# Mt Gilead Rezoning

## Ecological Assessment

Prepared for
**Mt Gilead Pty Ltd and S & A Dzwonnik**

17 September 2014

## DOCUMENT TRACKING

| ITEM | DETAIL |
|---|---|
| Project Name | Mt Gilead Rezoning – Ecological Assessment |
| Project Number | 12WOLECO-0037 |
| Project Manager | Bruce Mullins<br>Suite 4, 2-4 Merton St, Sutherland<br>02 8536 8611 |
| Prepared by | Belinda Failes, Jo Daly and Meredith Henderson |
| Reviewed by | Robert Humphries |
| Approved by | Bruce Mullins |
| Status | Final |
| Version Number | 3e |
| Last saved on | 17 September 2014 |
| Cover photo | Top left: undulating topography near creek headwaters. Top right: extensive pasture lands dominated by exotic species. Bottom left: grazing cattle. Bottom right: one of many constructed farm dams (B Failes March – April 2013) |

This report should be cited as 'ELA 2013. *Mt Gilead Rezoning – Ecological Assessment*. Prepared for Old Mill Properties Pty Ltd and RMB Lawyers, by Eco Logical Australia.'

## ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Old Mill Properties Pty Ltd, RMB Lawyers and Design & Planning.

# Contents

# List of Figures

# List of Tables

# Abbreviations

| Abbreviation | Description |
|---|---|
| APZ | Asset Protection Zone |
| BCAA | Biodiversity Certification Assessment Area |
| BCAM | Biodiversity Certification Assessment Methodology |
| BVT | Biometric vegetation type |
| CA | Controlled action |
| CCC | Campbelltown City Council |
| CEEC | Critically Endangered Ecological Community |
| CPW | Cumberland Plain Woodland |
| DGPS | Differential Geographic Positioning System |
| DP&I | NSW Department of Planning and Infrastructure |
| DSEWPaC | Department of Sustainability, Environment, Water, Populations and Communities |
| EEC | Endangered Ecological Community |
| EPBC Act | Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 |
| ELA | Eco Logical Australia Pty Ltd |
| EP&A Act | NSW *Environmental Planning and Assessment Act* 1979 |
| FM Act | NSW *Fisheries Management Act* 1994 |
| IDO | Interim Development Order |
| LEP | Local Environmental Plan |
| LGA | Local Government Area |
| NCA | Non-controlled action |
| NCA-PM | Non-controlled action – particular manner |
| NES | Matters of national environmental significance |
| NoW | New South Wales Office of Water |
| NSW | New South Wales |
| NV Act | NSW Native Vegetation Act 2003 |
| OEH | Office of Environment and Heritage |
| RC | Riparian Corridor |
| RFEF | River-flat Eucalypt Forest |
| SEPP 44 | State Environmental Planning Policy No. 44 – Koala Habitat Protection |
| SIS | Species Impact Statement |
| SSTF | Shale Sandstone Transition Forest |
| TEC | Threatened Ecological Community |
| TofB | Top of Bank |
| TSC Act | NSW *Threatened Species Conservation Act* 1995 |
| VMP | Vegetation Management Plan |

| Abbreviation | Description |
|---|---|
| VRZ | Vegetated Riparian Zone |
| WM Act | NSW *Water Management Act* 2000 |
| WoNS | Weeds of National Significance |

# Executive summary

Eco Logical Australia Pty Ltd (ELA) was contracted by Old Mill Properties Pty Ltd on behalf of Mt Gilead Pty Ltd and by RMB Lawyers on behalf of S and A Dzwonnik to undertake an Ecological Assessment for a proposed rezoning of a selected portion of property owned by Mt Gilead Pty Ltd and S and A Dzwonnik, hereafter referred to as the "study site", in south western Sydney.

Mt Gilead is comprised of several lots (Lot 59 DP 752042, Lot 61 DP 752042, part of Lot 1 DP 807555 and part of Lot 2 DP 807555) within the Campbelltown Local Government Area (LGA). Under the proposed rezoning approximately 210 hectares (ha) will be predominantly rezoned for residential development which includes 27.31 ha of land for conservation, riparian or open space. This land is currently zoned as No 1 (Non-urban) within the City of Campbelltown Interim Development Order No 15 (IDO15).

The proposed rezoning site is located south of Campbelltown city centre, bounded by Appin Road to the east, rural land and the Sydney Water canal to the west, Noorumba Reserve to the north and a registered Biobank site (Beulah) to the south. Vegetation across the site consists of both remnant and degraded native vegetation and exotic pastures.

Native vegetation within the boundaries of the site consists of three vegetation communities:

- Cumberland Plain Woodland (CPW)
- Shale Sandstone Transition Forest (SSTF)
- River-flat Eucalypt Forest (RFEF).

CPW is listed as a critically endangered ecological community (CEEC) under both the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Threatened Species Conservation Act 1995* (TSC Act). SSTF is listed as an endangered ecological community (EEC) under both these acts. RFEF is listed as endangered under the TSC Act only.

Searches of the Atlas of NSW Wildlife and EPBC Act Protected Matters Search tool identified 25 threatened flora species, 46 threatened fauna species (one invertebrate, six frog, two reptiles, 19 birds, 16 mammals) and 11 migratory fauna species within a 5 km radius of Mt Gilead.

Literature review and database searches were undertaken and followed by field survey of the proposed rezoning site. The Biodiversity Certification Assessment Methodology (BCAM) was followed to make an assessment of the vegetation on the site. This included identifying the type and biometric condition of the vegetation present and assigning the vegetation to a condition class. CPW, RFEF and SSTF areas were categorised using these assessments and mapped according to the condition classes – low and moderate to good, with ancillary codes of scattered paddock trees, moderate and good. Ancillary codes are used to reflect variation within condition classes.

Riparian zones were defined in the field to the Top of Bank (TofB), with appropriate vegetated riparian zones (VRZ) mapped. Some first order (Strahler 1) streams that either do not meet the definition of a creek, or are proposed for removal have been identified with conditional approval granted by the NSW Office of Water (NOW).

