MACQUARIE UNIVERSITY DESIGN EXCELLENCE STRATEGY AND URBAN DESIGN GUIDELINES

SUPPORTING DOCUMENTS

DATE: AUGUST 2018

MACQUARIE University

MACQUARIE
University

MACQUARIE UNIVERSITY PROPERTY

Macquarie University, NSW 2109
Telephone: +61 2 9850 7111

context

LANDSCAPE ARCHITECTS

Context Landscape Design
Level 2, 52 - 58 William Street
East Sydney, NSW 2001
Telephone: +61 2 8244 8900

ETHOS
URBAN

URBAN SOLUTIONS

Ethos Urban
173 Sussex Street
Sydney, NSW 2060
Telephone: +61 2 9956 6962

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Landscape Management Plan

(incorporating Weed Management Plan)

Macquarie University

June 2017

context

Document Control

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A	Preliminary Draft Issued for Review	DM	21/05/15
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Landscape Management Plan
(Incorporating Weed Management Plan)

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1.0 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 Landscape Management Plan as contained in this document.

The Landscape Management Plan (LMP) describes the landscape management activities to be undertaken by the Macquarie University Property Office or its agents for the long-term care of the Universities various open spaces. The historic and current landscape is discussed, the general landscape management principles of the University are outlined, and general landscape management activities are described. There is a focus on specific landscape types with particular management activities, and on landscape management activities which support the goals and objectives of the Design Excellence Strategy and Urban Design Guidelines. It proposes management activities which may be specific to and promote the landscape character of each precinct within the open space network.

The LMP covers the landscape management of both the existing and proposed future constructed landscapes, and the Vegetation Management Plan (VMP) prepared by CONTEXT/Lesryk Environmental Consultants 2015 covers the management of remnant native vegetation areas and habitat rehabilitation zones. There is some overlap as some areas of remnant vegetation, particularly in riparian corridors have been planted with introduced species over the years.

The campus open space is currently undergoing major changes as new projects are commenced and the Masterplan is implemented. For this reason the LMP does not provide a schedule or timetable of activities or reporting. A timetable of activities, reporting and inspections should be prepared by the Property Office for existing open space areas and new areas included as they are completed.

1.1 The Need for this Landscape Management Plan

Due to its high quality landscape setting, Macquarie University is recognised as a ‘Campus in the Park’. The ongoing management of the campus landscape is therefore fundamental in reinforcing the experience of the University into the future.

The Macquarie campus contains examples of biodiversity under threat from past extensive habitat loss. Around four hectares of the endangered Sydney Turpentine Ironbark Forest (STIF) community occurs as remnant bush around the University grounds, particularly to the northwest of the Mars Creek Lake.

In addition the University maintains the whole campus as an Arboretum comprising all trees and plants on the campus. These trees, growing in natural and planted habitats, provide a valuable resource for teaching and research and a pleasing and relaxing environment for the enjoyment of staff, students and visitors to the university. Where appropriate the university provides interpretive material throughout the campus which describes the arboretum, trees and ecological processes. The arboretum also provides habitat for many native birds and animals.

1.2 Where This Plan Applies

This LMP applies the entire open space network of the campus and includes landscape areas over podium or roofs, streetscapes and the sports fields. It includes all precincts. These are;

—**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

Refer to figure 1 showing the extent the area covered by the plan.

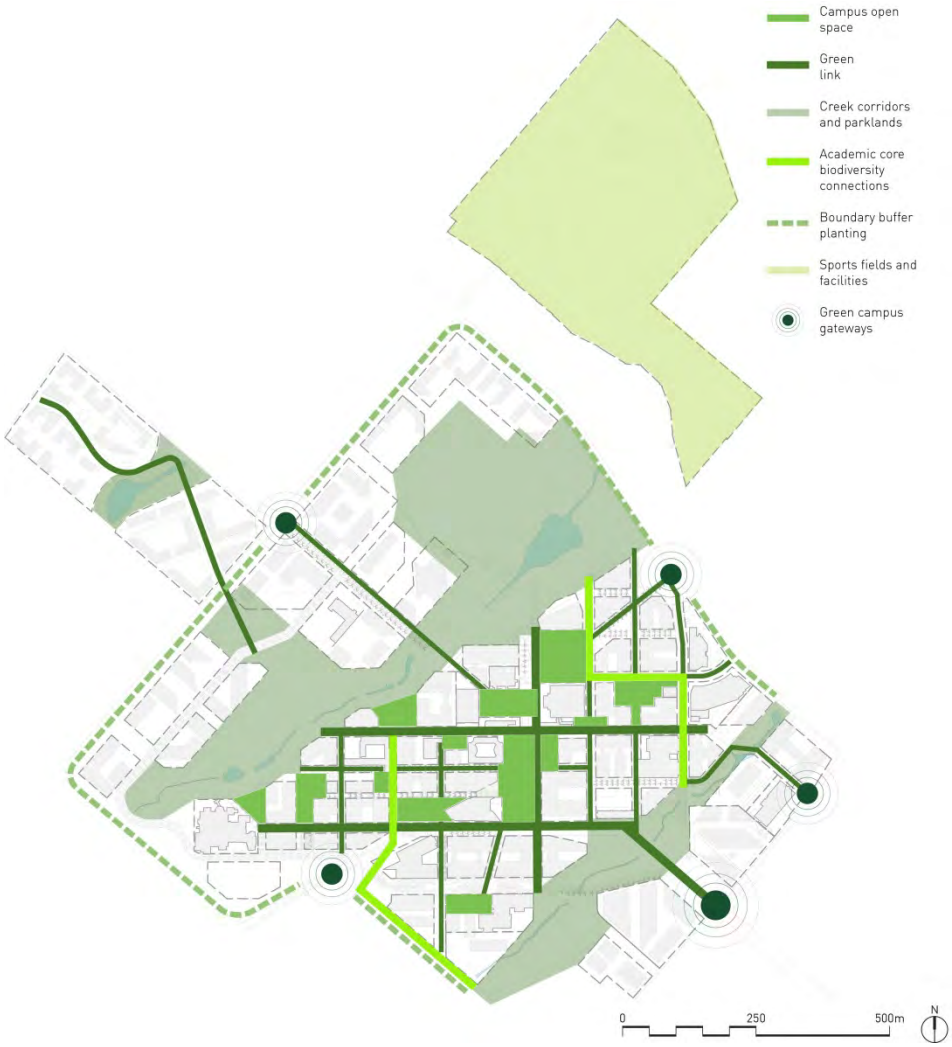

Figure 1 Extent of the campus covered by this LMP

1.3 Landscape Maintenance Responsibility

The Macquarie University Property Office will hold the first level of responsibility for the implementation of the Landscape Management Plan. The on-going, day-to-day implementation, monitoring and reviewing of the LMP will be undertaken by the by the Assets Manager, Campus.

1.4 Landscape Management Principles

The following landscape management principles have been identified as being consistent with the Concept Plan:

Minimise environmental impacts that may result from landscape management activities and utilise environmentally sustainable practices

Preserve, enhance and promote the bushland character of the university

For new and replacement plantings, consider the use of endemic plant species in the first instance. Next consider the appropriateness that the species selection may have in enhancing the character of the precinct or space in which it is to be planted and whether the species can enhance the Arboretum collection

Use specimen trees to unify and define the landscape character of particular outdoor spaces

Provide a safe environment, minimising potential risks to people, buildings and property

Incorporate water sensitive urban design (WSUD) techniques to manage stormwater, slow runoff, recharge groundwater, store for re-use and to passively irrigate landscape areas

Apply best practice bush regeneration in bushland areas and best practice landscape maintenance in landscaped areas

Provide a continuous and legible high quality path network that provides for safe, equitable and efficient movement. Give precedence to pedestrians over vehicles and improve access to all areas of the campus

Ensure that all new works comply with the requirements of AS 1428 Access and Mobility Design

Target noxious weeds and feral animals through the use of integrated pest management approaches

Integrate building and landscape design to provide external meeting and teaching and learning spaces

Provide opportunities for Aboriginal, environmental and informal learning and study in the landscape

Maintain high quality outdoor spaces, precincts and streetscapes

Maintain high quality sports precincts

Maintain high quality passive recreation areas

Manage bushfire risk in accordance with recognised guidelines

Provide opportunities for greater community involvement

Appropriately fund, plan and manage landscape maintenance to provide a measurable improvement of the campus landscape appearance, safety and amenity.

1.5 Report Structure

This report is to be read in conjunction with the:

- Macquarie University Campus Masterplan 2014 (Cox Richardson Architects and Planners 2014)
- Design Excellence Strategy and Urban Design Guidelines 2015 updated 2017, prepared by Cox Richardson Architects and Planners in conjunction with CONTEXT
- Vegetation Management Plan (VMP) 2015 for Macquarie University, prepared by Lesryk Environmental Consultants in conjunction with this LMP.

Section 1.0 provides an introduction to the LMP

Section 2.0 describes the general site conditions

Section 3.0 describes Specific Landscape Types

Section 4.0 describes management activities common to all landscape areas of the campus

Section 5.0 describes specific landscape management activities for specific areas of the campus

Section 6.0 describes Protective Measures for trees and vegetation

Section 7 Monitoring and Reporting

The report is structured to avoid duplication by separating maintenance activities into two categories:

1. Specific Landscape types – Those maintenance activities that are specific to particular landscape types. The specific landscape types are:
    a. Specimen Trees. These may be planted in lawn areas or in paving areas, as avenues and as street trees or in groupings
    b. Mass Planting Areas. These may be composed of single species plantings or mixes which may include trees shrubs and groundcovers
    c. Planting on Slab.
    d. Lawn Grasses and Sports Turf Grasses
    e. Native Grasses

2. All areas of the campus – Those maintenance activities that apply to all areas of the landscape within the University. These activities include:
    a. Disease and Insect Control
    b. Irrigation

3. Specific landscape management activities for specific areas of the campus. Specific areas of the campus are required to be managed in particular ways in order to preserve and enhance their unique landscape integrity. The specific areas are:

    a. Herring Road Gateway
    b. Balaclava Road Gateway
    c. Gymnasium Road Gateway
    d. Talavera Road Gateway
    e. Wally's Walk
    f. Macquarie Walk
    g. Sir Christopher Ondaatje Avenue

h. The Central Courtyard
i. The University Common
j. The Library Forecourt
k. Arts Lawn (West Common)
l. The Grove (East Common)
m. Mars Creek
n. University Creek
o. Culloden Creek
p. Mars Creek Plaza
q. Wally's Walk Open Space
r. Macquarie Theatre Courtyard
s. Cochlear Forecourt
t. Jim Rose Earth Science Garden
u. Talavera Park
v. Frank Mercer Biological Sciences Garden
w. University Avenue
x. Research Park Drive
y. Eastern Road
z. Western Road
aa. West Precinct Road
bb. Innovation Drive
cc. East-West Pedestrian Connections
dd. North-South Pedestrian Connections
ee. Sports Fields
ff. Residential Colleges

1.6 Intensity of use

A key factor in the frequency and types of landscape maintenance activities required for particular areas is the intensity of their use.

High Intensity Open Spaces

High intensity spaces occur throughout the campus and are places which provide pedestrian linkages to buildings within the University as well as being spaces that encourage social and leisurely activities. They are mixed use zones.

High intensity spaces include Streetscapes such as University Ave near the train station, The Central Courtyard, The University Common, The Library Forecourt, The Arts Lawn and The Grove.

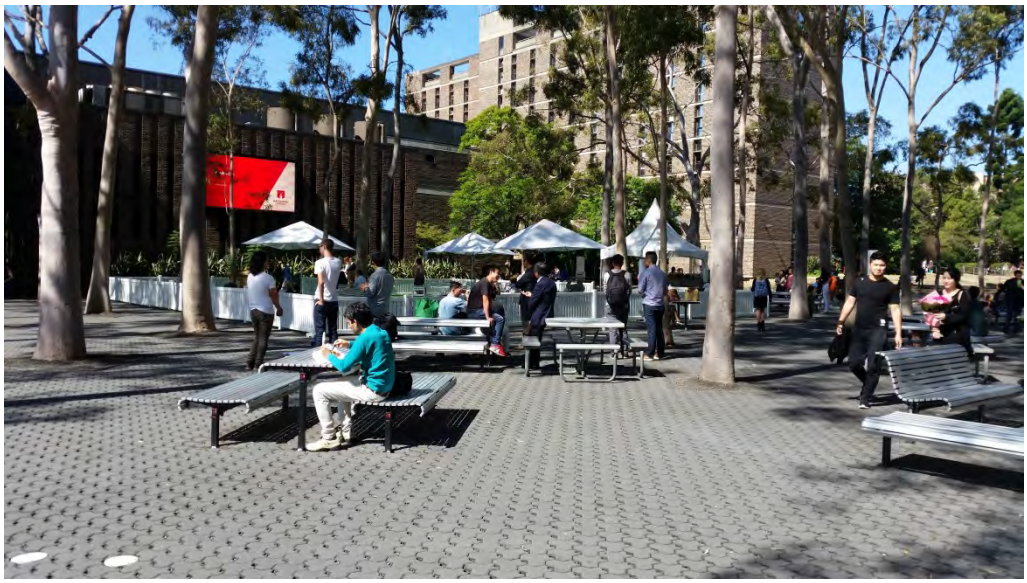

Figure 2 High intensity open space – Central Courtyard

Passive Open Spaces

Passive areas include smaller, informal spaces which cater for outdoor learning opportunities, breakout areas and recreational uses and larger areas which see occasional use by small numbers of people.

These spaces on the campus include Mars Creek Plaza, Wally's Walk Park, Macquarie Theatre Courtyard, Jim Rose Earth Science Garden, Talavera Park and Frank Mercer biological Sciences Garden, Mars Creek and University Creek.

Figure 3 Passive open space – Mars Creek Lawn

Sports Fields

Located on the corner of Talavera Road and Culloden Road in North Ryde the Macquarie University Sports Fields comprises of seven hectares of playing areas. Sports fields have short periods of intense activity and long periods of low activity.

The Sports Fields include Jim Campbell Sportsfield, Ross Gwilliam Sportsfield, Northern Oval and Roger Sheeran Oval.

Riparian Corridors and Bushland Areas

The riparian corridors on the Macquarie University campus run along Mars Creek and University Creek. The riparian areas are generally areas of low activity although recent riparian rehabilitation upgrades may encourage greater activity. Bushland areas should be managed using bush regeneration techniques that have a low environmental impact.

Bushland management zone relates to bushland areas within the campus. Bushland on the North-west corner of the campus is mapped as Bushfire Prone land Vegetation Category 2 and is to be managed with a 30 metre perimeter vegetation buffer.

Areas of mass planting are not generally susceptible to compaction from pedestrian usage therefore heavier textured soils can be used.

Figure 4 Mars Creek Riparian Zone showing regeneration of the 20m riparian corridor

1.7 Arboretum

The arboretum at Macquarie University is unique in being the only arboretum in Sydney that is located on a university campus. It contains trees that are remnant to the native plant communities as well as recent landscape planting. The arboretum is a resource for teaching and research and provides habitat for native birds and other animals. The campus contains a series of walks and gardens, some themed, which display a range of interesting plant species.

The University was established in the 1960's. Prior to this time, the main use of the area was for market gardens. During that time pockets of remnant vegetation were retained. These pockets are still evident and have increased in size over the last 4 decades. As a result of the changes in land use in the surrounding suburbs, there is an increase in the importance of the native vegetation within the campus. Located on the north-western corner of the campus and to the west of the lake

is the main area of remnant Sydney Turpentine Ironbark Forest vegetation community, however smaller pockets are located near the railway station and scattered throughout the campus.

When undertaking planting or replanting at the University, consider the introduction of rare and unusual native and exotic species to increase the arboretum's collection.

Macquarie University is located near areas of native vegetation in Christie Park and Lane Cove National Park. A key goal of the campus landscape management is integrate the campus with the natural surrounding areas and to encourage biological diversity.

Figure 5 Arboretum interpretive signage

A Bushcare Group has recently been established at Macquarie University to preserve the natural environment in particular the native vegetation and the watercourses. The activities of this group will be focussed around the restoration of the riparian zones with native vegetation. There is also a focus around improving the natural flow and water quality of Mars and University Creeks and improving the connectivity between areas of remnant native vegetation.

Figure 6 Bushcare interpretive signage

2.0 General Site Conditions

2.1 Soil

Macquarie University is located at the geological boundary between Hawkesbury Sandstone and Ashfield Shale of the Wianamatta Group. The gently undulating topography, remnant shale/sandstone transition forest communities (Sydney Turpentine Ironbark Forest, Sandstone Ridgetop Woodland) and occasional loose sandstone boulders in the creek line reflect this characteristic landscape typology.

As noted in the Geomorphologic Assessment conducted by Coffey Geotechnics, 'the geological profile typically consists of topsoil or pavement overlying residual clay. The Bedrock is generally shallow throughout the site, with the depth of overlying clay generally decreasing with elevation'.

2.2 Existing Vegetation

2.2.1 Cultural Plantings

The predominately native landscape at Macquarie University is the result of over 40 years of continuous planting, transforming the site from its previous use an orchard and market garden into

a ‘Campus in a Park’. It was the intention of Professor Clough, the original landscape architect for the campus, to create a gradual landscape journey from the urban streetscapes outside the campus through the transitional campus building zone to the natural landscape of Mars Creek and its densely planted native backdrop beyond.

Historical aerial photography (refer Figure 7, 8 and 9) illustrates the previous clearing of large tracts of existing vegetation for cultivation as an orchard and market garden. The 1943 view was taken after a bushfire and illustrates the reduced canopy that resulted.

Figure 7 2014 Aerial view. Source: SIX Maps

Figure 8 1943 Aerial view. Source: SIX Maps

Figure 9 1930's Aerial view. Source: Macquarie Uni Archives

Over 14,000 trees and shrubs were planted by Macquarie University throughout the campus between the late 1960s and 1970s, of which some 10,000 have matured and still exist on site. It was the intention of Professor Clough, the University planner at that time, to create a gradual 'landscape journey' from the 'urban streetscape' outside the campus into a natural core.

The earlier streetscapes are defined by informal plantings of *Corymbia, Eucalyptus* and *Syncarpia* species; mainly *Corymbia maculata, Corymbia citriodora* and *Eucalyptus saligna*. The tree planting is often in clumps and form part of the greater open space layout rather than the definition of the roadway. Due to the consistency of size and species, most of the trees within the streetscape would have been planted during the 60s and 70s, however there are a number of naturalized trees in the vicinity of the road reserves.

More recent plantings, for example on University Avenue, are laid out in a formal boulevard arrangement with regular spacing providing shade for the length of the road.

2.2.2 Mars Creek Vegetation and Riparian Corridor

Mars Creek is located at the northern extent of the Macquarie University campus. Land use of the creek corridor incorporates remnant bushland, planted exotic and native woodland, mown exotic grassland, teaching & research facilities and animal enclosures. The restoration of vegetation along Upper Mars Creek through the implementation of the two VMP's has been a success. Ideally, similar rehabilitation, including the possible removal of underground culverts, should be adopted downstream of Gymnasium Road.

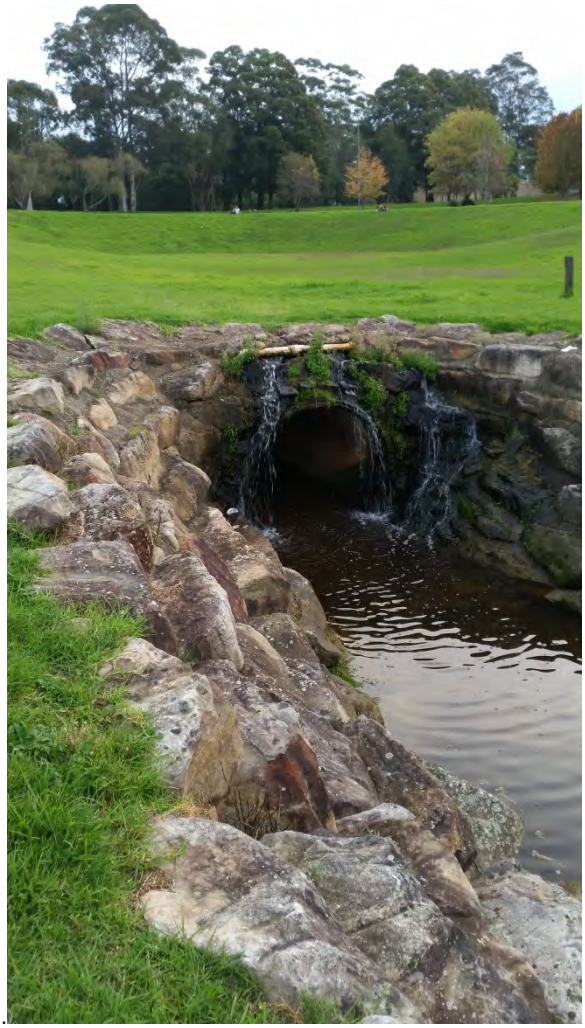

Figure 10 Underground culverts on Mars Creek should be considered for removal. This pipe travels in a direct line under the ampitheatre so the creek may need a slight diversion if the pipe is removed. Note that very little water is actually flowing in the pipe.

Mown lawns with planted Eucalyptus spp. and exotic deciduous trees form an open space perimeter in the south west of the creek corridor. Generally, Mars Creek is situated in a highly modified urban landscape with adjacent development including education facilities, medium density housing and commercial complexes, with Lane Cove National Park located to the north west of the creek corridor. (Total Earth Care, 2014)

A large, remnant stand of Sydney Turpentine Ironbark Forest (STIF) is located in the northern area of the creek corridor, with a smaller remnant stand of STIF located in the central area of the corridor south of the existing gymnasium building.

Refer to the Vegetation Management Plan (Lesryk, 2015) for additional information regarding the ongoing management of vegetation within the Mars Creek riparian corridor.

2.2.3 University Creek Vegetation and Riparian Corridor

University Creek is located in the southern area of the Macquarie University campus. Although a 'natural' watercourse, University Creek has been substantially altered over the past 50 years, with culverts, storm water inlets, constructed creek beds and banks contributing to its current flow and

flood regime. The south-eastern area of the creek zone and downstream is subject to periodic flooding.

The riparian corridor has been physically defined and limited by the development of the campus buildings, infrastructure and recreation zones over the last four decades and is often less than the desired 20m in width from the top of the bank. The current planting defines the creek line and creates a range of landscape experiences from the more open parkland landscape in the south west to a more ‘structured’ landscape past Research Park Drive to the north east.

The existing landscape in the riparian corridor of University Creek comprises open parklands and mown lawns set within rising topography on either side of the creek. The majority of the trees within the riparian corridor are native and are believed to have been planted in the late 1960’s and early 1970’s. Some remnant stands of STIF and Sydney Sandstone Ridgetop Woodland occur within the riparian zone. Recent plantings in conjunction with the University Avenue roadworks have re-introduced a balance of lawn, native lawn and STIF understorey to accommodate and balance biodiversity with passive recreation within the creek environs.

Refer to the Vegetation Management Plan (Lesryk, 2015) for additional information regarding the ongoing management of vegetation within the University Creek riparian corridor.

3.0 Specific Landscape Types

3.1 Specimen Trees

The existing trees on the Campus help to define spaces and provide character, shade, screening, wind protection, habitat, and a sense of scale. As each mature tree could be considered to have a commercial value ranging from several hundred to several thousand dollars (depending on the age, species, size and valuation method), it can be considered that the existing tree-scape is valuable in financial terms and is a major and physical asset.

In principle any tree with a trunk diameter of more than 150mm should be assessed by a qualified arborist prior to removal. This should not apply if the tree has major structural faults, is clearly senescent, an environmental weed or poses a health and safety risk.

Underground works, including excavation and service trenching, are frequently the major cause of damage to existing healthy trees. Consideration must been given to protection of the critical root zones of existing trees.

Tree selection for replacement and new tree plantings will be subject to individual designs however some key considerations for both landscape architects and landscape staff are to select endemic trees that contribute to local biodiversity first, then to consider whether the species can contribute to the character of the precinct in which it is planted (for instance, does it complement existing trees or contribute to a proposed theme for the space). Finally trees should be considered for their contribution to the goals of the University Arboretum.

All tree management on campus should refer to the *City of Ryde DCP 2010 Part 9.6 Tree Preservation* and the *City of Ryde Urban Forest Technical Manual and Application Guide.*

Refer to Section 6 for Tree Protection Measures.

All existing trees on Campus have been surveyed.

Avoid whipper-snipping grass at the base of trees because this can cause ring-barking and tree death. Clip around tree bases by hand or instead plant low groundcovers or mulch at the base of trees. Where trees are planted in paved areas, adjacent to the trunk use:

1. Gravel
2. resin-bonded gravel
3. permeable paving surrounds
4. proprietary tree grate or
5. a combination of the above

Figure 11 Specimen trees - *Liquidamber styraciflua* - in the Macquarie Theatre courtyard

3.1.1 Soil Management for Trees

Wherever trees are to be planted it is important to understand wether the existing in situ topsoil can be used as backfill, wether new topsoil, soil mix, soil conditioner or amendments needs to be imported, or if a mix of the above is best.

In general, the greater the soil/subsoil depth (the effective root depth) - the larger the tree that can be supported with minimal maintenance. The ideal soil profile for trees will have at least 3 horizons where the “A” horizon is the topsoil, the “B” horizon is Subsoil and the “C” horizon is the Subgrade. The minimum recommended topsoil depth for trees is 250mm with a minimum subsoil depth of 200mm. This will provide the tree with the minimum moisture/nutrient reserve and anchorage capacity.

In addition to a physical inspection of the soil to be used to assess field texture and structure and drainage capability, soils should also be analysed by a soil laboratory for the following properties at a minimum:

- pH
- Salinity (electrical conductivity)
- Cation exchange properties and exchangeable cations
- Major and minor nutrients
- Organic matter (%)

Where tree specimens in container sizes 25 litres or larger are to be planted, the subsoil should also be tested for:

- pH
- Salinity (electrical conductivity)

- Cation exchange properties and exchangeable cations
- Aggregate stability.

The most common amendments used to bring soils up to a standard suitable for plant growth are:

- Lime or dolomite to make acid pH soils more alkaline.
- Lime or Gypsum to enhance exchangeable calcium and eliminate sodicity
- Gypsum to make clay soils more friable
- Composts and/or manures to improve organic matter and nutrients levels
- Single or complete fertilisers often with trace elements to correct a particular deficiency or multiple deficiencies.

it is important that the backfill soil is returned in the layers in which it was excavated so that topsoil with organic content is placed back near the top 300mm of the backfill. Where the existing site topsoil backfill is unsuitable or insufficient it can be made up with:

Sandy loam or site won topsoil mixed with; Composted soil conditioner conforming with AS 4454	70-100% by volume 0-30% by volume	Eg. 8 parts washed sand/2 parts sandy loam/1 part compost. Amendments as reported by the soil test results.

