- What Garden Pest or Disease Is That? Organic and Chemical Solutions for Every Garden Problem. Judy McMaugh 2000 New Holland.



Vegetation Management Plan

(incorporating Threatened Species Plan)

Bushland Remnants, Macquarie University

July 2015

context

Lesnk
ENVIRONMENTAL



Document Control

ISSUE	DESCRIPTION	SIGNED	DATE
A	Preliminary Draft Issued for Review	DM	21/05/15
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Vegetation Management Plan

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with



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Appendix A: Database searches

Appendix B: Photographic record of the area surveyed

Appendix C: Photographic record of the study area

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Figure 2: Vegetation mapping of the study area

Figure 3: Study area vegetation

Figure 4: Resilience/Condition classes

Figure 5: Management Classes

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Table 1: Management classes

Table 2: Summary of management issues and goals

Glossary

Terms used throughout this report are:

- DECC NSW Department of Environment and Climate Change (now known as the NSW Office of Environment and Heritage)
- DECCW NSW Department of Environment, Climate Change and Water (now known as the NSW Office of Environment and Heritage)
- EPBC Act Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
- LGA Local Government Area
- m/m²/km metre(s) / square metres / kilometres
- NSW New South Wales
- NPWS NSW National Parks and Wildlife Service
- OEH Office of Environment and Heritage
- TEC Total Earth Care
- TSC Act NSW *Threatened Species Conservation Act 1995*
- VMP Vegetation Management Plan

Executive Summary

On behalf of the Macquarie University Property, Lesryk Environmental Pty Ltd was contracted by Context to prepare a Vegetation Management Plan (VMP). The purpose of the VMP is to:

- describe the native vegetation present within the University grounds
- assess its conservation significance
- provide comment on the value of those fauna habitats and dispersal links present
- identify management issues and goals
- recommend appropriate monitoring and maintenance regimes.

The VMP has been developed following on a review of literature relevant to the study area and from the undertaking of site investigations of those bushland remnants present within the University grounds. During these site investigations the diversity of plants and communities present was recorded, as were the dominant, obvious, fauna species.

The University grounds support a number of disparate areas of remnant native vegetation, the following communities being identified:

- Coastal Shale Sandstone Forest
- Coastal Enriched Sandstone Dry Forest
- Hornsby Enriched Sandstone Exposed Woodland
- Sydney Turpentine-Ironbark Forest.

Two “constructed” communities, Riparian Scrub and Flooded Gum Forest have also developed from rehabilitation works undertaken by the University.

Of these six communities, the Sydney Turpentine-Ironbark Forest is listed as a critically endangered ecological community on both the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and NSW Threatened Species Conservation Act 1995. The largest area of Sydney Turpentine-Ironbark Forest occurs in the Northwest Remnant while two smaller areas of this critically endangered ecological community are present elsewhere in the University grounds,

A small population of *Darwinia biflora*, which is listed as a vulnerable plant species on both the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and NSW Threatened Species Conservation Act 1995, occurs in Hornsby Enriched Sandstone Exposed Woodland in Ecology Reserve. A population of the state listed vulnerable plant species, *Epacris purpurascens* var. *purpurascens* occurs in Coastal Shale Sandstone Forest within the Northwest Remnant.

Fauna species of conservation significance known or likely to occur in the vicinity of the University grounds are the Powerful Owl, Grey-headed Flying-fox, Yellow-bellied Sheathtail-bat, Eastern Freetail-bat, Eastern False Pipistrelle, Eastern Bentwing-bat and Greater Broad-nosed Bat. Each of these species is listed as vulnerable under the NSW Threatened Species Conservation Act 1995, whilst the Grey-headed Flying-fox is also listed as vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

There is considerable variation within and amongst the native vegetation remnants in terms of their resilience and condition. Accordingly, four management classes have been developed by the University’s Property Section in order to prioritise and target management that will improve their biodiversity values.

It was found that the highest priority area was the Northwest Remnant. Strategies recommended to conserve this area include continuation (and systematic monitoring) of bush regeneration/rehabilitation, expanding the size of the remnant and application of “ecological” burns.

Other high priority areas are Mars Creek within Ecology Reserve and Sydney Turpentine-Ironbark Forest along University Creek. The riparian area of Marks Creek has been degraded by erosion, sedimentation, changes to soil nutrient levels and subsequent weed invasion. Its restoration requires engineering solutions beyond the expertise of the authors. Implementation of a VMP that has been prepared for remnant Sydney Turpentine-Ironbark Forest within the University Creek corridor would assist in maintaining its value (excluding vegetation already earmarked for removal i.e. at the ‘station site’). For the other vegetation remnants present in the University grounds, and for general improvement in its provision of fauna habitat, a range of issues, strategies and goals are provided.

It is considered that implementation of this VMP and others which it encompasses will meet the aims therein and maintain and enhance the biodiversity values of Macquarie University’s native vegetation.

1. Introduction

This report has been prepared to support the Campus-wide Macquarie University Design Excellence Strategy and Urban Design Guidelines.

The Design Excellence Strategy and Urban Design Guidelines are required under Condition B4 of the Concept Plan approval, and will act as a guiding document in implementing the recently completed Macquarie University Campus Master Plan 2014. In addition to the Design Excellence Strategy and Urban Design Guidelines, the Concept Plan conditions of approval also require detailed management plans to support new development in each precinct. These include the requirement to prepare a Vegetation Management Plan (VMP) as contained in this document.

Lesryk Environmental Pty Ltd has been contracted by Context Landscape Design to prepare this VMP (Figure 1). The purpose of the VMP is to:

- describe the native vegetation within the University grounds and assess its conservation significance
- provide comment on the value of those fauna habitats and dispersal links present
- identify management issues and goals
- recommend appropriate monitoring and maintenance regimes.



Legend

----- Study Area Boundary

■ Study Area Vegetation

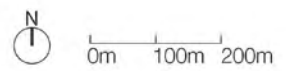


Figure 1. Study Area

2. Methods

2.1 Literature review

To assist in the preparation of this VMP a number of disparate studies that contain detailed information on the vegetation and fauna habitat of the study area were reviewed. These studies are:

- a conservation assessment and resilience mapping report prepared for Ecology Reserve (TEC 2010a)
- a conservation assessment and resilience mapping report for the Northwest Remnant (TEC 2010b) and an update of that report (TEC 2014)
- two vegetation management plans prepared for different sections of Mars Creek (Cardno 2010, Storm Consulting 2011)
- an ecological constraints analysis for lands that occur adjacent to University and College Creeks (Lesryk 2010a) and a VMP for a Sydney Turpentine – Ironbark Forest remnant within that area (Lesryk 2010b)
- a Review of Environmental Factors for road and drainage works along University and College Creeks (Definity 2010)
- a biodiversity enhancement plan prepared for the University as part of a post-graduate study exercise (Jurik and Aung 2014)
- A preliminary ecological assessment of Macquarie University conducted by EDAW (EDAW 2006).

2.2 Field survey

A field survey of the Universities bushland areas¹ was conducted by Paul Burcher (B.App.Sc) and Stephen Bloomfield (B.App.Sc) on 10 and 28 April 2015. The survey involved traversing the bushland areas of the site noting vegetation structure, species composition, condition and fauna habitat features. As detailed studies have already been undertaken on the intact bushland of the study area, these surveys were limited in time and scope.

The vegetation descriptions provided within this report draw on those of TEC (2010a, 2010b, 2014) as well notes made by the authors in the field.

¹ Those bushland stands within the University that were investigated as part of this VMP will hereafter be referred to as ‘the study area’.

3. Results

3.1 Literature review

3.1.1 Vegetation

EDAW undertook a preliminary ecological investigation of the University's grounds in 2006 (EDAW 2006). This was limited to the collation and review of existing, readily accessible information. Using the classification of NPWS (2002), they found three vegetation communities in the study area, these being:

- Sandstone Ridgetop Woodland within Ecology Reserve
- Western Sandstone Gully Forest within Ecology Reserve and Fauna Park
- Sydney Turpentine Ironbark Forest in two locations in the east of the study area near University Creek and within the Fauna Park as well as beside, and upslope of, Mars Creek west of Gymnasium Road.

TEC (2010a, 2010b and 2014) has undertaken detailed studies of the vegetation of Ecology Reserve and that of Fauna Park and its surrounds (collectively known as the Northwest Remnant). Following the classification system of DECCW (2009), Ecology Reserve was mapped as supporting two vegetation communities, these being:

- Coastal Enriched Sandstone Sheltered Forest
- Hornsby Enriched Sandstone Exposed Woodland.

Despite recognising and mapping variations within the structure and species composition of the intact native vegetation of the Northwest Remnant, TEC labelled all of it Sydney Turpentine - Ironbark Forest. The reports by TEC also include assessments of conservation significance, resilience and condition mapping and some management recommendations, these being incorporated into this report.

Storm Consulting (2011) prepared a VMP for a previously cleared 230 m section of Mars Creek where it runs through the 'Y' section of the university. This involved describing the biological and abiotic character of the area and prescribing on-ground works for site preparation, planting of native vegetation, soil amelioration and bolstering, installation of habitat features, weed control and the implementation of a two-year maintenance period.

In association with the development of temporary car parking facilities on previously cleared land to the east of the area addressed by Storm Consulting (2011), a VMP was prepared for the left bank of a 195 m section of Mars Creek. The report followed a similar format to that of Storm Consulting (2011), with proposed works planned, and budgeted over, a two-year period.

Lesryk (2010a) undertook an ecological constraints report which informed the Review of Environmental Factors prepared for works undertaken within and adjacent to University and College Creeks (Definity 2010). Lesryk found that three native vegetation communities occurred in this part of the study area namely:

- Smooth-barked Apple Open Forest
- Red Bloodwood – Sandstone Stringybark Woodland
- Rushland.

A modified area of remnant canopy trees with limited native understorey and groundcover on the right bank of University Creek was also considered to qualify as Sydney Turpentine-Ironbark Forest

under the TSC Act, but not as the corresponding community under the stricter definitions of the EPBC Act.

Subsequent to the Lesryk study, and recommended as a concept plan condition for proposed works along University Creek (Infinity 2010), Lesryk (2010b) prepared a VMP for the patch of Sydney Turpentine-Ironbark Forest on the right bank of University Creek. It described the vegetation and fauna habitat, the remnant's condition and resilience, and framed performance measures, techniques and specification for its rehabilitation.

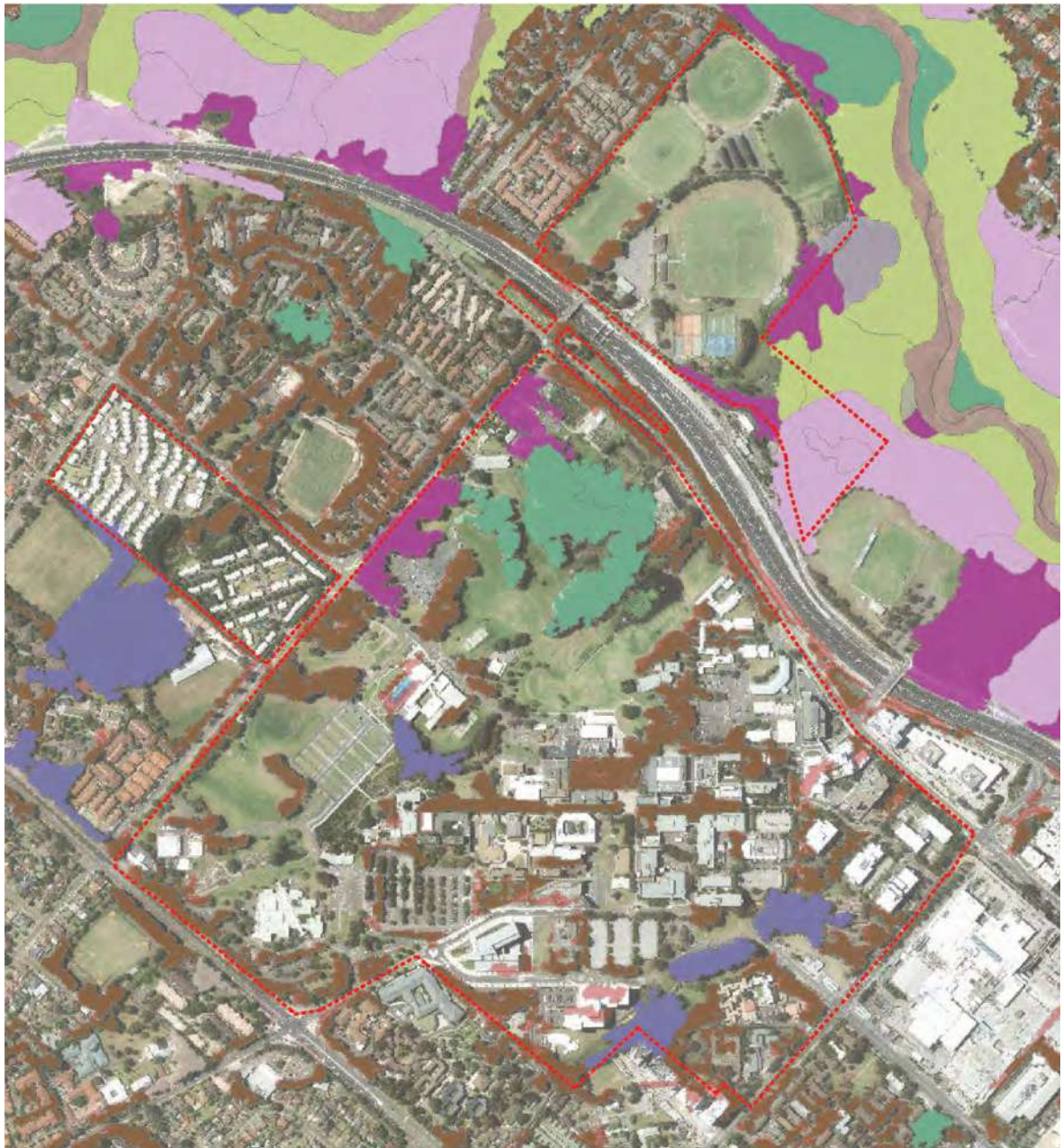
The most recent regional vegetation mapping that includes the study area was undertaken by NPWS (OEH 2013), which was an update of DECCW (2009). None of the study area's bushland was visited during this mapping exercise. As such, interpretation was based on aerial photographs, this indicating the presence of the following native vegetation communities (Figure 2):

- Coastal Enriched Sandstone Dry Forest covering most of the Fauna Park
- Coastal Shale-Sandstone Forest in the north of the Fauna Park and near Mars Creek to the south of the Fauna Park
- Hornsby Enriched Sandstone Exposed Woodland in Ecology Reserve
- Sydney Turpentine-Ironbark Forest beside, and upslope of, Mars Creek west of Gymnasium Road and in three patches near University Creek.