The biodiversity values of the Mt Gilead area was assessed using the BCAM. The rationale for this method was that BCAM quantifies the impacts and mitigation efforts of the proposed rezoning and there is also intent to negotiate Biocertification of the proposed development lands concurrently (but not prior to) the rezoning of the land. The core feature of the Biocertification methodology is to 'improve or maintain' (IoM) biodiversity values by assessing the loss of biodiversity and how these losses are offset by conservation measures within and/or outside the Biocertification Assessment Area (BCAA).

The proposed layout has attempted to satisfy all offsetting requirements on site through the BCAM. Of the 9.06 ha of Cumberland Plain Woodland mapped on site, approximately 7.35 ha of the higher quality CPW will be retained and 1.71 ha in poor condition, mostly scattered paddock trees, will be impacted.

Of the 24.97 ha of Shale Sandstone Transition Forest on the site, 11.18 ha will be impacted and 13.79 ha retained. The development will cover areas of moderate condition and scattered paddock trees for SSTF.

All of the River-flat Eucalypt Forest (RFEF), 1.16 ha (100%) is to be retained.

Fauna surveys were based on the requirements of the BCAM. This means that some threatened species that are "ecosystem credit" species were not subject to targeted survey. No threatened flora species were identified during the field surveys which were undertaken in early – mid 2013. Seven threatened fauna were detected during targeted surveys. All of these species were microchiropteran bats except for one bird; *Glossopsitta pusilla* (Little Lorikeet). Additional targeted surveys for species identified during database searches may be required at the detailed design and development application stage if areas of potential habitat are likely to be impacted by proposed development if Biocertification of the site is not pursued.

The proposed rezoning would at least maintain the interrupted connectivity with surrounding vegetation to the north (Noorumba Reserve) and south (Beulah Biobank site) within the study site. Vegetation within the study site forms a stepping stone of islands within a predominantly exotic ground cover. The proposed rezoning and conservation measures will enhance the condition of retained patches of woodland reducing the degree of fragmentation. However, there is more significant vegetation to the east of Appin Rd that connects Noorumba reserve and Beulah (refer to **Figure 1**).

Based on the intended conservations measures for different areas of the proposal (areas "permanently managed and funded" and areas "permanently managed") ELA assessed the balance of developed versus retained vegetation and calculated the quantum of credits required and generated on site using the BCAM (DECCW 2011). All three of the vegetation types exceeded their credit requirements on site under the proposal "permanently managed and funded" and "permanently managed" conservation measures scenarios.

Therefore, this report concludes that a balance between development and conservation is achievable and that for the purposes of the planning gateway, ecological issues are adequately addressed.

# 1 Introduction

## 1.1 DESCRIPTION OF PROJECT

Old Mill Properties Pty Ltd (on behalf of Mt Gilead Pty Ltd) and RMB Lawyers (on behalf of S and A Dzwonnik) commissioned Eco Logical Australia Pty Ltd (ELA) to undertake an Ecological Assessment as part of the proposed rezoning of land at Mt Gilead, Appin Road, Campbelltown.

Eco Logical Australia was commissioned to prepare a Flora and Fauna Assessment in 2005 (ELA, 2006) for Australand. Since the completion of the original flora and fauna report the development boundaries have changed and the conservation status of one threatened ecological community (Cumberland Plain Woodland) has increased to critically endangered under the *Threatened Species Conservation Act 1995* (TSC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This ecological assessment has addressed the survey requirements using the Biodiversity Certification Assessment Methodology (BCAM) as it is the intent of the major landowner (Mt Gilead Pty Ltd holding 84% of the study area) to pursue Biocertification prior to lodgement of the first Development Application.

## 1.2 REPORT OBJECTIVES

This report includes the findings of a comprehensive database search and literature review of the relevant statutory considerations associated with the environmental constraints present at the site, field survey results and an assessment of how the proposal may impact upon the site's values.

The objectives of the report are:

- To identify and describe the vegetation communities and flora species present in the study site, and describe their conservation significance
- To assess the likelihood of threatened and migratory fauna species listed on the schedules of the EPBC Act occurring within the study site, and their conservation significance
- To comment on the likely impact of the proposal on threatened ecological communities, populations, and species, and other environmental features pursuant to relevant statutory requirements.

## 1.3 STUDY SITE

The study site is located off Appin Road, approximately 5 km south of Campbelltown city centre within Campbelltown LGA (Local Government Area) (**Figure 1**). The study site is an irregular shape and includes Lot 59 DP 752042, Lot 61 DP 752042, part of Lot 1 DP 807555 and part of Lot 2 DP 807555. The total area of the study site is 210 ha. It is bounded by Appin Road to the east, rural land and the Sydney Water canal to the west, Noorumba Reserve to the north and Beulah, a registered Biobank site, to the south. The MDP dwelling numbers listed is as 1500 dwellings. The planning studies are investigating a range of 1400-1700 dwellings, with any number above the 1500 MDP number to be justified on the basis of capacity of the site and infrastructure. This study has assumed the maximum number of 1700 dwellings as a conservative base case for the generation of noise/ air quality/ traffic. The proposed rezoning will provide for the lots to be interspersed with open space containing bushland and waterways.

The study site is currently used for agricultural purposes with a small, disused shale quarry on site. There are constructed dams, remnant native vegetation and improved pastures on site. In the greater locality the landscape is a mosaic of new urban development and rural grazing.

The proposed rezoning site will be referred to as the 'study site' herewith. Location of the study site is shown in **Figure 1**.

## 1.4 PLANNING PROPOSAL

The study site is currently zoned as No 1 (Non-urban) within the City of Campbelltown Interim Development Order No 15 (IDO15). The proposed rezoning to "Urban Areas" will follow the *Proponent Instigated* Local Environmental Plans (LEP) Rezoning Process between Campbelltown City Council (CCC) and New South Wales Department of Planning and Infrastructure (DP&I). Stage two of the rezoning process was approved in late 2012 with the Minister for Planning issuing the Gateway Determination section 56 of the *Environmental Planning and Assessment Act 1979* (EP&A).