(Leake and Haege 2014, p.87)

Where the tree pit is deeper than 300mm (usually for trees in containers over 45 litres) and the existing site subsoil is unsuitable or insufficient a topsoil medium low in organic matter is required so that the organic matter does not “sour” at depths where there is less oxygen, It can be made up with a sandy, well-drained medium which contains low organic matter An example of the components may be:

Sandy loam	60-80% by volume
On-site clay loam or clay topsoil or subsoil	20-30% by volume
Composted soil conditioner conforming with AS 4454	<10% by volume

(Leake and Haege 2014, p.96)

3.1.2 Fertilising, composting and mulching

To ensure the health and vigour of trees are maintained.

All trees whether native or exotic will perform better when the soil conditions are healthy. Building healthy soils is the key to achieving the long term maintenance goals of mass-planted landscape areas. Soil health is primarily achieved with regular applications of organic soil conditioners such as animal manures, decomposed green waste or proprietary blends of compost.

Fertilising and composting are not critical maintenance activities except where there are obvious deficiencies but should be assessed on an annual basis by observation and leaf analysis.

Maintain an adequate level of mulch maintained in planter beds in order to maximise water conservations and to supress weeds.

Note: NPK ratios listed are for native trees. Increase P above >=5 for exotic trees.

Maintenance Action Required	Frequency
Where obvious deficiencies are evident 60 grams/plant (trees) Controlled Release fertiliser such as Nutricote Total TE 360 Day - 17.6: 2.9:6.9 per plant. Or:	Only to be applied if the plant is noticeably under stress and the plant will benefit from the application of the fertiliser Inspect annually; however apply in late Spring if required.
3 x 20 gram slow release fertiliser tablet per plant . N:P:K ratio – 18:3:10	Only to be applied if the plant is noticeably under stress and the plant will benefit from the application of the fertiliser Inspect annually; however apply in late Spring if required.
Where soils are dry, hydrophobic and as a regular maintenance procedure, top up all garden beds with 30-50mm depth of Soil conditioner as composted animal manure, decomposed green waste or proprietary blends such as “Botany Humus” as available from Australian Native Landscapes. For extreme cases use a proprietary soil-wetting agent.	Bi-annually, applied at any time of year.
Maintain mulch to a depth of 75mm, through periodic applications. Use same mulch as originally specified in each planting	As required, however should not be necessary more than once per year

3.1.3 Pruning

Carry out all tree pruning in accordance with AS 4373 Pruning of amenity trees. Prune trees to maintain driver sight lines; to remove dead wood from over hanging paths, cycle-ways and roads, to maintain vegetation health and to remove branches or trees that are likely to pose a risk to public safety. Prune to an extent where this will not re-occur as a problem in the period to next routine maintenance without compromising overall form and growth potential of the tree.

Suitable timing for pruning should be determined by the arborist so as to maintain vegetation health, however all trees should be inspected regularly and especially after high winds to determine any action required.

Of particular note are recent avenue tree plantings on University Avenue. Refer to Figure 12. The *Tristaniopsis laurina* will eventually require underpruning to 4 metres to accommodate passing buses. This should be achieved over a period of time with the first pruning 12 months after establishment to “lift” the crown and provide a clear trunk to one metre. The following year the trunk should be lifted to 2 metres and so on until the tree is mature enough to have a velar trunk to

4m with a well-balanced crown.

Figure 12 Recently planted avenue of *Tristaniopsis laurina* in the central median of the recently upgraded University Avenue. These should be progressively underpruned to "lift" the canopy to four metres to allow for passing large vehicles.

Suitable timing for pruning should be determined by the arborist so as to maintain vegetation health.

Dead limbs containing hollows should not be removed unless there is a risk to public safety; limbs with hollows that are trimmed from trees should be left in a suitable location on the ground to provide habitat.

The installation of nest boxes should be considered if tree hollows are removed.

Removed timber and native vegetation, unless diseased, should be considered for reuse on-site either as habitat logs in bushland areas where appropriate, or mulched in garden beds.

Prune to reduce continuous canopy within the APZ.

Remove dead or dying trees from the campus as required. This may be necessary when trees mature, after damage or adverse environmental conditions.

Pruning - Work Required	Frequency
Prune to remove split leaders, remove dead and heavily damaged limbs. As maturity permits prune lower branches to collar to 2.5 metres min. above ground level. (note; this is a general rule only as some trees have low branches which are essential to the form of the tree, and some trees will be sued for screening purpose where low foliage is required.)	As required
Prune all trees when limbs and branches hang lower than 4 metres over a roadway or parking	

space and 3 m over a walkways, path or cycleway	

3.1.4 Replacement Plantings

To ensure that the density, species and design intent of established tree plantings is maintained. In figure 5 illustrates the *Liquidamber* tree planting at the graduation statues, a tree has died and snapped mid-trunk. This should be replaced immediately with the largest specimen that can be reasonably procured and practically handled into position.

Replacement Plantings - Work Required	Frequency
Replace failed, senescent or damaged plantings. Densities, sizes and species used are to be in accordance with those specified in the original landscape plans.	As required
Water replacement plantings for a minimum of 12 weeks after planting	As required to ensure survival.

Figure 13 The dead tree in the background should be immediately replaced as this is a high profile location used for graduation photos.

3.1.5 Tree Guards, surrounds and Stakes

Replace tree guards/stakes when damaged and/or remove them when no longer required.

Remove tree surrounds where there is the danger that trunks will outgrow the diameter of the surround. Refer to figure 14.

Work Required	Frequency of Work
- Replace tree guards or stakes for trees and shrubs if they are damaged or removed prior to the establishment of the plant. Replace with the same or equivalent guard/stake.	As required until final removal at 12 months

- Remove tree guards and stakes	after planting

Figure 14 The metal surround should be removed well before the trunk outgrows the circumference.

3.2 Mass Planting Areas

Mass planting areas can vary in appearance from mass plantings of single species (eg. *Lomandra sp., Dianella sp. Liriope sp.*) to more complex beds containing advanced trees, low and tall shrubs and ground covers. Planting sizes can include tubestock up to super advanced or semi-mature container sizes. In general, mass planted beds are either planted with native species or exotic species but may also include both.

Mass planted areas must balance design and aesthetics with the application of the principles of Crime Prevention through Environmental Design (CPTED). The highest priority for the management of mass planted beds should be given to areas that pose a security risk or are currently high maintenance.

The key differences in the management of native plants are their requirement for low-phosphorous fertilisers and a lower fertiliser rate than exotic species generally (although this doesn't apply to Australian rainforest plants – some species of which are endemic to the locality). Plants of the Pea group (including *Acacias, Pultenaeas* and *Hardenbergias*) and *Casuarinas* are also able to fix their own Nitrogen.

Natives also have lower water requirements in comparison to exotics and are adapted to the harsher Australian conditions.

Endemic native plants will tolerate site soils without amendment better than exotics, and if no fertilisers are added there may be a lesser invasion by exotic weeds.

For the above reasons native plantings make a more sustainable option in respect of the long term landscape management and should always should be considered for use on the campus before exotic species. For ease of maintenance it may be beneficial to keep native and exotic species apart although this may not always satisfy design intentions.

Most native plants including native rainforest plants prefer free draining soils.

Exotic planting beds will generally require more frequent fertilising, watering in dry periods and will benefit from more frequent applications of soil conditioner.

The edges of the beds will be defined by appropriate means. Beds shall be weed free and mulched annually to suppress weed growth and retain moisture content within the soil. Where irrigation is not present, garden beds should be watered during dry spells to remove undue plant stress and the potential for die-back.

Pruning will be carried out on shrubs that require it according to species to remove the dead and damaged branches and to retain natural shape and encourage good flowering to improve health and vigour. Where die-back of plant material has been identified new plants will be planted as soon as possible, using species originally specified or that maintain the character and continuity of the planting.

Figure 15 Recent mass planting of natives - Lomandra, Westringia Leptospermum and Melaleuca. A lower Phosphorous component fertiliser should be used in areas of solely native planting.

The key management activities required for mass planting areas are:

3.2.1 Soil Management for Mass Planted Areas

Areas of native mass planting require a sandy loam to clay loam topsoil mix which is suitable for the planting of grasses, woody and herbaceous perennials and occasionally trees. The following mix is suitable for plants that do not have high nutrient requirements and are not susceptible to compaction. Note that if phosphorous sensitive natives are used, the phosphorous levels of all components must be checked for suitability. Additional drainage may be required depending on the situation.

Sandy loam or site won topsoil mixed with; Composted soil conditioner conforming with AS 4454	70-100% by volume 0-30% by volume	*Eg. 8 parts washed sand/2 parts sandy loam/1 part compost.* *Amendments as reported by the soil test results.*

(Leake and Haege 2014, p.87)

Areas of exotic mass planting with higher nutrient requirements can have a higher compost component as below:

Sandy loam or site won topsoil mixed with; Composted soil conditioner conforming with AS 4454	70-90% by volume 10-30% by volume 30-60% by volume for organic	*Eg. 8 parts washed sand/2 parts sandy loam/3 parts compost.* *Amendments as reported by the soil test results.*

	soil variant	

(Leake and Haege 2014, p.89)

3.2.2 Fertilising, Composting and Mulching

To ensure the health and vigour of mass plantings are maintained.

All mass planted areas whether native or exotic will perform better when the soil conditions are healthy. Building healthy soils is the key to achieving the long term maintenance goals of mass-planted landscape areas. Soil health is primarily achieved with regular applications of organic soil conditioners such as animal manures, decomposed green waste or proprietary blends of compost.

Fertilising and composting are not critical maintenance activities except where there are obvious deficiencies but should be assessed on an annual basis by observation and leaf analysis.

Note: NPK ratios listed are for native plants. Increase P above >=5 for exotic mass planting beds.

Maintenance Action Required	Frequency
50-100 grams per square metre of Organic fertiliser such as Dynamic Lifter Composted chicken manure, Blood and Bone, fish meal and seaweed NPK ratio – 3.7:2:1.8	Annually. Applied late Spring and again in autumn (higher rate for fast-growing plants).
Where obvious deficiencies are evident use10 grams/plant (groundcovers), 20 grams/plant (shrubs) and 60 grams/plant (trees) Controlled Release fertiliser such as Nutricote Total TE 360 Day - 17.6: 2.9:6.9 per plant. N:P:K ratio– 18:3:10	Annually. Applied late Spring
Where soils are dry, hydrophobic and as a regular maintenance procedure, top up all garden beds with 30-50mm depth of Soil conditioner as composted animal manure, decomposed green waste or proprietary blends such as “Botany Humus” as available from Australian Native Landscapes. For extreme cases use a proprietary soil-wetting agent.	Bi-annually
All currently mulched areas should gradually be converted to groundcover where possible. Mulch should continue to be applied to a depth of 75mm to retain moisture and minimise weeds until groundcover is established. Mulch applied should be weed-free.	As required, however should not be necessary more than once per year.

3.2.3 Pruning

Ground cover and shrubs should be maintained at a maximum height of 0.5 m along path edges for personal security. Appropriate species selection in these areas will reduce the need for ongoing maintenance.

Remove dead or dying plant material from mas planted areas on the campus as required. This may become necessary as plantings mature, after damage or adverse environmental conditions.

Pruning Mass Planted Areas - Work Required	Frequency
For low shrub species as per appropriate type: Tip prune to encourage density to 50-100mm	As required after flowering
For low shrub species as per appropriate type: Prune evenly to a height of 500mm above ground along path edges. Prune away from paths where required	Every 4 years after flowering

3.2.4 Replacement Plantings

To ensure that the density and species of established plant material within mass planted areas is maintained.

Replacement Plantings in Mass Planted Areas - Work Required	Frequency
Replace failed, senescent or damaged plantings. Densities, sizes and species used are to be in accordance with those specified in the original landscape plans.	As required
Water replacement plantings for a minimum of 12 weeks after planting.	As required to ensure survival.

3.2.5 Weeding

Weeding is listed under “Mass Planted Areas” because it is the area of greatest concern for weeds in the fabricated landscape, note however that weed control in bushland and other landscape types is also covered in this section.

A noxious weed is a plant declared to be noxious under the NSW Noxious Weeds Act 1993. Noxious weeds can be agricultural weeds, environmental weeds or have a direct impact on human health.

Environmental weeds are non-local plants that can invade and change natural areas and threaten the survival of native plants and animals. After land clearing, environmental weeds are considered to be the next greatest threat to our indigenous biological diversity.

Environmental weeds have the potential to readily invade garden bed areas and potentially impact on the adjacent areas of bushland and creek reserves.

In addition to the environmental hazard posed by weeds, weeds occurring in mass planted beds, growing from the base of trees and from pavement can be unsightly and presents an untidy appearance.

The Ryde Council currently has a defined list of noxious weeds in the City of Ryde: http://www.ryde.nsw.gov.au/Environment/Animals+and+Plants/Noxious+Weeds This list defines plants that are classified as weeds and should be removed from the Campus and not planted in any new works.

This list provides a good basis for management and includes many problem garden weeds. However there are further species that have been identified under the Weed Management Act (1999) that should be specifically excluded from the site. Many of these plants are commonly available in the nursery trade so their use needs to be broadly discouraged.

For control of weeds on the Campus comply entirely with the ***Noxious and environmental weed control handbook*** *a guide to weed control in non-crop, aquatic and bushland situations NSW D P I* Management Guide Sixth Edition. A copy of the handbook can be downloaded at the link:

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/123317/noxious-and-environ-weed-control-handbook.pdf

Figure 16 While not a noxious weed and more of a nuisance weed, the Portulaca species in this bed could be easily controlled if the garden bed were more densely planted.

To ensure that environmental and noxious weeds do not reproduce within or spread into mass planted areas and compete with plantings and spread to other areas or nearby bushland.

Weeding and weed control is considered to be a critical maintenance action.

Maintenance Action Required	Frequency
Prevent reproduction of weeds by destroying seedlings and established weeds before seed set or other propagules form. Remove by hand in the first instance (where infestations are low). Ensure that the entire weed including all roots is removed. Dispose of the weeds off site.	Monthly
Remove by Herbicide application any weeds which cannot be controlled by hand removal. Herbicide application must occur before weed seed set. Non-target species and areas must be reinstated if damaged by herbicide application.	
Herbicide use to be in accordance with regulation rates and manufacturers recommendations. Herbicide use must comply with the requirements of the *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.	
After spraying, lop any dead weeds flush with the ground surface and dispose of the cuttings.	
Use of bio-degradable herbicide is mandatory	

3.3 Planting on Slab

On slab planting areas require particular vigilance in terms of their landscape maintenance. On slab planting areas should be designed with excellent drainage characteristics, but this leaves them susceptible to rapid drying-out because they do not have the moisture buffering capacity provided by subsoils. On slab planting should incorporate sub-surface drip irrigation to prevent drying out On campus they are generally intensive areas and any lawn on slab will be subject to increased wear.

Figure 17 Planting and lawn over a concrete slab near the library. Note the shape of the garden bed results in an area too narrow and difficult to plant. A different resolution could have prevented this.

3.3.1 Soil Management for On Slab Planting

`On slab soil media 'A' horizon requires a well-drained growing media with a saturated density of under 2400kg/m^3. To maintain the structure and porosity of the soil over long periods of time and to avoid volume loss the formulation must include low density mineral components such as ash, perlite, scoria, pumice and diatomaceous earth or the artificial components of urea formaldehyde and Styrofoam.

Physically, the media has the properties of a potting mix and is assessed using the methodology of AS 3743.

The "A" horizon on-slab would typically be 300mm deep for all on-slab planter boxes, containers and garden beds and may be composed of:

Sandy loam or site won topsoil	20-40% by volume
Horticultural ash, perlite, or similar lightweight low-density mineral matter or mixtures of these	30-60% by volume
Composted soil conditioner conforming with AS 4454	20-30% by volume

(Leake and Haege 2014, p.100)

Where the soil profile is deeper than 300mm, an on slab soil media "B" horizon is required. The characteristics are an open granular well-drained growing media with a total saturated density under 2400kg/m^3. This growing media is to be used on the subsurface layer below the 'A' horizon soil.

To maintain the structure and porosity of the soil over long periods of time and to avoid volume loss the formulation must contain low-density mineral components including ash, perlite, scoria, pumice and diatomaceous earth, or artificial components such as urea formaldehyde and Styrofoam. (Leake and Haege 2014, p.102)

Sandy loam or site won topsoil	10-30% by volume
Horticultural ash, perlite, or similar lightweight low-density mineral matter or mixtures of these	30-50% by volume
Composted 10mm pine bark	20-40% by volume
Composted soil conditioner conforming with AS 4454	<20% by volume

3.4 Lawn Grasses and Sports Turf Grasses

Significant areas of the Campus are surfaced in exotic lawn, turf or pasture grass. These areas contribute to the character of the Campus, and are important to open space and passive recreation areas. However, they have high demands for maintenance, and require commitment of significant resources particularly in irrigation, fertilizing and mowing and the maintenance of a thick sward that does not wear readily.

The level of maintenance required for particular lawn areas should be considered within the context of their intensity of use.

Figure 18 The lawn in the Central Courtyard is underperforming due to wear, possibly poor construction and competition from tree roots. A larger raised lawn may be preferable.

The traditional European aesthetic determines that grass should be kept lush and green all year round. This is possible and appropriate for high use areas but this perception is gradually changing and it is now more acceptable that in the Australian climate, lawn areas may be subject to seasonal change and browning off in summer. This aesthetic is appropriate for low-use areas that will not be subject to year-round wear.

Specific issues with the existing lawn and grass on the Campus include:

- A range of grass varieties are used on campus. Has one variety been observed to perform better than others?
- In some high use areas, compaction and wear caused by pedestrian and service vehicle has caused grass to die with bare soil remaining.
- While maintaining a complete grass cover under mature trees is desirable, it can be difficult to maintain. A surface mulch or groundcover planting may be more appropriate.
- Maintenance and access for mowing of grass on steep is a potential occupational health and safety risk. Embankments steeper than 3:1 should be considered for planting treatments so that mowing is not required. Tractor drawn mowers should never mow slopes steeper than 3:1 and it is not advisable to use hand mowers on slopes between 3:1and 2:1 and never on slopes 2:1 or steeper.
- Restrict the provision of high quality, well maintained lawn to sports fields, high traffic areas and premium passive use areas. Aim to reduce the amount of resources dedicated to maintaining lawn and grass areas. Clippings should remain where they fall under most circumstances and should not be raked up and removed. In high traffic areas this may require more frequent mowing so that the clippings are smaller and fall into the turf more easily.
- Designate 'lawn maintenance zones' for Campus. Within these zones grass may be irrigated, mown, fertilized and otherwise maintained as necessary to provide high quality lawn, suited to its uses. Such is the case with the inner grassed areas of the central campus which is mown with a catcher.
- In low-use areas, irrigation, fertilization, mowing and maintenance should be reduced.
- Good drainage is essential to turf health. Identify prolonged wet spots and rectify with sub-surface drainage installation.
- Areas of “Grass-Pave” parking occur on campus – These may be replaced in the future. In the meantime to maintain adequate grass cover, lawn management practices such as watering during dry oeriods, fertilising and topdressing must be implemented.
- Outside the lawn maintenance zones, plant deep rooting, drought tolerant grass varieties and planting or seeding of "Mowless" type grasses. A *Microlaena* lawn has recently been sown on University Creek. The use of tufting type native grasses may be more appropriate in some areas.
- More sustainable grass and turf management practices should be explored across the Campus, including limiting the use of fertilizers and developing an irrigation masterplan to determine a strategic and water efficient approach to irrigation on the site.

Figure 19 The Ampitheatre is a special case but in most circumstances a slope such as this is too steep for safe mowing and should be planted. Note that the mowing regime has allowed the grass to grow long which is desirable in an area of occasional use.

Compaction

On occasion where compaction of turf areas cannot be managed through prevention, and the quality of turf is declining (usually due to poor drainage), special machines that remove cores of soil, make slits or grooves or spike holes must be used. Perform all these operations as often as necessary when turf is in active growth in summer (but not when temperatures are extreme or there are drying winds). Following these procedures, turf may require more frequent watering to offset the increase in evaporation.

Topdressing

Topdressing is a thin layer of growing media applied to turf. Components are usually sand but whatever is used it *must always be more free-draining than the growing media under the turf and should always have the same consistency over consecutive applications*. Topdressing over time and properly applied will fill hollows and provide a smooth finish. The addition of free-draining sand will also improve drainage and infiltration and therefore improve turf health. It is an operation suited to all High Traffic areas and less so to large expanses of passive recreation lawn.

Thatch Management

Thatch – the decomposing dead parts of turf - builds up over time on the surface of the rootzone. Some thatch is beneficial and is normally decomposed by earthworms at a rate that keeps it at an optimal level, but as it gets too thick (for instance when pH is too high or when chemicals are applied – both of which kill earthworms), most of the turf ends up rooted in the thatch rather than in the topsoil which exposes it to rapid drying out during hot periods.

Thatch can be controlled by vertical mowing. The blades are set so they penetrate to the bottom of the thatch. If the thatch is thick, a second pass may be required at right angles to the first. Following vertical mowing remove the cut thatch.

3.4.1 Soil management and mowing for Turf in High Traffic Areas

Areas of high usage require soils that allow for a high resistance to compaction. A sandy, well drained turf underlay allows for fast drainage and a sufficient water holding capacity for turf growth. Example components are:

Medium grade clean sand Sandy loam soil or site soil Composted soil conditioner conforming with AS4454	60-80% by volume 10-30% by volume 10% by volume	e.g.7 parts washed sand/2 part sandy loam/1part compost

(Leake and Haege 2014, p.82)

Base level requirements for turf fertilisers in high traffic areas are:

Lime and/or dolomite	2kg/m^3 at mixing
Balanced compound NPK turf starter fertiliser	2.9kg/100m^2 after placement
Minor trace elements	300g/m^3 at mixing

(Leake and Haege 2014, p.82)

To ensure that the density of the grass sward and the height of the grass in high traffic areas is maintained:

Turf in High Traffic Areas - Work Required	Frequency
Remove litter before mowing	At each mowing
Cut grass height must not be less than 40mm or greater than 60mm high. Do not remove more than 50% of the grass height at any one time.	Spring – every 5 weeks Summer – every 4 weeks Autumn – every 5 weeks Winter – every 12 weeks
Clippings to be removed. Consider leaving clippings where they fall if acceptable.	At each mowing

3.4.2 Soil management and mowing for Turf in Passive Recreation Areas

Soils in passive areas require the provision of moderate resistance to compaction. In these areas a sandy loam 'turf underlay' topsoil mix is suitable. This soil mix provides a high water holding capacity reducing the requirement for watering during dry periods.

Example components are:

Medium-coarse grade washed sand Sandy loam soil or site soil Composted soil conditioner conforming with AS4454	30-50% by volume 40-60% by volume 10% by volume	e.g.5 parts washed sand/4 part site soil or sandy loam/1part compost

To ensure that the density of the grass sward and the height of the grass in passive recreation areas are maintained:

Turf in Passive Recreation Areas - Work Required	Frequency
Remove litter before mowing	At each mowing
Cut grass height must not be less than 50mm or greater than 80mm high. Do not remove more than 50% of the grass height at any one time.	Spring – every 6 weeks Summer – every 5 weeks Autumn – every 6 weeks Winter – every 12 weeks
Clippings to remain where they fall except when near drains or footpaths	At each mowing

3.4.3 Soil management and mowing for Turf in in Sports Fields

Sports turfs require a sandy root zone soil for rapid drainage which contains a minimum amount of silt and clay to provide a reasonable cohesion and water holding capacity. The main requirement being that the rootzone allows for rapid removal of rain or irrigation water so that play is interrupted for the shortest time. The infiltration rate should vary between 150mm/hr (newly laid sports turf) to 50mm/hr after several years of play. An example of the components to use are:

Medium grade clean sand Sandy loam soil or site soil Composted soil conditioner conforming with AS4454	80-90% by volume 5-10% by volume 5-10% by volume	e.g. 8 parts washed sand/2 parts sandy loam/1 part compost

(Leake and Haege 2014, p.84)

Base level requirements for sports turf fertilisers are the same as for High traffic areas.

Rolling

In addition to the management techniques listed for Turf in High Traffic Areas, sports field turf and specifically cricket pitches will require rolling during preparation of the pitch for a match. Prior to

rolling, the lower part of the rootzone must not be too wet or too dry. Rolling must be undertaken only by experienced greenkeepers.

Other sports turf types will require rolling from time to time during renovation.

3.4.4 Weeds in Turf

Many weeds in turf are controlled by regular mowing and others are encouraged when lawns are cut too low, as is Bindii – the most common and unpleasant weed in turf. Where Bindii *(Soliva pterosperma)* occurs in the lawn raise the mowers cutting height. Bindii also prefers acidic, low-nutrient soil, so apply dolomite at the rate of one handful per square metre in autumn and fertilise turf with a handful of poultry manure per square metre in spring, summer and autumn.

3.5 Native Grasses

Native grasses are a viable alternative to lawn grasses where areas are only used occasionally. Many native grass species are capable of being mown infrequently and just as mowing helps to increase the sward of lawn grasses, it has the same effect on native grasses.

A distinction must be made between native grass areas on campus that are intended to be walked and sat upon (as these may require mowing) and those which are purely ornamental. Where native grasses are for ornamental purposes only, a larger selection of species can be used.

The advantages of native grasses over exotics grasses are that they require less water and fertiliser and less frequent mowing.

Figure 20 A native grass (*Themeda triandra*) intended for an ornamental purpose only, but with infrequent mowing can be used as a lawn for occasional use.

Suitable species are:

Microlaena stipoides (Weeping Grass) and cultivars

*Themeda triandra (*Kangaroo Grass) and cultivars

Bothriochloa macra (Red Grass)

Rytidosperma spp. (Wallaby Grass)

Zoysia macrantha (Prickly Couch) and cultivars

Echinopogon caespitosus (Tufted Hedgehog Grass)

Poa affinis (Poa)

Figure 7 A *Microlaena* lawn. *Microlaena Stipoides* has recently been sown via hydromulching in the University Creek corridor.

Native grasses can be grown on those soil mixes listed for turf in section 3.4.1 and 3.4.2 depending on the intensity of use. Note that fertilisers should be decreased in areas planted to native grasses because it degrades native grasses in favour of exotic grasses and annual weeds.

To ensure that native grasses are maintained in a way that supports their survival and persistence in the landscape:

Native Grasses - Actions Required	Frequency
Mow all areas of native grasses flatter than 3H:1V. Do not mow during flowering and seeding. Where mowing is required at this time, mow in a pattern that allows sections of at least 50% of any given area to persist with flowering seed heads. Maintain length not less than 200mm.	Minimum of once per year to a maximum of two times per year
Native Grass Areas steeper than 3H:1V (and including all other areas where burning may replace mowing as a management tool) may be maintained by controlled / planned fire according to ecological and catchment requirements; in some communities, no planned fire will be applied, but in other areas fire will be applied within a defined fire frequency range and prescription. The action must be co-ordinated with Roads and Maritime, Rural Fire Service and Local Council.	As required during the controlled burn season as established by the Rural Fire Service

4.0 All Areas of the Campus

4.1 Disease and Insect Control

Always consider biological and non-chemical controls in favour of chemical controls in the first instance because the margin for error is far greater with chemicals. For example most insecticide will also harm beneficial insects as well as the target species.