Elsewhere, patches of planted eucalypts and other landscaped plantings are indicated as 'Urban Exotic/Native' or 'Weeds and Exotics'.

Vegetation mapping of the Cumberland Plain undertaken by NPWS (2002) indicates that the following occur within the study area:

- Sandstone Ridgetop Woodland and Unclassified Vegetation in Ecology Reserve
- Turpentine-Ironbark Margin Forest in the Fauna Park and along Culloden Road
- Turpentine-Ironbark Forest along Culloden Road south of the Waterloo Road intersection.



Legend

- | | | |
|---|---|--|
|  Coastal Shale-Sandstone Forest |  Urban Exotic / Native |  Coastal Sandstone Gallery Rainforest |
|  Sydney Turpentine-Ironbark Forest |  Hornsby Enriched Sandstone Exposed Woodland | |
|  Weeds and Exotics |  Coastal Sandstone Gully Forest | |

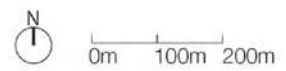


Figure 2. Vegetation Mapping of the Study Area (OEH 2013)

3.1.2 Threatened species

3.1.2 (a) Flora

The review of reports prepared in relation to the study area show that one threatened flora species has been recorded. This is the shrub, *Epacris purpurascens* var. *purpurascens*, which is listed as vulnerable under Schedule 2 of the TSC Act. TEC (2010a) found this species in three discrete locations in the Northwest Remnant. Their follow-up survey in 2014 found that one of these sub-populations had increased in extent and numbers (from two to 25); the second had remained the same, while the third occurrence of two plants had disappeared.

Epacris purpurascens var. *purpurascens* was also reported to occur in Ecology Reserve (Downing and Paternoster [2010] in TEC 2010b) though no details on the exact location or number of plants present is supplied. There is also a 2011 record of *Darwinia biflora* in the University's Herbarium (J. Macris pers. comm.). This small shrub, which is listed as vulnerable on the TSC Act and the EPBC Act, was found in Ecology Reserve in open sandstone woodland near the access trail from Christie Park.

OEH (2015) indicates 18 other flora species listed on the Schedules of the TSC and/or EPBC Acts that have been found within a 5 km radius of the study area (Appendix A). There is also a 2011 record of *Darwinia biflora* in the University's Herbarium (J. Macris pers. comm.). This small shrub, which is listed as vulnerable on the TSC Act and the EPBC Act, was found in Ecology Reserve in open sandstone woodland near the access trail from Christie Park.

3.1.2 (b) Fauna

OEH (2015a) indicates 35 species listed on the Schedules of the TSC and/or EPBC Acts that have been detected within 5 km of the study area. Of these, one is known to have breed within the campus grounds, this being the Green and Golden Bell Frog (*Litoria aurea*). This species was recorded breeding in the Lungfish Ponds near Fauna Park during the early 1990's (OEH 2015a, White and Pyke 1996) and from Macquarie University Industry Park in 1999 (OEH 2105a), however, it is no longer thought to be present on campus.

3.1.3 Soils

Three soil landscapes, namely the Glenorie, Lucas Heights and Gymea soil landscapes, are mapped by Chapman and Murphy (1989) as occurring in the study area.

The Glenorie soil landscape occurs on the upper slopes of the study area generally above the 60 m contour line. This soil landscape is derived from the underlying Ashfield and Bringelly Shales of the Wianamatta Group. On upper slopes, such as those in Fauna Park, soils are generally moderately deep red and brown podzols. Along drainage lines, such as Mars Creek, humic gleys, yellow podzols and gleyed podzols may occur (Chapman and Murphy 1989).

The Lucas Heights soil landscape occurs immediately downslope of the Glenorie soil landscape and covers most of Fauna Park, and the lower slopes near Mars Creek east of Gymnasium Road. It also occurs east of University Creek. The geology of the Lucas Heights soil landscape is primarily the Mittagong Formation, however this unit may include minor intrusions of Hawkesbury Sandstone and Ashfield Shale. Soils are moderately deep, hard-setting yellow podzols and yellow soliths (Chapman and Murphy 1989).

The Gymea soil landscape occurs on the steeper sandstone slopes adjacent to Mars Creek north of the M2 Motorway. Soils of this landscape are derived from the underlying Hawkesbury Sandstone. They are shallow to moderately deep yellow earths, earthy sands on crests and inside

of benches, shallow siliceous sands on leading edges of benches; localised gleyed podsolc soils and yellow podsolc soils on shale lenses and shallow to moderately deep siliceous sands along drainage lines (Chapman and Murphy 1989).

Disturbed Terrain is also mapped as occurring in an ellipsoid shaped area stretching from the playing fields across the M2 to the north-eastern part of Fauna Park. It is noted that soil landscape mapping was undertaken prior to construction of the M2 Motorway.

3.2 Study area description

3.2.1 Vegetation communities/fauna habitats

Six distinct vegetation communities were recognised in the study area (Figure 3). For ease of reference, nomenclature follows that of OEH (2013), apart from constructed communities.

3.2.1 (a) Sydney Turpentine – Ironbark Forest

Sydney Turpentine – Ironbark Forest occurs on the Glenorie soil landscape on gently sloping land in the upper third of the Northwest Remnant (Zone 5 of TEC 2014). The native soil in this zone has a strong clay influence and shows little evidence of Hawkesbury Sandstone. The canopy is dominated by Turpentine (*Syncarpia glomulifera*) and Red Mahogany (*Eucalyptus resinifera*) with occasional White Stringybark (*E.globoidea*) and a few Grey Ironbark (*E.paniculata*). The understorey, which is generally to 6 m, is sparse to mid-sparse and dominated by Sweet Pittosporum (*Pittosporum undulatum*).

Within the boundary fences the groundcover to 0.75m is dense and dominated by Basket Grass (*Oplismenus imbecillus*), Kidney Weed (*Dichondra repens*), Weeping Meadow Grass (*Microlaena stipoides*), Wiry Panic (*Entolasia stricta*), Common Rush (*Juncus usitatus*), Flax-lily (*Dianella caerulea*) and Mat-rush (*Lomandra longifolia*). There are also seedlings of Sweet Pittosporum, Turpentine and Mock Olive (*Notolaea longifolia*). To the east of the boundary fence, canopy trees of the community are present above a regularly slashed groundcover of introduced grasses such as Panic Veldt Grass (*Ehrharta erecta*) and Carpet Grass (*Axonopus affinis*).

TEC (2014) commented that bush regeneration works within this vegetation type, and the reduction of the negative influence of herbivory, have increased its structural and floristic diversity and improved its resilience and condition.

Small degraded patches of Sydney Turpentine – Ironbark Forest also occurs in the narrow strip of land between Talavera Road and near Mars Creek upstream of Gymnasium Road where just a few canopy trees remain.

On the right bank of University Creek, south of the new University Avenue, is another remnant of Sydney Turpentine – Ironbark Forest covering about 0.1ha. Here the canopy is dominated by Smooth-barked Apple, along with Turpentine, Blackbutt and Thin-leaved Stringybark. There is a sparse to mid-dense shrub layer composed of Lantana (*Lantana camara*), Sweet Pittosporum, Dogwood (*Ozothamnus diosmifolius*) and Sydney Golden Wattle (*Acacia longifolia*). The groundcover is dense and dominated by Morning Glory (*Ipomoea indica*) and Panic Veldt Grass, with a few indigenous species such as Flax-lily, Weeping Meadow Grass, Beard Heath (*Leucopogon juniperinus*) and Mat-rushes (*Lomandra spp.*).

Lesryk (2010b) found that there was a low level of weed invasion in this remnant, and that it could regenerate and recover without the need for supplementary revegetation works.

Sydney Turpentine – Ironbark Forest is listed as an endangered ecological community under the TSC Act and a critically endangered ecological community under the EPBC Act.

Fauna Habitat

This area is suitable for the foraging and sheltering requirements of small to large birds, reptiles, amphibians and mammals, particularly those that are urban tolerant (i.e. possums). Given the lack of hollows, breeding requirements would be restricted to the smaller and medium sized nest building birds.

3.2.1 (b) Coastal Shale Sandstone Forest

This community occurs within the Lucas Heights soil landscape downslope of the Sydney Turpentine – Ironbark Forest in the Northwest Remnant and as small patches in the University Creek catchment near Herring Road north of railway station entrance. Its floristic composition exhibits a mix of species found on both sandstone and clay. In the Northwest Remnant the canopy is variously dominated by Snappy Gum (*Eucalyptus racemosa*), Red Mahogany, Smooth-barked Apple (*Angophora costata*) and Red Bloodwood (*Corymbia gummifera*) with occasional occurrences of Sandstone Stringybark (*E. sparsifolia*) and Turpentine while in the Herring Road remnant there is a canopy of Red Bloodwood and Sandstone Stringybark. The shrub layer to 3m is diverse and common species are Bushy Needlebush (*Hakea sericea*), Tick Bush (*Kunzea ambigua*), Sydney Golden Wattle, Sweet-scented Wattle (*A. suaveolens*), Pillflower (*Ozothamnus diosmifolius*), Sweet Pittosporum (*Pittosporum undulatum*), Blackthorn (*Bursaria spinosa*), *Leucopogon juniperinus* and Pine-leaved Geebung (*Persoonia pinifolia*). The ground layer is also often dense with common species being Mat-rush (*Lomandra longifolia*), Kangaroo Grass (*Themeda triandra*), Bladey Grass (*Imperata cylindrica*), Weeping Meadow Grass (*Microlaena stipoides*), Bracken (*Pteridium esculentum*) and Flax-lily (*Dianella caerulea* var. *producta*). In the Herring Road remnant there is a mix of native and introduced species in the groundcover with Agapanthus (*Agapanthus africanus*), Mat-rush (*Lomandra longifolia*), Flax-lily and *Leucopogon juniperinus* being common.

A small, degraded patch of this community occurs between Talavera Road and the M2. Here there is a canopy of Smooth-barked Apple, Red Mahogany, Snappy Gum and Red Bloodwood with a simplified understorey of Sweet Pittosporum and a groundcover dominated by Bladey Grass.

Fauna habitat

The Northwest Remnant is suitable for the foraging and sheltering requirements of small to large birds, reptiles, amphibians and mammals, particularly those that are urban tolerant (i.e. possums). Given the lack of hollows, breeding requirements would be restricted to the smaller and medium sized nest building birds.



Legend

- | | |
|--|---|
|  Sydney Turpentine-Ironbark Forest |  Hornsby Enriched Sandstone Exposed Woodland |
|  Coastal Shale Sandstone Forest |  Constructed Riparian Scrub/
Open Forest |
|  Coastal Enriched Sandstone
Dry Forest |  Flooded Gum Forest |

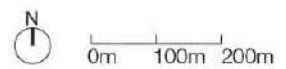


Figure 3. Study Area Vegetation

3.2.1 (c) Coastal Enriched Sandstone Dry Forest²

This community occurs on the lower slopes adjoining Mars Creek in Ecology Reserve. It is dominated by a 25 m high canopy of Sydney Peppermint (*Eucalyptus piperita*) and Smooth-barked Apple. Small tree species commonly include Old Man Banksia (*Banksia serrata*), Sweet Pittosporum and Parramatta Green Wattle (*Acacia parramattensis*). A shrub layer to 4 m is dominated by Paperbark Tea-tree (*Leptospermum trinervium*), Tick Bush, Bushy Needlebush (*Hakea sericea*), Flax-leaved Wattle (*Acacia linearis*) and Pink Spider Flower (*Grevillea sericea*). Ground layer species include Mat-rush (*Lomandra longifolia*), Flax-lily (*Dianella caerulea* var. *producta*), Bracken (*Pteridium esculentum*), Saw Sedge (*Gahnia clarkei*) and Wiry Panic (TEC 2010).