The planning proposal is to rezone the study site to a combination of residential, rural and conservation/riparian/open space land use. 158.46 ha is proposed for residential (includes development and detention basins), 24.18 ha for conservation and riparian (offset) with the balance (26.94 ha) being retained (**Figure 2**).

Conservation lands are designed to protect areas of moderate and good quality vegetation as well as maintain ecological links through the site to conservation areas north and south of the study site.

Conservation zones will be protected and managed via:

- Zoning RE1 – Public Recreation zone and RU2 – Rural Zone with a terrestrial biodiversity overlay
- A Vegetation Management Plan that will lead to the improvement of the vegetation and habitat condition by addressing weeds, feral animals and uncontrolled access.

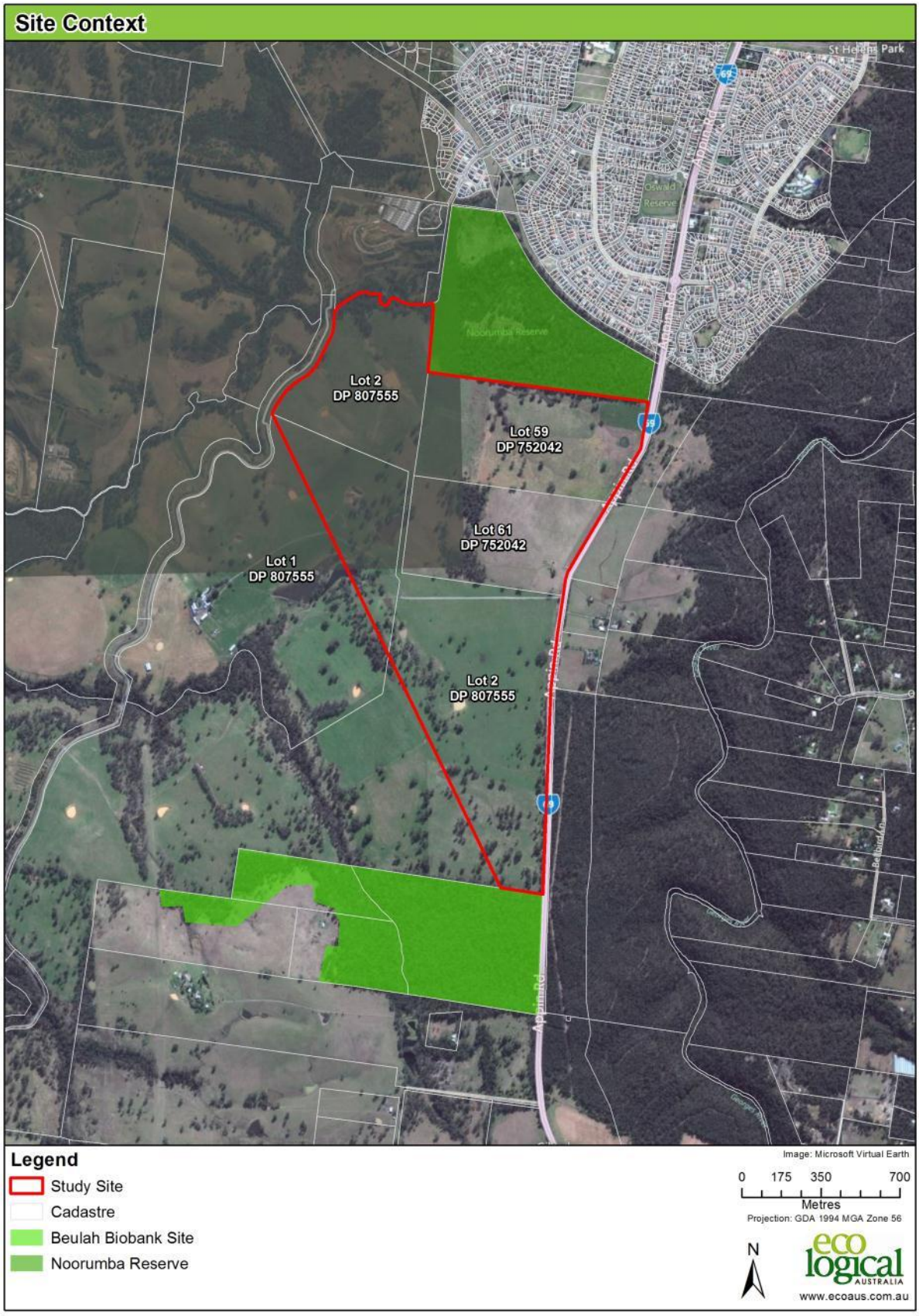



**Figure 1: Location of the proposal rezoning**

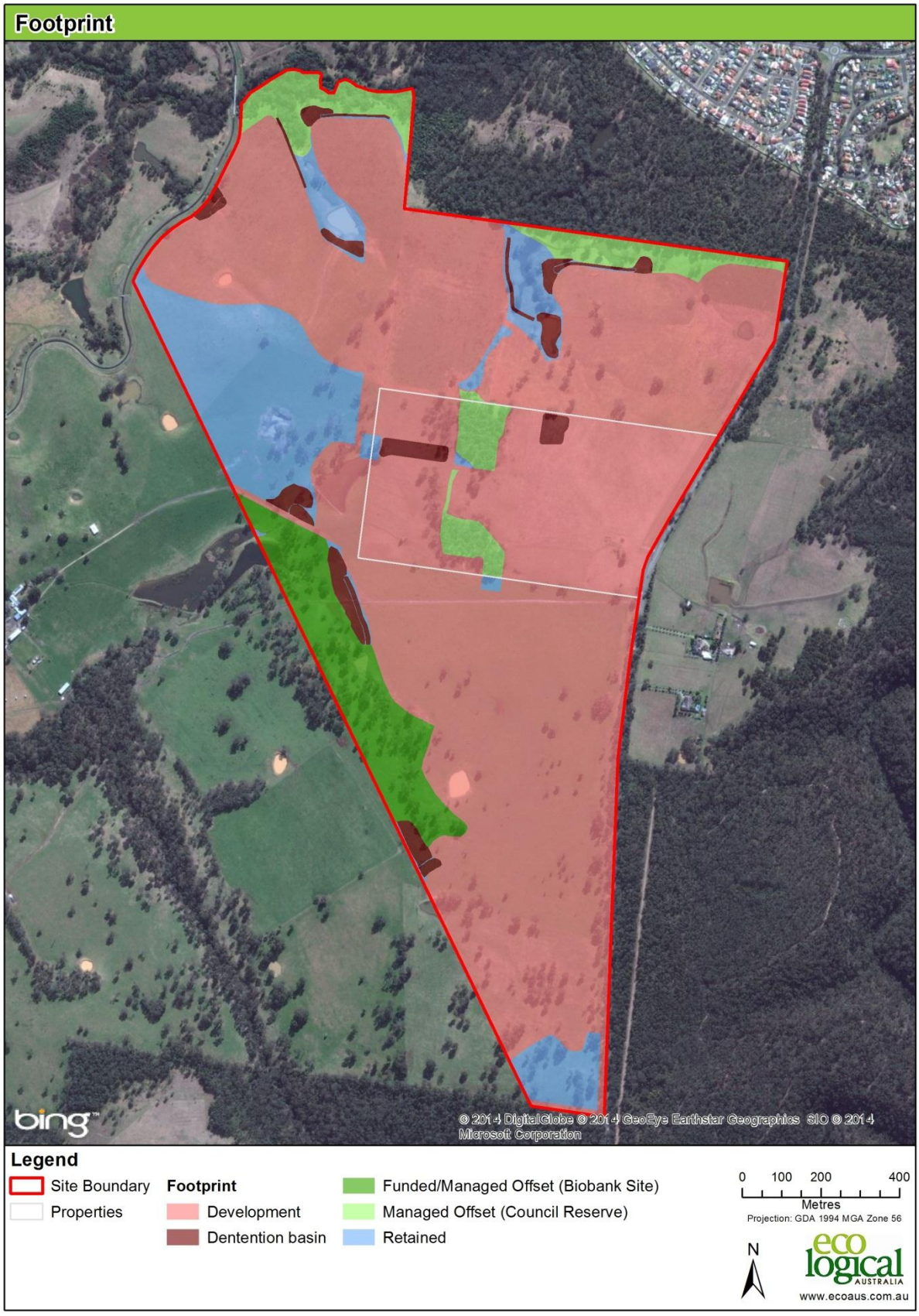



**Figure 2: Proposed future land use**

# 2 Legislative requirements

Commonwealth and State legislation and policies, as well as local policies apply to the assessment, planning and management of ecological issues within the study site at Mt Gilead. A brief outline of the relevant Commonwealth and State Acts and Policies, and local policies, is provided below. The following are relevant to the proposed works:

- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)
- NSW *Threatened Species Conservation Act 1995* (TSC Act)
- NSW *Water Management Act 2000* (WM Act)
- NSW *Fisheries Management Act 1994* (FM Act)
- NSW *Native Vegetation Act 2003 (NV Act)*
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection* (SEPP 44)
- *Campbelltown Interim Development Order No 15 (IDO15)*
- Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act)

## 2.1 STATE LEGISLATION AND POLICIES

### 2.1.1 Environmental Planning and Assessment Act (1979)

The *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal planning legislation for NSW, providing a framework for the overall environmental planning and assessment of development proposals. It provides a framework for the overall environmental planning and assessment of proposals. Various pieces of environmental legislation, including the TSC Act, are linked to the EP&A Act for environmental assessment. The EP&A Act also provides for the making and implementation of environmental planning instruments i.e. State Environmental Planning Policies, Regional Environmental Plans and Local Environmental Plans.

Local Environmental Plans can be amended by the Minister under section 59 of the Act, following consideration of a Planning Proposal (s55), a gateway determination (s56) and Community Consultation (s57).