For a comprehensive reference to the identification, diagnosis and control of of pests and diseases refer to "*What Garden Pest or Disease Is That? Organic and Chemical Solutions for Every Garden Problem" by Judy McMaugh 2000 New Holland*

4.2 Irrigation

Water sensitive urban design principles must be applied in order to minimise the use of potable water. This may include:

- Falling pavements to landscape or grass areas or by introducing permeable pavements
- Harvesting stormwater from nearby buildings for storage and later use for the irrigation of the sports fields
- The use of sub-surface irrigation in order to reduce the use of water.
- The use of bio-retention vegetated swales to slow and polish runoff and recharge groundwater

Water Sensitive Urban Design principles should be incorporated into the surrounding landscape to slow and filter runoff for the improvement of the water quality of the catchments of Mars Creek and University Creek.

Figure 21 "Castellated kerb" allows water into the central median where it is "polished" by vegetation and slowed from entering the stormwater system. Planting benefits by being passively watered.

Figure 22 A partially planted drainage swale in the Cochlear Forecourt.

New building works require detention tanks and/or infiltration retention systems for storing stormwater. Tank storages should be considered as a source of irrigation water for gardens in the vicinity. Plantings on slab will almost certainly require an automatic irrigation system, usually delivered by a sub-surface drip network. Ensure that irrigation valve boxes are located in convenient and logical locations and set flush with the ground. Ensure enough garden taps are also provided so that all areas of the garden can be watered if automatic irrigation fails. Assume 30 metre length hoses to be used so 60-65 metres between tap locations is a good general rule.

The irrigation system to be designed, supplied and installed by an experienced specialist irrigation sub-landscape contractor, nominated by the Landscape Contractor and approved by the University or their landscape consultant. After selection they will be required to prepare detailed irrigation plans and specification for approval by the University prior to commencing work. The Landscape Contractor will co-ordinate the irrigation installation to the Universities approval. Ensure completion of the irrigation system before the commencement of any other landscape works, so as to provide a readily available supply of water to planting areas.

Upon completion of the installation of irrigation works the Landscape Contractor is to run through the system to ensure that it is operating correctly and instruct the client's representative in the correct operation and maintenance of the system. Manuals, warranties, and a minimum of two programs, summer and winter are to be provided to the client's representative at the time of completion.

At the completion of the installation the landscape contractor must provide complete dimension drawings, based on the approved design plan, of the entire irrigation system as executed, clearly indicating the type and location of all sprinkler lines, heads, etc. This is essential to ensure that the irrigation lines and valve boxes can be located for repair and replacement.

The University has an all of campus drawing prepared by David Buckle and Associates titled; *"Macquarie University Hydraulic Services Potable Cold Water and Fire Hydrants".* This drawing should be referred to when new tap points and irrigation is to be installed and Work as Executed irrigation drawings should be kept with this document.

5.0 Specific Landscape Management Activities for Specific Areas of the Campus

Each of the following specific areas of the campus has been identified in the Macquarie University Design Excellence Strategy and Urban Design Guidelines and a series of landscape principles for each has been described with the objective of retaining and enhancing the identity of each.

The following maintenance issues for each specific area are highlighted with a view to improving the management of the spaces in order to achieve these principles.

5.1 Primary public domain spines

Wally's Walk

Character

Wally's Walk is characterised by an avenue of Plane trees running for the full length of the Walk. Not all trees are uniform in size and some trees are suffering due to overshadowing and close proximity to buildings. The understorey is varied throughout its length, there are occasional large weedy gaps in the understorey, but the predominant understorey plant is *Hedera Helix* (English Ivy).

Figure 23 The western end of Wally's Walk - Plane Trees with Ivy below.

Comments

- Consider the introductions of *Platanus* (Plane Tree) hybrids when making replacements and choose types that are suited to shaded situations. Infill bare areas with understorey planting.

- Consider replacement of the *Jacaranda* at the Corner with Christopher Ondaatje Ave with a Plane Tree
- Infill bare understorey areas with new groundcovers to match existing.
- Use a limited understorey palette with *Hedera Helix* as the dominant species

Figure 24 Plane trees adjacent to the building are stunted due to shade and proximity to the building

Wally's Walk Replacement Tree Schedule

Botanical Name	Common Name	Mature Size (H x W)	Notes
Platanus x acerifolia	London Plane	14 x 10m	Plane trees form an Avenue for the full length
Platanus improved cultivars			

Macquarie Walk

Character

Macquarie Walk is currently a road but will eventually be pedestrianised and will be the key pedestrian link due to its connection in the east with the railway station. The current Herring road "Gateway" and University Creek "Crossing" projects will establish strong landscape themes for the Walk.

Comments

Starting in the east, an avenue of Queensland Kauri (*Agathis robusta*) is proposed. This will provide an iconic entry where Macquarie Walk meets University Avenue. The Walk will then traverse

University Creek via a proposed 9 metre wide bridge. The landscape surrounds in this section of the walk will be viewed from the bridge and will consist of the existing riparian trees with proposed endemic understorey planting and native grass lawns accessible to the University population. Where the bridge" lands" to the western side of the creek there is a significant clump of existing Tallowoods (*Eucalyptus microcorys*) which are to be retained.

Figure 25 The "Crossing" bridge over University Creek will "land" behind the clump of Tallowoods shown in the centre of the picture and will connect with Macquarie Walk.

The creek transition zone of the walk terminates where the walk intersects with Christopher Ondaatje Ave after which a Plaza Zone commences adjacent to the proposed University Common.

Figure 26 Looking West down the Axis of the proposed Macquarie Walk. The Creek transition Zone ends where it intersects with Christopher Ondaatje Walk at the pedestrian crossing in the middle ground.

The planting will transition here from the informal planting of the Creekside to formal streetscape planting which will continue to the west. Exotic deciduous trees should be used to delineate the "Plaza".

The current precedent for streetscape planting occurs at the library and the Australian Hearing Hub where Grey Gums (*Eucalyptus punctata*) have been planted as a street tree. It is suggested that over time the full length of the Walk with the exception of the Plaza Zone, riparian zone and the intersection with University Avenue to the south should be planted with an avenue of Grey Gums.

The landscape management goals of the Macquarie Walk will be to strengthen each of these planted landscape zones – use riparian trees and planting in the Creek Zone, use exotic deciduous trees in the Plaza Zone, use Pyrus "Chanticleer" to match those on University Avenue at the intersection and use Grey Gums as the street tree for the length of the Walk. The underplanting on the south-eastern edge of Macquarie Walk opposite the Common should be bold and dense to form an edge to the plaza and to visually terminate the common.

Figure 27 Grey Gum street trees outside the library -the precedence for future streetscape planting along Macquarie Walk. Note stakes and metal collar should be removed.

Existing street trees along Macquarie Drive have a galvanised metal collar around the base of the trunk to keep the gravel surround in place. This should be removed over time to prevent trunk girdling. Timber stakes on existing street trees should also be removed.

Suggested Macquarie Walk Replacement Tree Schedule

Botanical Name	Common Name	Mature Size (H x W)	Notes
Agathis Robusta	Queensland Kauri	14 x 10m	Gateway Entry street trees
Anetholea anisata	Aniseed Tree		Creek Zone tree planting
Angophora costata	Smooth-barked Apple		
Allocasuarina littoralis	Black She-oak		
Ceratopetalum apetalum	Coachwood		
Synoum glandulosum	Scentless Rosewood		
Syncarpia glomulifera	Turpentine		
Tristaniopsis laurina	Water Gum		
Eucalyptus punctata	Grey Gum		Street trees from University Common to the South

Nyssa sylvatica	Black Gum	11 x 6 m	Plaza trees delineating University Common
Pyrus ussuriensis	Manchurian Pear	9 x 7 m	
Ulmus parvifolia	Chinese Elm	10 x 11 m	
Pyrus "Chanticleer"	Ornamental Pear	9 x 7 m	Intersection with University Avenue in the South

Figure 28 When traffic is removed, the southern edge of the Walk can be converted to a formal avenue. The existing Flooded Gums shown can be retained in the background.

Sir Christopher Ondaatje Avenue

Character

Sir Christopher Ondaatje Avenue runs North-south and takes in several campus spaces along the way. As a result it takes on the character of the spaces that it passes through – notably the University Common and the Central Courtyard. This is compatible with the landscape principles which seek to reflect Asian sensibilities of enclosure and openness. Ultimately the Avenue will connect Mars and University Creeks.

Figure 29 The edge of the University Common from Sir Christopher Ondaatje Avenue planted with Liquidambers

Comments

To reinforce these principles with the landscape planting the existing garden beds in front of buildings should be reinforced with dense plantings that create an edge. Where new trees are required use screening trees against buildings such as Lilly Pilly (where sunlight access to buildings is not affected), and use deciduous trees in open areas to increase the sense of contrast between openness and enclosure. Pruning should be undertaken to “lift” the canopy of deciduous trees and evergreen native trees should not be under-pruned to maintain bushiness to the ground.

Where there is space; for instance where the Walk passes the Common and the Grove, consider planting double rows of avenue trees.

The existing under-planting has large gaps which could be infilled to improve delineation. The Avenue is also used for interpretive plantings along its length. This should be continued but with consideration for denser planting within interpretive planting areas to achieve a consistent look along the length of the walk and to exclude weeds.

Sir Christopher Ondaatje Avenue Replacement Tree Schedule

BOTANICAL NAME	COMMON NAME	MATURE SIZE (H X W)	NOTES
Flindersia australis	Crows Ash	10 x 8 m	Other species may be used eg; for interpretive gardens.
Arytera lautererana	Corduroy Tamarind	10 x 8 m	
Toona ciliata	Red Cedar	20 x 10 m	

Brachychiton discolor	Pink Lacebark	10 x 5 m	

5.2 Primary parks and plazas

The University Common and Library Lawn

Character

The University Common is a very large open space with a large expanse of lawn, planted and paved areas.

Comments

Various tree species are used throughout the Common. No particular extant species is seen as a precedent for further planting. Consider extending the range of species to more unusual selections to improve the arboretum collection. Generally frame outside extent of the space with evergreen native trees and use deciduous trees to delineate plaza areas.

The central feature of the Common is the large expanse of lawn for passive recreation. The lawn requires attention due to invasion by Clover and other weeds. The Clover advantages the lawn by reducing the amount of nitrogen fertiliser the lawn requires, but does not wear well. Observe the lawn as the warm season returns and observe whether the turf increases and the Clover decreases. If not, apply a single application of a proprietary spring lawn fertiliser followed at six to eight-week intervals by an application of sulphate of ammonia at 15g per sq m. The nitrogen content encourages grass growth and acts as a deterrent to the clover. Other weeds such as Bindi's may require chemical control before seed set.

The open vista across the library lawn should be retained.

Figure 30 Clover in lawn. The Clover adds nitrogen but does not wear well. Take remedial action if the lawn does not increase in vigour as the weather warms.

Shrub garden beds to the north and south of the Common require replanting. A strong planting theme should be developed that includes tall shrubs/small trees not commonly used in landscape plantings to improve the arboretum collection. A visual connection to the central courtyard can then be achieved with lower under-planting.

Figure 31 Shrub beds between the Central Courtyard/Wally's Walk and the University Common. Replace with plantings that allow a visual connection between the spaces – small trees with clear trunks and low under-planting.

Suggested University Common Replacement Tree Schedule

BOTANICAL NAME	COMMON NAME	MATURE SIZE (H X W)	NOTES
Angophora costata	Smooth-Barked Apple	15 x 10 m	
Pyrus ussuriensis	Manchurian Pear	9 x 7 m	
Arytera lautererana	Corduroy Tamarind	10 x 8 m	
Rhodoleia championii	Hong Kong Rose	5 x 5 m	Replacement small trees for north and south shrub beds
Tabebuia argentea	Silver Trumpet Tree	5 x 5 m	
Barklya syringifolia	Crown of Gold	5 x 5 m	

The Central Courtyard

Character

The Central Courtyard is dominated by a grid planting of nearly 100 Lemon-scented Gum (*Corymbia citriodora)* planted to represent a Phalanx of the Roman Army.

The courtyard was once mostly grassed, now only a smaller central lawn, broken up by paths, remains. The lawn is worn and not conducive to use for sitting.

The surrounding buildings are concrete, the paving and the trunks are grey and the furniture is silver.

Comments

Wherever Gums are damaged or die they should be replaced immediately to maintain the integrity of the original plan. The lawn should be raised and the paths that dissect it removed to make it more useful and to improve the condition of the lawn. Colourful furniture, some sections of brighter paving and some judicious under-storey planting would all help to brighten up the space.

Figure 32 Dead Lemon Scented Gum should be replaced.

Figure 33 The existing lawn should be raised and the intersecting paths removed.

Central Courtyard Replacement Tree Schedule

BOTANICAL NAME	COMMON NAME	MATURE SIZE (H X W)	NOTES
Corymbia citriodora	Lemon-scented Gum	30 x 10 m	Replace dead or dying trees immediately

The Grove (East Common)

Character

The Grove is an informal space with a forest atmosphere created by a grove of Eucalypts with a sensitively fitted sinuous path and picnic settings.

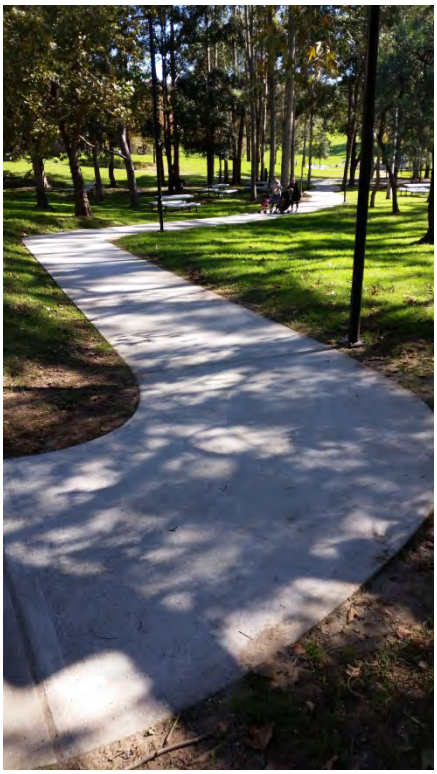

Figure 34 Path through the Grove

Comments

The Grove requires attention to the lawn area under the trees to ensure that a thick sward is maintained. Where turf is to be replanted, shade tolerant varieties could be introduced.

To the East of the Grove adjacent to the paved forecourt of Building E7b and to the west Adjacent to the Campus Hub Building there is the opportunity for deciduous shade tree planting with preferably interesting species to add to the Arboretum collection.

Arts Lawn (West Common)

The Arts Lawn will be built on land that is currently a car park. Some existing Eucalypts occur at the edges of the car park. These should be retained where possible in any future development. The landform should step down towards Mars Creek and planting should not prevent a visual link to the Creek.

5.3 Secondary Parks and plazas

Frank Mercer Biological Sciences Garden

The diversity of plantings should be maintained and enhanced in the spirit of the teaching garden for which it was envisaged. A landscape maintenance audit should be undertaken to ensure that the objectives of the garden and the cultural requirements of all plantings are being met.

Jim Rose Earth Science Garden

The diversity of plantings should be maintained and enhanced in the spirit of the teaching garden for which it was envisaged. Currently there are many bare spots in the garden. A landscape maintenance audit should be undertaken to ensure that the objectives of the garden and the

cultural requirements of all plantings are being met. The courtyard is divided into two sections, with the gardens on the north and west planted with Laurasian (predominantly) northern hemisphere species while the gardens on the eastern and southern sides are planted with Gondwanan (predominantly) southern hemisphere species. The path between the two is referred to as the "Wallace Line". The audit should identify further replacement plantings that continue the biogeographic story and which also contribute to making the garden a pleasant retreat.

Figure 35 Bare spots could be replanted with appropriate species. Watering requirements should be checked.

Mars Creek Plaza

Mars Creek Plaza is a proposed plaza which will terminate the future extension of Macquarie Walk. Ensure that any future planting does not screen views to Mars Creek or prevent solar access. The Plaza will mediate between the more formal Macquarie Walk and the natural area down to Mars Creek.

Figure 36 Potential view from the proposed Mars Creek Plaza

Wally's Walk Park

The lawn is a popular passive recreation space as it slopes to the north with views to the Mars Creek corridor.

Figure 37 Wally's Walk Park

There are a few spots where the lawn has worn or is underperforming and also gaps in planting. These should be reviewed for any remedial action that can be taken.

Western Road Park

The recently completed Western Road Park is a roof garden (refer to section 3.3). The landscape maintenance schedule accompanying the construction documentation should be reviewed for inclusion into the ongoing maintenance and inspection checklist and as-built drawings should be reviewed and updated for location of irrigation.

Macquarie Theatre Courtyard

Character

The Macquarie Theatre Courtyard is a fairly recent landscape wrapping around two sides of the building - east and south - with large areas of gravel and concrete pavement.

There are patches of Mondo Grass missing at the entrance which should be replaced immediately. A steeply sloping lawn to the south of the building is planted to lawn. This area is difficult to access for maintenance and should be replanted in its entirety with a low maintenance, drought-tolerant groundcover such as *Lomandra* (already planted at the top of the bank)

Figure 38 Mondo Grass bed requiring replacement planting

Figure 39 Steeply sloping lawn should be replaced with low maintenance groundcovers such as *Lomandra* shown at the top of bank.

On the grassy bank leading up to building W3A there are sections of the slope too steep for grass to succeed. Consider replacement with low-maintenance, drought-tolerant garden beds.

Cochlear Forecourt

The Cochlear Forecourt landscaping is now well-established. There are some bare areas on the University Avenue frontage which require replacement landscaping and denser plant spacing.

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)
Agathis robusta	Kauri Pine	5
Pyrus calleryana "Chanticleer"	"Chanticleer"	3
Tristaniopsis laurina	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)
Flindersia australis	Crow's Ash	5
Toona ciliata	Red Cedar	5
Waterhousia floribunda 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)
Angophora costata	Smooth-Barked Apple	5
Eucalyptus punctata	Grey Gum	5
Waterhousia floribunda	Weeping Lilly Pilly	3

Eastern Road

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

Western Avenue

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

West Precinct Road

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

Secondary East-West Pedestrian Connections

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

Secondary North-South Pedestrian Connections

BOTANICAL NAME	COMMON NAME	Underprune lower branches to a height of; (m)
Backhousia myrtifolia	Grey Myrtle	3
Elaeocarpus eumundii	Blueberry Ash	3
Flindersia pimenteliana	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)
Angophora costata	Smooth-Barked Apple	15 x 10 m
Corymbia gummifera	Red Bloodwood	25 x 10 m
Eucalyptus haemastoma	Broad-leaved Scribbly Gum	15 x 10 m
Eucalyptus piperita	Sydney Peppermint	20 x 10 m
Eucalyptus sclerophylla	Hard-leafed Scribbly Gum	20 x 10 m
Eucalyptus squamosa	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 B – Three Monthly Maintenance Audit Form

This form is to be completed by the Campus Asset Manager responsible for landscape assets.
Two copies of this completed form are required. One is to be issued to maintenance staff for action. The second is to be maintained for records.
Extra pages can be attached to the electronic record if needed

Date of Inspection: _____

Inspected by: _____

Location	Landscape Type / Area	Issue	Remediation Works Required	Cost Estimate	Date to be completed	Variation/ Defect?

Signed: _____ Date: _____

Issued to: _____ Date: _____

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

Lesnok ENVIRONMENTAL

Document Control

ISSUE	DESCRIPTION	SIGNED	DATE
A	Preliminary Draft Issued for Review	DM	21/05/15
B	Final Draft Issued for Review	DM	27/05/15
C	Final Draft Issued for Review	DM	23/06/15
D	**Final Issue**	**DM**	**31/07/15**

Vegetation Management Plan
(Incorporating Threatened Species Plan)

Bushland Remnants, Macquarie University

July 2015

context

with

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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/m^2/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.

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 areas[1] 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.

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 podsolic soils and yellow podsolic 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 understory, 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.

Figure 3. Study Area Vegetation

3.2.1 (c) Coastal Enriched Sandstone Dry Forest[2]

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 weed 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 Park[3], 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), *Tetratheca 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 Sheathtail-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**

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'.

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	*Epacris purpurascens* var. *purpurascens* 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 overshading 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 Replenishment of native ground covers in riparian area
	Remnant STIF/CSSF trees near Research park Drive	Moderate	4	Loss of remnant canopy	
	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	
Acacia bynoeana	V	E	Heath/scrub on clayey ridge-tops and slopes.
Acacia pubescens	V	V	Variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland.
Callistemon linearifolius	V	V	Rock platforms in dry sclerophyll forest on the coast and adjacent ranges.
Darwinia biflora	V	V	Heath/scrub on clayey ridge-tops and slopes between Lane Cove and the Hawkesbury River.
Darwinia peduncularis	V	V	On or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone.
Deyeuxia appressa	E	E	Record is from 1941. Locally extinct and little known of its ecology.
Epacris purpurascens var. purpurascens		V	Open forest/woodlands on deeper shales and near creeks.
Eucalyptus camfieldii	V	V	Heath/scrub on clayey ridge-tops and slopes.
Eucalyptus nicholii	V	V	Northern tablelands species commonly planted in Sydney.
Eucalyptus scoparia	V	V	Northern tablelands species commonly planted in Sydney.
Genoplesium baueri		V	Sparse sclerophyll forest and moss gardens over sandstone.
Grammatis stenophylla	E	E	Grows on rocks in rainforest and in wet sclerophyll forest.
Haloragodendron lucasii	E	E	Very localised in sheltered gullies in Barra Brui.
Leptospermum deanei	V	V	In sandstone scrub near watercourses.
Melaleuca deanei	V	V	Heath/scrub on clayey ridge-tops.
Persoonia hirsuta	E	E	Woodland and heath on clayey ridge-tops

Pimelea curviflora var. curviflora	V	V	Heath/scrub on clayey ridge-tops.
Prostanthera marifolia	X	CE	Unknown. Formerly confined to the Seaforth area.
Tetratheca glandulosa	V	V	Heath/scrub on moderately clayey ridge-tops and slopes.
Wilsonia backhousei		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
Pseudophryne australis	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.
Litoria aurea	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 (*Typha spp*.), spikerush (*Eleocharis spp*.), *Juncus kraussii, Schoenoplectus litoralis* and *Sporobolus virginicus*. 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.
Varanus rosenbergi	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.
Nettapus coromandelianus	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.
Ptilinopus superbus	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.
Apus pacificus	Fork-tailed Swift	M		Aerial feeder that rarely lands in Australia during summer migration.	Low. May potentially fly over the study area.
Hirundapus caudacutus	White-throated Needletail	M		Aerial feeder that rarely lands in Australia during summer migration.	Low. May potentially fly over the study area.
Ephippiorhynchus asiaticus	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
Ardea ibis	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.
Botaurus poiciloptilus	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.
Ixobrychus flavicollis	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.
Haliaeetus leucogaster	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.
Hieraaetus morphnoides	Little Eagle		V	Open and riparian woodlands, grassland and arid regions, shunning dense forest.	Low. May potentially fly over the study area.
Pandion cristatus	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.	
Numenius minutus	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.
Callocephalon fimbriatum	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.
Calyptorhynchus lathami	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.
Glossopsitta pusilla	Little Lorikeet		V	Eucalyptus forest and woodland, particularly along water courses. Requires small tree hollows for nesting	Low. Potential to fly across project area.
Lathamus discolor	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.
Ninox connivens	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.
Ninox strenua	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.
Tyto novaehollandiae	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.
Merops ornatus	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
Anthochaera phrygia	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 (*Eucalyptus sideroxylon*), White Box (*E. albens*), Yellow Box (*E. melliodora*) and Yellow Gum (*E. leucoxylon*) as well as heavy infestations of mistletoe (*Amyema spp.*).	Low. Potential to fly across/forage within northern portion of project area.
Daphoenositta chrysoptera	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.
Petroica boodang	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.
Dasyurus maculatus	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.
Cercartetus nanus	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
Petaurus australis	Yellow-bellied Glider		V	Restricted to areas of tall, mature eucalypts.	Low. There is no habitat within the study area for this animal.
Pteropus poliocephalus	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.
Saccolaimus flaviventris	Yellow-bellied Sheathtail-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.
Mormopterus norfolkensis	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.
Falsistrellus tasmaniensis	Eastern False Pipistrelle		V	Hollow-roosting bat that forages in eucalypt woodland.	High. Potential to forage within/traverse study area. No roosting habitat present.
Miniopterus schreibersii	Eastern Bentwing-bat		V	Cave-roosting bat that forages in well-timbered habitats	High.

Scientific name	Common name	EPBC	TSC	Habitat*	Likelihood of occurrence
oceanensis				and open grasslands.	Potential to forage within/traverse study area. No roosting habitat present.
Scoteanax rueppellii	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.

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

Macquarie University, Macquarie Park, NSW

Prepared for Macquarie University / 16 June 2017

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Taylor Thomson Whitting (NSW) Pty Ltd, Consulting Engineers | ABN 81 113 578 377
48 Chandos Street, St Leonards NSW 2065 | +612 9439 7288 | ttw.com.au

Structural
Civil
Traffic
Facade
Consulting
Engineers

Contents

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.