This community suffers significant weed growth compared to the woodland that occurs upslope. Most of this weed growth occurs directly along the edges of Mars Creek and on the left bank between the creek and the cleared area upslope. Common weeds are Trad (*Tradescantia fluminensis*), Small-leaf Privet (*Ligustrum sinense*), Large-leaf Privet (*Ligustrum lucidum*), Japanese Honeysuckle (*Lonicera japonica*), Mist Flower (*Ageratina riparia*), Crofton Weed (*A. adenophora*) and Black Ash (*Acer negundo*) (TEC 2010). Some Coral Trees (*Erythrina crista-galli*) that previously occurred along the bank (TEC 2010) have been successfully poisoned.

3.2.1 (d) Hornsby Enriched Sandstone Exposed Woodland

This community occurs on the dry exposed, north-facing slope of Ecology Reserve. The canopy is dominated by 10 m to 15 m tall Snappy Gum (*Eucalyptus racemosa*) with a mid-storey commonly composed of Dwarf Apple (*Angophora hispida*) and Old Man Banksia (*Banksia serrata*), these reaching a height of 8 m. The often dense shrub layer that is 2 m to 6 m tall is particularly diverse with common species being Paperbark Tea-tree (*Leptospermum trinervium*), Tick Bush, Hop Bush (*Dodonaea triquetra*), Bush-pea (*Pultenaea tuberculata*) and Bushy Needlebush. The groundcover, which is composed of low shrubs and forbs, is dominated by *Micrantheum ericoides*, Wiry Panic (*Entolasia stricta*), Coral Heath (*Epacris pulchella*), Spear Oat Grass (*Anisopogon avenaceus*), *Bossiaea obcordata* and Twisted Sedge (*Cyathochaeta diandra*). Common twiners include Apple Berry (*Billardiera scandens*) and Devil's Twine (*Cassytha pubescens*). Weed species in this community are generally absent (TEC 2010).

Fauna habitat

Due to its contiguity with large expanses of bushland in Lane Cove National Park³, the presence of rock outcrops and a drainage line, and its structural and floristic diversity, Ecology Reserve is considered suitable habitat for a range of both flying and non-flying mammals, smaller bird species and herpetofauna that are disadvantaged by those weedier, structurally simple habitats that occur elsewhere in the study area.

² Following DECCW (2009) this community was referred to as Coastal Enriched Sandstone Sheltered Forest by TEC (2010) but there has been a slight name change in the updated version of the regional mapping by OEH (2013).

³ Which occurs immediately north of the University grounds.

3.2.1 (e) Constructed Riparian Scrub

Along Mars Creek, upstream of Gymnasium Road, is dense scrub that has been formed from plantings carried out as part of the works associated with the implementation of two VMP's (Cardno 2010, Storm Consulting 2011). In that part of the plantings near the carpark there is dense growth of young eucalypts such as Smooth-barked Apple and Sydney Peppermint and shrubs such as Wattles (*Acacia spp*) and Water Gum (*Tristaniopsis laurina*), whilst near the creek, common groundcover species are Mat-rush (*Lomandra longifolia*), Flax-lily (*Dianella caerulea*), Bracken (*Pteridium esculentum*) and Kangaroo Grass (*Themeda australis*).

Fauna habitat

This area consists of densely planted reeds, sedges, shrubs and small trees. The drainage line has steps and riffle sequences, as well as snags. These habitats provide for the foraging, breeding and/or sheltering requirements of a range of small to medium birds, insectivorous bats (microchiropterans), reptiles, amphibians and invertebrates.

No stags or hollows are present within this area. As such no hollow-dependant species would be roosting or breeding in this environment.

The Buff-banded Rail (*Gallirallus philippensis*), which is considered regionally significant (DECC 2008), was detected utilising this habitat area during the field survey.

3.2.1 (f) Flooded Gum Forest

This community occurs adjacent to an ephemeral drainage line west of the Culloden Road/Waterloo Road intersection. The canopy is dominated by 30 m tall planted Flooded Gum (*Eucalyptus grandis*), a species native to the NSW north coast and south-east Queensland. Other canopy species present are Blackbutt (*Eucalyptus pilularis*), Spotted Gum (*Corymbia maculata*) and Swamp Oak (*Casuarina glauca*). The small tree layer consists of the introduced Privet (*Ligustrum spp*) and Black Ash, and the native Sweet Pittosporum. The groundcover contains a mixture of grasses, forbs and herbs. Common species are Weeping Meadow Grass (*Microlaena stipoides*), Flax-Lily, Mat-rush, Scurvy Weed (*Commelina cyanea*), Kidney Weed and the noxious weed, Asparagus Fern (*Asparagus aethiopicus*). The creek banks are vegetated by a dense growth of Crofton Weed (*Ageratina adenophora*).

Aerial photography (<http://maps.six.nsw.gov.au/>) shows that this area had been cleared as part of the region's agricultural development well before 1943.

Whilst the canopy of this forest is dominated by introduced species it does have the potential to be further rehabilitated towards native bushland. In its current form, this community is also a habitat for plants and animals.

Fauna habitat

This area is suitable for the foraging and sheltering requirements for a narrow range of native birds, mostly aggressive edge-tolerant species such as Noisy Miner (*Manorina melanocephala*) and Laughing Kookaburra (*Dacelo novaeguineae*). Due to the dense vegetative cover and the presence of a drainage line, some reptiles and amphibians may also be present. Some native mammals, particularly those that are urban tolerant (i.e. possums and some microchiropterans) are likely to be present, however, given the lack of stags and hollows, these species are unlikely to be breeding or sheltering in this forest.

The Powerful Owl (*Ninox strenua*), which is listed as threatened under the TSC Act, has been recorded in Marsfield Park, approximately 800 m to the south-west, and may occasionally forage through this forest.

3.2.2 Endangered ecological communities

One TSC Act listed endangered ecological community occurs in the study area, namely Sydney-Turpentine Ironbark Forest. This community is located in the upper part of the Northwest Remnant and on the right bank of University Creek near Morling College. There are also some remnant trees of this community near Research Park Drive that include species from both this community and Coastal Shale Sandstone Forest that could be regarded as part of the endangered ecological community.

Although TEC (2010b and 2014) mapped all of the Northwest Remnant as Sydney-Turpentine Ironbark Forest only that area designated as 'Zone 5' by TEC (2010b) is considered to conform to the description for this community provided by the NSW Scientific Committee. This patch, the one near University Creek and the remnant trees do not qualify as the EPBC Act critically endangered ecological community of the same name as they are all less than the area thresholds required under the Threatened Species Scientific Committee's determination (TSSC 2005).

3.2.3 Wildlife corridors

At a regional scale there is a tenuous link between the vegetation on campus and Lane Cove National Park. Whilst this link is present, it is acknowledged that the M2 is a major barrier to the dispersal movements of ground traversing native fauna. Therefore, the movements that do occur are considered to be restricted to medium and large sized birds, mega and micro-chiroptera, and those reptiles and amphibians that are tolerant of traversing through those culverts present.

For those species that do cross the M2, south into the University campus from Lane Cove National Park, a fragmented corridor is present. To connect with Terrey's Creek, which is approximately 1 km to the west, this corridor follows a number of urban 'stepping stones' including Marsfield and Stewart Parks. The bushland present in association with Terrys Creek is contiguous with Lane Cove National Park. It is noted that only flying species are considered to use the entirety of this corridor.

The main corridor within the campus grounds is that which incorporates those habitat areas that extend along Mars Creek, including the Northwest Remnant. The lack of developed habitat between Macquarie Lake and Gymnasium Road is recognised as a barrier to the movement of fauna, particularly small birds. This area has also been recently highlighted as a 'significant gap' within the 'Biodiversity Enhancement Plan' (Jurik and Aung 2014).

In addition, though there are open woodland stands outside the Mars Creek corridor, there is a lack of any form of understorey development which also prevents the dispersal of small birds and ground traversing species.

The University Creek corridor does not link up with any other significant areas of habitat outside the boundaries of the University campus. The buildings present in association with the University, and the surrounding road network (including the M2), are a major barrier to the dispersal movements of native fauna. Therefore, the movements that do occur are considered to be restricted to urban-tolerant medium and large sized birds, possums, mega and micro-chiroptera, and reptiles and amphibians. This would include animals such as the Noisy Miner (*Manorina melanocephala*), Laughing Kookaburra (*Dacelo novaeguineae*), Common Brushtail Possum (*Trichosurus vulpecula*), Eastern Water Dragon (*Physignathus lesueurii*), Eastern Water Skink (*Eulamprus leuraensis*), *Lampropholis* species, Striped Marsh Frog (*Limnodynastes peronii*) and

Common Eastern Froglet (*Crinia signifera*). Each of these species was recorded in association with University Creek during a 2009 fauna investigation of this system (Lesryk 2009a). It is noted that Long-finned Eels (*Anguilla reinhardtii*) were also identified within University Creek during that study (Lesryk 2009a).

Flying mammals (mega and micro-chiroptera) and larger birds from beyond the campus grounds (i.e. within the nearby Lane Cover National Park) are considered to traverse the urban infrastructure boundaries and may utilise and forage within both this corridor and the University grounds.

3.2.4 Threatened species

3.2.4 (a) Flora

As discussed in section 3.1.2 (a), two threatened species have been recorded in the study area, these being *Epacris purpurascens* var. *purpurascens* and *Darwinia biflora*. *Epacris purpurascens* var. *purpurascens* is listed as vulnerable under the TSC Act and is known to occur in the Coastal Shale Sandstone Forest of the Northwest Remnant. *Darwinia biflora* is listed as vulnerable under the TSC Act and the EPBC Act and is known to occur in Hornsby Enriched Sandstone Exposed Woodland in Ecology Reserve near Christie Park.

Of the 18 other flora species listed under the Schedules of the TSC and EPBC Acts which have been found within a 5 km radius of the study area (Appendix A), *Tetradlea glandulosa* has suitable potential habitat in the eastern, upper slopes of Ecology Reserve.

3.2.4 (b) Fauna

Of the 35 threatened fauna species detected within 5 km of the study area, it is considered that seven are considered likely to occur within/utilise the University grounds. These are the:

- Powerful Owl (*Ninox strenua*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Yellow-bellied Sheath-tail-bat (*Saccolaimus flaviventris*)
- Eastern Freetail-bat (*Mormopterus norfolcensis*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

Each of these species is listed as vulnerable under the TSC Act, whilst the Grey-headed Flying-fox is also listed as vulnerable under the EPBC Act.

Given the lack of stags, tree hollows and suitable cave substitutes, none of these species are considered to utilise those habitats present in the university grounds for breeding or roosting purposes. They are expected to forage throughout the study area on occasion.

4. Vegetation resilience and condition

Figure 4 indicates the vegetation resilience and condition of the different vegetation communities in the study area. This map is derived from work done by TEC (2010a, 2010b, 2014) in the Northwest Remnant and Ecology Reserve, and by the authors elsewhere. The following key from TEC (2010) was used to classify the vegetation remnants present.

Vegetation Resilience and Condition Classes Key

1	Soil profile intact for regeneration pathways (possible original soil profile and possible soil stored seed, seed rain or underground plant parts capable of reshooting)	
2	Virtually weed free and all vegetation layers present (except if due to natural causes e.g. fire, storm)	VERY HIGH
2*	Some minor weed growth or layers absent	
3	Minor weed infestations but no layers absent	HIGH
3*	Weed infestations or disturbance leading to decline of at least one layer	
4	Loss or strong decline of at least one layer but some active resilience at ground layer	MEDIUM
4*	Loss or strong decline of at least two layers with no or little active resilience at ground layer.	LOW
1*	Soil profile NOT intact for regeneration pathways (No possibility of original soil profile nor any possibility for regeneration of soil-stored seed, seed rain or underground plant parts capable of reshooting)	NOT NATIVE VEGETATION



Legend

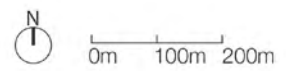


Figure 4. Resilience / Condition Classes

5. Management classes




The study area's management classes follow the Bushland Asset Classes developed by Macquarie University's Property Section. To retain consistency with the University's Operational Management Manual the same system has been adopted for this VMP. Table 1 details the five classes. The study area's bushland, and its management classes, are illustrated on Figure 5 (overleaf).

Table 1: Management classes

Management Class	Distinguishing features
1. High Integrity Bushland	Class 1 vegetation is in good to very good condition. On average, this vegetation requires only half-an-hour per 100 m ² each year to maintain its state. In addition to meeting the 'healthy' target criteria, Class 1 has probably the lowest year to year maintenance cost of any land use in the University.
2. Managed Recovery	Class 2 usually covers vegetation for which there has been an intervention to trigger native regeneration. It requires ongoing weeding effort to keep the balance of plant regrowth favouring native flora until the forest structure fully regenerates. Class 2 is on a trajectory towards becoming /returning to Class 1. Management effort averages around two hours per 100 m ² per annum (broadly labour-comparable with lawn maintenance).
2a. Bushcare Program	Class 2a are the 'Managed Recovery' sites adopted by bushcare@mq and supported with a recurring component of volunteer work. In terms of the sustained management effort involved, bushcare sites usually consume somewhere between Classes 2 and 3 in allocated time per year.
3. Intensive Management	Class 3 may be either degraded bushland at the very beginning stages of weed removal, or a recent planted bushland site that is subject to high weed invasion risk. On average, around 10 hours per 100 m ² a year is required to support the development of native resilience. All areas of Class 3 should become Class 2 following 1-3 years at this intensity of management, and optimally become Class 1 bushland within 8-15 years.
4. Outside Scope	Sites at present excluded from ecological management initiatives. Examples include future development precincts; sites where existing uses would not be compatible with ecological restoration; and several regeneration areas 'in-waiting'.