### 2.1.2 Threatened Species Conservation Act (1995)

The NSW *Threatened Species Conservation Act 1995* (TSC Act) aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. The Act also aims to protect critical habitat, and eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities.

Whilst the rezoning of land does not trigger any particular mechanisms of the TSC Act, matters relating to threatened species, endangered populations and endangered ecological communities are typically considered in the plan-making (i.e. rezoning) stage to ensure subsequent development can be undertaken without having a significant impact on these matters. If a development is likely to have a significant impact on these matters, a Species Impact Statement (SIS) must be prepared and submitted with the Development Application.

Should the Planning Authority pursue Biocertification, an application must be made to Minister under Part 7AA of the TSC Act to have the land biocertified, the consequence of which is that the consent authority (i.e. Campbelltown City Council), is not required to assess impacts to biodiversity values at the DA stage.

### 2.1.3 Water Management Act (2000)

A controlled activity approval under the Water Management Act 2000 (WM Act) is required for certain types of developments and activities that are carried out in or on waterfront land which is land within 40m of a river, lake or estuary. The NSW Office of Water (NoW) have prepared guidelines for riparian corridors on waterfront land, including guidance on vegetated riparian zones (VRZ) and infrastructure development within this area. Whilst a rezoning is not considered a controlled activity, the principles of the Act and the guidelines can be used to ensure land zoning is conducive to the protection of vegetated riparian zones during the subdivision stage of the site when a Controlled Activity approval is likely to be required.

### 2.1.4 Fisheries Management Act (1994)

The *Fisheries Management Act* (1994) lists threatened aquatic species which require consideration when addressing the potential impacts of a proposed development. If a proposed development is likely to significantly affect a threatened species, population, population or their habitats, SIS is required to be prepared.

### 2.1.5 Native Vegetation Act (2003)

The *Native Vegetation Act 2003* regulates the clearing of all native vegetation in NSW except on land listed under Schedule 1 of the Act. The NV Act provides a framework for the conservation and sustainable management of native vegetation in NSW.

The Campbelltown LGA is excluded for the NV Act, and therefore, the NV Act does not apply to this proposal.

### 2.1.6 Campbelltown Interim Development Order No 15

The study site is currently zoned as No 1 (Non-urban) within the City of Campbelltown Interim Development Order No 15 (IDO15). Rezoning will create residential, rural and conservation/riparian/open space zones.