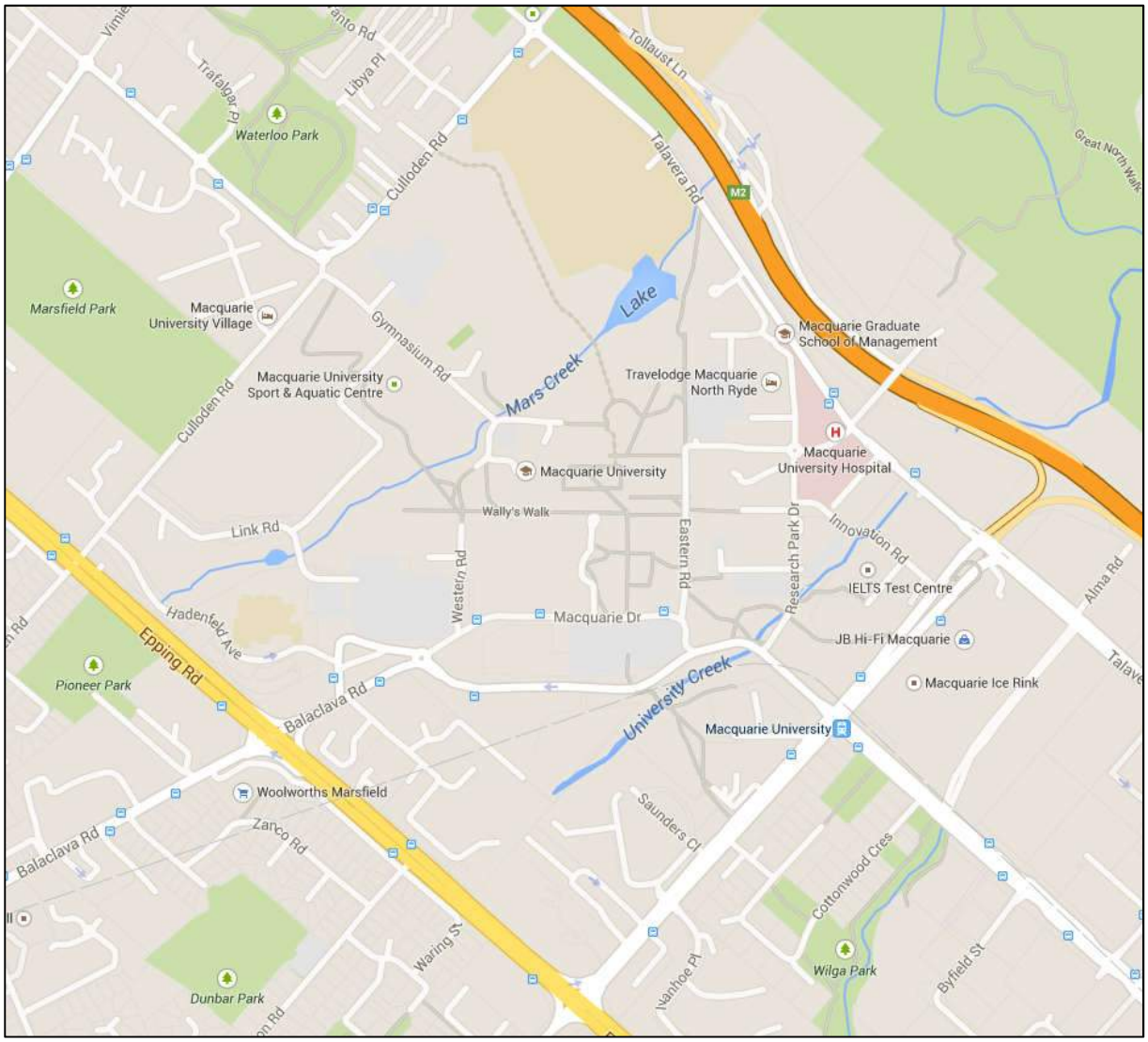


Figure 1 Locality Plan (source: Google)

Figure 2 Aerial Photo

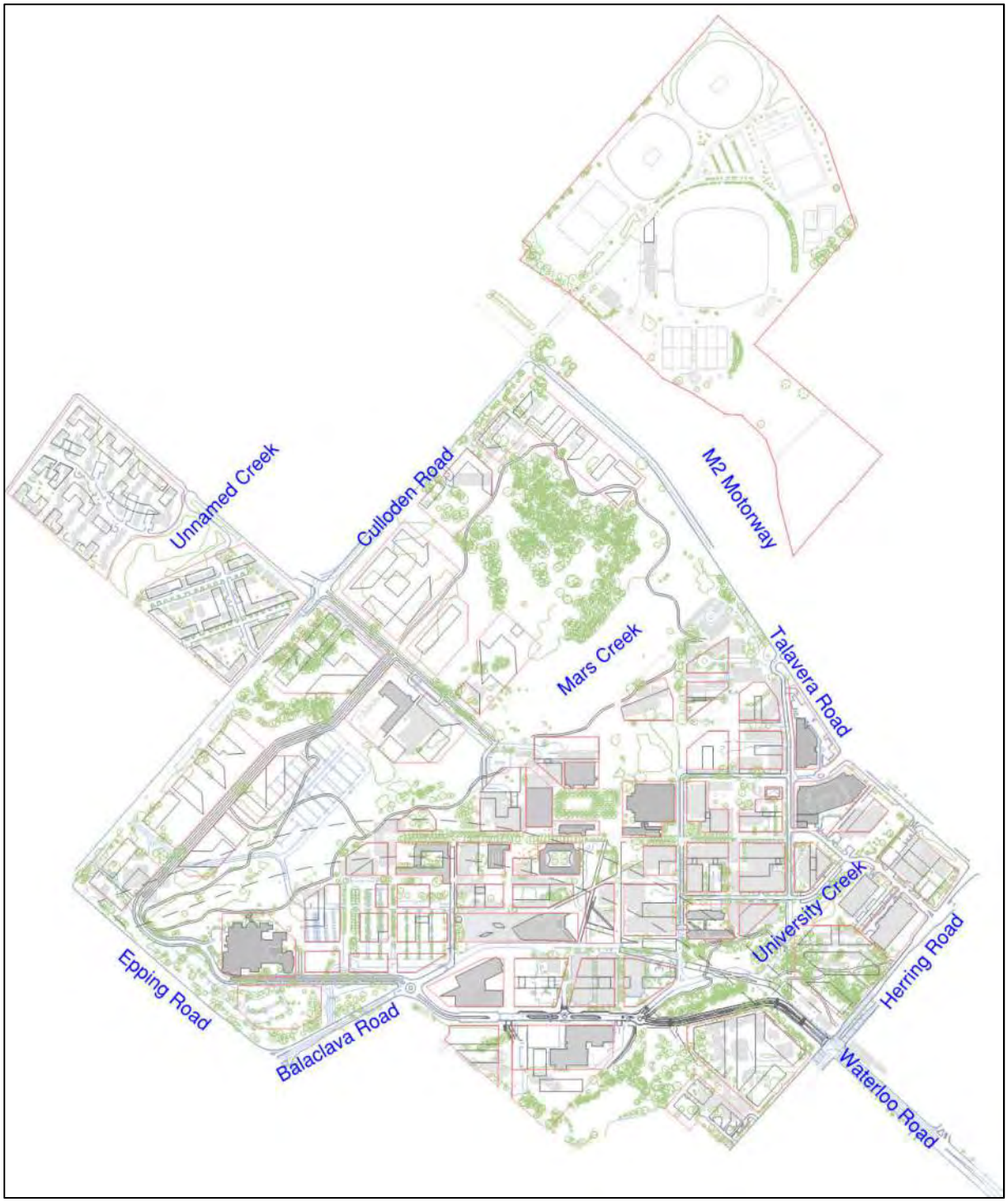


Figure 3 Macquarie University Master Plan

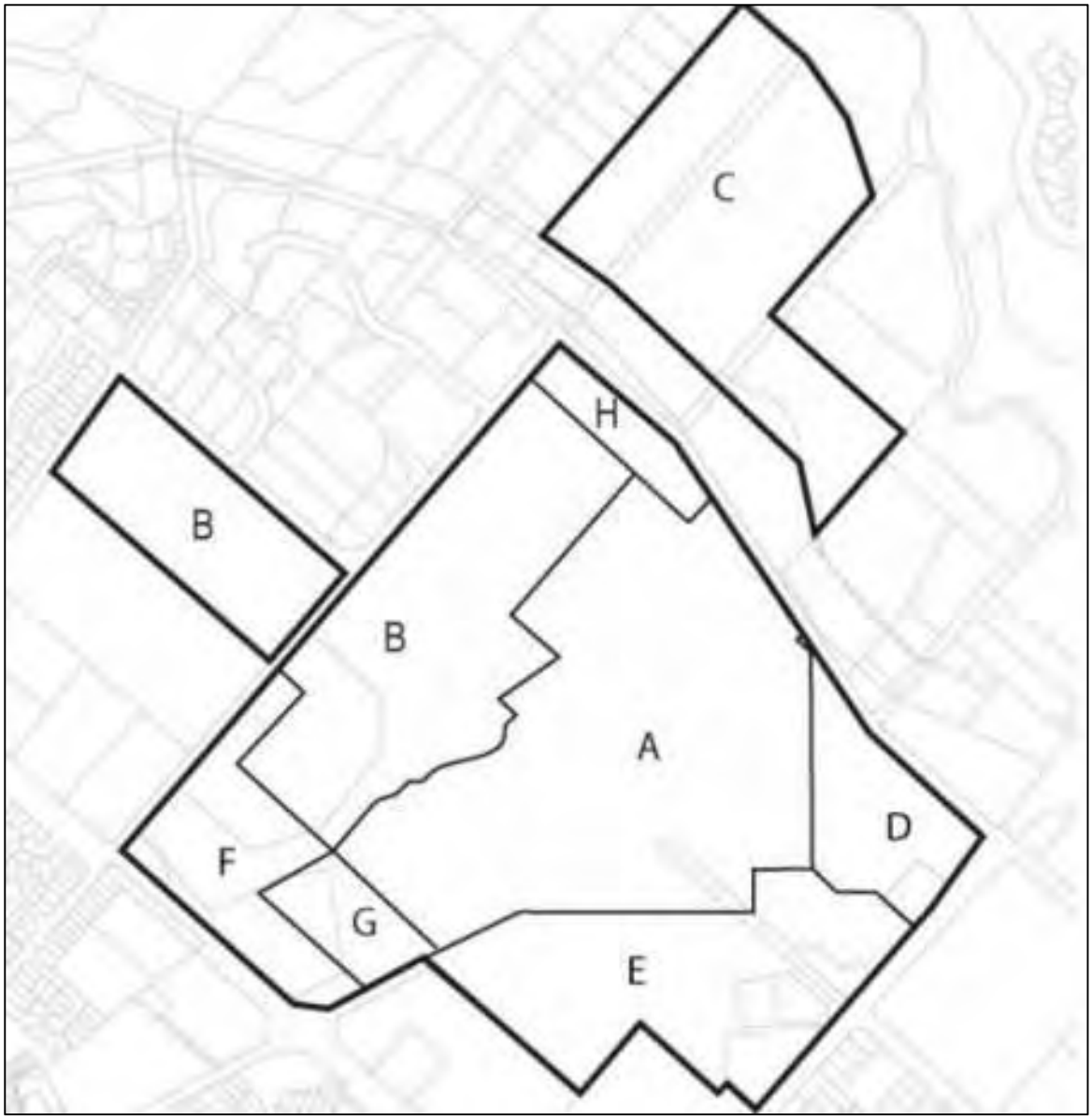


Figure 4 Precinct Layout (Source Cox Design Excellence Strategy and Urban Design Guidelines)

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

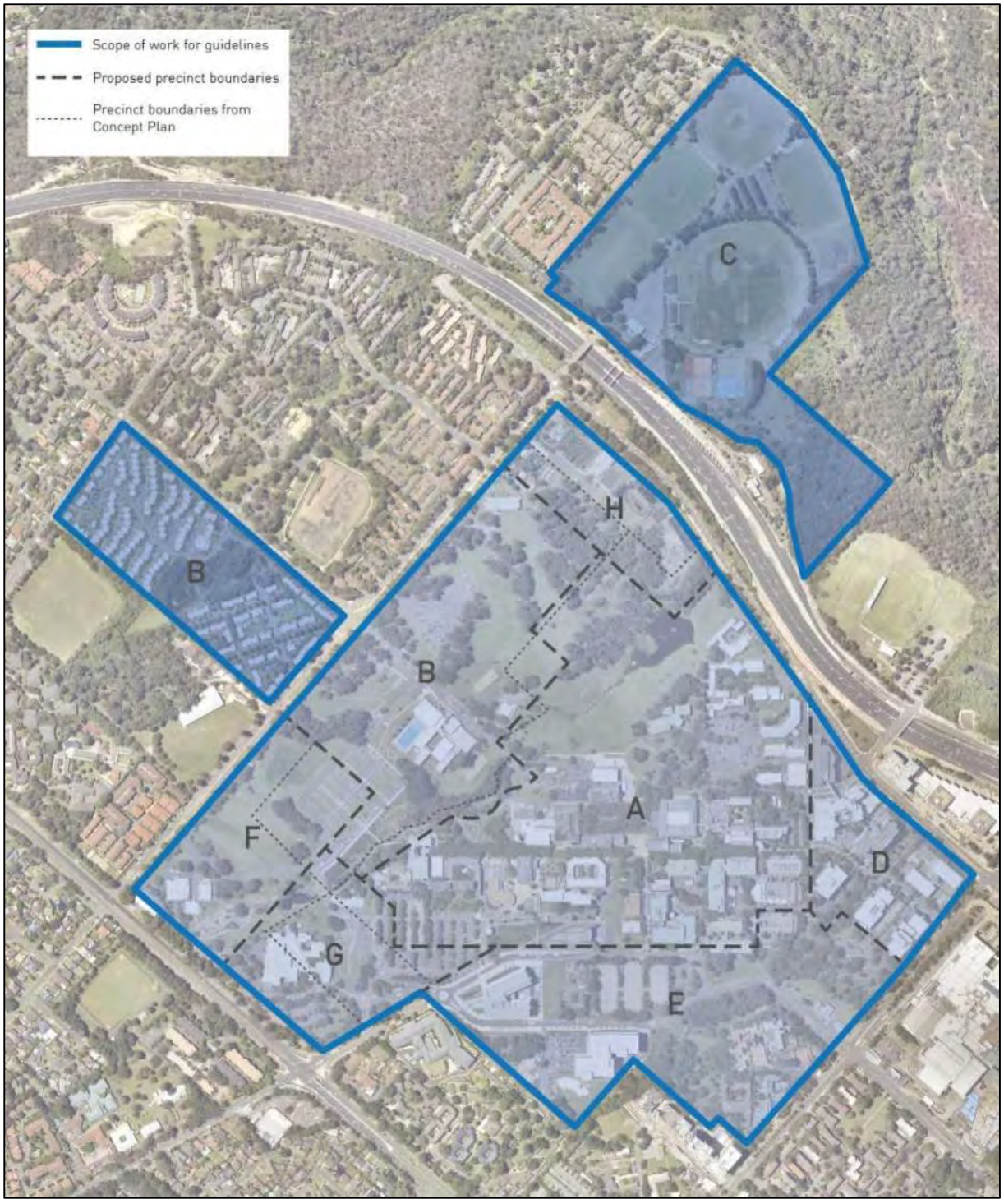


Figure 5 Proposed Precinct Boundaries (Source Cox Design Excellence Strategy)

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.

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.

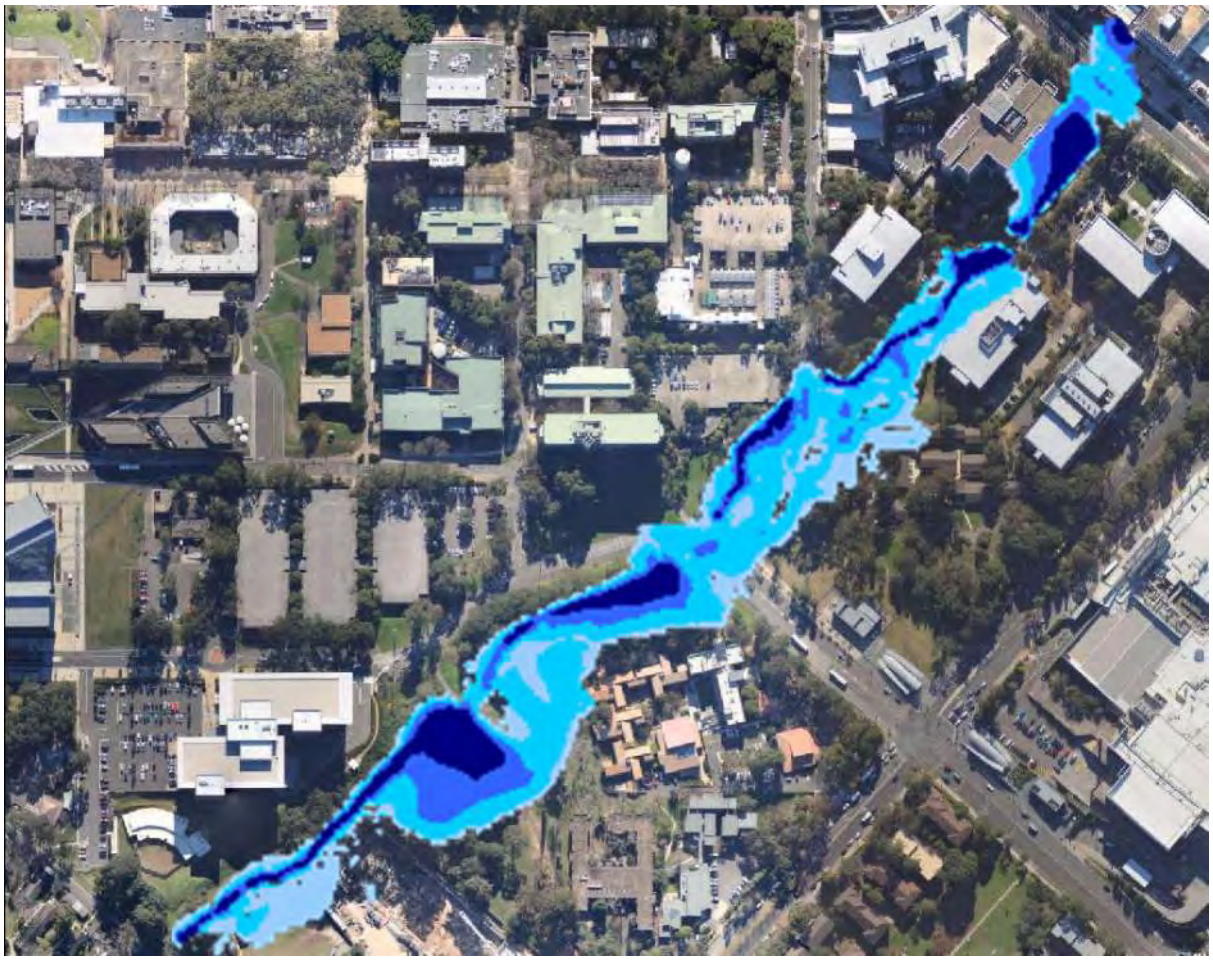


Figure 6 Pre-2013 100-year flood model results in University Creek

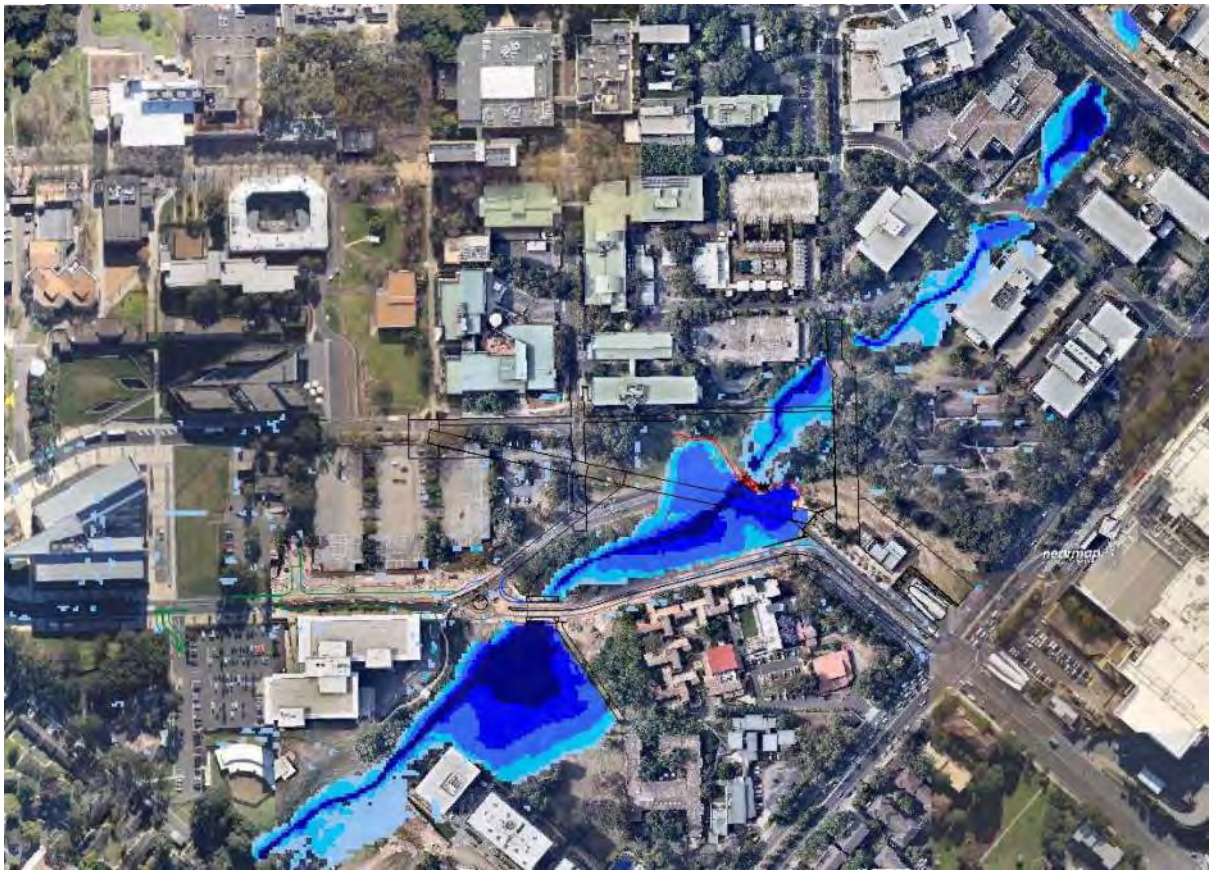


Figure 7 Proposed 100-year flood results in University Creek (Refer to Appendix A for detailed map)

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: – 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.

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 he 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.

Prepared by
TAYLOR THOMSON WHITTING (NSW) PTY LTD

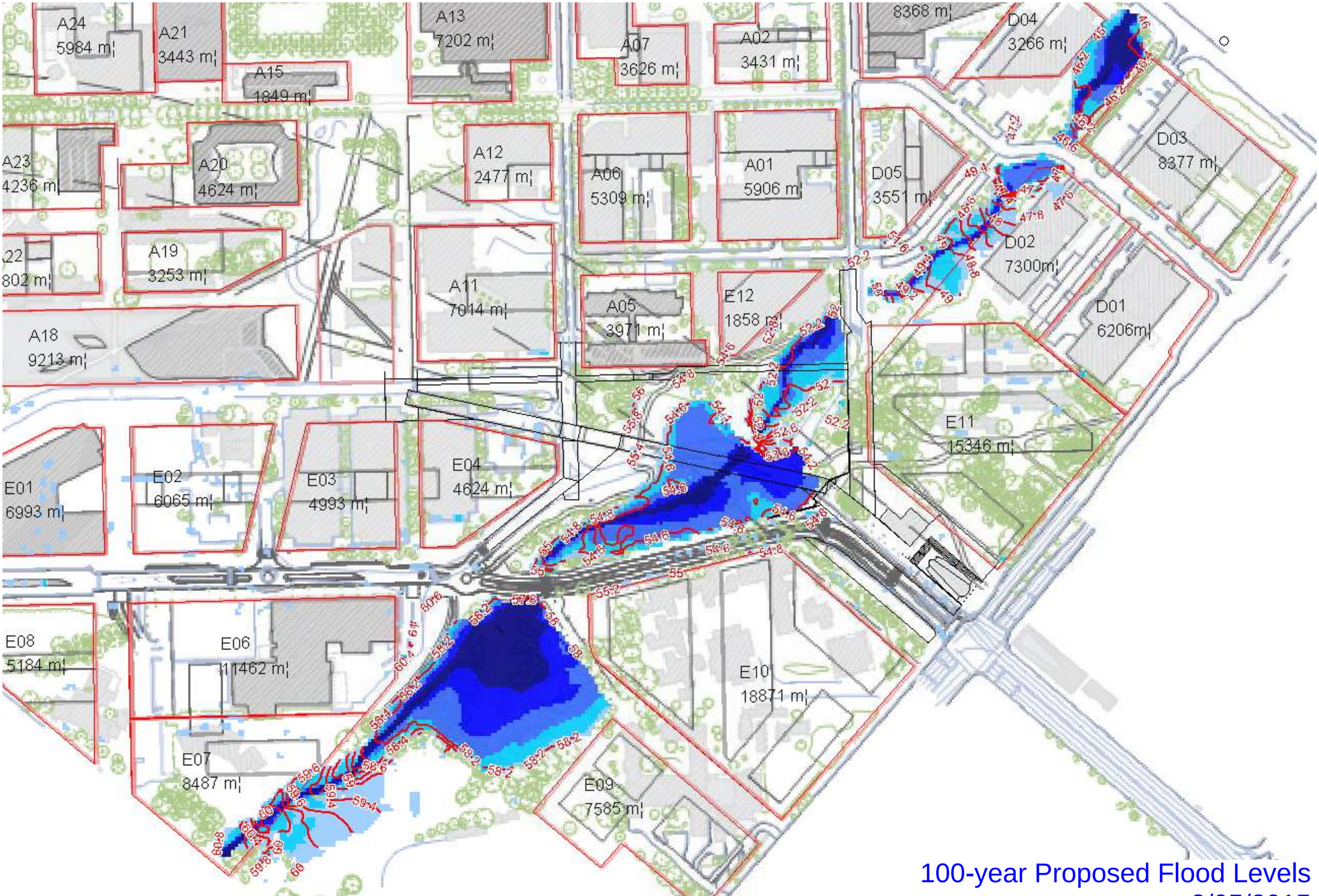
EIRIAN CRABBE
SENIOR ENGINEER

Authorised By
TAYLOR THOMSON WHITTING (NSW) PTY LTD

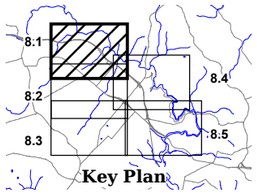
STEPHEN BRAIN
TECHNICAL DIRECTOR

\\ttw\dfs\Jobfiles\2013\1314\131406\Reports\TTW\170616 Stormwater and Utilities Managment Plan Rev. 1.docx

Appendix A – Flood Maps



100-year Proposed Flood Levels
8/05/2015



Mapping Limit

NORTH

LEGEND
Water Depth (m)

- 0.1 to 0.2
- 0.2 to 0.4
- 0.4 to 0.6
- 0.6 to 0.8
- 0.8 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- > 2.0
- Flood Contour (m)