Legend

- | | |
|---|--|
|  Class 1 |  Class 4 |
|  Class 2 |  Bushcare Sites |
|  Class 3 | |

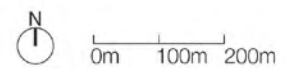


Figure 5. Management Classes

6. Management issues and goals

The following section is a discussion of the various management issues that pertain to the bushland remnants of the study area. A summary of these issues has been provided in Table 2.

It is considered that the highest priority for management of the study area's bushland is the maintenance, and possible expansion of, the Sydney Turpentine-Ironbark Forest and Coastal Shale Sandstone Forest that occurs in the Northwest Remnant. This will require ongoing weed control and supplementary planting of component species in areas where they are depleted. Details on the current condition of the vegetation and changes since 2010 are contained in TEC (2014). Macquarie University Property should investigate the possibility (and cost) of expanding the Sydney Turpentine-Ironbark remnant eastwards to encompass existing canopy trees that occur above an introduced grass groundcover. Apart from increasing the overall area of this endangered ecological community, this would also enhance the resilience of the remnant and improve fauna habitat.

Another important component of management will be the application of fire to assist in stimulating regrowth of a range of fire-adapted species. Fire will also reduce areas of dominance by a narrow range of species such as Tick Bush. It is recommended Macquarie University Property consult the Rural Fire Service and/or NSW Fire and Rescue about assistance with such burns, which would also act to reduce bushfire hazard to the buildings within Fauna Park.

For wet sclerophyll forests such as the Sydney Turpentine-Ironbark Forest and Coastal Shale Sandstone Forest communities, prescribed burns should be conducted at intervals of between 15 and 30 years (NPWS 2004).

It is recommended that monitoring plots be established within the Northwest Remnant to determine changes in vegetation structure and composition over time and thus the efficacy of the regeneration and rehabilitation methods being employed. For cost-effectiveness, this would best be conducted by undergraduate students under the supervision of qualified staff but could also be carried out by suitable contractors.

Apart from the loss of two plants, the *Epacris purpurascens* var. *purpurascens* population appears to be viable and will continue to be so with the undertaking of continued bush regeneration works.

Another high priority area for vegetation management is Mars Creek within Ecology Reserve. The riparian area, within both the university's property and downstream in Lane Cove National Park has been degraded by erosion, sedimentation, changes to soil nutrient levels and subsequent weed invasion. These have arisen as a result of modification to the creek upstream, including the provision of culverts under the M2, the proliferation of hard surfaces and other deleterious features of urban development.

Appropriate fire intervals in Ecology Reserve also need determining. The last wildfire was in 2002 and an interval of this ilk is well within that considered suitable for heathy woodland vegetation (NPWS 2003). A prescribed burn has been agreed with OEH for next one to two years when this section of the valley is reach in their hazard reduction program. Surveys for *Darwinia biflora* are also more likely to be successful after fire due to propagation of the species and ease of detection with less shrub and groundcover vegetation present.

The restoration of vegetation along Upper Mars Creek through the implementation of the two VMP's has been successful. Ideally, similar rehabilitation, including the possible removal of underground culverts, should be adopted downstream of Gymnasium Road. This would provide

further habitat for locally occurring flora and fauna and provide a linkage between currently partially isolated habitat areas along and near the creek.

Engineering solutions to moderate flow volumes and velocities into Ecology Reserve (e.g. construction of a device north of the M2 or increasing the capacity of University Lake) should be considered but are beyond the expertise of the authors. A rehabilitation plan for the riparian area of Ecology Reserve should be formulated using species typical of Coastal Enriched Sandstone Dry Forest as described by OEH (2013).

Instigation of the VMP for the rehabilitation of the University Creek Sydney Turpentine-Ironbark Forest remnant (Lesryk 2010b) has been delayed due to the works associated with new University Avenue access. Once this has been completed, as a high priority, it is recommended that the VMP be acted upon.

As part of the Station North development, the Coastal Shale Sandstone Forest remnant near Herring Road will be removed. Amongst other measures to offset the loss of this woodland, Lesryk (2010c) proposed the translocation of its soil to an area between the University's playing fields and Lane Cove National Park. When the development of the Station North site commences, it is recommended that these works proceed.

Due to the relatively young age class of the canopy species within the study area, there are no hollow-bearing trees present. This could be rectified by the installation of artificial nest boxes. The design and placement of such boxes should favour their adoption by microchiropterans as their roosting habitats are more restricted locally whereas hollow-dependent birds (such as cockatoos, lorikeets and kookaburras) are common. Other fauna habitat embellishments that could be adopted are enhancement of reed vegetation around the wetland area of Upper Mars Creek to assist species, such as the regionally significant Buff-banded Rail; and the provision of more woody debris and sandstone boulders within the Northwest Remnant and along Upper Mars Creek, which would assist in regeneration of populations of invertebrates, reptiles and amphibians.

Given its relatively small and isolated nature, and that it is vegetated primarily with introduced species and therefore difficult to rehabilitate, it is considered the Flooded Gum Forest west of Culloden Road is a low priority area for vegetation management.

Table 2: Summary of management issues and goals

Area	Vegetation Type/Condition Class	Priority	Management Class	Management Issues	Goals
Northwest Remnant	Sydney Turpentine-Ironbark Forest (STIF) and Coastal Shale Sandstone Forest (CSSF) all classes	High	1, 2, 4	Fire Management Monitoring	Increased floristic diversity, stimulation of natural regeneration and establishment of successional diversity. Mosaic of areas with different fire history Determine effectiveness of rehabilitation strategies.
	Sydney Turpentine-Ironbark Forest/Medium and Coastal Shale Sandstone Forest/Medium	High	2	Weed Control/bush regeneration	Condition Class upgraded to high. Determine effectiveness of weed rehabilitation strategies.
	As above.	Moderate	4	Future regeneration	Progressive migration of mown edge.
	Coastal Shale Sandstone Forest/Very High-High	High	3	<i>Epacris purpurascens</i> var. <i>purpurascens</i> population. Monitoring	Maintenance of population at or above existing level.
Ecology Reserve	All Vegetation	High		Prescribed burn	Maintain and enhance biodiversity
	Coastal Enriched Sandstone Dry Forest/Medium	High	2	Weed Control/bush regeneration	Condition Class upgraded to high Stabilisation of banks.

Area	Vegetation Type/Condition Class	Priority	Management Class	Management Issues	Goals
	Coastal Enriched Sandstone Dry Forest/High-Very High	Low	1	Removal of Spotted Gums	Prevent spread and overshadowing by introduced species.
	Hornsby Enriched Sandstone Exposed Woodland	Low	1	Survey for threatened flora species	Determine presence/absence.
Mars Creek	Constructed Riparian Scrub and Coastal Enriched Sandstone Dry Forest/low	Moderate	2, 3	Weed Control and supplementary planting Enhance reed vegetation, particularly around wetland area	Condition Class upgraded to medium. Provide further protective habitat for fauna species, such as Buff-banded Rail.
	Cleared area downstream of Gymnasium Road	Moderate		Vegetation rehabilitation	Creation of riparian zone habitat/wildlife corridor complimenting that upstream.
University Creek	STIF/Medium (adjacent to Dunmore Lang College)	High	2	Instigation of VMP for STIF (excluding 'station site'); Weed Control and supplementary plan	Condition Class upgraded to high
	Remnant STIF/CSSF trees near Research park Drive	Moderate	4	Loss of remnant canopy	Replenishment of native ground covers in riparian area
	CSSF near Herring Road	Moderate	4	Removal of remnant for Station North development	Translocation of soil to area adjacent to University's playing fields or adjoining Fauna Park remnant

Area	Vegetation Type/Condition Class	Priority	Management Class	Management Issues	Goals
West of Culloden Road	Flooded Gum Forest	Low	4	Weed Control (esp. Privet and Black Ash) Planting of native canopy and understorey species	Condition Class upgraded to medium.
All areas	All types	Low	All	Lack of hollow-bearing trees. Increase to quantities of sandstone outcrops and coarse woody debris	Initiate and monitor installation of artificial nest boxes for microchiropterans to improve habitat for these species within the campus. Provision of habitat for invertebrates, reptiles and amphibians.

7. References

- Cardno 2010, *Vegetation management plan for Upper Mars Creek valley*. Unpublished report prepared for Macquarie University Office of Property
- Chapman, GA, and Murphy, CL 1989, *Soil landscapes of the Sydney 1:100,000 sheet*, Soil Conservation Service of NSW, Sydney, NSW
- Churchill, S 2008, *Australian Bats*, Reed - New Holland, Frenchs Forest, NSW
- Cogger, H 2004, *Reptiles and Amphibians of Australia*, Reed Books, Chatswood, NSW
- Definity 2010, *Macquarie University, University and College Creeks, Review of Environmental Factors June 2010*. Unpublished report prepared for Macquarie University Property.
- Department of Environment and Climate Change 2008, *Rapid fauna habitat assessment of the Sydney Metropolitan Catchment Management Authority Area*, Department of Environment and Climate Change, Hurstville, NSW
- Department of Environment, Climate Change and Water 2009, *The Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area*. Department of Environment and Climate Change NSW, Hurstville, NSW
- EDAW 2006, *Macquarie University preliminary ecological assessment*, EDAW, unpublished report prepared for Macquarie University Office of Property
- Frith, HJ (Ed) 2007, *Complete book of Australian birds*, Readers Digest, Surry Hills, NSW.
- Jurik, J and Aung, T 2014, *Biodiversity Enhancement Plan*. Unpublished report prepared for GSE844 - Environmental Management Practice at Macquarie University.
- LesryK Environmental Consultants 2010a, *Ecological Constraints Report, University and College Creeks Study*, Macquarie University. Unpublished report prepared for Definity, St Leonards.
- 2010b *Vegetation Management Plan for Sydney Turpentine-Ironbark Forest Macquarie University, Ryde*. Unpublished report prepared for Definity, St Leonards.
- 2010c *Vegetation and Habitat Offset Works to Compensate for Clearing Vegetation in the Station North Precinct at Macquarie University, Macquarie Park*. Unpublished report prepared for Definity, St Leonards
- NSW National Parks and Wildlife Service 2002, *Native Vegetation of the Cumberland Plain, Western Sydney*. NSW National Parks and Wildlife Service, Hurstville, NSW
- 2004, *Guidelines for ecologically sustainable fire management*, NSW National Parks and Wildlife Service, Hurstville, NSW
- Office of Environment and Heritage 2013, *The native vegetation of the Sydney Metropolitan Area, volume 2: vegetation community profiles*, version 2.0., NSW Office of Environment and Heritage, Sydney, NSW
- 2015a, *Bionet: Atlas of NSW Wildlife: Point records for the Sydney CMA area*, NSW Office of Environment and Heritage, Sydney, NSW
- 2015b, *Threatened Species*, NSW Office of Environment and Heritage, Sydney, NSW.
<http://www.environment.nsw.gov.au/threatenedspecies/>
- Storm Consulting 2011, *Vegetation management plan for Upper Mars Creek valley*, unpublished report prepared for Macquarie University Office of Property
- Total Earth Care 2010a, *Conservation assessment and resilience mapping Ecology Reserve, Macquarie University*, unpublished report prepared for Macquarie University Office of Property

- 2010b, *Conservation assessment and resilience mapping Northwest Remnant*, Macquarie University, unpublished report prepared for Macquarie University Office of Property

- 2014, *Vegetation community mapping assessment and update 2014*

Northwest Remnant, Macquarie University, unpublished report prepared for Macquarie University Office of Property

Threatened Species Scientific Committee 2005, *Turpentine-Ironbark Forest of the Sydney Basin Bioregion. Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on amendments to the List of Ecological Communities under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Australian Government Department of the Environment <http://www.environment.gov.au/node/14559>

White, AW and Pyke, GH 1996, Distribution and conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales, *Australian Zoologist*, 30(2):177-89

Van Dyck, S and Strahan, R (Eds) 2008, *The mammals of Australia* (3rd edition), Reed New Holland, Sydney, NSW.