A draft Campbelltown LEP 2014 is currently on exhibition.

Conservation zones will be protected and managed via:

- Zoning RE1 – Public Recreation zone and RU2 – Rural Zone with a terrestrial biodiversity overlay
- A Vegetation Management Plan that will lead to the improvement of the vegetation and habitat condition by addressing weeds, feral animals and uncontrolled access.

### 2.1.7 State Environmental Planning Policy No. 44 – Koala Habitat Protection

SEPP 44 encourages the conservation and management of koala habitats in certain local government areas (LGAs). SEPP 44 aims to encourage the conservation and management of natural vegetation areas that provide habitat for koalas to ensure permanent free-living populations will be maintained over their present range and reverse the current trend of koala population decline. SEPP 44 achieves this by:

- Requiring the preparation of plans of management before development consent can be granted in relation to areas of Core Koala Habitat
- Encouraging the identification of areas of Core Koala Habitat
- Encouraging the inclusion of areas of Core Koala Habitat in environment protection zones.

Whilst the mechanisms of SEPP 44 do not apply to rezoning of land, the principles and aims of the SEPP should be considered during the plan making stage (refer to section 4.5).

## 2.2 COMMONWEALTH LEGISLATION

### 2.2.1 Environment Protection and Biodiversity Conservation Act (1999)

The EPBC Act establishes a process for assessing the environmental impact of activities and developments where matters of 'national environmental significance' (NES) may be affected. NES matters relevant to this study include threatened species, ecological communities and migratory species that are listed under the Act.

Under the Act, any action which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Commonwealth Department of the Environment (formerly Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)) which is responsible for administering the EPBC Act.

Actions that may have a significant impact on one or more matters of NES need to be referred to the Department under the EPBC Act. The EPBC Act referrals process can produce one of three outcomes:

> Non-controlled action (NCA): Assessment and approval under the EPBC Act is **not required**. The project may proceed without further approval under the EPBC Act.
>
> Non-controlled action – particular manner (NCA-PM): Assessment and approval under the EPBC Act is **not required** provided the action is undertaken in a specific way (similar to conditions).
>
> Controlled Action (CA): (The project will or is likely to have a significant impact on one or more matters of national environmental significance.) The project will require full assessment and approval before it can proceed.

This report identifies EPBC Act matters of NES. The nationally threatened ecological communities and threatened and migratory species occurring or having the potential to occur in the assessment area are outlined in **Appendix A.**

Whilst amendments to the LEP are not considered an 'action' under the EPBC Act, consideration of matters of National Environmental Significance at the plan making stage can reduce the risk that subsequent development will have a significant impact on these matters.

# 3 Methods

## 3.1 LITERATURE REVIEW AND DATABASE SEARCH

Searches of BioNet / Atlas of NSW Wildlife and the EPBC Protected Matters Search Tool for threatened flora and fauna which have either been previously recorded within the region or are likely to occur due to the presence of suitable habitat were undertaken on 23 November 2012. A search of a 10 km radius around the study site was undertaken. The threatened species profiles database which supports the Biobanking Assessment Tool v2.0, was also accessed to identify which species required targeted survey. Species from these searches were combined to produce a list of threatened fauna and flora species that may occur within the study site.

**Appendix A** of this report lists the threatened flora and fauna species identified by the database searches as potentially occurring within a 5 km radius of the study site.

A review of literature relating to this study site was undertaken prior to field survey and the assessment of potential impacts of the proposed rezoning. The distribution of vegetation communities was considered with review of both NSW Office of Environment and Heritage (OEH) vegetation maps of the Cumberland Plain (NSW NPWS 2002) and the vegetation maps prepared in ELA (2006).

Prior to the field assessment a gap analysis was conducted of the BCAM survey requirements.

## 3.2 FIELD SURVEY - VEGETATION

Field surveys were designed to validate mapping of the vegetation communities, Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF) as determined from the desktop studies and literature review. CPW is listed as a Critically Endangered Ecological Community (CEEC) and SSTF is listed as an Endangered Ecological Community (EEC) under both the EPBC Act and the TSC Act. RFEF is listed as an Endangered Ecological Community under the TSC Act only.

ELA validated NPWS vegetation mapping of the study site on 16th and 28th February and 1st and 6th of March, 2006 (ELA 2006). Surveys included validation of vegetation communities and condition and identification of potential threatened flora habitat

Additional floristic surveys were undertaken by Bruce Mullins (senior ecologist) and Belinda Failes (ecologist) over five field days, 25th and 26th March, 4th April, 27th June and 20th September 2013. Surveys followed the NSW Biobanking Methodology (DECC 2009). Targeted threatened flora surveys were conducted in potential habitat. Random meanders for threatened flora species were undertaken in areas of suitable habitat in accordance with OEH guidelines (DEC 2004). Due to previous land use and habitat modification for agricultural purposes, most of the site was deemed unsuitable for threatened flora, and only selected areas of the study site were surveyed (**Figure 3**).

The biodiversity credit calculator determined that the following flora species require field survey (**Table 1**).