0 200 400
metres

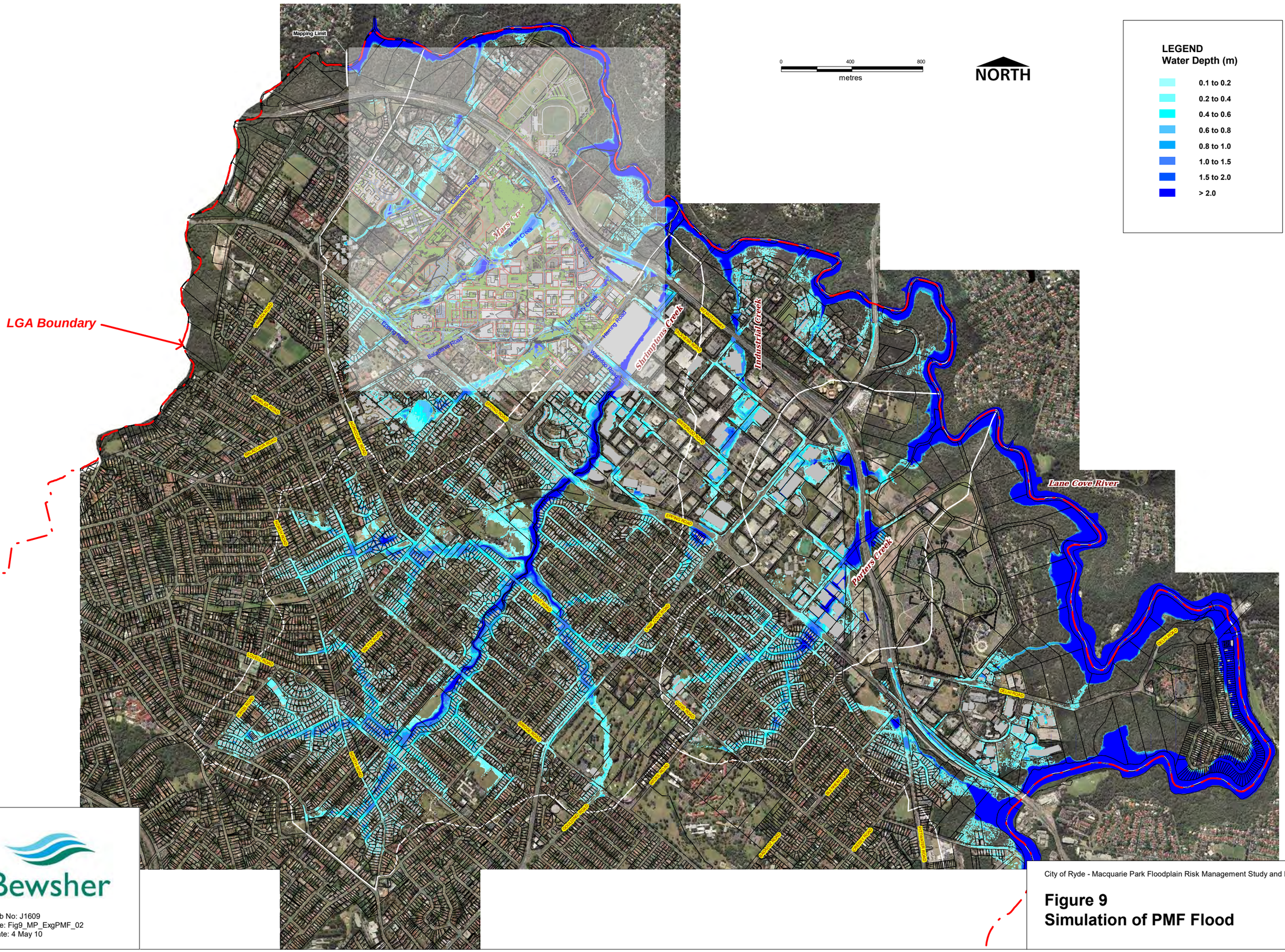
Culloden Road
Mars Creek
Mars Creek
M2 Motorway
Talavera Road
University Creek
Herring Road
Waterloo Road
Epping Road
Balaclava Road
MIERA ROAD
M2 MOTORWAY

Bewsher

Job No: J1609
File: Fig8.1_MP_Exg100y_02
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)



Bewsher

Job No: J1609
File: Fig9_MP_ExgPMF_02
Date: 4 May 10

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

Figure 9
Simulation of PMF Flood

Figure 49 100 Year ARI Design Flood Event, Existing Catchment Peak Flood Extent

Culvert ID	Top Water Level - Culverts (mAHD)							
	Existing				Post Development			
	No blockage			50% blockage	No blockage			50% blockage
	1 yr ARI	5 yr ARI	100 yr ARI	100 yr ARI	1 yr ARI	5 yr ARI	100 yr ARI	100 yr ARI
C1	69.56	69.99	70.94	64.47	69.33	69.54	69.72	70.77
C2	63.10	63.48	64.07	61.56	63.025	63.42	63.95	64.32
C3	58.52	58.98	60.15	60.06	58.44	58.89	60.09	59.98
C4	55.66	56.08	56.64	57.44	55.58	56.02	56.56	57.26
C5	53.62	53.82	54.02	54.47	53.58	53.80	54.00	54.47
C6	40.61	40.88	41.32	45.59	40.46	40.84	41.13	45.84

Table G: Top Water Levels in 30 minute storm events

Appendix B – Hydraulic Services

DBA Hydraulics
Building Environmental Services
ABN: 103 106 282 875

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Utilities Report

Company	**: Taylor Thompson Whitting (NSW) Pty. Ltd.**	**Date**	**: 17 July 2015**
Attention	**: Stephen Brain**	**From**	**: Len Hutton**
Project	**: Macquarie University Masterplanning to 2065**	**Sent**	**: By email**
Subject	**: Utilities Report for Hydraulic Services**	**File**	**: 3020**

Introduction

This report has been prepared to satisfy Condition 4 of the Macquarie University Concept Plan which requires a Utilities Management Plan to be put in place as contained in 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 apprized 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.

The services covered by this study are potable water and natural gas supplies. Each of these services is described as follows.

Potable Water & Fire Hydrant Services

Existing 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 1) and Culloden Roads (Figure 2). 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:

- 2976 MU Potable Cold Water & Fire Hydrants H-000 to H-020

The cover page of the Potable Cold Water & Fire Hydrants document set is displayed as Figure 3.

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Utilities Report

Figure 1. Balaclava Rd Main Meter

Figure 2. Culloden Road Main Meter

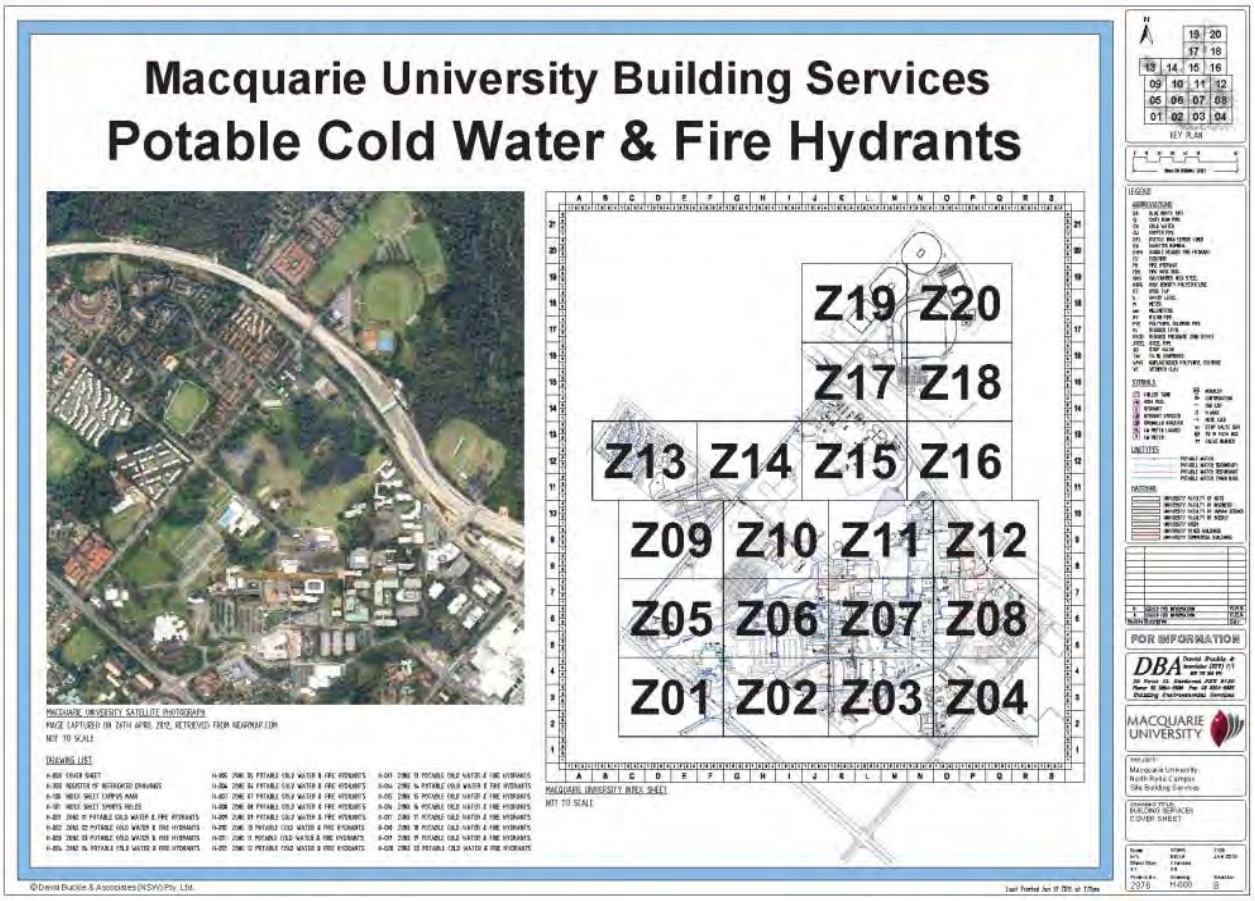


Figure 3. Macquarie University Potable Cold Water & Fire Hydrants zone plans index page.

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Masterplanning

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 A).

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.

Supply Design Principals

The design principals to be adopted for Macquarie University water infrastructure are aimed at providing a robust network with a degree of redundancy built in by the inclusion of multiple connections to Sydney Water mains and the adoption of ring mains and sub ring main loops ensuring that each significant asset is fed from a network without a single point failure. This level of redundancy will require the planned extension of Sydney Water mains in Talavera Road to avoid single point weakness. This degree of protection is provided in two levels of security. The primary level of security being provided to those services reticulated within the primary services tunnel feeding the core academic buildings where this level of security of supply already exists. The non core academic buildings are currently served from direct buried street services which currently are not provided with this level of redundancy and need extensions to perimeter mains or completion of sub loops to shore up mains stability.

The exception to this general principal is the sports field precinct which is isolated from the campus and the authority infrastructure by the M2 Motorway.

The sports field precinct varies from the main campus in that it is virtually on a peninsula and relies upon a single point of connection to Sydney Waters infrastructure via a meter and backflow prevention station located at Culloden Road Sports Precinct entrance (Figure 4).

Figure 4. Sports Fields Main Meter

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Utilities Report

Potable water use in this precinct is limited various showers and sanitary facilities around the sports fields and greenkeepers sheds with no significant commercial usages. The Utilities Action Plan continues to adopt this level of land use as sports fields and open parkland. The anticipated peak water demands for potable use would never exceed the current peak simultaneous demands imposed by the irrigation system requirements.

We are currently unaware of any sub-metering or monitoring of functional usages in this precinct.

The primary water usage in the sports field precinct is top up water supply to the various irrigation systems employed around the precinct. Subject to prevailing climate and drought conditions this water supply to irrigation systems can be curtailed at any time given notice by Sydney Water.

An alternative water supply suitable for use as irrigation is being researched. The source of this supply is a sewer mining system adopting a natural biological filtration bed system which we understand is still undergoing final certification processes.

It should be noted that the current irrigation systems installed have been constructed in such a manner as to be able to adopt an alternative water supply without risking back flow contamination of the potable water supply usages.

Any change of use or alternative water supply proposals proposed for this precinct will require the preparation of a demand analysis to be incorporated into the overall hydraulic model to ensure that the current infrastructure is capable of supporting the proposal.

Natural Gas Services

Existing 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:

- 2976 MU Natural Gas & High Voltage Electricity H-000 to H-020

The cover page of the Natural Gas & High Voltage Electricity document set is displayed as Figure 5.

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

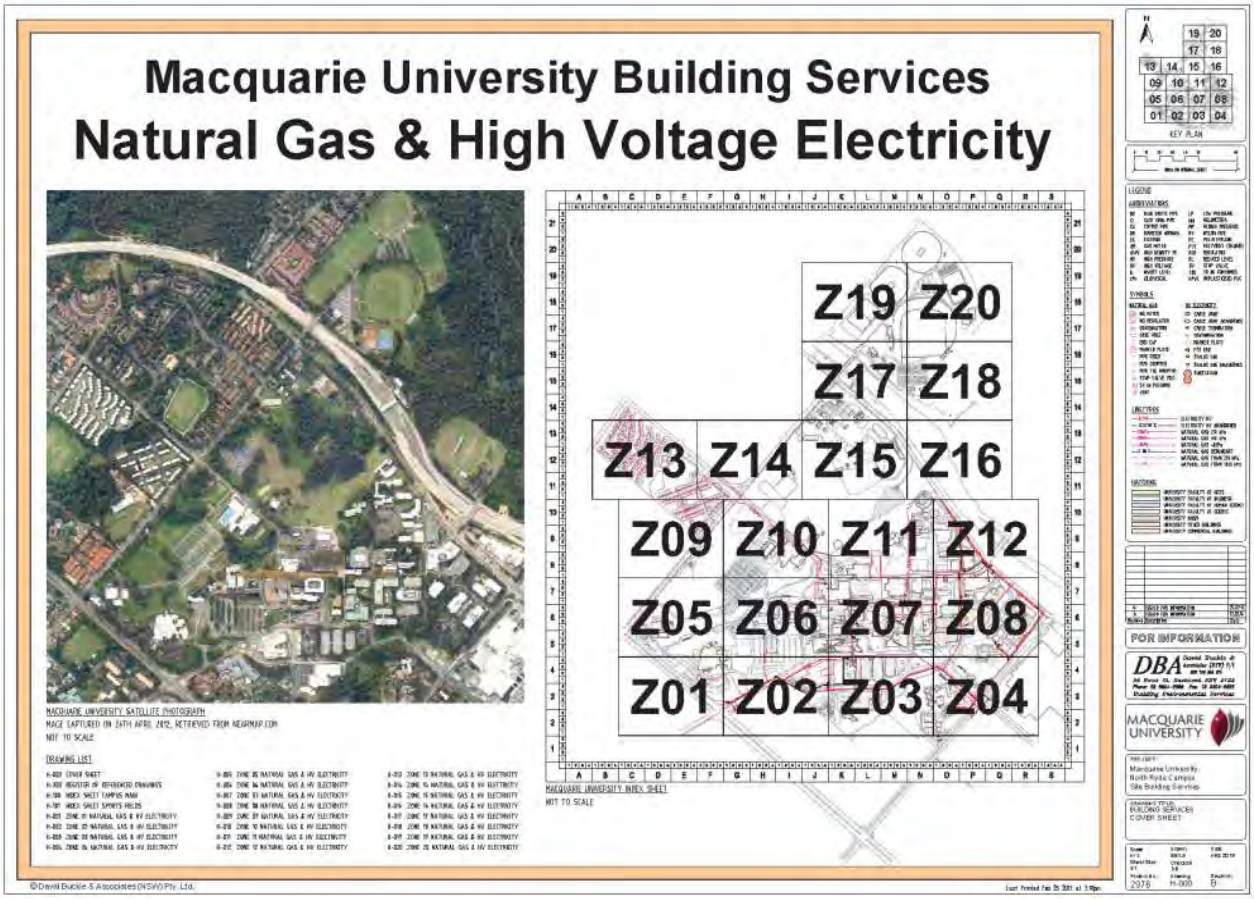


Figure 5. Macquarie University Natural Gas & High Voltage Electricity zone plans index page.

Masterplanning

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 A).

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 he proposed load.

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Utilities Report

Services Tunnels

The original Macquarie University campus site was developed around a central plant concept with central services reticulated to points of use via a tunnel system which linked all key buildings. The advantage of the tunnel concept was that all services remained accessible for servicing or connection to and rendering upgrade works easy without the need for excavation or major interruption to services. In the ensuing years and following changes in social behaviour these tunnels have been adopted by security staff as a method of discrete movement around the site and for covert building entry.

Following the early construction of buildings on the site the tunnel system of servicing buildings from central plant has lost favour and the later buildings have adopted local packaged plant and not been connected to, or the tunnels extended to cover them. The current master plan concept is to re-embrace the tunnel concept and extend the current system of tunnels to cover the future core academic structures. This concept is illustrated in the accompanying drawings titled H02 Hydraulic Services Concept Plan Potable Water & Fire Hydrants and H03 Hydraulic Services Concept Plan Natural Gas (refer Appendix A).

The adoption of the tunnel concept will enable the reticulation of central energy waste heat and cooling from any central energy plant without interruption to faculty services and render such sustainable energy projects more viable. This tunnel system is restricted to the core academic campus precinct.

In cognisance of the security staff preference for use of the tunnel system as a concealed access way we propose a change of design parameter for the tunnel system by introducing a system of building connection point alcoves whereby all valves and connection points within the tunnels will be located in gated alcoves immediately outside the tunnels leaving the spine of the system free for access.

Should you require any further information please contact the undersigned.

Yours truly,
For David Buckle & Associates

Len Hutton

David Buckle & Associates (NSW) Pty Ltd
Suite 8, 38 Rowe St, Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au

Appendix A

The following documents are attached as Appendix A:

- H01 Hydraulic Services Concept Plan Services Zoning
- H02 Hydraulic Services Concept Plan Potable Water & Fire Hydrants
- H03 Hydraulic Services Concept Plan Natural Gas

ZONES

SPORTS FIELDS / OPEN SPACE ZONE SERVICED BY AUTHORITY STREET MAINS

PERIMETER ZONE SERVICED BY AUTHORITY STREET MAINS (TYP)

ACCOMMODATION PRECINCT INDEPENDENT OF CAMPUS INFRASTRUCTURE

CORE ACADEMIC ZONE SERVICED BY UNIVERSITY (TYP)

PERIMETER ZONE SERVICED BY AUTHORITY STREET MAINS (TYP)

PERIMETER ZONE SERVICED BY AUTHORITY STREET MAINS (TYP)

CORE ACADEMIC ZONE SERVICED BY UNIVERSITY (TYP)

EXISTING SERVICES TUNNEL (TYP)

COMMERCIAL ZONE SERVICED BY UNIVERSITY (TYP)

IMAGERY REFERENCE:
GOOGLE EARTH PRO V 7.1.2.2041. (JANUARY 1, 2014). MACQUARIE UNIVERSITY, NSW, AUSTRALIA. 33° 46 25.77"S, 151° 46' 45.54"W, EYE ALT 1 KM. AEROMETREX 2015. HTTP://WWW.EARTH.GOOGLE.COM [JULY 16, 2015].

LEGEND:

LINETYPES AND HATCHING:

- EXISTING SERVICES TUNNEL OUTLINE (TUNNEL OFFSET 4M FOR CLARITY)
- PERIMETER AUTHORITY MAIN SERVICED
- NON-ACADEMIC COMMERCIAL MU SERVICED
- CORE ACADEMIC MU SERVICED
- SPORTS FIELDS AUTHORITY MAIN SERVICED

ABBREVIATIONS:

CW	COLD WATER	kPa	KILOPASCAL
DN	DIAMETER NOMINAL	NG	NATURAL GAS
EX	EXISTING	TYP	TYPICAL

Revision	Description	Date
P3	PRELIMINARY ISSUE FOR INFORMATION	17.07.2015
P2	PRELIMINARY ISSUE FOR INFORMATION	29.05.2015
P1	PRELIMINARY ISSUE FOR COMMENT	07.05.2015

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TaylorThomsonWhitting
Consulting Engineers
48 Chandos Street St.Leonards NSW 2065
T: +61 2 9439 7288 F: +61 2 9439 3146 twsyd@ttw.com.au
Taylor Thomson Whitting (NSW) Pty Ltd A.C.N. 113 578 377

DBA Hydraulics
Building Environmental Services
Suite 8, 38 Rowe St. Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au
David Buckle & Associates (NSW) P/L ABN 33 106 282 875

CLIENT:
MACQUARIE UNIVERSITY
OFFICE OF MAJOR PROJECTS
SYDNEY NSW 2109
PH: (02) 9850 7111

PROJECT:
CAMPUS MASTER PLAN
HYDRAULIC SERVICES

DRAWING TITLE:
HYDRAULIC SERVICES
CONCEPT PLAN
SERVICES ZONING

PRELIMINARY

SCALE	DRAWN	DATE
1:250	EB/LH	JULY 15
SHEET	CHECKED	REVISION
B1	DB	P3
PROJECT NO.	DRAWING	NORTH
3020	H-01	

LAST PRINTED
July 17 2015 at 10:32am

POTABLE WATER AND FIRE HYDRANTS

EXISTING COLD WATER SERVICE (TYP)
EX CW DN100
DN150
EX CW DN300
EXISTING SYDNEY WATER MAIN (TYP)
EX CW DN250
EX CW DN150
CW DN150
EX CW DN150
CW DN150
PROPOSED COLD WATER SERVICE (TYP)
CW DN150
EX CW DN150
EXISTING SYDNEY WATER MAIN (TYP)
EXISTING COLD WATER SERVICE (TYP)
EX CW DN100
EX CW DN150
EX CW DN150
CW DN100
CW DN100
EX CW DN150
EX CW DN250
EX CW DN150
PROPOSED SERVICES TUNNEL EXTENSION (TYP)
EXISTING SERVICES TUNNEL (TYP)
EX CW DN150
EX CW DN250
PROPOSED COLD WATER SERVICE (TYP)
EX CW DN150
CW DN150
CW DN150
CW DN150
CW DN100
EX CW DN250
EXISTING SERVICES TUNNEL (TYP)
EX CW DN150
EX CW DN300
EX CW DN150
EX CW DN150
EXISTING COLD WATER SERVICE (TYP)
EX CW DN200
EXISTING SYDNEY WATER MAIN (TYP)
EX CW DN150
EX CW DN600
EX CW DN100
EX CW DN500

IMAGERY REFERENCE:
GOOGLE EARTH PRO V 7.1.2.2041. (JANUARY 1, 2014). MACQUARIE UNIVERSITY, NSW, AUSTRALIA. 33° 46 25.77"S, 151° 46' 45.54"W, EYE ALT 1 KM. AEROMETREX 2015. HTTP://WWW.EARTH.GOOGLE.COM [JULY 16, 2015].

LEGEND:

LINETYPES AND HATCHING:

- EXISTING SERVICES TUNNEL OUTLINE (TUNNEL OFFSET 4M FOR CLARITY)
- SERVICES TUNNEL EXTENSION PROPOSED
- EX WATER SERVICE
- PROPOSED WATER SERVICE
- SYDNEY WATER NETWORK

ABBREVIATIONS:

CW	COLD WATER	kPa	KILOPASCAL
DN	DIAMETER NOMINAL	NG	NATURAL GAS
EX	EXISTING	TYP	TYPICAL

SYMBOLS:

- END CAP
- SERVICE CONTINUATION

Revision	Description	Date
P3	PRELIMINARY ISSUE FOR INFORMATION	17.07.2015
P2	PRELIMINARY ISSUE FOR INFORMATION	29.05.2015
P1	PRELIMINARY ISSUE FOR COMMENT	07.05.2015

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80mm ON ORIGINAL SHEET

TaylorThomsonWhitting
Consulting Engineers
48 Chandos Street St.Leonards NSW 2065
T: +61 2 9439 7288 F: +61 2 9439 3146 tteyd@ttw.com.au
Taylor Thomson Whitting (NSW) Pty Ltd A.C.N. 113 578 377

DBA Hydraulics
Building Environmental Services
Suite 8, 38 Rowe St. Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au
David Buckle & Associates (NSW) P/L ABN 33 106 282 875

CLIENT:
MACQUARIE UNIVERSITY
OFFICE OF MAJOR PROJECTS
SYDNEY NSW 2109
PH: (02) 9850 7111

PROJECT:
CAMPUS MASTER PLAN
HYDRAULIC SERVICES

DRAWING TITLE:
HYDRAULIC SERVICES
CONCEPT PLAN
POTABLE WATER & FIRE HYDRANTS

PRELIMINARY

SCALE	DRAWN	DATE
1:3000	EB/LH	JULY 15
SHEET	CHECKED	REVISION
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PROJECT NO.	DRAWING	NORTH
3020	H-02	

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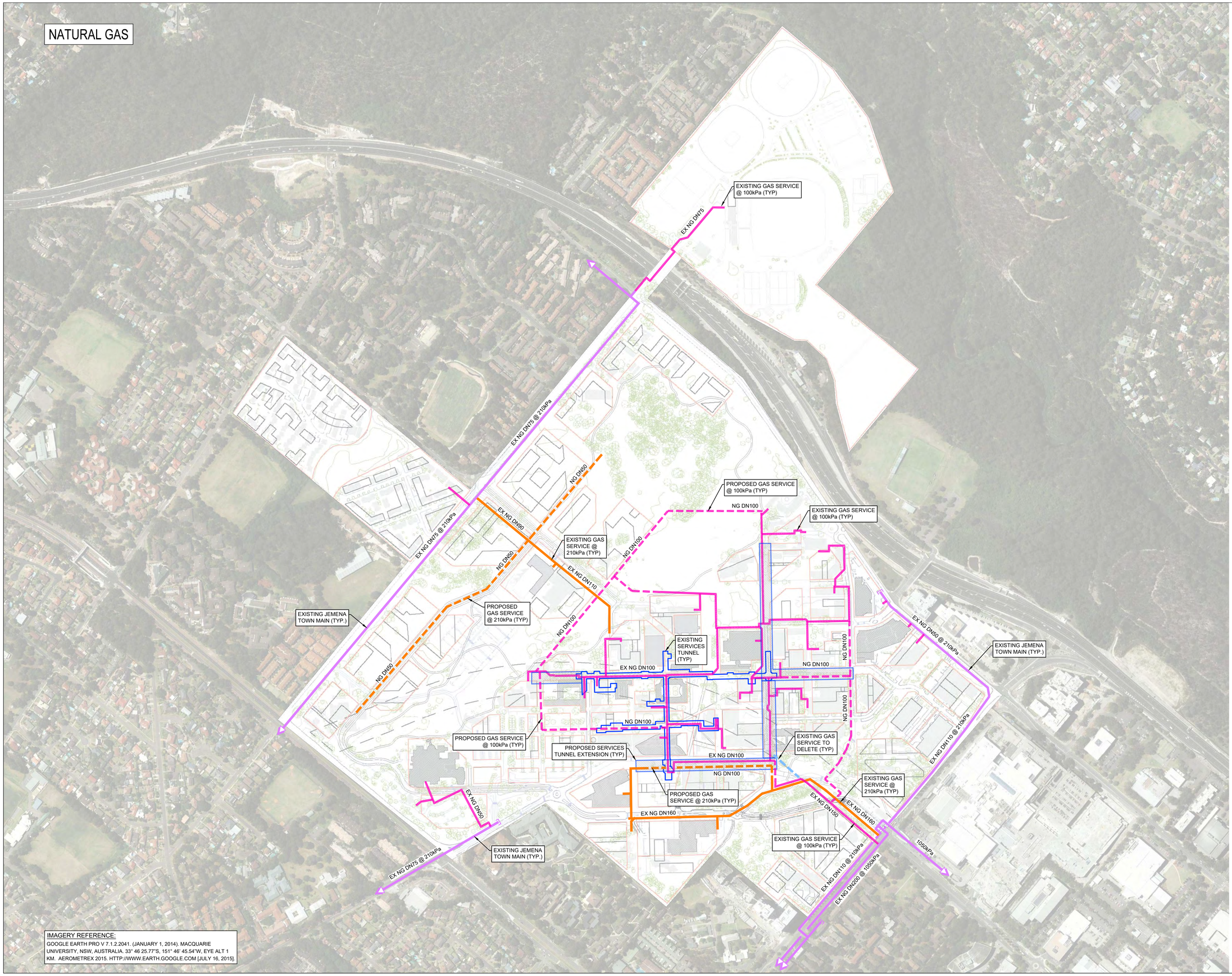
July 17 2015 at 10:36am

NATURAL GAS



IMAGERY REFERENCE:
GOOGLE EARTH PRO V 7.1.2.2041. (JANUARY 1, 2014). MACQUARIE UNIVERSITY, NSW, AUSTRALIA. 33° 46 25.77"S, 151° 46' 45.54"W, EYE ALT 1 KM. AEROMETREX 2015. HTTP://WWW.EARTH.GOOGLE.COM [JULY 16, 2015].