Appendix A: Locally-occurring threatened flora species

Key

E - endangered

V - vulnerable

X - extinct

CE - critically endangered

Species	Status		Habitat (OEH 2015b & author's field notes)
	EPBC	TSC	
<i>Acacia bynoeana</i>	V	E	Heath/scrub on clayey ridge-tops and slopes.
<i>Acacia pubescens</i>	V	V	Variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland.
<i>Callistemon linearifolius</i>	V	V	Rock platforms in dry sclerophyll forest on the coast and adjacent ranges.
<i>Darwinia biflora</i>	V	V	Heath/scrub on clayey ridge-tops and slopes between Lane Cove and the Hawkesbury River.
<i>Darwinia peduncularis</i>	V	V	On or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone.
<i>Deyeuxia appressa</i>	E	E	Record is from 1941. Locally extinct and little known of its ecology.
<i>Epacris purpurascens</i> var. <i>purpurascens</i>		V	Open forest/woodlands on deeper shales and near creeks.
<i>Eucalyptus camfieldii</i>	V	V	Heath/scrub on clayey ridge-tops and slopes.
<i>Eucalyptus nicholii</i>	V	V	Northern tablelands species commonly planted in Sydney.
<i>Eucalyptus scoparia</i>	V	V	Northern tablelands species commonly planted in Sydney.
<i>Genoplesium baueri</i>		V	Sparse sclerophyll forest and moss gardens over sandstone.
<i>Grammatis stenophylla</i>	E	E	Grows on rocks in rainforest and in wet sclerophyll forest.
<i>Haloragodendron lucasii</i>	E	E	Very localised in sheltered gullies in Barra Brui.
<i>Leptospermum deanei</i>	V	V	In sandstone scrub near watercourses.
<i>Melaleuca deanei</i>	V	V	Heath/scrub on clayey ridge-tops.
<i>Persoonia hirsuta</i>	E	E	Woodland and heath on clayey ridge-tops

<i>Pimelea curviflora</i> var. <i>curviflora</i>	V	V	Heath/scrub on clayey ridge-tops.
<i>Prostanthera marifolia</i>	X	CE	Unknown. Formerly confined to the Seaforth area.
<i>Tetratheca glandulosa</i>	V	V	Heath/scrub on moderately clayey ridge-tops and slopes.
<i>Wilsonia backhousei</i>		V	Saltmarsh

Appendix B: Locally-occurring threatened fauna species

Key

E - endangered

V - vulnerable

EP - endangered population (TSC Act only)

M - migratory (EPBC Act only)

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
<i>Pseudophryne australis</i>	Red-crowned Toadlet		V	Almost totally confined to drainage lines in areas of Hawkesbury Sandstone, especially those that support weathered shale lenses.	Low. There is no habitat within the study area for this animal.
<i>Litoria aurea</i>	Green and Golden Bell Frog	V	E	Inhabits a variety of environments, including disturbed sites, ephemeral ponds, wetlands, marshes, dams and stream-sides, particularly those that contain one or more of the following aquatic plants: bullrush (<i>Typha spp.</i>), spikerush (<i>Eleocharis spp.</i>), <i>Juncus kraussii</i> , <i>Schoenoplectus litoralis</i> and <i>Sporobolus virginicus</i> . Prefers water bodies with a lack of well-developed emergent vegetation, free of chemical contamination and no introduced fish species.	Low. Formerly recorded in Lungfish Ponds (east of Northwest Remnant near Talavera Road) in the 1990s but apparently no longer extant.
<i>Varanus rosenbergi</i>	Rosenberg's Goanna		V	The preferred habitat of the Heath Monitor includes wet and dry sclerophyll forests, woodlands and heath lands particular those that occur on sandy or calcareous	Low. Could potentially occur in

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
				soils. The Heath Monitor is mostly a terrestrial species, shelter in burrows, hollow logs and rock crevices.	Ecology Reserve.
<i>Nettapus coromandelianus</i>	Cotton Pygmy-Goose		E	This species is found in coastal and sub-coastal districts of north eastern NSW, formerly as far south as the Clarence River. The Cotton Pygmy-goose is an almost entirely aquatic species, preferring deep freshwater lagoons, swamps and dams. It uses tree hollows adjacent to water for nesting and breeding sites.	Low. There is no habitat within the study area for this animal.
<i>Ptilinopus superbus</i>	Superb Fruit-Dove		V	Distributed along the Queensland coast between Byfield and Cape York Peninsula, however migrations to southeastern Australia do occur at irregular intervals. The Superb Fruit-dove inhabits rainforests, and occasionally nests in nearby eucalypt forests, and feeds on a range of rainforest fruits, particularly the laurels.	Low. There is no habitat within the study area for this animal.
<i>Apus pacificus</i>	Fork-tailed Swift	M		Aerial feeder that rarely lands in Australia during summer migration.	Low. May potentially fly over the study area.
<i>Hirundapus caudacutus</i>	White-throated Needletail	M		Aerial feeder that rarely lands in Australia during summer migration.	Low. May potentially fly over the study area.
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork		E	Inhabits freshwater wetlands, where it mainly eats fish, though also known to eat reptiles, frogs, crabs, rodents and carrion.	Low. There is no habitat within the study area for this animal.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
<i>Ardea ibis</i>	Cattle Egret	M		Wet pasture with tall grass, shallow open wetland and margins, mudflats.	Low. There is no habitat within the study area for this animal.
<i>Botaurus poiciloptilus</i>	Australasian Bittern	E	E	Shallow, vegetated freshwater or brackish swamps, usually dominated by tall, dense reed beds of Cumbungi.	Low. There is no habitat within the study area for this animal.
<i>Ixobrychus flavicollis</i>	Black Bittern		V	Occurs through the wet coastal areas of NSW, Queensland, the Northern Territory and Western Australia, favouring densely vegetated watercourse margins.	Low. There is no habitat within the study area for this animal.
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	C		Large rivers, fresh and saline lakes, reservoirs, estuaries, coastal seas, islands.	Low. There is no habitat within the study area for this animal.
<i>Hieraaetus morphnoides</i>	Little Eagle		V	Open and riparian woodlands, grassland and arid regions, shunning dense forest.	Low. May potentially fly over the study area.
<i>Pandion cristatus</i>	Eastern Osprey		V	The Osprey is a large, coastal, fish eating raptor which has been recorded feeding upon mullet, rock cod, brim, leather jacket and whiting. This species normally builds a huge stick nest either in a large, dead tree, on a rocky outcrop or on the ground, though artificial structures	Low. There is no habitat within the study area for this animal.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
				have also been known to be utilised.	
<i>Numenius minutus</i>	Little Curlew	M		Most often found feeding in short, dry grassland and sedgeland, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools or areas seasonally inundated.	Low. There is no habitat within the study area for this animal.
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo		V, EP ⁴	In summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. Moves to lower altitudes in winter, preferring more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. Requires large tree hollows for nesting and roosting.	Low. Potential to fly across/forage within northern portion of project area.
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo		V	Eucalypt woodland and feeds almost exclusively on casuarina fruit. Requires large tree hollows for nesting.	Low. Potential to fly across project area.
<i>Glossopsitta pusilla</i>	Little Lorikeet		V	Eucalyptus forest and woodland, particularly along water courses. Requires small tree hollows for nesting	Low. Potential to fly across project area.
<i>Lathamus discolor</i>	Swift Parrot	E	E	Autumn-spring non breeding migrant from Tasmania. When over-wintering on the mainland, this species is dependent on winter-flowering eucalypt species and	Low. Potential to fly

⁴ Endangered population in the Hornsby and Ku-ring-gai LGAs.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
				lerp.	across/forage within northern portion of project area.
<i>Ninox connivens</i>	Barking Owl		V	Timbered hills, forests and savannah woodlands of coastal and subcoastal eastern and northern Australia.	Low. There is no habitat within the study area for this animal.
<i>Ninox strenua</i>	Powerful Owl		V	Large tracts of open or closed sclerophyll forest or woodlands but can occur in fragmented landscapes as well. Gullies consisting of wet to dry sclerophyll forest with a dense understorey. Nests in large hollows, nearly always in the trunk or top of a mature eucalypt.	High. Recorded in Marsfield park and Lane Cove National park. Likely to occur in Ecology Reserve and possibly the Flooded Gum Forest near Culloden road.
<i>Tyto novaehollandiae</i>	Masked Owl		V	Open forest with a sparse mid-storey layer, but with patches of dense low ground cover.	Low. There is no habitat within the study area for this animal.
<i>Merops ornatus</i>	Rainbow Bee-eater	M		The Rainbow Bee-eater inhabits open forests and woodlands, often near water bodies. This bird roosts at night in shrubs. They are breeding migrants to Australia, nesting in burrows dug into sandy banks or bare, flat ground.	Low. Potential to fly across/forage within northern portion of project area.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
<i>Anthochaera phrygia</i>	Regent Honeyeater	E	CE	Open forests, woodlands, timbered watercourses, and a variety of other habitat types. This species feeds primarily on four eucalypt species, Red Ironbark (<i>Eucalyptus sideroxylon</i>), White Box (<i>E. albens</i>), Yellow Box (<i>E. melliodora</i>) and Yellow Gum (<i>E. leucoxylon</i>) as well as heavy infestations of mistletoe (<i>Amyema spp.</i>).	Low. Potential to fly across/forage within northern portion of project area.
<i>Daphoenositta chrysoptera</i>	Varied Sittella		V	Eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	Low. Potential to fly across/forage within northern portion of project area.
<i>Petroica boodang</i>	Scarlet Robin		V	The Scarlet Robin breeds in scrubby eucalypt forests and woodlands but forage out into more open habitat in autumn and winter.	Low. There is no habitat within the study area for this animal.
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	E	V	Wet and dry sclerophyll forests through to rainforests. Males known to move up to 8 km in one night.	Low. There is no habitat within the study area for this animal.
<i>Cercartetus nanus</i>	Eastern Pygmy-possum		V	Heathland, woodland and rainforest that support a large number of proteaceous and myrtaceous plants.	Low. There is no habitat within the study area for this animal.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
<i>Petaurus australis</i>	Yellow-bellied Glider		V	Restricted to areas of tall, mature eucalypts.	Low. There is no habitat within the study area for this animal.
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V	Rainforests, open forests, woodlands, Melaleuca swamps, Banksia woodlands, commercial fruit crops and urban areas including residential gardens.	High. Potential to forage within/traverse study area.
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat		V	Although considered a forest dweller, collections of this species have come from a variety of habitats. Roosts in hollow-bearing trees.	High. Potential to forage within/traverse study area. No roosting habitat present.
<i>Mormopterus norfolkensis</i>	Eastern Freetail-bat		V	Hollow-roosting bat that forages in dry eucalypt forests and woodlands.	High. Potential to forage within/traverse study area. No roosting habitat present.
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle		V	Hollow-roosting bat that forages in eucalypt woodland.	High. Potential to forage within/traverse study area. No roosting habitat present.
<i>Miniopterus schreibersii</i>	Eastern Bentwing-bat		V	Cave-roosting bat that forages in well-timbered habitats	High.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
<i>oceanensis</i>				and open grasslands.	Potential to forage within/traverse study area. No roosting habitat present.
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat		V	Hollow-roosting bat that forages in eucalypt woodlands and rainforest.	High. Potential to forage within/traverse study area. No roosting habitat present.

* Habitat requirements were generally extracted from Frith (2007), Churchill (2008), Cogger (2000), Van Dyck and Strahan (2008) and OEH (2015b) with other references used being identified in the bibliography.

Appendix C: Photographic record of the study area

Plate1: Sydney Turpentine – Ironbark Forest, Northwest Remnant



Plate 2: Coastal Shale Sandstone Forest, Northwest Remnant.



Plate 3: Mars Creek, Ecology Reserve showing scouring of banks



Plate 4: Riparian Scrub, Upper Mars Creek



Plate 5: Flooded Gum Forest west of Culloden Road.



6. SUPPORTING DOCUMENTS

6.3 UTILITIES MANAGEMENT PLAN AND STORMWATER MANAGEMENT PLAN

Stormwater Management Plan & Utilities Management Plan (Rev. 1)

**Macquarie University,
Macquarie Park, NSW**

Prepared for Macquarie University / 16 June 2017

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1.0 Introduction

Macquarie University is planning to develop parcels of land within the campus for commercial, research and University use.

This report has been prepared to summarise the utilities, stormwater design and flooding constraints present at Macquarie University, in Macquarie Park, for master-planning purposes.

TTW have prepared the stormwater and flooding strategy. David Buckle and Associates have prepared servicing strategy for water, sewer and gas. JDG Consulting have prepared electrical and communications servicing strategy.

1.1 Macquarie University

The University is bound by Culloden Road to the west, Talavera Road to the north, Herring Road to the east and Epping Road to the south.

Mars Creek and University Creek run through the University in a north easterly direction. The location plan, aerial image, Master Plan and precinct plan are shown in Figures 1 to 4 respectively.