**Table 1: Threatened flora species required for survey by the Biodiversity credit calculator**

| Scientific Name | Common Name | Conservation Status | | Survey Timing | Surveys undertaken during survey time? |
|---|---|---|---|---|---|
| | | TSC ACT | EPBC ACT | | Yes/No |
| *Acacia bynoeana* | Bynoe's Wattle | E | V | Sep – Mar | Yes |
| *Acacia pubescens* | Downy Wattle | V | V | All year | Yes |
| *Cynanchum elegans* | White-flowered Wax Plant | E | E | All year | Yes |
| *Dillwynia tenuifolia* | | V | - | All year | Yes |
| *Dillwynia tenuifolia* - endangered population Kemps Creek | | EP | - | | |
| *Epacris purpurascens* var. *purpurascens* | | V | - | All year | Yes |
| *Eucalyptus benthamii* | Camden White Gum | V | V | All year | Yes |
| *Galium australe* | | E | - | Nov – Mar | Yes |
| *Grevillea juniperina* subsp. *Juniperina* | Juniper-leaf Grevillea | V | - | All year | Yes |
| *Grevillea parviflora* subsp. *parviflora* | Small-flower Grevillea | V | V | All year | Yes |
| *Grevillea parviflora* subsp. *supplicans* | | E | - | All year | Yes |
| *Gyrostemon thesioides* | | E | - | All year | Yes |
| *Hibbertia superans* | | E | - | Jul – Dec | Yes, in Dzwonnik's site |
| *Leucopogon fletcheri* subsp. *fletcheri* | | E | - | All year | Yes |
| *Marsdenia viridiflora* subsp. *viridiflora* - endangered population | | EP | - | All year | Yes |
| *Melaleuca deanei* | Deane's Paperbark | V | V | Dec – Feb | No |
| *Persicaria elatior* | Knotweed | V | V | Dec – May | Yes |
| *Persoonia bargoensis* | Bargo Geebung | E | V | Dec – May | Yes |
| *Persoonia hirsuta* | Hairy Geebung | E | E | Dec – May | Yes |
| *Persoonia nutans* | Nodding Geebung | E | E | All year | Yes |
| *Pimelea curviflora* var. *curviflora* | | V | V | All year | Yes |
| *Pimelea spicata* | Spiked Rice - Flower | E | E | All year | Yes |
| *Pomaderris brunnea* | Rufous Pomaderris | V | V | All year | Yes |
| *Pterostylis saxicola* | Sydney Plains Greenhood | E | E | Sep – Nov | Yes in Dzwonnik's site |
| *Pultenaea pedunculata* | Matte Bush-pea | E | - | Sep – Nov | Yes in Dzwonnik's site |

| Scientific Name | Common Name | Conservation Status | | Survey Timing | Surveys undertaken during survey time? |
|---|---|---|---|---|---|
| | | TSC ACT | EPBC ACT | | Yes/No |
| *Tetratheca glandulosa* | | V | V | Jul - Nov | Yes in Dzwonnik's site |
| *Wahlenbergia multicaulis* - endangered population | Tadgell's Bluebell | EP | - | All year | Yes |

Note: V = vulnerable, E = endangered, EP = endangered population.

## 3.3 BIOMETRIC PLOTS

BioMetric Vegetation Type Database (DECC 2009) has been used to classify vegetation types within the study site. Vegetation mapping conducted by NPWS (2002) was validated during the survey and the results incorporated into this report.

ELA used previous mapping of vegetation communities as stratified units prior to field assessment. Stratification of vegetation types is required under the BCAM guidelines to determine the survey effort. BCAM guidelines use remnant size (hectares) and condition class to define these units. The assessment of the study site required six plots to meet the BCAM requirements (based on the number and area of vegetation zones). ELA conducted a total of 18 plots within the assessment area, including seven in 'cleared' areas. The location of plots is provided in **Figure 3**, with one plot surveyed outside the study site.

Quadrats were consistent with the NSW Biobanking Methodology (DECC 2009). Quadrats consisted were 0.04 ha (20 m x 20 m) nested in 0.1 ha (20 m x 50 m) transect. All above ground vascular flora species identified to the lowest possible unit. Habitat features, including a number of hollow-bearing trees, length of fallen logs (>10 cm diameter) and projected foliage cover for native and exotic vegetation in each strata were estimated in accordance with the method along the transect.

Quadrats and transects were conducted in the following vegetation units:

- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin (1 plot)
- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin (4 plots)
- Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin (8 plots)
- Exotic pastures (5 plots).