LEGEND:

LINETYPES AND HATCHING:

- EXISTING SERVICES TUNNEL OUTLINE (NOTE: TUNNEL OFFSET 4M FOR CLARITY)
- SERVICES TUNNEL PROPOSED
- EX GAS SERVICE @ 100kPa
- EX GAS SERVICE @ 210kPa
- EX GAS SERVICE TO DELETE
- PROPOSED GAS SERVICE @ 100kPa
- PROPOSED GAS SERVICE @ 210kPa
- JEMENA TOWN MAIN

ABBREVIATIONS:

CW	COLD WATER	kPa	KILOPASCAL
DN	DIAMETER NOMINAL	NG	NATURAL GAS
EX	EXISTING	TYP	TYPICAL

SYMBOLS:

- END CAP
- SERVICE CONTINUATION

Revision	Description	Date
P3	PRELIMINARY ISSUE FOR INFORMATION	17.07.2015
P2	PRELIMINARY ISSUE FOR INFORMATION	29.05.2015
P1	PRELIMINARY ISSUE FOR COMMENT	07.05.2015

0 10 20 30 40 50 60 70 80
80mm ON ORIGINAL SHEET

TaylorThomsonWhitting
Consulting Engineers
48 Chandos Street St.Leonards NSW 2065
T: +61 2 9439 7288 F: +61 2 9439 3146 tws ys@ttw.com.au
Taylor Thomson Whitting (NSW) Pty Ltd A.C.N. 113 578 377

DBA Hydraulics
Building Environmental Services
Suite 8, 38 Rowe St. Eastwood NSW 2122
02 9804 8086 david@davidbuckle.com.au
http://www.davidbuckle.com.au
David Buckle & Associates (NSW) P/L ABN 33 106 282 875

CLIENT:
MACQUARIE UNIVERSITY
OFFICE OF MAJOR PROJECTS
SYDNEY NSW 2109
PH: (02) 9850 7111

PROJECT:
CAMPUS MASTER PLAN
HYDRAULIC SERVICES

DRAWING TITLE:
HYDRAULIC SERVICES
CONCEPT PLAN
NATURAL GAS

PRELIMINARY

SCALE	DRAWN	DATE
1:2000	EB/LH	JULY 15
SHEET	CHECKED	REVISION
B1	DB	P3
PROJECT NO.	DRAWING	NORTH
3020	H-03	

LAST PRINTED
July 17 2015 at 10:41am

Frawley Design Services Pty Ltd
ABN: 23 059 201 900
PO Box 519
Kensington NSW 1465
Phone: 02 9663 3004
Fax: 02 9313 8806
Email: info@frawleydesignservices.com.au
www.frawleydesignservices.com.au

MACQUARIE UNIVERSITY
RYDE CAMPUS MASTER PLAN
SEWERAGE RETICULATION

EXISTING SEWERAGE SYSTEM

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. The accompanying plan shows the location of these sewers and their respective catchments.

In addition there is a Sydney Water sewerage system that services the University's housing villages on the north-western side of Culloden Road.

Apart from the Sydney Water sewers shown on the plan, the Campus is serviced by a network of sewerage reticulation lines owned and maintained by the University.

MASTER PLAN PROPOSALS

1. Commercial Development Sites

In accordance with Sydney Water's servicing policies, individual points of connection to a sewer main will be required for each leasehold parcel of land excised by subdivision. To comply with these policies, it will be necessary to extend Sydney Water's sewer system to provide a connection point within the boundaries of each parcel.

2. Impacts on Sydney Water's Infrastructure

a) In early 2008 discussions were held with Sydney Water regarding the proposed expansion of Gross Floor Areas (GFA) within precincts Station South and Epping Road West. At that time it was estimated that expansion would proceed in keeping with the following timeframes:

- 2007-2012: - 75,000m^2 GFA
- 2012-2017: - another 75,000m^2 GFA
- 2017-2031: - a further 200, 000m^2 GFA

In response, Sydney Water determined that the existing sewer system had sufficient capacity for the proposed developments of 2007-2012 and 2012-2017. However the development planned for 2017-2031 would require amplification of the Balaclava Road Carrier beneath the M2 Motorway.

b) The extent of mains augmentation based upon the current Master Plan cannot be determined accurately without further study. All the same, a preliminary examination clearly indicates that there will be no spare capacity in either sewer Carrier beyond 2017 and as a consequence, upsizing will be necessary.

Brian Frawley

Brian Frawley
MIS Aust

PLAN

ACCOMPANYING FRAWLEY DESIGN SERVICES' REPORT DATED 6.9.2012

SEWER

225 mm

CULLODEN RD

WATERLOO RD

TRAFALGAR PL

UBYA PL

TALAVERA RD

CARRIER

SEWER

CREEK

300 mm P.

MARS

MACQUARIE UNIVERSITY

APPROX EXTENT OF CATCHMENT

M2 MWY

CHRISTIE RD

CARRIER

375mm

MWY

EPPING RD

BALACLAVA RD

SEWER

300MM P.

ROAD

BALACLAVA

KARALEE ST

KARINGAL CT

LUNIKET ST

KOORONG

ZANICO

WARING

HERRING

WATERLOO CRES

ALMA

TALAVERA

VIMIERA

Map:173 Grid:N16 Edition:Sydney UBD Edition 41

0m 40m 80m 120m 160m 200m

Scale 1:5000

Page

Appendix C – Electrical Services

JDG Consulting

Level 3 Accredited Service Provider
Green Futures Pty Ltd
A.C.N. 078 387 489
Suite 407 Atlas Norwest
2-8 Brookhollow Ave
Baulkham Hills NSW 2153
Ph: 02 8861 1888
Fax: 02 8861 1899
www.jdgconsulting.com.au
Email:jdg@jdgconsulting.com.au

28 May 2015

Mr Stephen Brain,
Taylor Thomson Whitting Pty Ltd
L3, 48 Chandos Street
St Leonards NSW 2065

Our ref: 15-2133

MACQUARIE UNIVERSITY
AUTHORITY ELECTRICAL AND TELECOMMUNICATIONS INFRASTRUCTURE

Electrical

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.

Internal to the University campus, High Voltage conduits and cables reticulate within the footpaths. HV feeders from Epping Zone substation enter the site from Herring Road to the north, Balaclava Road to the South West and also Culloden Road to the North West. More recent connections from Macquarie Zone substation enter the site via Waterloo Road with the majority of the site electricity supply capacity available from Macquarie Zone Substation at the South Eastern end of the site.

The greater part of the proposed development within the Macquarie University is within the South East portion of the site adjacent the Waterloo Road entry. HV feeders run within Waterloo Road footpath from Macquarie Zone substation providing supply to existing private development along University Ave and Research Park Drive. Current Ausgrid works are providing additional feeder connections along Waterloo Road from the Macquarie Zone Substation into University Avenue that will provide supply for future development around the Macquarie Park station precinct and existing buildings will be replaced with new high rise mixed development north and south of the station precinct.

Further development within the Macquarie University is proposed in the short term including refurbishment of existing buildings and existing HV infrastructure is sufficient to provide supply to these developments.

Development for the Macquarie University site within the long term will require augmentation of the current Ausgrid network to enable connection of supply including new conduit and HV cabling within the footpaths of the future roads that will be constructed to strengthen the connection between Culloden Road, University Ave and Macquarie Drive. Limited capacity for connection of additional HV feeders from Epping Zone substation and Macquarie Zone Substation are available due to existing road infrastructure constraints and the reducing capacity of the electricity supply available from the existing Ausgrid network infrastructure due to the rapidly developing commercial district of Macquarie Park adjacent to Macquarie University. It is envisaged that a new Ausgrid Zone Substation will be required to be constructed at a location that allows for connection to the existing transmission cabling to support long term development within the Macquarie University site.

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.

New underground telecommunication conduits and pits connect services running from the Herring and Waterloo Road intersection and can accommodate additional proposed telecommunication requirements of proposed new developments.

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

New Telecomminciations 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.

Yours faithfully,

JDG Consulting

Cheralee Heynes

Director

Drawing No.:	Size:	Plot Date.:
1821-E01	A0	4.07.12

Date	No.	Description
4.07.12	A	MASTERPLAN ISSUE FOR INFORMATION

LEGEND

- S.35642 — SUBSTATION LOCATION & NUMBER
- HV DISTRIBUTION FROM EPPING ZONE SUBSTATION
- HV DISTRIBUTION FROM MACQUARIE PARK ZONE SUBSTATION

S.35789 ASTRONOMY AND OBSERVATORIES
ANIMAL ENCLOSURE
UNIVERSITY HOUSING
Epp Pa 14
N3 CARPARK
LAKE
Panel 5
S.4434 Capacity 1.0MVA
GRADUATE SCHOOL OF MANAGEMENT
FROM EPPING ZONE SUBSTATION
LIGHTHOUSE THEATRE
S.8431 Capacity 1.0MVA
N2 CARPARK
W10A GYM
TENNIS COURTS
Sports Centre
GOLF RANGE
N1 CARPARK
C9B
C10A SAM
C9A MARKET
S.8729
CoGen Capacity 4.5MVA
C7A LIBRARY
Central Courtyard
LINCOLN C8A
S.1915 Capacity 3.0MVA
Tunnel
HUB
EXISTING FEEDERS FROM EPPING ZONE SUBSTATION
TO ENERGY AUSTRALIA'S EPPING ROAD MAJOR ZONE SUBSTATION
Y6A PURCHASING
Y6B
Y4A PRINTERY
AUSTRALIAN FILM TV & RADIO SCHOOL
Banksia Cottage
X6A
S.7892 Capacity 600kVA
S.5923
AFTVS&R School
X4 CARPARK
X3 CARPARK
W4 CARPARK
X5A
X5B
W6C
W6B
W5A
W5B
MACQUARIE THEATRE
W6A
W5C
C5B
C5A
C5C
S.3672 Capacity 1.0MVA
S.36012
S.36013
Capacity 1.0MVA
C3A
C3B
C4A
C4B
C4C
E3B
E3A
Library
taxi bus stand
MACQUARIE DRIVE
bus stands
X2A
AHH
W1 CARPARK
W2 CARPARK
C1 CARPARK
C1 CARPARK
C2 CARPARK
C3 CARPARK
E1 CARPARK
S.47942
S.4564
FROM EPPING ZONE SUBSTATION
S.2728
S.5328
S.4564
Epp Pa 2
Epp Pa 19
S.2044
S.3740
S.4514
S.5465
S.5448
S.6861
Gurnaut Cottage
S1A
Parents Co-op Childcare
S11A
Cochlear
S.36014 Capacity 4.5MVA
E10A CARPARK SCIENCE ROAD
E8B
E8A
E8C
F7A
F7B
F7 CARPARK
E7B
E7A
E5A
E5B
E6B
S.7328 Capacity 3.0MVA
F5B CARPARK
E6A
F5A CARPARK Biological Labs on Roof
E4 Capacity CARPARK
F3A CARPARK
S.8146 Capacity
E14D
E14C
E14A
E14B
E12C
E12B
E12A
F11A
E11A
GSM CARPARK
HOTEL
HOTEL CARPARK
F10A
F9A
F9B
F9C
S.35642
S.35643 Capacity 1.8MVA
S.35844 Current Capacity 3.0MVA
F8A
GOODMAN FIELDER
S.6154
S.6636
BD BUILDING
S.4873 SIEMENS
S.7741
S.7740 DOW CORNING
S.4874
S.6151
S.8697
S.8696
MACQUARIE UNIVERSITY RESEARCH FARM
S.1796
UNIVERSITY HOUSING
FROM EPPING ZONE SUBSTATION
Current
Future
6.500A Station Precinct North
SITE
S.7000
MACQUARIE SHOPPING CENTRE
NEW & EXISTING 11kV FEEDERS FOR KNOWN NEW DEVELOPMENT
ROBERT MENZIES COLLEGE
S.3771
DUNMORE LANG COLLEGE
S.3515
MQ Pa 17
MQ Pa 10
FROM MACQUARIE PARK ZONE SUBSTATION
N

Electrical Consultant:

JDG Consulting
Suite 407, Atlas Building
2-8 Borookhollow Ave
Baulkham Hills NSW 2153
Phone: 02 8861 1888
Fax: 02 8861 1899
jdg@jdgconsulting.com.au
www.jdgconsulting.com.au

JDG Consulting
Engineering Consultants
ASP Level 3 &
Electrical Services

Project:

MACQUARIE UNIVERSITY CAMPUS

Drawing Title:

ELECTRICITY INFRASTRUCTURE HV DISTRIBUTION MASTER SITE PLAN

Drawing No.

1821-E01

Drawn By:	Scale:	Rev:
JDG	1:1600	A

Project No.:	Date:
12-1821	4.07.12

Do not dimension or scale off this drawing - always refer to architectural plans.

Drawing No.:	Size:	Plot Date.:
1821-E02	A0	4.7.12

Date	No.	Description
4.07.12	A	INVENTORY REPORT ISSUE

DISCLAIMER

THIS DRAWING HAS BEEN PREPARED BY JDG CONSULTING BASED ON VISUAL OBSERVATIONS MADE ON CAMPUS AND REPRESENTS THE ASSUMED INTERCONNECTIONS BETWEEN SUBSTATIONS AND BUILDING MSBs AS AT JUNE 2012 - A TOTAL AUDIT OF THE CAMPUS ELECTRICAL DISTRIBUTION SYSTEM HAS NOT BEEN UNDERTAKEN AND THEREFORE THE DETAILS INCLUDED ON THIS SCHEMATIC MUST NOT BE RELIED UPON WITHOUT VERIFICATION BY A SUITABLY QUALIFIED ENGINEER.

SPECIAL NOTE

INTERCONNECTIVITY BETWEEN SUBSTATIONS AND MSBs AS SHOWN ARE RELATIONSHIPS AND NOT CONSUMER MAIN ROUTES

SPECIAL NOTE

SUBSTATION POSITIONS SHOWN ON THIS DRAWING ARE APPROXIMATE ONLY AND SHALL NOT BE CONSTUED AS OTHERWISE

S.35789 FROM EPPING ZONE SUBSTATION

S.7391 FROM EPPING ZONE SUBSTATION

S.8421 FROM EPPING ZONE SUBSTATION

Sports Centre

S.8729 FROM EPPING ZONE SUBSTATION

CoGen

S.1915

S.35642

S.35643

FUTURE S.47259 FROM MACQUARIE PARK ZONE SUBSTATION

S.35844 FROM MACQUARIE PARK ZONE SUBSTATION

S.6154 FROM EPPING ZONE SUBSTATION

Tunnel

Theatre

S.7328 FROM EPPING ZONE SUBSTATION

S.4873 FROM EPPING ZONE SUBSTATION

S.7741

S.8422

S.8147 FROM EPPING ZONE SUBSTATION

S.4874 FROM EPPING ZONE SUBSTATION

S.7740

S.7392 FROM EPPING ZONE SUBSTATION

S.8146 FROM EPPING ZONE SUBSTATION

S.5923 FROM EPPING ZONE SUBSTATION

S.36012

S.36013

TBS

S.8697

S.8698 FROM EPPING ZONE SUBSTATION

S.3673 FROM EPPING ZONE SUBSTATION

S.1796 FROM EPPING ZONE SUBSTATION

S.4564 FROM EPPING ZONE SUBSTATION

S.36014 FROM MACQUARIE PARK ZONE SUBSTATION

S.3771 FROM EPPING ZONE SUBSTATION

S.3515 FROM EPPING ZONE SUBSTATION

FROM MACQUARIE PARK ZONE SUBSTATION

UNIVERSITY HOUSING

GRADUATE SCHOOL OF MANAGEMENT

LIGHTHOUSE THEATRE

W10A GYM

E14D

E11A

E10D CARPARK

F9A

F9B

F9C

F7A

F7B

E7B COURTYARD

E7A

E8A

E8C

E5A

E5B

E6A

E3B

E3A

F5B CARPARK

F5A CARPARK

F3A CARPARK

C9B

C5B

C5A

C5C

X5B

X5A

W6C

X6A Banksia Cottage

AUSTRALIAN FILM TV & RADIO SCHOOL

X4 CARPARK

X3 CARPARK

W4 CARPARK

X2A

C1 CARPARK

E1 CARPARK

ROBERT MENZIES COLLEGE

DUNMORE LANG COLLEGE

94.616

129.733

170.638

FROM MACQUARIE PARK ZONE SUBSTATION

MACQUARIE UNIVERSITY
SYDNEY ~ AUSTRALIA

Electrical Consultant:

JDG Consulting
Suite 407, Atlas Building
2-8 Brookhollow Ave
Baulkham Hills NSW 2153
Phone: 02 8861 1888
Fax: 02 8861 1899
jdg@jdgconsulting.com.au
www.jdgconsulting.com.au

JDG Consulting
Engineering Consultants
ASP Level 3 &
Electrical Services

Project:

MACQUARIE UNIVERSITY CAMPUS
HERRING ROAD
MACQUARIE PARK

Drawing Title:

ELECTRICITY INFRASTRUCTURE MASTER PLAN SUPPLY ARRANGEMENTS

Drawing No.

1821-E02

Drawn By:	Scale:	Rev:
JDG	NTS	A

Project No.:	Date:
12-1821	4.07.12

Macquarie University

Macquarie University Design Guidelines

Transport and Accessibility Report

Rev A | 16 March 2017

Job number 224322-09

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

ARUP

Contents

Tables

Figures

1 Introduction

1.1 Background

This report has been prepared to provide transport design guidelines, supporting 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 transport and accessibility report as contained in this document.

This document supports the transport principles and objectives outlined in the Transport Accessibility Constraints and Design Solutions Report (Arup, 2010) developed for the Precinct E Concept Plan.

1.2 Macquarie University Master Plan

Macquarie University (MQU) has previously developed a Concept Plan which was granted approval on 13 August 2009. The previous Concept Plan looked at an increase in commercial and academic space within the university. The plan also proposed additional housing precincts for university purposes, upgrading the road network and rationalisation of University car parking locations.

In 2014, MQU revisited the campus vision to address the next 50 year phase of the University's growth, reflected in the Macquarie University Campus Master Plan 2014. Importantly, the Master Plan does not represent a significant change to the development potential achieved during the timeframe of the approved Concept Plan.

1.3 Report Structure

This Transport and Accessibility report, which supports the *Macquarie University Design Excellence Strategy and Urban Design Guidelines* addresses the following issues:

Section 1 Introduction

Section 2 Existing Transport Conditions

Section 3 Design Objectives

Section 4 Transport Strategy

2 Existing Transport Conditions

2.1 Road Network

2.1.1 Major Roads

MQU is surrounded by a number of major roads which carry significant traffic volumes. These roads, including the administrative classification, are:

- Epping Road (State road)
- M2 Motorway (State road)
- Herring Road (Regional road between Epping Road and Talavera Road)
- Talavera Road (Regional road between Lane Cove Road and Talavera Road)
- Waterloo Road (Local road)
- Balaclava Road (Local road)
- Culloden Road (Local road)

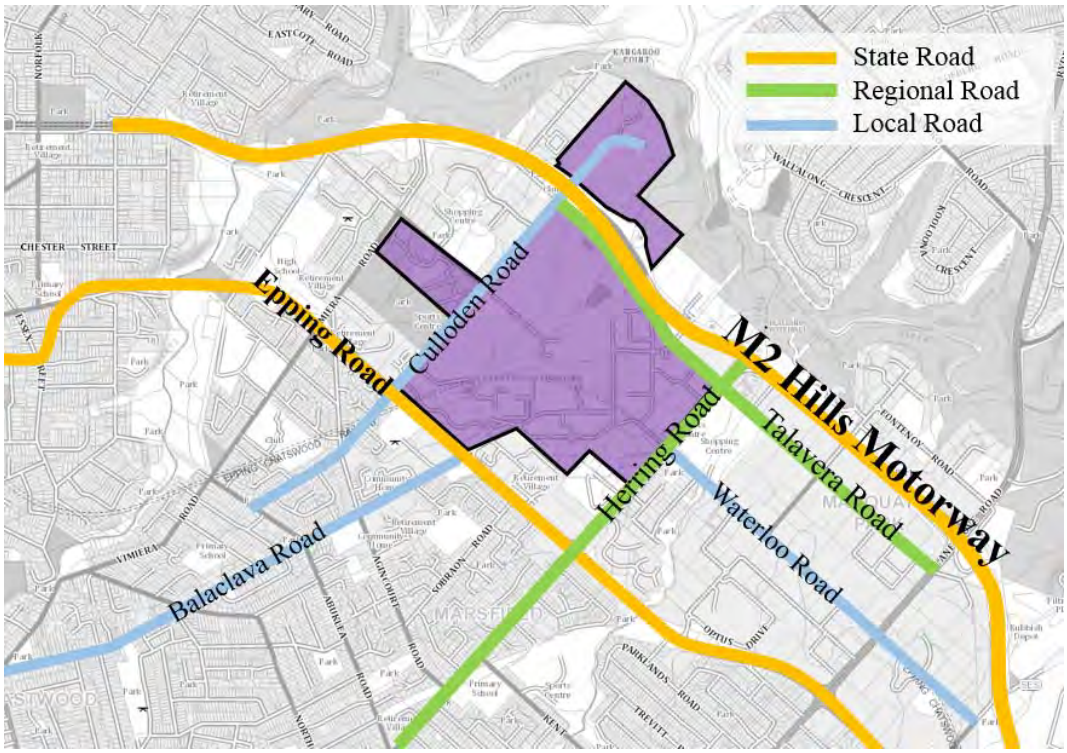


Figure 1 Road Network Surrounding Macquarie University

Source: SixMaps 2015

2.1.2 Key Intersections

The operation of the Macquarie Park road network is primarily a function of the performance of key intersections including:

- **Waterloo Road / Herring Road:** Directly adjacent to MQU and Macquarie Shopping Centre, this intersection is signalised with pedestrian crossing facilities on all approaches. The northern leg of this intersection provides direct access to MQU.
- **Epping Road / Balaclava Road:** Controlled by traffic signals with pedestrian crossing facilities on all approaches. Left turn slip lanes are provided on the north, south and west approaches. Bus priority lanes exist on Epping Road.
- **Epping Road / Herring Road:** Controlled by traffic signals with pedestrian crossing facilities on all approaches. Bus priority lanes exist on Epping Road.
- **Herring Road / Talavera Road / M2 Ramps:** The eastern leg of this signalised intersection provides vehicular access to the westbound on-ramp of the M2 Motorway. The western leg provides access to Talavera Road from the new M2 off ramp, with only left and right turn movements permitted. Pedestrian crossing facilities are provided on the eastern and northern legs. Right turn movements from Talavera Road into Herring Road are for buses only.
- **Talavera Road / Technology Place / Christie Road:** This intersection is controlled by traffic signals, with pedestrian crossing facilities on all four legs. The Christie Street leg of the intersection is an extension of the eastbound off-ramp and on-ramp of the M2 Motorway.
- **Culloden Road / Waterloo Road:** At the northern end of the campus, this intersection is controlled by a roundabout. There are no dedicated pedestrian crossing facilities provided. The southern leg (Gymnasium Road) of the intersection is off-centre with the other three approaches.

2.2 Car Parking

There are currently in the order of 4,000 on-site parking spaces across the campus in a mixture of multi-storey and at-grade car parking areas. These areas are accessed from a number of internal circulation roads. All parking is operated under a restricted parking area scheme. Short term parking and annual permits are available for students and staff.

During peak semester periods, the demand for parking near the Academic Core can significantly exceed supply, while more remote parking areas typically have some spare capacity.

Current parking areas within MQU are indicated in Figure 2.

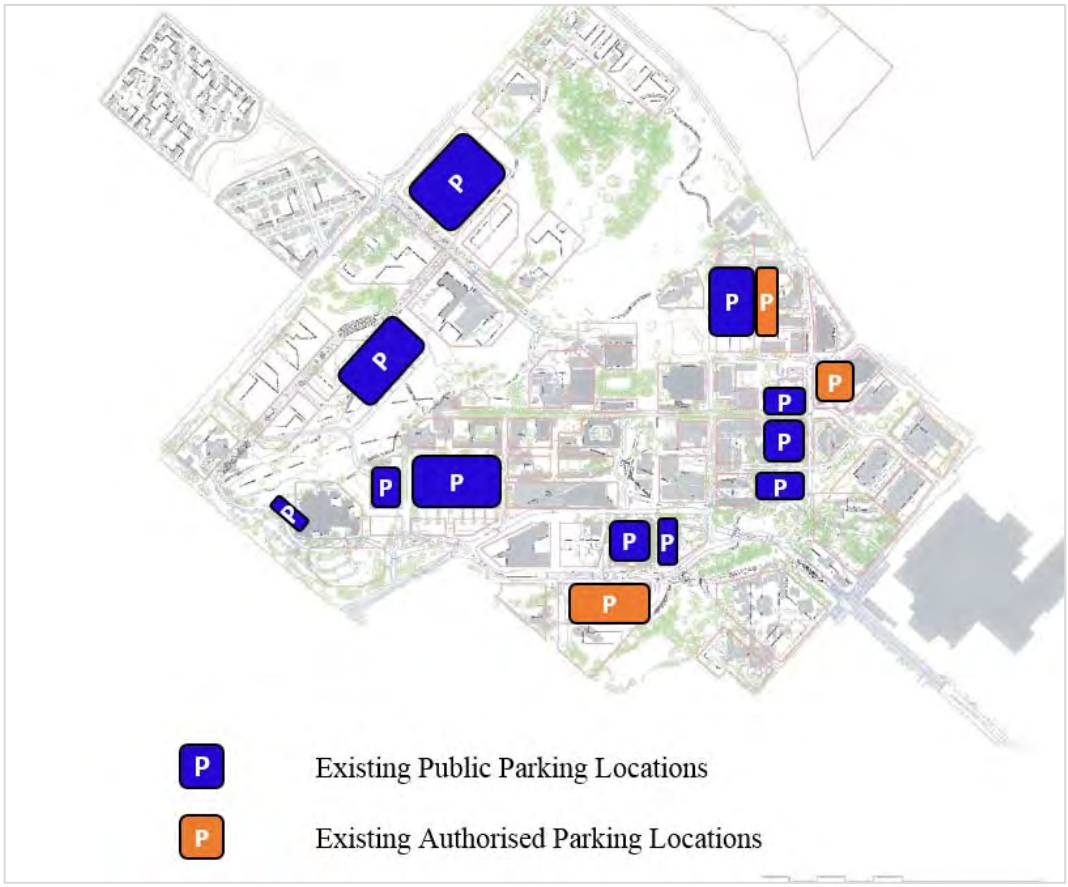


Figure 2 Existing onsite parking

2.3 Public Transport

2.3.1 Buses

MQU is served by 24 different bus routes, running to and from the campus throughout the day. Additionally, some further bus services utilise the nearby bus interchange on Herring Road adjacent to Macquarie Shopping Centre.