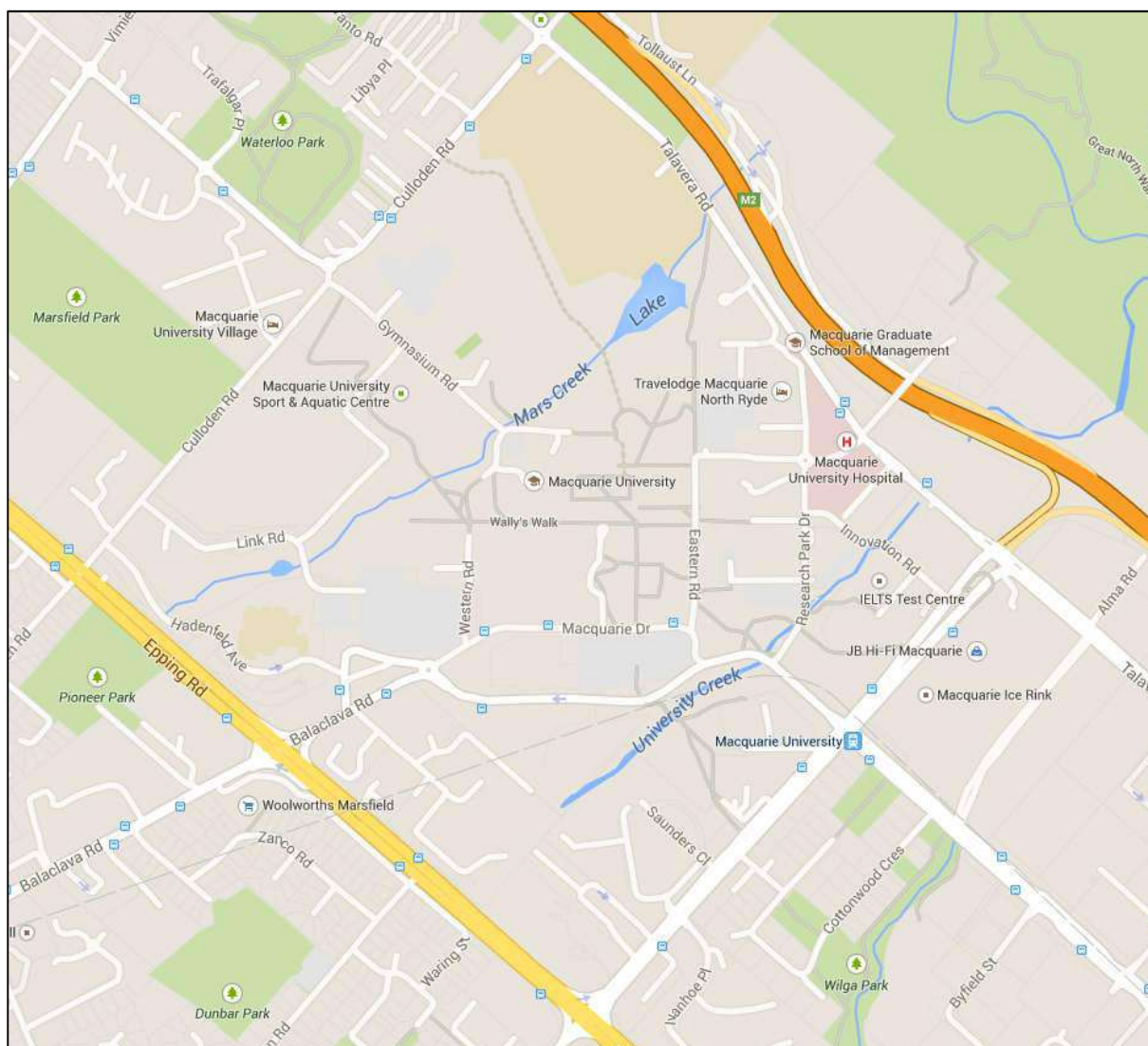


Figure 1 Locality Plan (source: Google)



Figure 2 Aerial Photo

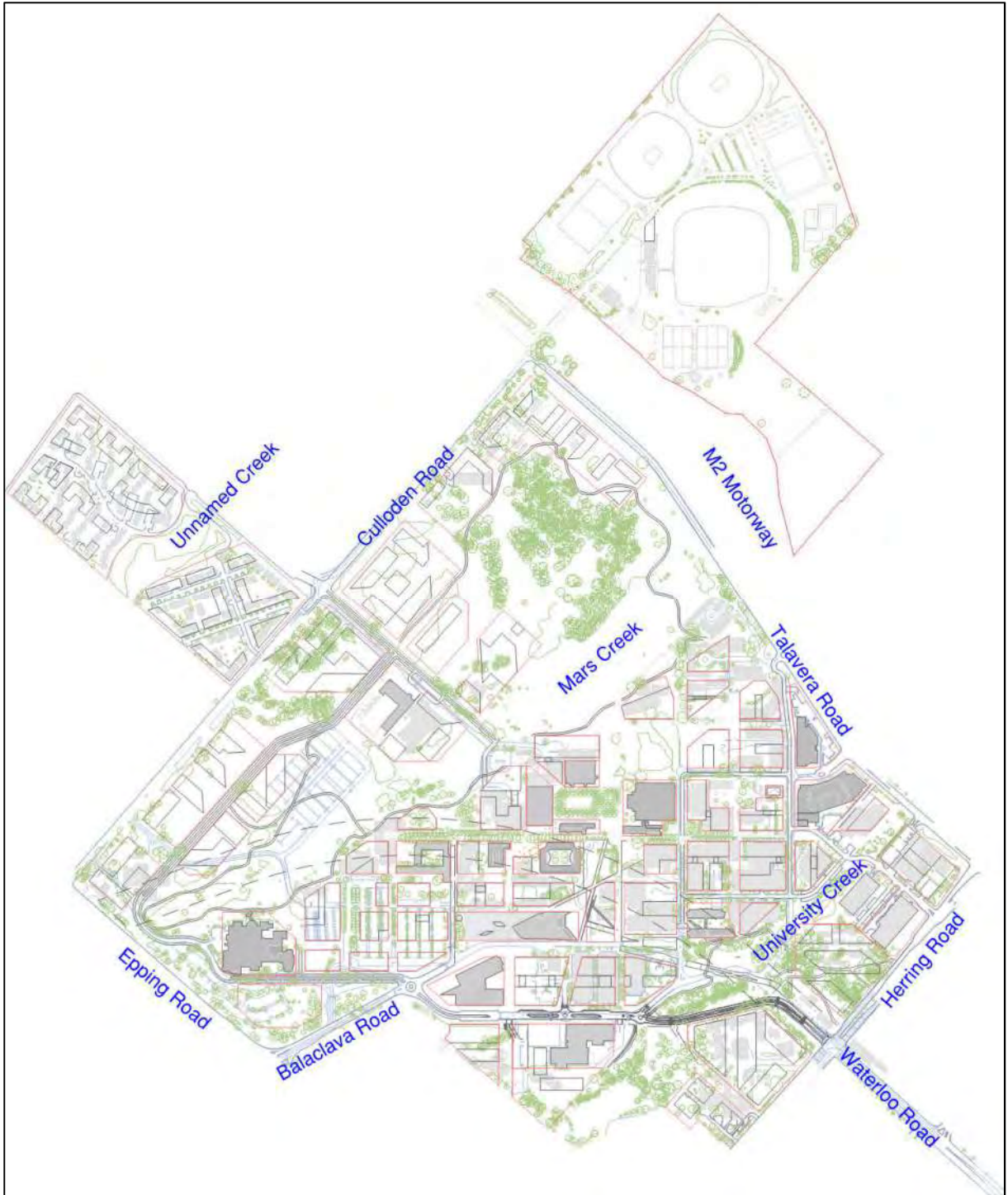


Figure 3 Macquarie University Master Plan

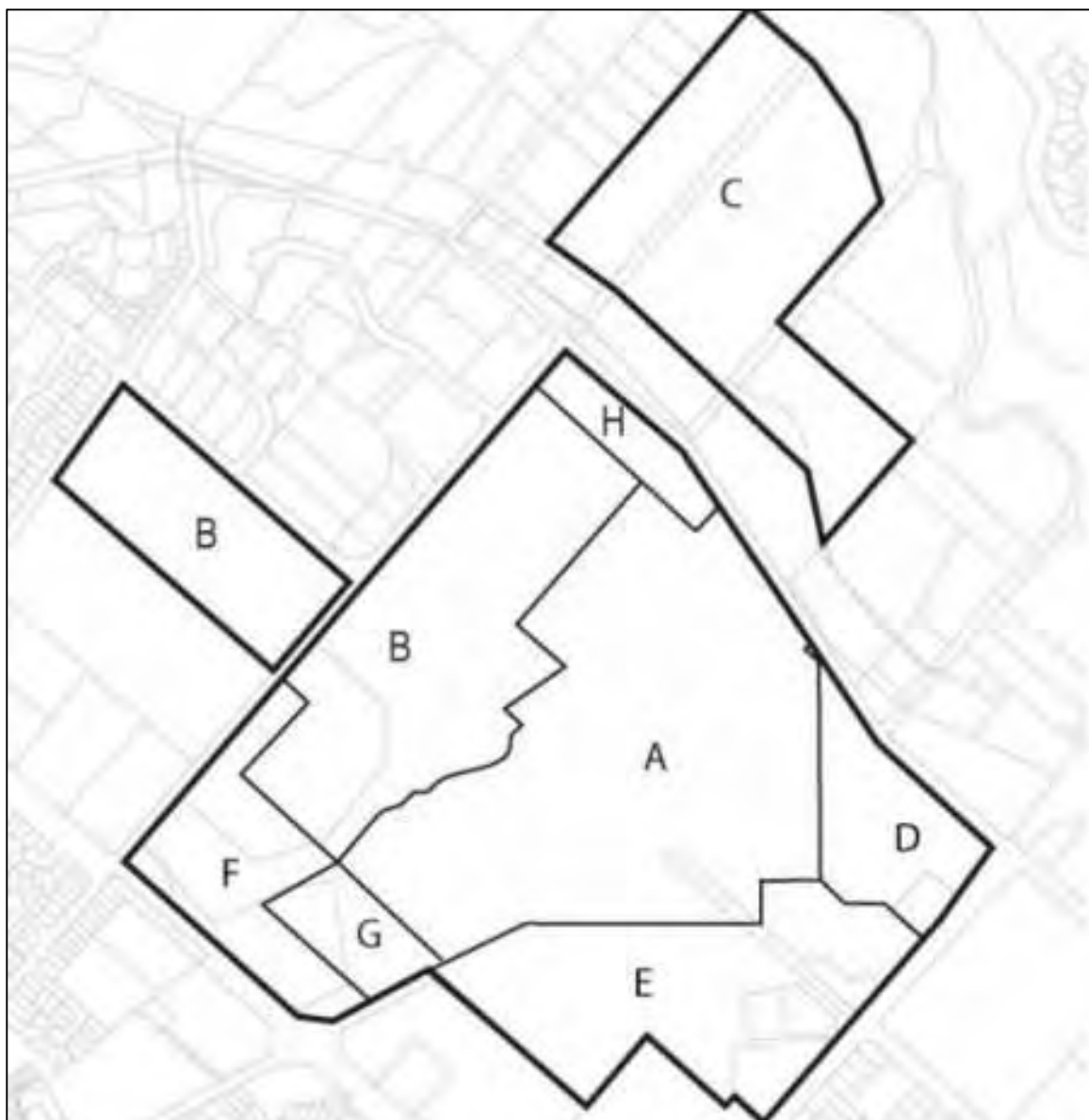


Figure 4 Precinct Layout (Source Cox Design Excellence Strategy and Urban Design Guidelines)

Table 1 University Precincts

Precinct A	Academic Core
Precinct B	University Housing
Precinct C	University Open Space and Playing Fields
Precinct D	Macquarie University Research Park (MURP) and Private Hospital
Precinct E	Station South
Precinct F	Epping Road West
Precinct G	Epping Road Precinct Expansion
Precinct H	Talavera Road North

Under the Concept Plan, the maximum additional GFA across the campus is limited by precinct as per Table 2. Under the master plan, this represents a vision for growth over the next 50 years.

Minor changes to the Concept Plan precinct boundaries are proposed due to the adjustments, upgrades and development under the Master Plan. Changes to these boundaries are shown in Figure 5.

Table 2 Maximum additional GFA

Precinct D	136,000 m ²
Precinct E (Station North)	90,000 m ²
Precinct E (Station South)	85,000 m ²
Precinct E (Triangle South of University Avenue)	155,000 m ²
Precinct F	70,000 m ²
Precinct A	61,200 m ²
Other	Not nominated



Figure 5 Proposed Precinct Boundaries (Source Cox Design Excellence Strategy)

1.2 Relevant Documents

The following documents have been reviewed in preparing this document:

- City of Ryde Development Control Plan 2014 (DCP)
- University Creek Stormwater Management Plan (TTW, December 2014)
- Macquarie Park Floodplain Risk Management Study & Plan (Bewsher, 2010)
- Mars Creek Catchment Environmental Plan (Storm Consulting)
- Civil Engineering plans prepared by TTW
- Architectural plans (Cox Richardson)
- Macquarie University Design Excellence Strategy and Urban Design Guidelines draft 6 (Cox Richardson)
- Macquarie University Infrastructure Plan

2.0 Riparian Zone, Flooding and Stormwater

C4 – Riparian Zone, Flooding and Stormwater	Preparation of a Stormwater Management Plan, incorporating a Vegetation and Threatened Species Plan (on a precinct basis as required via C3).	Landscape Rehabilitation Plan and Vegetation Management Plan Stormwater Management Plan Utilities Management Plan	Previous studies expanded to include the remainder of the main campus.
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2.1 Stormwater Drainage

2.1.1 Design Criteria

Drainage designs for future works will follow the requirements set out in the DCP. Subsurface systems will be designed to capture and convey a 20-year storm event. Overland flow paths will be designed to convey flows from a 100-year storm event.

The IFD extracted from the Bureau of Meteorology’s IFD tool and presented in Table 3 will be used for future design development.