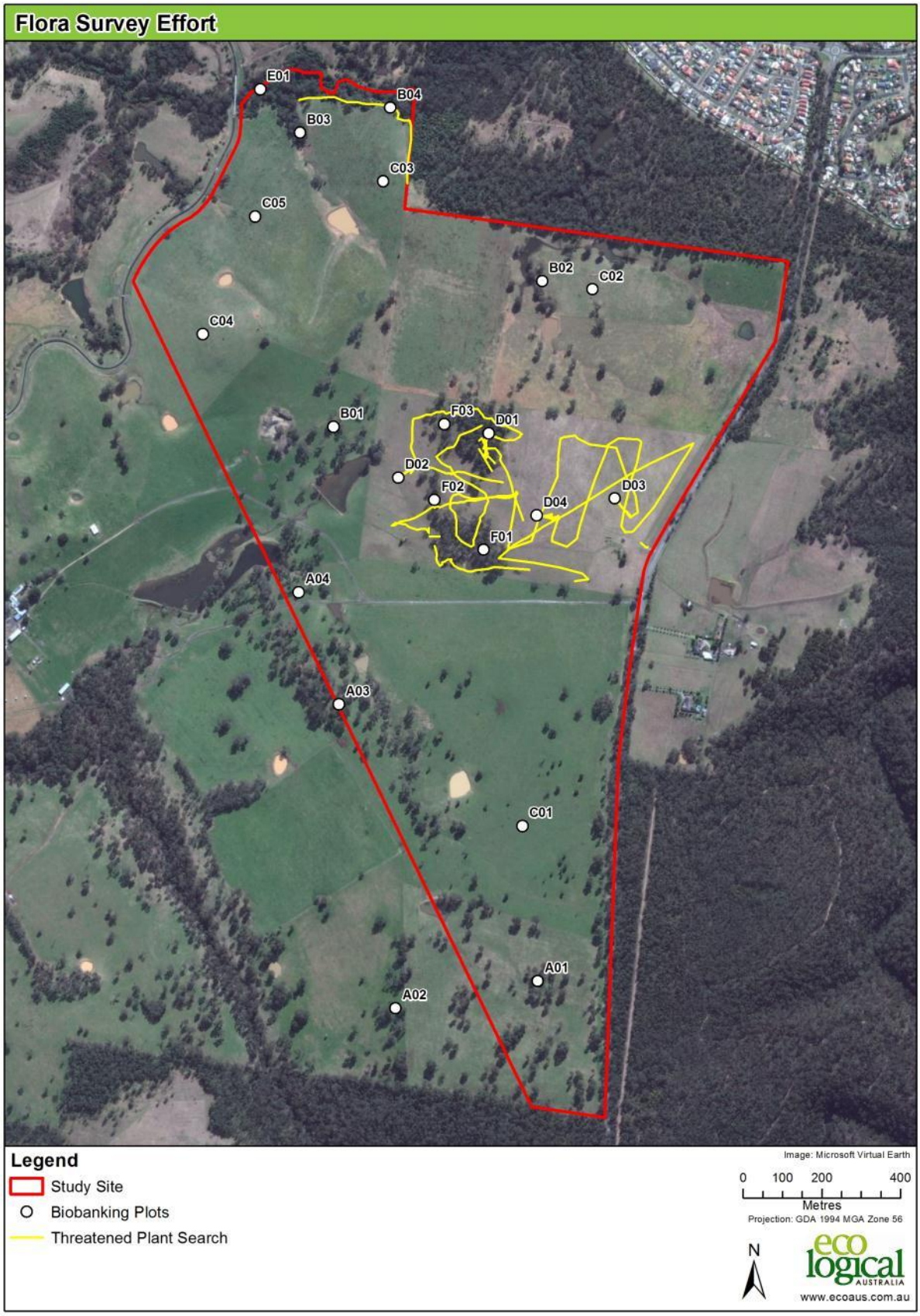



**Figure 3: Survey plot locations and targeted flora survey within study site boundary**

## 3.4 FIELD SURVEY - FAUNA

The following threatened fauna species were predicted by the Biodiversity credit calculator tool (**Table 2**). The species in the table directed the survey techniques applied at Mt Gilead with opportunistic observations of fauna noted during traverses of the study site.

**Table 2: Threatened fauna species required for survey by the Biodiversity credit calculator**

| Scientific Name | Common Name | Conservation Status | | Survey Timing | Surveys undertaken during survey time? |
|---|---|---|---|---|---|
| | | TSC ACT | EPBC ACT | | Yes/No |
| BIRDS | | | | | |
| *Callocephalon fimbriatum* | Gang-gang Cockatoo | V | - | All Year | Yes |
| *Callocephalon fimbriatum* population in the Hornsby and Ku-ring-gai LGA | Gang-gang Cockatoo population | E1 | - | | |
| *Circus assimilis* | Spotted Harrier | V | - | All Year | Yes |
| *Hieraaetus morphnoides* | Little Eagle | V | - | All year | Yes |
| *Lophoictinia isura* | Square-tailed Kite | V | - | Sep – Mar | Yes |
| FROGS | | | | | |
| *Heleioporus australiacus* | Giant Burrowing Frog | V | V | Sep – May | Yes |
| *Litoria aurea* | Green and Golden Bell Frog | E1 | V | Aug – Mar | Yes |
| MAMMALS | | | | | |
| *Miniopterus schreibersii oceanensis* | Eastern Bent-wing Bat (breeding habitat) | V | - | Sep - May | Yes |
| *Myotis macropus* | Large-footed Myotis (breeding habitat) | V | - | All year | Yes |
| *Pteropus poliocephalus* | Grey-headed Flying-fox (camps) | V | V | All year | Yes |
| REPTILES | | | | | |
| *Varanus rosenbergi* | Rosenberg's Goanna | V | - | Nov - Feb | Yes |

The location of fauna survey is in **Figure 4**.

### Birds

Six bird surveys were conducted between the hours of 9:05 am and 10:45 am over four mornings (25th and 26th March, 10th April and 19th July 2013) in preferred habitat (**Figure 4**). Surveys conducted in March and July included two ecologists over 20 survey minutes. The surveys in April were conducted by one ecologist over 30 minute intervals.

Surveys for nocturnal birds were not conducted as part of this assessment. Where possible indirect evidence of owl wash, faecal pellets or large hollow bearing trees were recorded during a general traverse of the study site.

**Mammals**

Microchiropteran (microbats) bat surveys used ultrasonic Anabat detectors set at the edge of two different dams and one patch of woodland within the study site on the 10 to 11 April, and 17 to 18 July 2013. Anabat detectors were programed to operate between 1800 hours and 0600 hours for two consecutive nights in accordance with DEC (2004). Anabat calls were analysed by Alicia Scanlon (ecologist, Eco Logical Australia).

Habitat features were noted in the Biometric plots and while traversing the site. These included:

- presence of hollow bearing trees
- presence of standing or flowing water bodies (permanent or intermittent) and fringing vegetation
- rocks and rocky outcrops.

**Reptiles and amphibians**

Waterbodies were inspected to assess their suitability for the target frog species; *Litoria aurea* (Green and Golden Bell Frog) and *Heleioporus australasicus* (Giant Burrowing Frog). Upon inspection, these habitat were deemed unsuitable, thus, species survey for these species was not undertaken.

Opportunistic observations and potential habitat features were recorded for reptiles and amphibians during general site traverse. All waterbodies and drainage lines were surveyed during riparian assessment.

## 3.5 FIELD SURVEY - RIPARIAN ZONES

A desktop literature assessment was undertaken including a review of the previous riparian assessment conducted as part of the flora and fauna report (ELA 2006). All streams and drainage lines were categorised prior to field inspection. Stream categorisation followed the *Guidelines for controlled activities* set out by the NSW *Office of Water* (NOW) (DWE 2008) (formerly the Department of Water and Energy). This methodology is based on the Strahler Stream Order classification which identifies Riparian Corridor (RC) widths as measured from the Top of Bank (TofB) and minimum Vegetated Riparian Zone (VRZ) widths.

In summary, the riparian and aquatic habitat assessment includes:

- Mapping of Top of Bank (TofB) using a differential GPS (DGPS),
- Classification of the condition and recovery potential of stream reaches within the study site,
- Categorisation of each stream using the Strahler methodology,
- Identification of heavily degraded streams or areas of overland flow that do not meet the definition of a ‘river’ and are suitable for removal.

The riparian categorisation and corridor mapping has been carried out in accordance with the Strahler-based methodology. All streams identified from 1:25,000 topographic map series were inspected and validated in the field. Drainage lines that were not classified in this assessment are deemed to be of limited riparian value or do not meet the definition of a river.