Bus services run at high frequencies in both the morning and evening peak periods (approximately 70 services in the peak hours) with lower frequencies at off-peak times.

University Avenue currently provides bus stop locations within MQU. Further interchange facilities are provided both within the campus and at the Macquarie Shopping Centre. The area between University Avenue and Balaclava Road is currently used as a layover facility for some terminating buses, prior to commencing their next route service.

A summary of existing bus services through MQU is presented in Table 1 and bus stop locations illustrated in Figure 3.

Table 1 Macquarie University bus services

Route No.	Route	Frequency during peak hour		Operator
		8.00am to 9.00am	5.00pm to 6.00pm	
M41	Hurstville to Macquarie	6	6	Metro Bus
M54	Parramatta to Macquarie Park	6	6	Metro Bus
140	Manly to Epping	1	1	Sydney Buses
197	Macquarie University to Mona Vale	1	3	Forest Coach Lines
288	Epping to City	3	3	Sydney Buses
290	Epping to City	5	2	Sydney Buses
292	Marsfield to City	2	2	Sydney Buses
294	Macquarie Centre to City	2	1	Sydney Buses
295	North Epping to Macquarie Centre	4	4	Sydney Buses
459	Macquarie University to Strathfield	2	2	Sydney Buses
506	Macquarie University to City	3	3	Sydney Buses
507	Macquarie University to City	2	3	Sydney Buses
518	Macquarie University to City	2	3	Sydney Buses
544	Auburn to Macquarie Centre	2	2	Sydney Buses
545	Parramatta to Chatswood	6	6	Sydney Buses
550	Chatswood to Parramatta	0	0	Sydney Buses
565	Chatswood to Macquarie University	1	2	Transdev NSW Buses

Route No.	Route	Frequency during peak hour		Operator
		8.00am to 9.00am	5.00pm to 6.00pm	
575	Macquarie University to Hornsby	4	4	Transdev NSW Buses
611	Macquarie University to Blacktown	5	7	Hills Bus
619	Castle Hill to Macquarie Park	4	2	Hills Bus
621	Castle Hill to City	2	3	Hillsbus
630	Blacktown to Macquarie Centre	2	2	Hillsbus
651	Castle Hill to Macquarie and City	2	3	Hillsbus
740	Plumpton to Macquarie Park	3	2	Busways

Source: Sydney Buses, Hills Buses, Transdev, Busways and Forest Coach Lines 2015

Figure 3 Bus stop locations

2.3.2 Trains

MQU is unique in that it is the only metropolitan university in Sydney with a dedicated railway station. Macquarie University Station is located only a short walk from the Academic Core, providing services between 5am and 11pm on a typical weekday. Since the integration of the station with the CityRail network in October 2009, 13 train services every hour (nine towards the city) arrive at the station during peak hours. These services provide direct rail access to Epping and Chatswood.

2.4 Walking

Universities are unique in the sense that they concentrate a variety of functions within reach of pedestrians and are considered as self contained neighbourhoods where classrooms, offices, apartments, student centres, child care facilities, performance halls, art galleries, gymnasiums, swimming pools, sports arenas, shopping places etc are all in close proximity.

Campus design is based on the notion that walking is an expected mode of transport within the university.

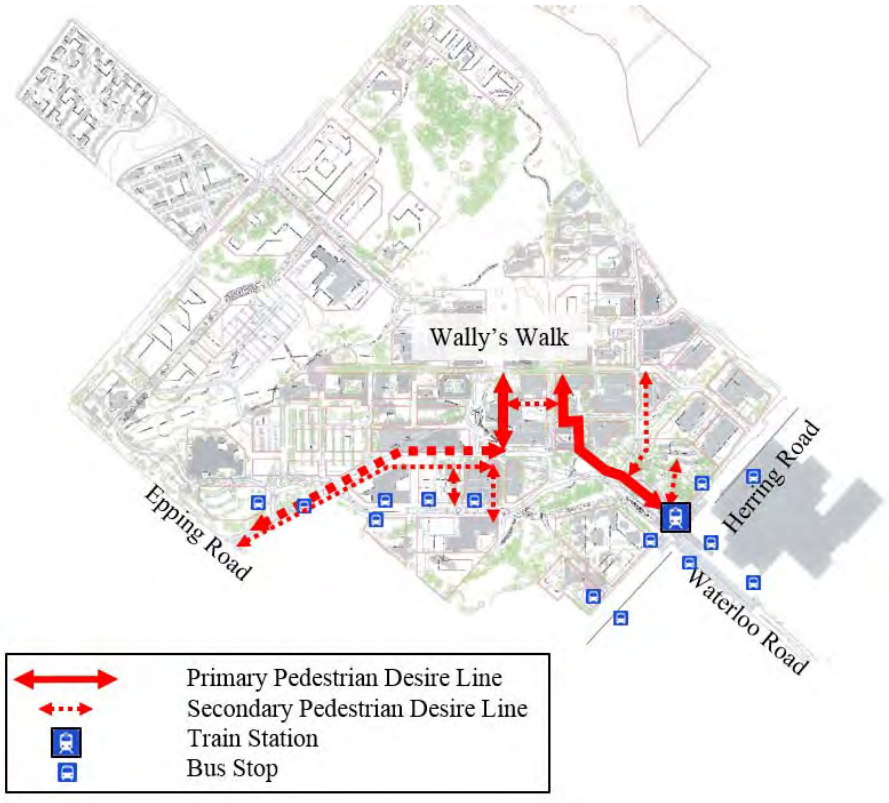


Figure 4 Existing pedestrian desire lines

The key pedestrian desire lines, shown in Figure 4 are focused on the Academic Core and transport nodes such as the railway station, bus stops and parking areas. These paths are well defined through the use of lighting, wide footpaths and seating. A series of small pathways run through the Academic Core, providing

students access between the various land uses contained within MQU. The local vehicle circulation roads within the campus do provide for pedestrian movements.

2.5 Cycling

There are presently no dedicated cycling facilities (i.e. on road bike lanes, shared paths) within MQU. Some end of trip facilities are provided, such as parking, showers and lockers. Two additional bike hubs have recently been constructed on campus, adjacent to both Eastern Road near the Central Courtyard and Western Road near the W4 car park. Each of these hubs include capacity to store 26 bikes in a secure cage, 2 solar powered showers and 28 lockers.

Cycling currently makes up only a small proportion of overall trips to MQU. Reasons for this may include:

- The University is surrounded by high traffic, major arterial roads which are not conducive to walking and cycling.
- Isolated on and off-road cycle facilities currently exist in the vicinity of the campus, but these do not yet constitute a comprehensive network.

A summary of the existing cycle network surrounding MQU is shown in Figure 5. The majority of the cycle routes located within MQU are shared with pedestrians.

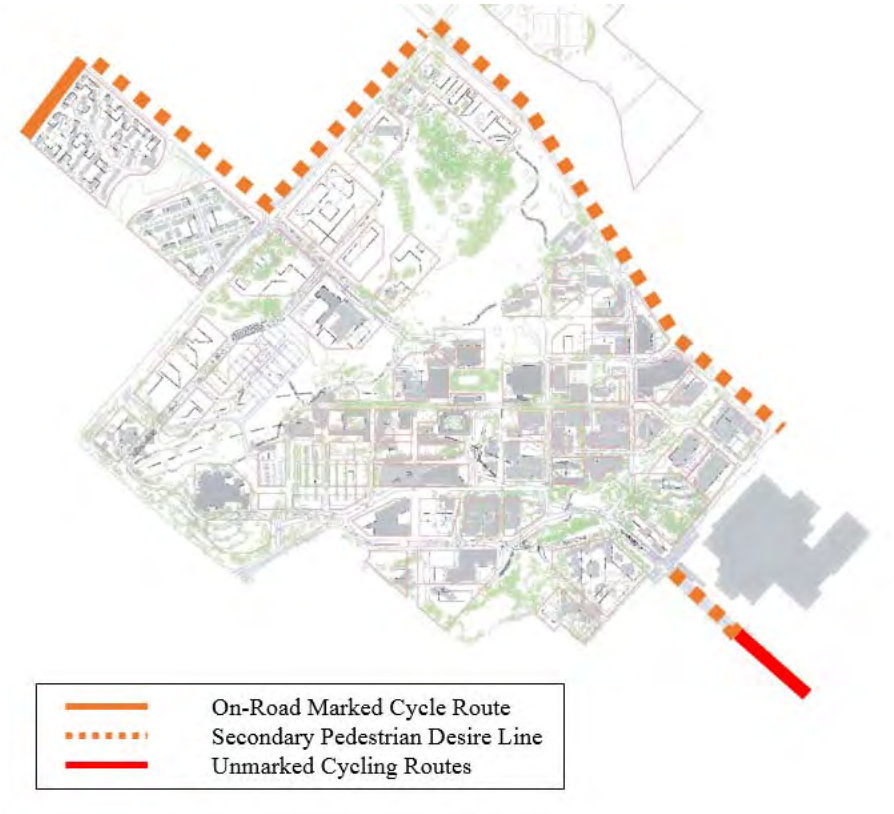


Figure 5 Existing cycling routes

2.6 Travel Patterns

Existing data relating to student and staff travel patterns to MQU has been taken from 2011 Journey to Work Census data, and a user travel survey undertaken as part of a campus sustainability strategy in 2014. The 2006 census data is also analysed to gain and understanding the travel habits before the opening of the Epping to Chatswood rail line.

2.6.1 Journey to Work

The Journey to Work Census data for all trips with a final destination of Macquarie Park is presented in Table 2. It should be noted that this data only includes those people who consider Macquarie Park to be their location of full time employment and therefore excludes student trips.

Table 2 Journey to Work Census Data – Trips to Macquarie Park

Mode	2006	2011
Car as driver	74%	67%
Bus	8%	7%
Car as passenger	6%	4%
Train	5%	16%
Walked only	5%	4%
Other mode	2%	2%

As seen from the table, more recent census data indicates a mode shift from car users to public transport as a journey to work method. The proportion of car users decreased from 74% to 67%, while train users increased from 5% to 16% following the opening of the Epping to Chatswood rail line in 2009.

2.6.2 2014 Travel Survey

GTA Consultants was commissioned by MQU in July 2014 to undertake a travel demand survey of the site. A total of 967 students, staff and employees completed both physical and online surveys. The results of the travel survey with respect to access mode into MQU is shown in Figure 6. This indicates that private vehicle at 30% is still the most popular mode of transport to the University, however access by bus (21%) and rail (27%) are also popular modes of transport.

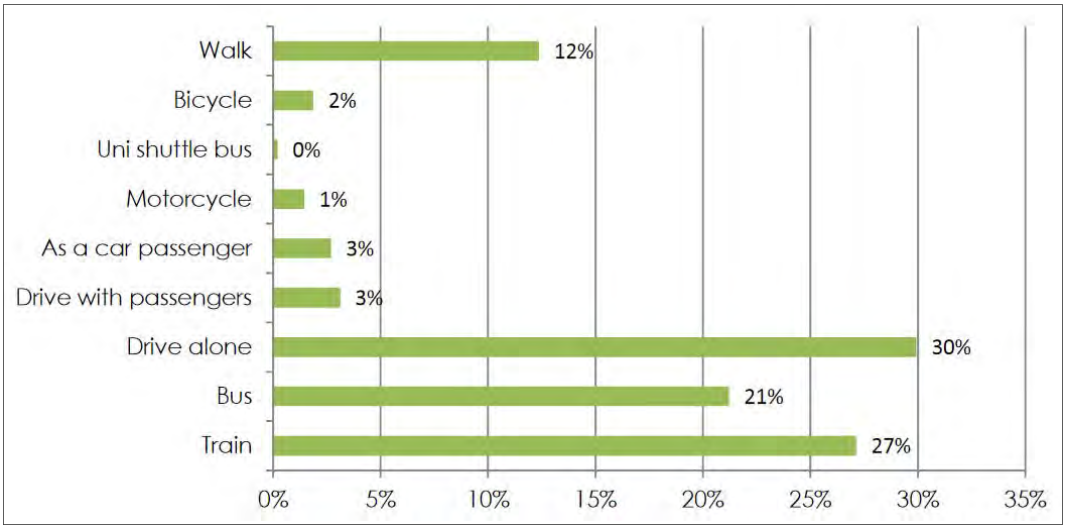


Figure 6 Main mode of transport to Macquarie University

Source: 2014 Macquarie University travel survey report (GTA Consultants)

The level of public transport usage (train and bus) has increased significantly from 13% in 2010 to 37% in 2012 (plus a proportion of 14% multi-modal trips) and 48% in 2014. Bus usage has increased from 8% to 21% over this period, whilst train usage has increased from 6% to 27%. The increase in train patronage is reflective of the improved train frequencies servicing the Macquarie University Railway Station. A summary of the travel trends to MQU is shown in Figure 7.

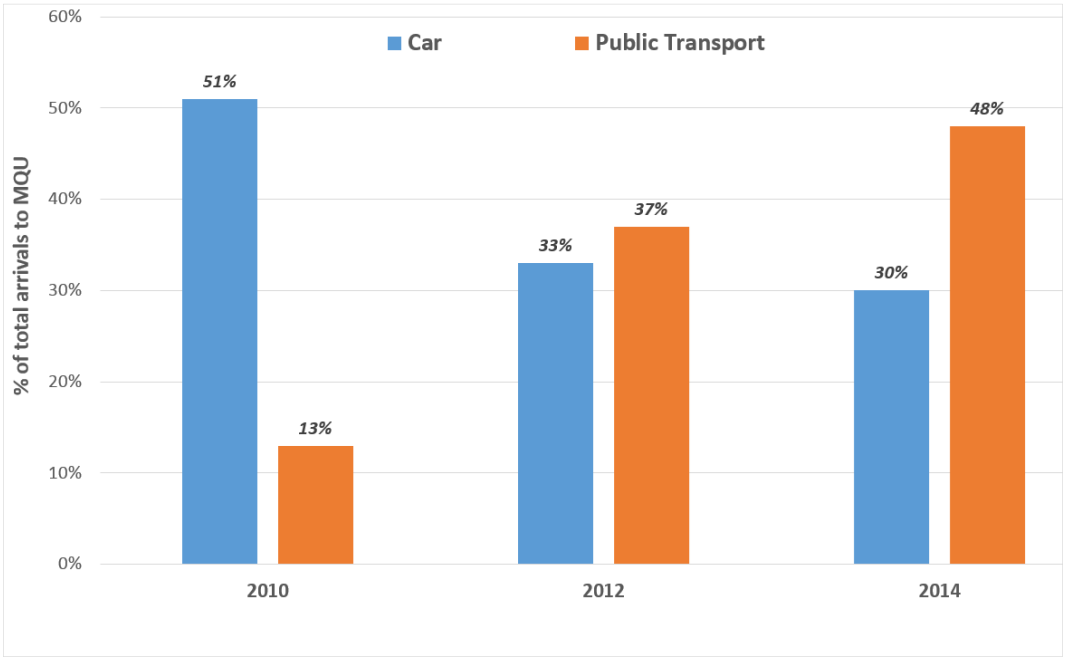


Figure 7 MQU travel trends

2.6.3 Demographic Data

The 2014 Macquarie University Travel Survey analysed the distribution of the home location of students and staff. This distribution is presented in Figure 8, and demonstrates a high proportion of students and staff live within close proximity (5km) to the campus. This is within feasible cycling distance. Further, a high number of students and staff live within a 2km radius of the campus which is a viable walking distance.

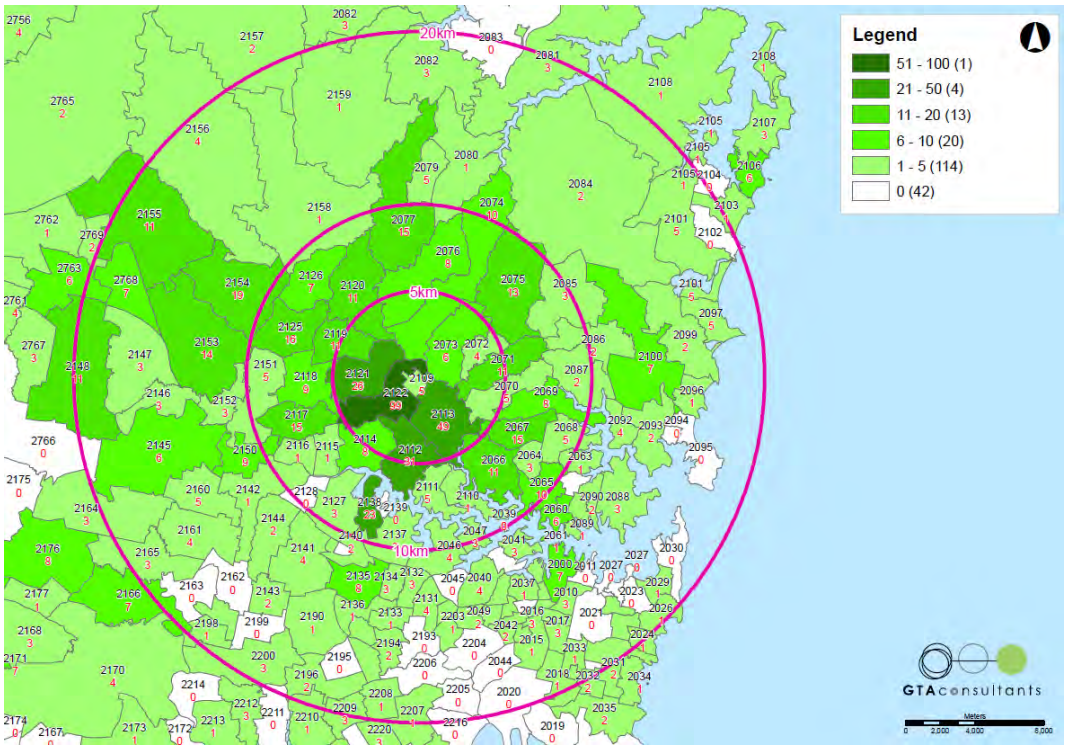


Figure 8 Home location of MQU students and staff

Source: 2014 Macquarie University travel survey report (GTA Consultants)

The majority of staff and students were found to reside in the northern Sydney area. The top five postcodes for student/staff population were as follows:

- 2122: Eastwood, Marsfield
- 2133: Macquarie Park, North Ryde, East Ryde
- 2112: Putney, Ryde, Denistone East
- 2121: Epping, North Epping
- 2138: Rhodes, Liberty Grove, Concord

3 Design Objectives

3.1 User Groups

Universities are unique in the sense that they hold distinct communities. They concentrate a variety of functions within reach of pedestrians and are considered as self contained neighbourhoods where classrooms, offices, apartments, student centres, child care facilities, performance halls, art galleries, gymnasiums, swimming pools, sports arenas and shopping places are all in close proximity. They have their own streets, squares and open spaces, where people can stroll and get together. Campus design is based on the notion that walking is an expected mode of transport within the university.

The various land uses within the Macquarie University campus define the user groups of the campus. The key land uses of Macquarie University include:

- Academic Core
- commercial and research precinct
- open space
- university housing
- parking
- sporting fields

User groups for the purposes of transport are then defined as:

- students
- staff
- commercial employees
- visitors
- through traffic
- deliveries

It will be an integral part of the wider university campus and master planning strategy to consider the needs of all of these user groups.

The flexible nature of classes and timetables influence pedestrian environment and movement. Recreational facilities invite a wide range of patrons to the university outside typical university times including weekends. University housing on the periphery of the campus also provides people presence outside typical university times. Patronage to the campus is also influenced by semester dates with typical class timetables run for approximately half of the year.

Traffic and observational data suggests that movements to the Macquarie University campus follow typical peak periods, that is, they have strong weekday AM and PM peaks although these peaks are not as pronounced as an office development.

3.2 Hierarchy of Movement

The transport strategy for the Macquarie University campus is based on a hierarchy of movement as illustrated in Figure 9.

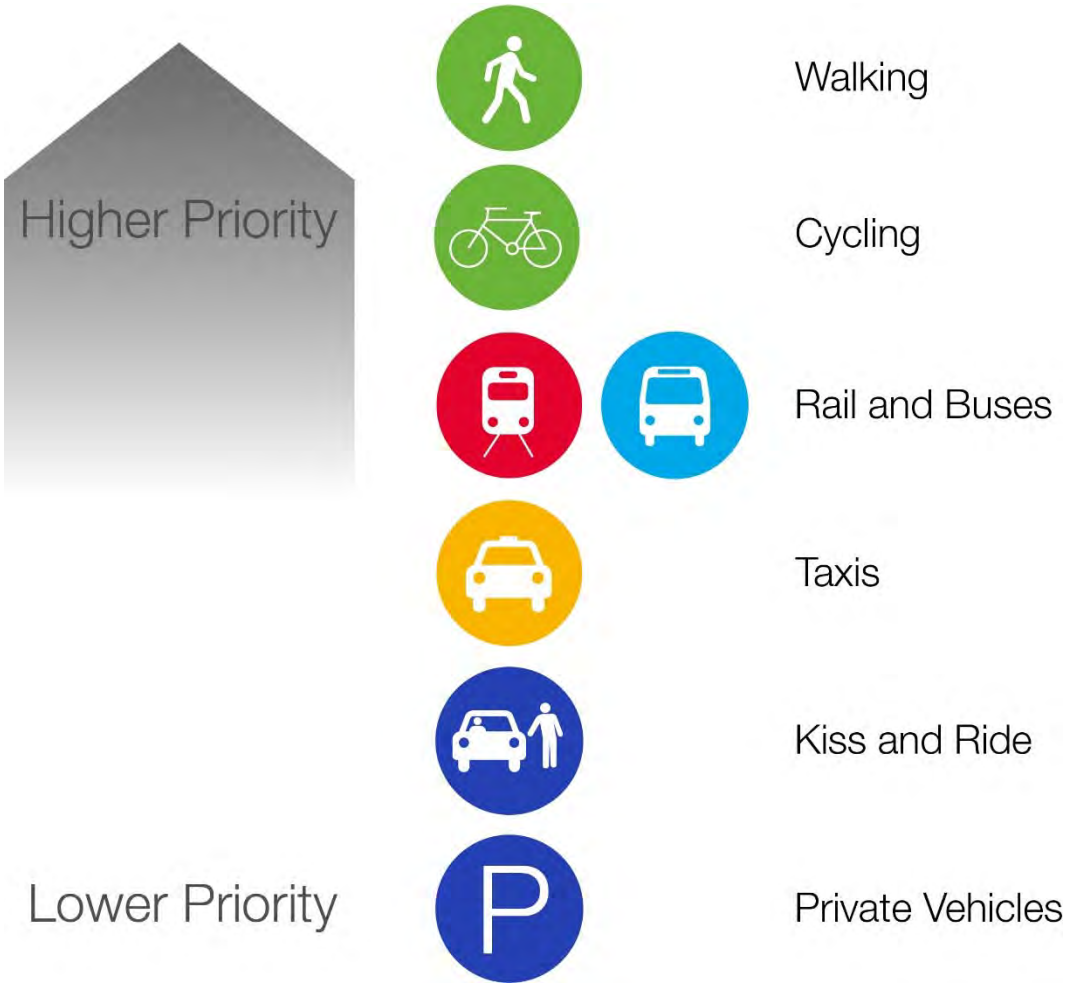


Figure 9 Hierarchy of movement

The hierarchy assumes that priority will be given to non-motorised forms of transport – walking and cycling, in addition to public transport – bus and train. The lowest priority will be given to the private car and parking. Walking is the primary mode of transport within the campus.

The hierarchy of movement supports the intention of the Macquarie University Concept Plan including:

- a 40% non-car mode share target for both academic and commercial uses.
- a cap on the total car parking supply.

Existing travel data suggests the current non-car mode share across the campus is currently significantly below the 40% non-car mode share target.

3.3 Design Principles

The following transport design principles have been developed for the Macquarie University campus:

- to provide a road, pedestrian and bicycle network for the precinct that is consistent with the intention of the Concept Plan for the overall campus
- to provide high quality, direct pedestrian access to Macquarie University Station the Academic Core and other key areas
- to provide good access to bus stops
- to separate pedestrian and vehicular traffic by providing convenient and safe movement paths for pedestrians, and, wherever possible, giving pedestrians priority at conflict points such as intersections
- to provide high quality facilities for bicycle traffic
- to minimise vehicular traffic as much as possible, particularly non-university 'rat-running' traffic
- to permit efficient access to the various car parking facilities which will generally consist of basement parking within new commercial developments
- to provide an attractive urban environment with high levels of amenity including the creation of 'entry statements' at the Balaclava Road and Herring Road entrances to the Campus
- to protect the environmental qualities and water management function of University Creek, Mars Creek and College Creek by minimising the number of water crossings
- to minimise vehicular traffic movements through the Academic Core and direct private vehicles to the periphery of the campus
- to remove all bus layovers within the campus

4 Transport Strategy

4.1 Overview

The Macquarie University Master Plan has been developed to enhance connectivity, safety and amenity for all campus users – particularly pedestrians. It is intended to direct vehicular traffic to the periphery of the campus to improve the pedestrian environment within the campus core. A new pedestrian focused landscaped entry from Herring Road is planned which will provide a direct, uninterrupted pedestrian link between Macquarie University railway station and the core of the campus.

4.2 Opportunities and Constraints Analysis

Specific opportunities and constraints that were identified in developing the transport strategy for the Macquarie University campus include:

Opportunities

- re-configured road network leading to improved facilities for pedestrians and cyclists
- enhanced access between the Academic Core and public transport nodes including Macquarie University station and the Herring Road bus interchange
- improved intersections and pedestrian road crossing points
- improved gateway to the university from external roads, particularly at the Herring Road gateway

Constraints

- limited number of vehicular and pedestrian crossings of University Creek
- topography of precinct with a significant fall from the Academic Core towards University Creek
- conflict between high volumes of pedestrians and vehicular traffic
- need to provide vehicular access to all development parcels rather than providing access to a small number of perimeter car parks
- the need to retain vehicular access to railway station service building
- potential for changes to road network to lead to an increase in non-university through traffic
- requirement to maintain bus movements (including bus layover) within the campus in the short term

4.3 Pedestrians

Macquarie University campus has been designed on the basis that walking is an expected and primary mode of transport.