Table 3 IFD data

	2-YEAR	50-YEAR
1 hour	36.27 mm/hr	70.83 mm/hr
12 hour	8.21 mm/hr	17.68 mm/hr
72 hour	2.61 mm/hr	5.89 mm/hr
Skew	0.00	
F2	4.3	
F50	15.85	

2.2 Water Sensitive Urban Design

The City of Ryde DCP 2014 Part 8.2 provides the following stormwater quality targets:

- b. WSUD measures incorporated into the development must satisfy the following pollutant target controls;
- 90% reduction in the post development mean annual load of total pollutant loads (greater than 5mm)
 - 85% reduction in the post development mean annual load of Total Suspended Solids (TSS)
 - 60% reduction in the post development mean annual load of Total Phosphorous (TP)
 - 45% reduction in the post development mean annual load of Total Nitrogen (TN)

It is recommended that the above removal rates are incorporated to future developments at the University.

2.2.1 Rainwater Reuse

With extensive landscaped areas, Macquarie University is well placed to capture roof water for irrigation use. It is recommended that roof water capture is considered for future developments at the University

2.3 Flooding

Flood studies have been undertaken for both University Creek and Mars Creek.

2.3.1 University Creek

TTW has undertaken flood modelling for University Creek. Refer to University Creek Stormwater Management Plan (TTW, December 2014) for details of the flood modelling. Results of the analysis are presented in **Figure 6** and **Figure 7**. A more detailed map of the proposed flood levels is contained in Appendix A.

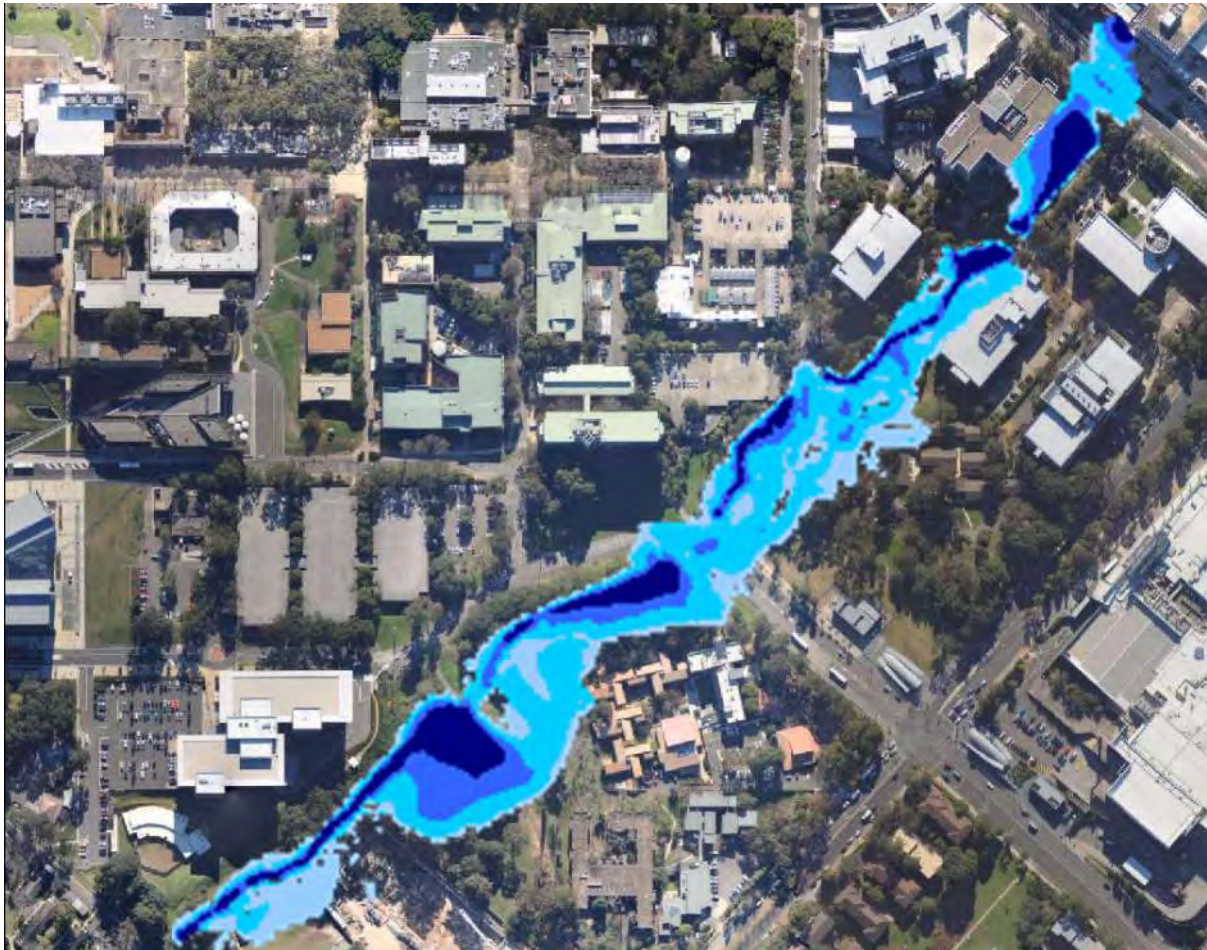


Figure 6 Pre-2013 100-year flood model results in University Creek

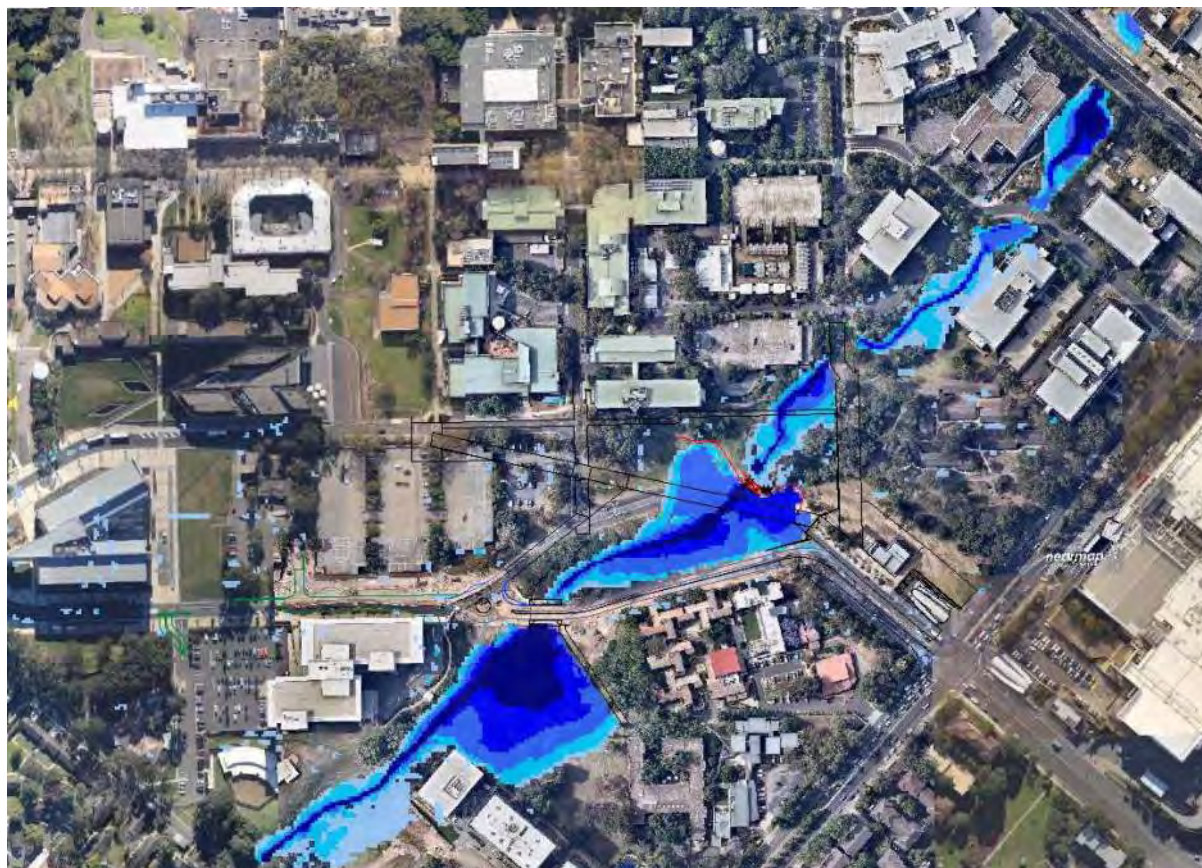


Figure 7 Proposed 100-year flood results in University Creek (Refer to Appendix A for detailed map)

2.3.2 Mars Creek

Bewsher prepared a flood study report covering Mars Creek in April 2010. The results from their 100-year flood modelling are presented in **Figure 8**.



Figure 8 Extract from Bewsher's report - 100 year flood modelling results in Mars Creek

Storm Consulting prepared a Catchment Environmental Plan for Mars Creek. The plan includes flood mapping and levels. Refer to Appendix A in this document for the full flood map with levels. Developments adjacent to the creek will consider flooding and riparian setbacks.



Figure 9 Extract from Storm Consulting's Mars Creek Catchment Environmental Plan

2.3.3 Flooding Controls

The Ryde Council DCP 2014 outlines the following controls for building adjacent to flood affected land:

- The level of habitable floor areas to be equal to or greater than the 100 year flood level plus freeboard of 500mm.
- Non-habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard of 500mm where possible, or otherwise no lower than the 20 year flood level plus freeboard of 500mm unless justified by a site specific assessment.
- Habitable floor levels to be minimum 500mm above adjacent ground levels.
- Non-habitable floor levels to be minimum 300mm above adjacent ground levels.
- Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year flood.

The DCP 2014 (chapter 8.2, section 4.4.2) includes the requirement that the entrance to basement car parks is above the Probable Maximum Flood (PMF). Correspondence with Council has confirmed this requirement due to the risk of basement car park flooding.

- Basement parking or parking at levels below the adjacent flood levels, a bunded crest at the estimated PMF (probable maximum flood) level prior to descent into the parking area, must be provided such that inundation of the area is prevented.

Modelling of the PMF flood event will need to be undertaken for both Mars Creek and University Creek to inform constraints on future development.

2.4 Construction Phase Stormwater Management

During the construction, erosion and sediment control plans shall be implemented to prevent sediment laden stormwater from entering the council drainage network and the local watercourses. Stormwater controls on site will be detailed in an erosion and sediment control plan, generally in accordance with the “Blue Book” - Managing Urban Stormwater: Soils and Construction (Landcom NSW). The plan will vary based on construction staging and methodology, but will typically include:

- upstream clean water diversion;
- silt fences;
- sedimentation basin;
- dust control; and
- vehicle wash down.

The erosion and sediment control plan includes an inspection and maintenance schedule. The erosion and sediment control plan mitigates against sediment laden stormwater entering the council drainage system and the downstream environment.

3.0 Roadworks

The proposed road layout requires realignment and widening to accommodate the Concept Plan site layout required and the recently constructed Eastern Entry and Precinct E works. New roads are proposed in precincts B, F and G.

4.0 Utilities

C14 – Utilities	Preparation of: <ul style="list-style-type: none"> - A detailed water supply infrastructure analysis - Services masterplan - Water supply needs analysis. Prior to the submission of the first application for building works.	Utilities Management Plan	Previous study expanded to include the remainder of the main campus.
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Macquarie University has developed a campus wide Infrastructure Plan. This plan will be updated to incorporate future infrastructure changes due to the Masterplan development. Any proposed works must refer to the latest version of the Infrastructure Plan.

5.0 Hydraulic Services

David Buckle and Associates has prepared services plans for hydraulic servicing for the masterplan. Notes and overview plans have been included in Appendix B of this document.

The existing Macquarie University site has no stand-alone hydraulic services and relies entirely upon external authority infrastructure as its source of basic services. The authorities responsible for delivering these services have over the past several years been apprised of Macquarie University's expansion plans going forward and have augmented and or planned to augment their infrastructure to cater for the anticipated demands. Feasibility studies have been carried out to validate the assumptions made in projected loads.

5.1 Existing Potable Water and Fire Hydrant Services

Water supply is provided to the site by water mains surrounding the site which are controlled by Sydney Water. Previous studies have indicated that these mains are capable of supporting the proposed developments with some off site augmentation being required by Sydney Water to meet demand. This augmentation requirement is particularly relevant to the North Western segment of the core campus where this off site augmentation will need to have been completed prior to development.

The existing core campus site at Macquarie University has two connections to this Sydney Water infrastructure located within Balaclava Road (Figure 10) and Culloden Roads (Figure 11). These two points feed the privately owned internal water services infrastructure / ring mains that serve the internal development zones within the site. The layout of the existing Macquarie University potable water network is detailed in campus zone plans developed by David Buckle & Associates (NSW) P/L:



Figure 10 Balaclava Rd Main Meter



Figure 11 Culloden Road Main Meter

5.1.1 Masterplanning Potable Water and Fire Hydrant Services

Current masterplanning provides for all developments on the perimeter of the site to be supported by Sydney Water external infrastructure including the future residential expansion of residential (3,500 beds) on the western side of main campus. The masterplanning zones are shown on the accompanying drawing titled H01 Hydraulic Services Concept Plan Services Zoning (refer Appendix B).