The proposed pedestrian network for the Macquarie University campus is based on a network of primary, secondary and tertiary links. It is based on key attractors and the likely intensity of pedestrian movement on each link. Pedestrian desire lines will be characterised by movements between the rail station, Herring Road bus interchange, car parks, Macquarie Centre and the Academic Core. Other key nodes include student housing, recreational facilities and the private hospital. Pedestrian crossings will be provided on major desire lines, to cater for the future north-south walking links

Fundamental to the transport strategy for the MQU campus is the establishment of the Academic Core as a pedestrian precinct, with vehicular access north of Macquarie Walk (previously known as Western Road) generally limited to service and emergency vehicles.

The transport strategy proposes some key amendments to the road network layout and configuration servicing the campus compared to that presented in the initial Concept Plan. These amendments are targeted to enhance pedestrian safety and connectivity, and include

- Removal of vehicular traffic along Macquarie Drive to pedestrianise this route from Balaclava Road to Waterloo Road.
- Closure of Research Park Drive near University Avenue. This measure would facilitate the provision of a continuous, uninterrupted pedestrian connection between Macquarie University railway station and the Academic Core of the campus. This will include a new pedestrian bridge across University Creek.
- Reducing the width of the University Avenue road carriageway to support a widened footpath on the northern side of the road. The Herring Road entry to the University will require a major reconfiguration to create a ‘gateway’ – incorporating a wide, tree lined pedestrian oriented environment. This will create a public realm commensurate with a private road serving a pedestrian oriented campus, accommodating the increased pedestrian movements expected as the campus grows over the coming years.
- Conversion of Macquarie Drive north of Western Road (now known as Macquarie Walk) from a bus link to a pedestrian only route
- Provision of a new vehicle and pedestrian connection from Talavera Road serving Precinct E

There will also be provision of tactile pavement surfacing along Waterloo Road within the University campus. This will have the effect of slowing vehicle speeds as drivers realise they are no longer travelling along an arterial road. This will discourage drivers from utilising this road as a through route, reducing traffic volumes and providing an improved environment for both pedestrians and cyclists.

The proposed pedestrian network for the MQU campus is shown in Figure 10. The network will be a combination of footpaths along road corridors and other walkways.

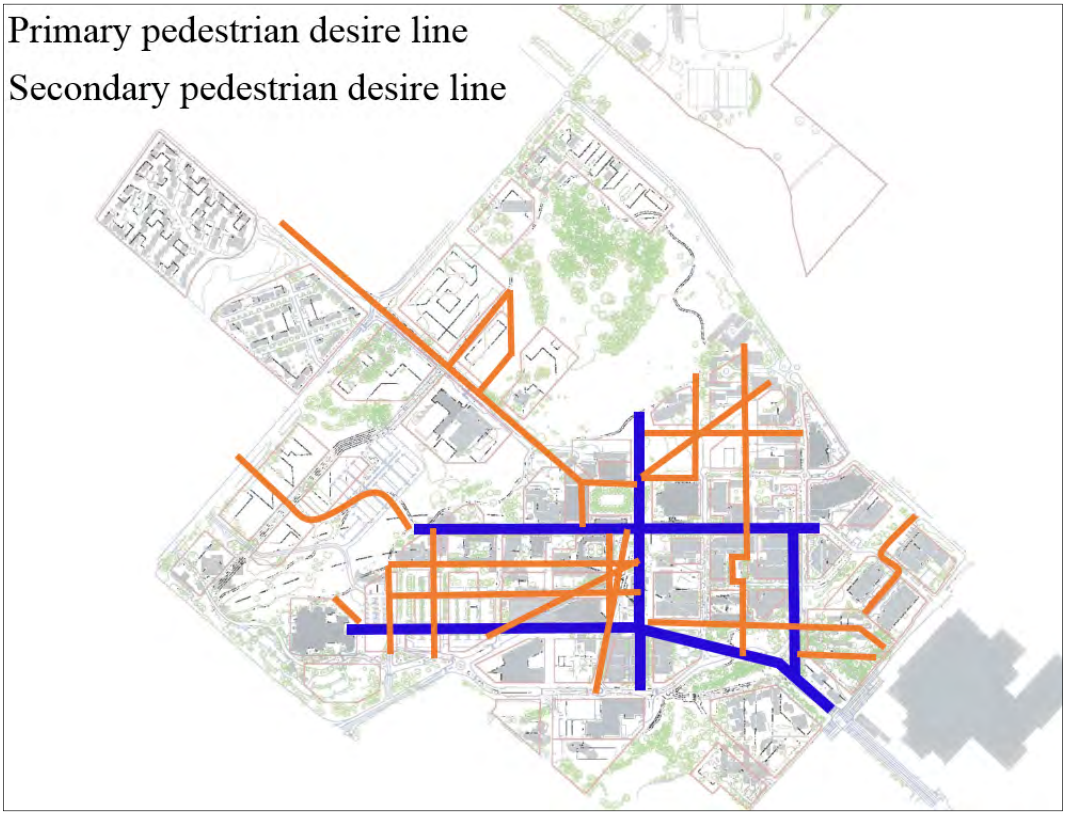


Figure 10 Proposed pedestrian network

4.4 Cyclists

Macquarie University has long promoted cycle access to the campus. The Master Plan formalises the main cycle corridors around the campus provides links to regional and district networks.

The proposed bicycle network for the MQU campus is shown in Figure 11. The network will include connections to key external bicycle routes including:

- Waterloo Road and Shrimptons Creek
- Talavera Road and Brown's Waterhole
- Culloden Road
- Epping Road

University Avenue will be the primary bicycle route though the campus. This will provide for a direct connection to the shared path on the eastern side of Epping Road and will also minimise conflicts with pedestrians in the Academic Core.

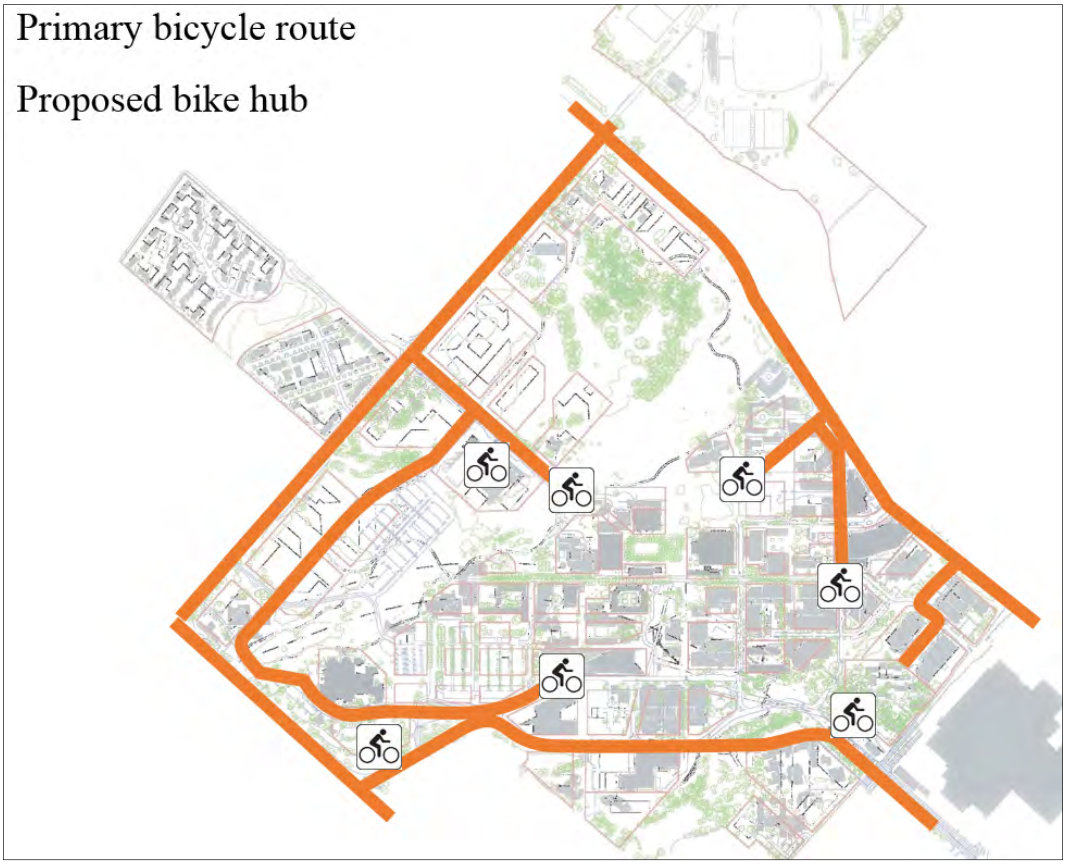


Figure 11 Proposed bicycle network

In addition to the marked bicycle routes, all roads within the university will support cycling by maintaining low vehicular traffic speeds with low vehicular traffic volumes.

Bike hubs are located on the fringe of the Academic Core so that cyclists can conveniently park their bikes close to where they need to go.

4.5 Bus Movements

Approximately 70 bus services per hour currently pass through the MQU campus. While the movement of buses through the campus is integral to providing good public transport access for students and staff, the transport strategy has been developed to minimise their impact on pedestrian movements and safety within the core of the campus.

The routing of buses though the campus has therefore been modified as part of the long term Concept Plan road layout. The transport strategy proposes to re-route all eastbound bus services that currently utilise Macquarie Drive to University Avenue. This is shown in Figure 12. Bus stops are to be located on University Avenue, with good pedestrian connections to be provided into the Academic Core.

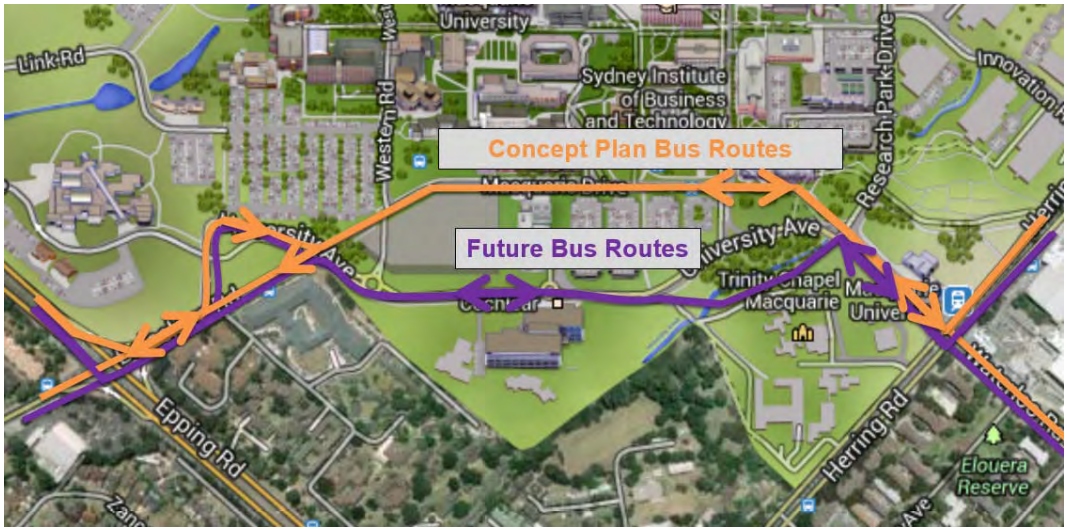


Figure 12 Bus services through MQU

Transport for NSW are currently investigating the provision of an improved bus interchange on Herring Road adjacent to Macquarie Centre to replace the existing bus interchange. It has been assumed that if this interchange is constructed, a significant proportion of existing campus bus services will continue to be routed through the university. However, the new interchange, with increased capacity, would allow for some of the less frequent services to be removed from the campus road network.

A number of bus services currently layover (i.e. extended stays between services) within the campus. The transport strategy makes provision for layover bays however these should be located well away from the Academic Core. The longer term plan is that no buses will layover on the MQU campus. This is in association with the development of the Herring Road bus interchange.

4.6 Future Public Transport Upgrades

Several public transport enhancements have the potential to benefit MQU in the future. These are described in the section below.

4.6.1 Sydney Metro Northwest

Sydney Metro Northwest (previously known as the North West Rail Link), is the first stage of Sydney Metro. The project is scheduled for completion in 2019 and will deliver eight new railway stations to Sydney's North West, providing a connection into Chatswood and the Sydney CBD. Passengers will be provided with rail services every four minutes during peak periods and every 10 minutes across the day.

The new rail line will ultimately connect with Metro City & Southwest - the second stage of the Sydney Metro network. This will provide residents of the Riverstone Town Centre with direct rail services between Bankstown, the Sydney CBD, North Sydney, Macquarie Park and the North West Growth Centre.

The Sydney Metro Northwest map is illustrated in Figure 13.

MQU will benefit from this new rail system which will have trains operating every four minutes during peak hours.

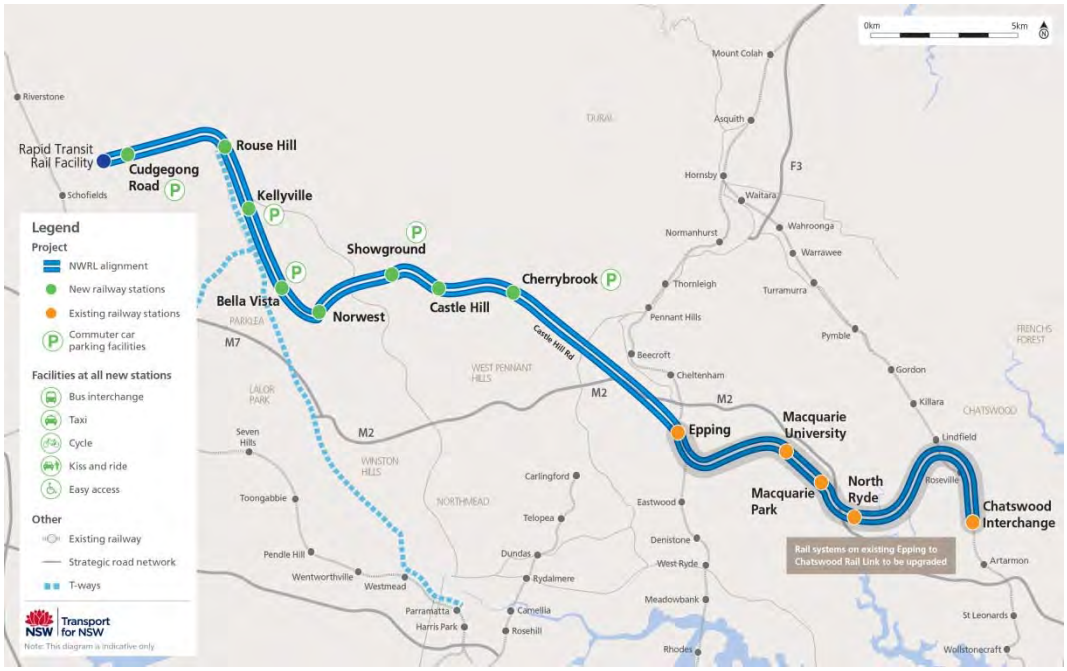


Figure 13 Sydney Metro Northwest map

Source: Transport for NSW, 2014

4.6.2 Sydney Metro City and Southwest

Sydney Metro is the next major rail project identified in Sydney's Rail Future. Sydney Metro scope has been developed to meet the Project objectives and deliver key elements of Stages 4 and 5 of Sydney's Rail Future.

In June 2014 the NSW Government announced the Sydney Metro concept, including the Sydney Harbour Crossing and Western Extension to Bankstown proposals. The project would extend rapid transit under Sydney Harbour, through the central business district (CBD) of Sydney and west to Bankstown, with capacity to run up to 30 trains per hour in each direction through the city on the new line.

The Project represents a major increase in the capacity of Sydney's rail network, providing a 60 per cent increase in the number of trains in the peak periods and catering for an extra 100,000 customers per hour. Sydney Metro would significantly improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity.

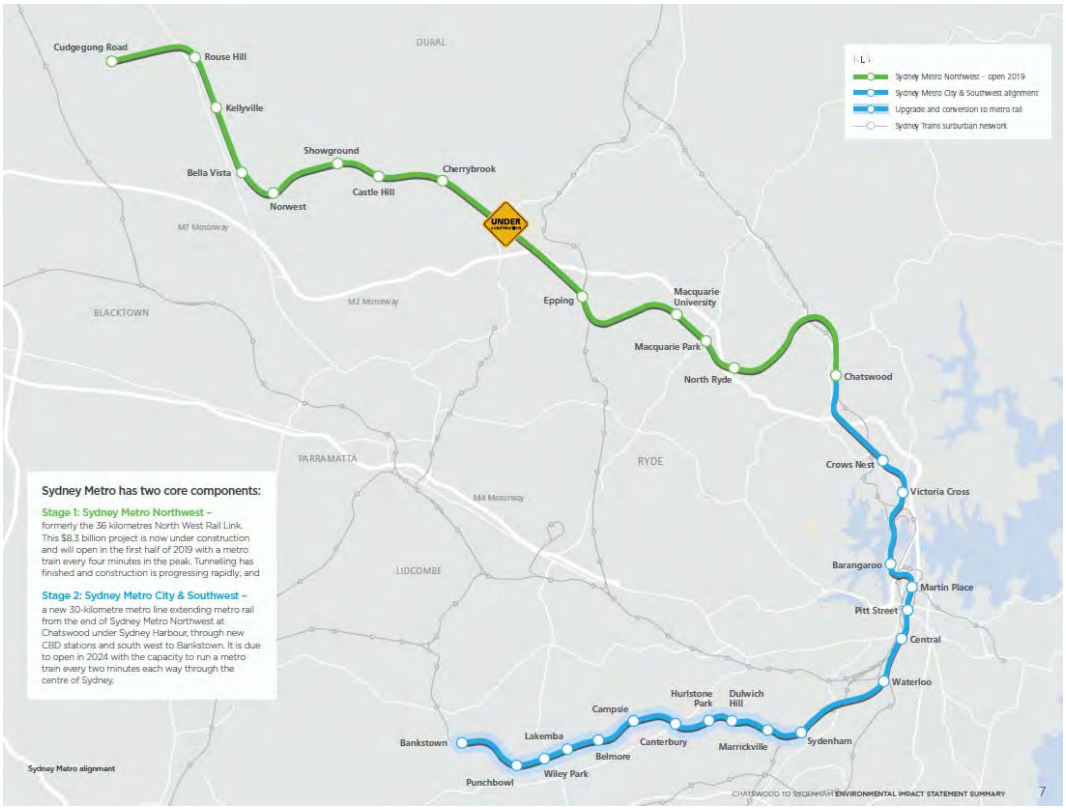


Figure 14 Sydney Metro Project

Source: Transport for NSW

4.7 Road Network

The road network supporting the campus will generally be based on the road alignments presented in the Concept Plan with no additional roads proposed. The plan includes a hierarchy of roads that contributes to an understanding of the land requirements, alignment and design.

The proposed road hierarchy is summarised in Table 3.

Table 3 MQU road hierarchy

Primary road (17.5m – 30m)	**Secondary road (17.5m – 20m)**
• Balaclava Road • University Avenue • Innovation Road • West Precinct Road • Research Park Drive (northern end) • Hadenfield Road	• Eastern Road • Technology Place • Western Road • Gymnasium Road

Since the development of the MQU Concept Plan, there have been a number of variations to the envisaged road network layout. These variations are primarily the result of enhancements to the pedestrian network within the campus. Variations to the road network compared to that initially envisaged in the Concept Plan includes the following:

- The primary roads are no longer 3 or 4 lanes as described in the Concept Plan, they are now 2 lanes. The secondary roads and shareways are the same as the Concept Plan
- Closure of the southern end of Research Park Drive (connecting with University Avenue) to facilitate the provision of a continuous, uninterrupted pedestrian connection between Macquarie University railway station and the Academic Core of the campus
- Conversion of Macquarie Drive north of Western Road (now known as Macquarie Walk) from a bus link to a pedestrian only route
- Realignment of University Avenue to support vehicular access into commercial developments with Precinct E
- Conversion of the existing one-way section of Balaclava Road to two-way operation to enhance pedestrian and vehicular movements in the precinct. This measure would alleviate the existing issue of buses impacting on traffic movements as they turn left into Hadenfield Avenue, as well as safety issue of bus passengers having to cross two lanes of northbound traffic on Hadenfield Avenue.
- Provision of a new access road into Precinct E which connects to Talavera Road (see Figure 15)

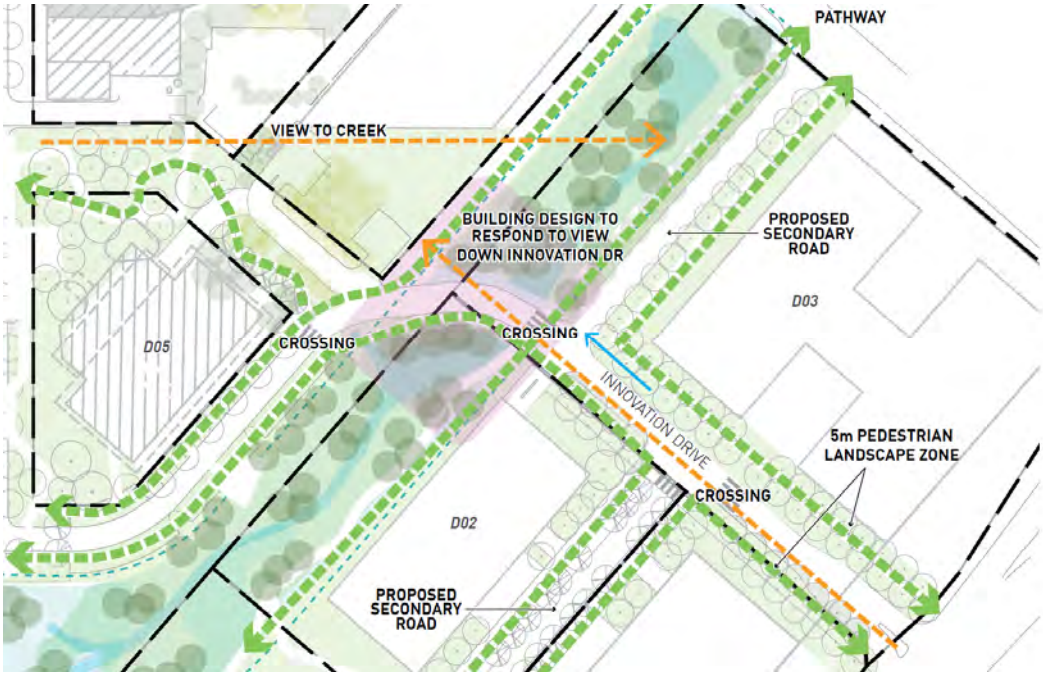


Figure 15 New access road into Precinct E

- Reducing the width of the University Avenue road carriageway to support a widened footpath on the northern side of the road.

These changes to the road network are summarised in Figure 16 below.

Figure 16 Changes to access arrangements and internal road network

4.8 Road Cross Sections

Road cross sections for primary and secondary roads within the campus are illustrated in Figure 17 and Figure 18 respectively.

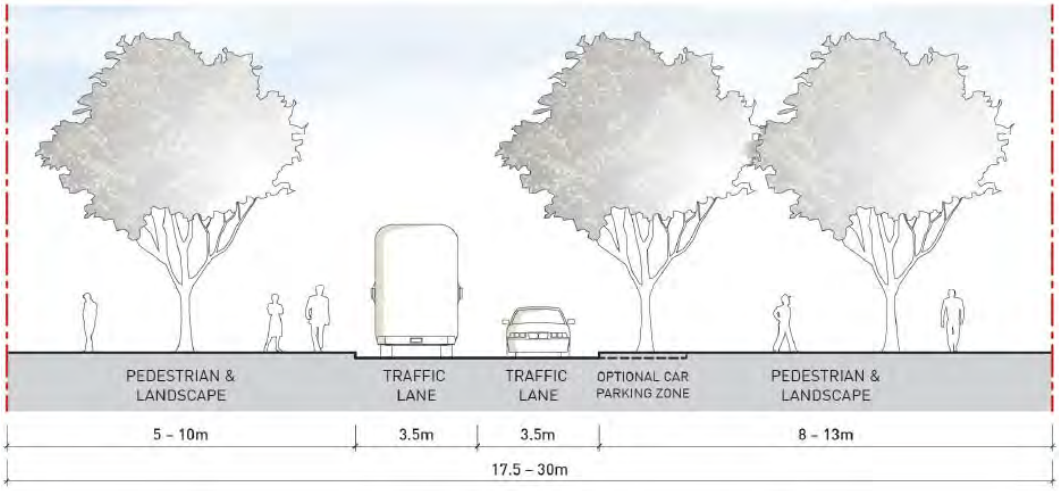


Figure 17 Cross section – primary road

Source: Cox Richardson architects

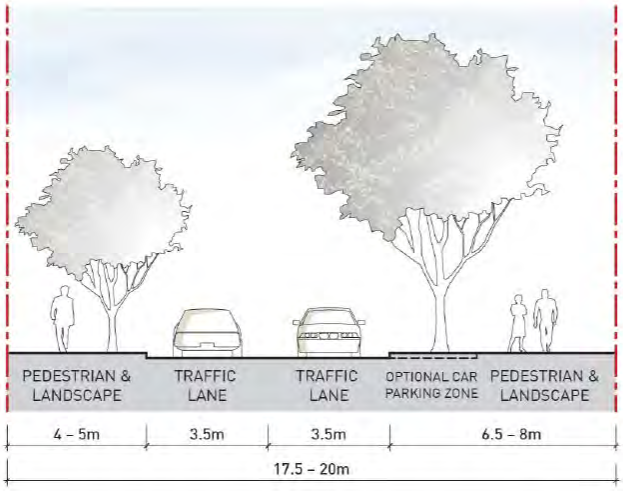


Figure 18 Cross section – secondary road

Source: Cox Richardson architects

4.9 Parking

4.9.1 Parking Strategy

The transport strategy has been developed to remove traffic from the campus core by locating car parking areas at the periphery of the campus. As presented in Figure 19 below, three new major car parking areas are proposed on the western and northern boundaries of the campus – providing over 3,000 parking bays. The parking structures will be linked directly to the pedestrian network, providing convenient and safe access to and from the Academic Core.

Figure 19 Car parking strategy

4.9.2 Parking Controls

Each new development within the MQU campus will generally be self-sufficient in terms of parking with parking to be contained within the basement of each development where appropriate. The Macquarie University Concept Plan condition (B1) permits a maximum of 10,800 spaces across the campus.

Parking for commercial uses will generally be provided at a rate of no more than 1 space per 80m^2 GFA. There is, however, some flexibility in the provision of parking across the campus, i.e. some developments could have a higher rate of parking and others a lower rate of parking, as long as the overall maximum number of spaces for the precinct is not exceeded.

It would be expected that on full-development of the campus, sites closest to the railway station would have lower parking rates than those located furthest from the railway station.

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