All internal development sites will be supported by the Macquarie University internal water mains infrastructure. The internal water mains infrastructure which is monitored on behalf of the University by David Buckle & Associates (NSW) Pty. Ltd. has been interrogated by applying additional loads and has shown that the planned developments can be supported by installing the mains extensions shown on the accompanying drawing titled H02 Hydraulic Services Concept Plan Potable Water & Fire Hydrants (refer Appendix A).

This process of determining water demand analysis for each proposal and incorporating projected peak loads into the hydraulic model of the network is to be carried out for each development proposal prior to commencement to ensure that the existing campus local infrastructure is capable of supporting the projected load.

There is a potential requirement for fire water storage on site to cope with water demand in the case of a fire on site during the domestic demand peak period

5.2 Existing Sewer

The main Campus is serviced by two sewer carriers known as the Mars Creek Carrier and the Balaclava Road Carrier, both of which are Sydney Water assets. Apart from the Sydney Water sewers, the Campus is serviced by a network of sewerage reticulation lines owned and maintained by the University.

5.3 Masterplanning Sewer

Future works will require extensions of the existing sewer network.

Discussion in 2008 with Sydney Water indicated future work planned for 2017 to 2067 would require amplification of the Balaclava Road Carrier beneath the M2 Motorway. Further studies will be required to determine the extent and staging of the augmentation.

5.4 Existing Natural Gas Services

Gas infrastructure to Macquarie University is provided by Jemena. This external infrastructure has recently been upgraded and is capable of supporting current projected loads with the possible exception of any large form of alternative energy scheme such as co-generation and or fuel cell technology adoption.

The Macquarie University campus is provided currently with three independent gas services feeding the internal gas networks. These networks consist of 1 x 100kPa service and 2 x 210kPa services. The layout of the existing Macquarie University natural gas network is detailed in campus zone plans developed by David Buckle & Associates (NSW) P/L:

5.5 Masterplanning Natural Gas Services

The 2 x 210kPa services have adequate capacity to serve projected loads as indicated by the Macquarie University Masterplan by installing the natural gas extensions shown on the accompanying drawing titled H03 Hydraulic Services Concept Plan Natural Gas (refer Appendix B).

The 100kPa service is currently stressed and requires monitoring of future load capacity. The system is capable of being augmented by increasing pressure through the network or be distressed by load shedding proposals.

As with the water services any proposed development fronting public roads on the perimeter of the site will be served with natural gas direct from the authority mains located within the street.

Any proposed development on the site will require the preparation of a gas load analysis for inclusion in the authority and or internal mains capacity models to ensure that the existing infrastructure is capable of supporting the proposed load.

6.0 ELECTRICAL SERVICES

JDG Consulting has prepared electrical and telecommunication servicing plans for the masterplan. Notes and overview plans have been included in Appendix C of this document

6.1 Existing Electrical Services

Ausgrid currently provide electricity supply to the Macquarie University site with High Voltage feeders from both Epping Zone Substation which is located to the West of the site and Macquarie Zone Substation to the East.

Ausgrid currently service the Precinct E Station South site via the Epping Zone Substation to the north-west of the University Campus.

New high voltage conduits run underground from the Macquarie Park Zone Substation along Waterloo Road have been installed to accommodate additional proposed HV augmentation cabling to service the proposed new developments. Internal to the University Campus new conduits run in easement allocations to Ausgrid requirements.

High voltage (HV) (Voltage 11kV) distribution cables run underground in conduit along Epping Road from the north-west to Herring Road then run on the north-west side of Herring Road to the north-east past Waterloo Road.

HV distribution cables also run underground in conduit along Balaclava Road from the north-west to University Ave then run both to the north along Western Road to the north of the Campus and on the south-east side of University Ave to the centre of the Campus.

Residential Colleges facing Herring Road are supplied via the existing HV distribution cables and kiosk substations that will eventually be decommissioned and removed from site.

6.2 Masterplanning Electrical Services

Development for the Macquarie University site within the long term will require augmentation of the current Ausgrid network.

All existing and new services will be run underground. Augmentation of the electricity supply inside the University is required to serve the demands anticipated in Precinct E.

It is proposed to secure an additional 2 off HV distribution feeders from Ausgrid by undertaking additional augmentation works with approval of Ausgrid.

As the masterplan development of the University progresses, the feasibility of establishing a new Ausgrid Zone Substation and the options available to the University in regard to electricity supply to meet all foreseeable future demands will need to be assessed.

In the longer term, utilisation of HV distribution from Ausgrid either from a new Campus Zone Substation or otherwise from an existing upgraded Zone Substation via augmentation works will be based on the options available at the time of construction.

6.3 Existing Telecommunications

Telstra Corporation currently serves the site via the local Telstra telephone exchange to the north-west of the University Campus. Residential Colleges are supplied via the existing telecommunication services running along Herring Road.

6.4 Masterplanning Telecommunications

It is important to note that at this stage no copper or fibre services have been set aside to accommodate the new developments.

New underground telecommunication conduits running from the Herring Road / Waterloo Road intersection will be installed to accommodate additional proposed telecommunication requirements of proposed new developments.

New Telecommunications conduits and pits will be required to be installed within the footpath of all new road infrastructure to provide the capacity for new development to connect copper and fibre services.

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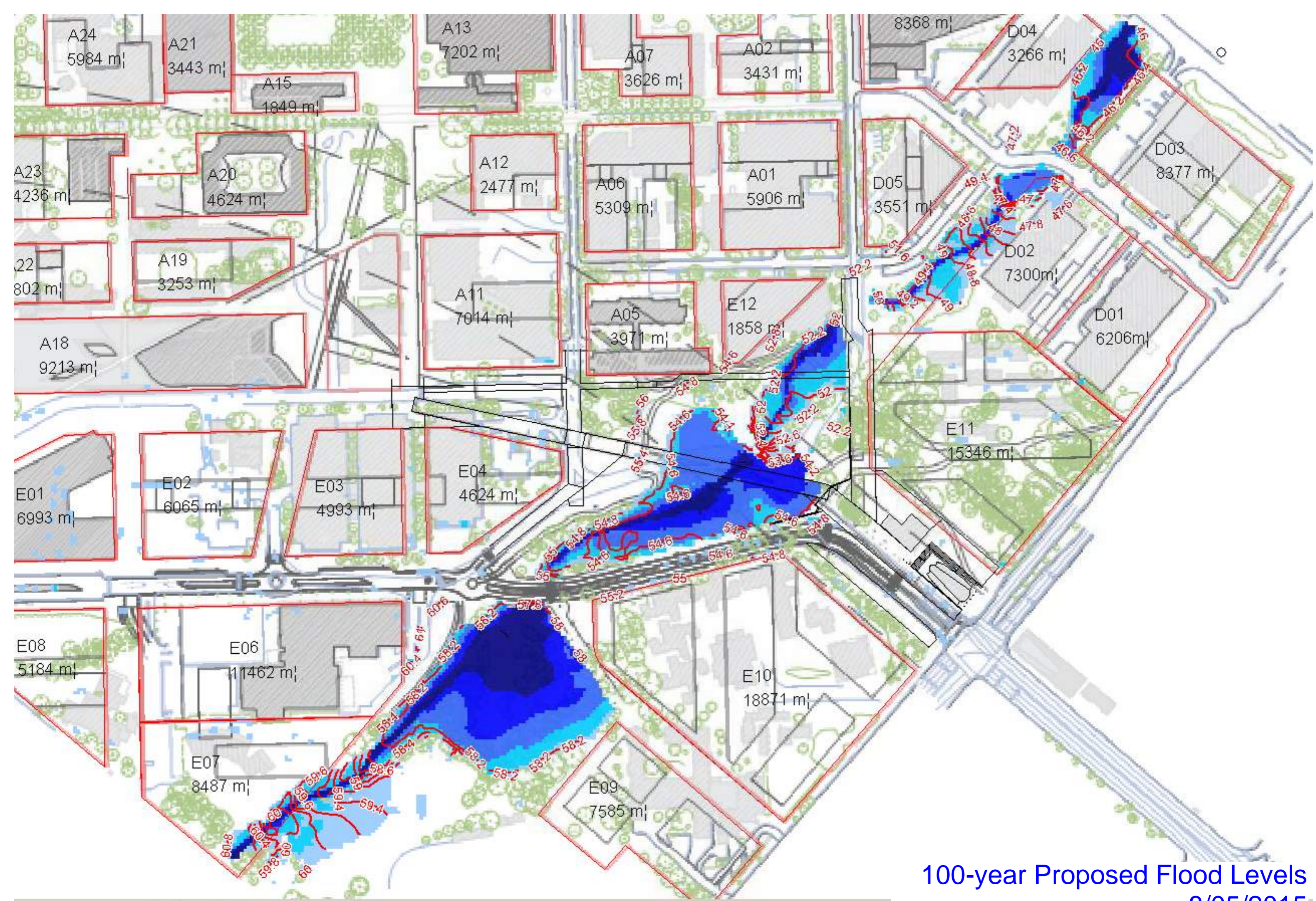
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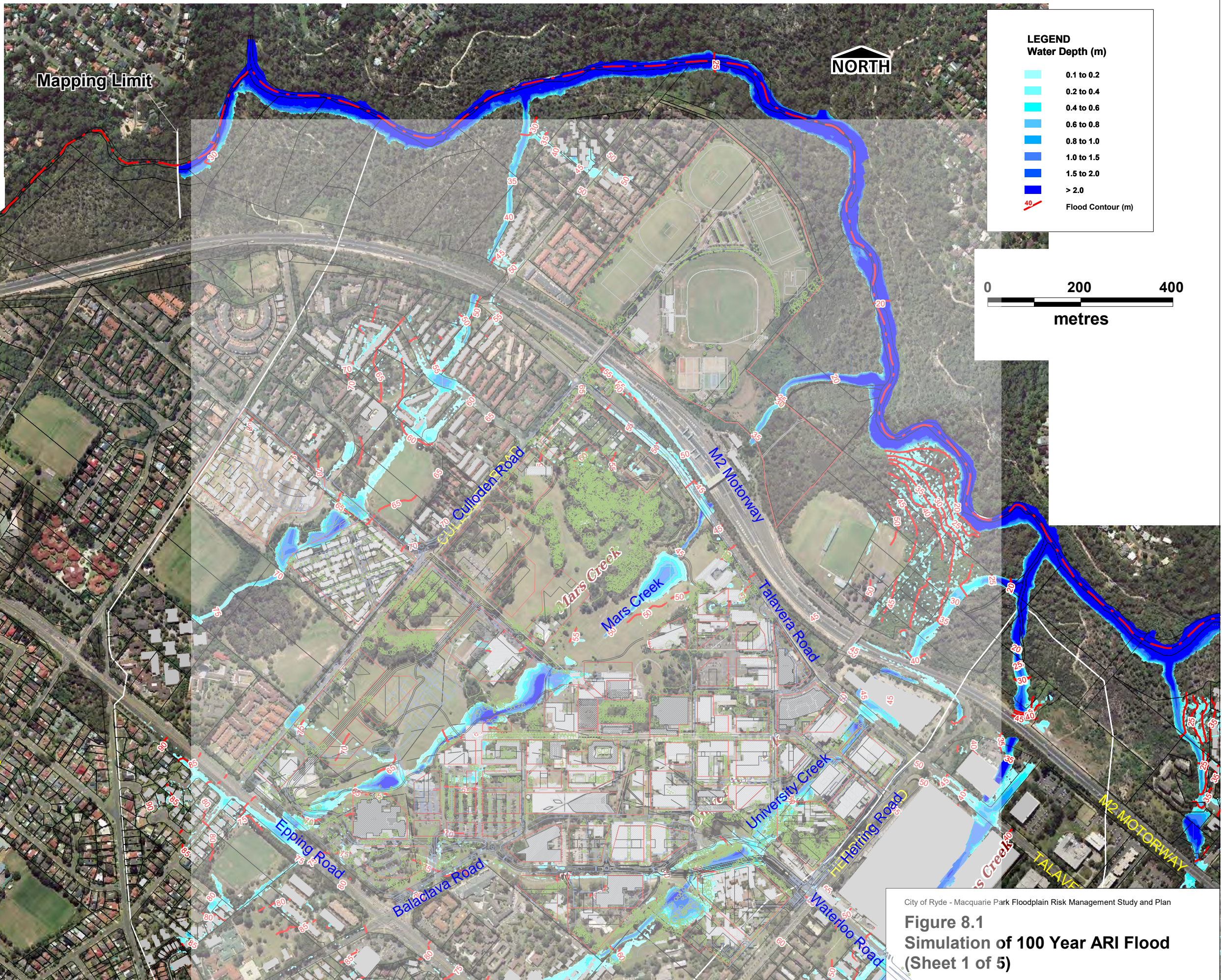
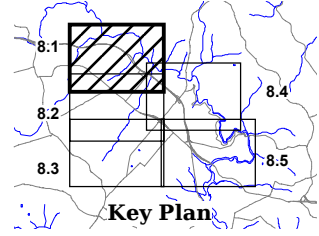
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Appendix A – Flood Maps



100-year Proposed Flood Levels
8/05/2015



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Date: 4 May 10

City of Ryde - Macquarie Park Floodplain Risk Management Study and Plan

Figure 8.1
Simulation of 100 Year ARI Flood
(Sheet 1 of 5)