Field surveys were conducted over 1.5 days by an aquatic ecologist, Ian Dixon, and assisted by ecologist Belinda Failes. Top of Bank (TofB) mapping was conducted along all watercourses present in the study site using a DGPS (accuracy 50 cm - 70 cm). The TofB mapping was cross-checked during desktop review of up-to-date high resolution satellite imagery. In some situations the watercourses have been significantly disturbed and in some areas display no true bed and bank characteristics.

Watercourse reach numbers have been assigned to enable clear identification and descriptions of the relevant sections of each watercourse. The condition of each reach was assessed, along with its recovery potential, using the method outlined in Geomorphic Categorisation of Streams in the Hawkesbury Nepean Catchment (DLWC 2000) document. The condition of each stream was classified into one of the following categories:

- Near intact condition
- Good condition
- Moderate condition
- Degraded condition.

A detailed assessment of the hydrology of each watercourse reach enabled the allocation of a stream order value (from 1 to 3) as per the Strahler System. Using the Strahler system, numbering occurs from the top of the catchment with the smallest headwaters being assigned as 1st Order. Stream order number increases downstream through the catchment as tributaries merge and form larger streams.

The Office of Water (NoW) guidelines for vegetated riparian zones (VRZ) and riparian corridors (RC) are listed in **Table 3**.

**Table 3: Recommended riparian corridor widths**

| Watercourse Type | VRZ Width (each side of watercourse) | Total RC Width |
|---|---|---|
| 1st order | 10 m | 20m + channel width |
| 2nd order | 20m | 40m + channel width |
| 3rd order | 30m | 60m + channel width |
| 4th order or greater | 40m | 80m + channel width |

Source: NoW 2012


**Figure 4: Location of fauna survey sites**

# 4 Results

## 4.1 LITERATURE REVIEW AND DATABASE SEARCH

Database searches and literature review were conducted using 5 km search radius from the Mt Gilead study site. **Figure 5** shows the locations of threatened flora species in the locality i.e. within a 5 km radius of the study site and **Figure 6** to **Figure 8** shows the locations of threatened fauna species in the locality.

These database searches revealed the likely occurrence of four endangered ecological communities, 28 threatened flora species, 46 threatened fauna species (one invertebrate, six frog, two reptiles, 19 birds, 16 mammals and two fish species) and 11 migratory fauna species within the locality.

The results of the BCAM species search revealed that there were 25 plant species (see Section 3.2 above) and 10 animal species that required survey (see Section 3.4 above). There were an additional two populations that required survey, one plant and one animal population. All of these species are called 'species credit species' and require surveys to be conducted in the appropriate season with an approved methodology where there is appropriate habitat.

There were a further 21 species which are called 'ecosystem credit species'. These species do not require survey but are assumed to be present on site due to the habitat features of the study site (**Table 4**).

**Table 4: Threatened species that were ecosystem credit species.**

| Scientific Name | Common Name |
|---|---|
| BIRDS | |
| *Burhinus grallarius* | Bush Stone-curlew |
| *Climacteris picumnus victoriae* | Brown Treecreeper (eastern subspecies) |
| *Glossopsitta pusilla* | Little Lorikeet |
| *Lathamus discolor* | Swift Parrot |
| *Melithreptus gularis gularis* | Black-chinned Honeyeater (eastern subspecies) |
| *Neophema pulchella* | Turquoise Parrot |
| *Ninox connivens* | Barking Owl |
| *Ninox strenua* | Powerful Owl |
| *Petroica boodang* | Scarlet Robin |
| *Stagonopleura guttata* | Diamond Firetail |
| *Tyto novaehollandiae* | Masked Owl |
| *Xanthomyza phrygia* | Regent Honeyeater |
| INVERTEBRATES | |
| *Meridolum corneovirens* | Cumberland Plain Land Snail |
| MAMMALS | |
| *Dasyurus maculatus* | Spotted-tailed Quoll |
| *Falsistrellus tasmaniensis* | Eastern False Pipistrelle |
| *Miniopterus schreibersii oceanensis* | Eastern Bent-wing Bat |

| Scientific Name | Common Name |
|---|---|
| *Mormopterus norfolkensis* | Eastern Freetail-bat |
| *Myotis macropus* | Large-footed Myotis |
| *Phascolarctos cinereus* | Koala |
| *Pteropus poliocephalus* | Grey-headed Flying-fox |
| *Scoteanax rueppellii* | Greater Broad-nosed Bat |

## 4.2 VEGETATION COMMUNITIES

The NPWS vegetation mapping and ELA (2006) surveys formed the foundation for the Biocertification Assessment. Three unique native vegetation communities were mapped within the study site. The classification of each community was converted to Biometric vegetation types and relevant listing as threatened ecological communities (TEC) under both the EPBC and TSC Acts. Following field survey at the study site, three vegetation communities (**Table 5**) have been mapped for the site, plus there was a large area of cleared vegetation mapped as exotic pasture. **Table 5** also indicates the number of plots completed per vegetation type.

**Table 5: Vegetation community terminology**

| Vegetation Community | Corresponding Biometric Vegetation Type | Corresponding Endangered Ecological Community | No. of plots required under BCAM | Number of plots surveyed |
|---|---|---|---|---|
| Cumberland Plain Woodland (CPW) | Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin | Cumberland Plain Woodland in the Sydney Basin Bioregion* | 3 | 4 |
| Shale Sandstone Transition Forest (SSTF) | Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin | Shale / Sandstone Transition Forest | 7 | 8 |
| River-flat Eucalypt Forest (RFEF) | Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plains, Sydney Basin | River-flat Eucalypt Forest | 1 | 1 |
| Exotic pasture | N/A | | 5 | 5 |

*Note: this community is Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest under the EPBC Act.

Native vegetation communities were consistent with the low to moderate-good BCAM condition categories. Mixed native / exotic grassland where the percentage of native species cover is less than 50% is not recognised as a native vegetation community under the BCAM and has been categorised as exotic pasture. Exotic pasture was considered cleared land.

Distribution of the vegetation including condition classes is mapped in **Figure 12**.

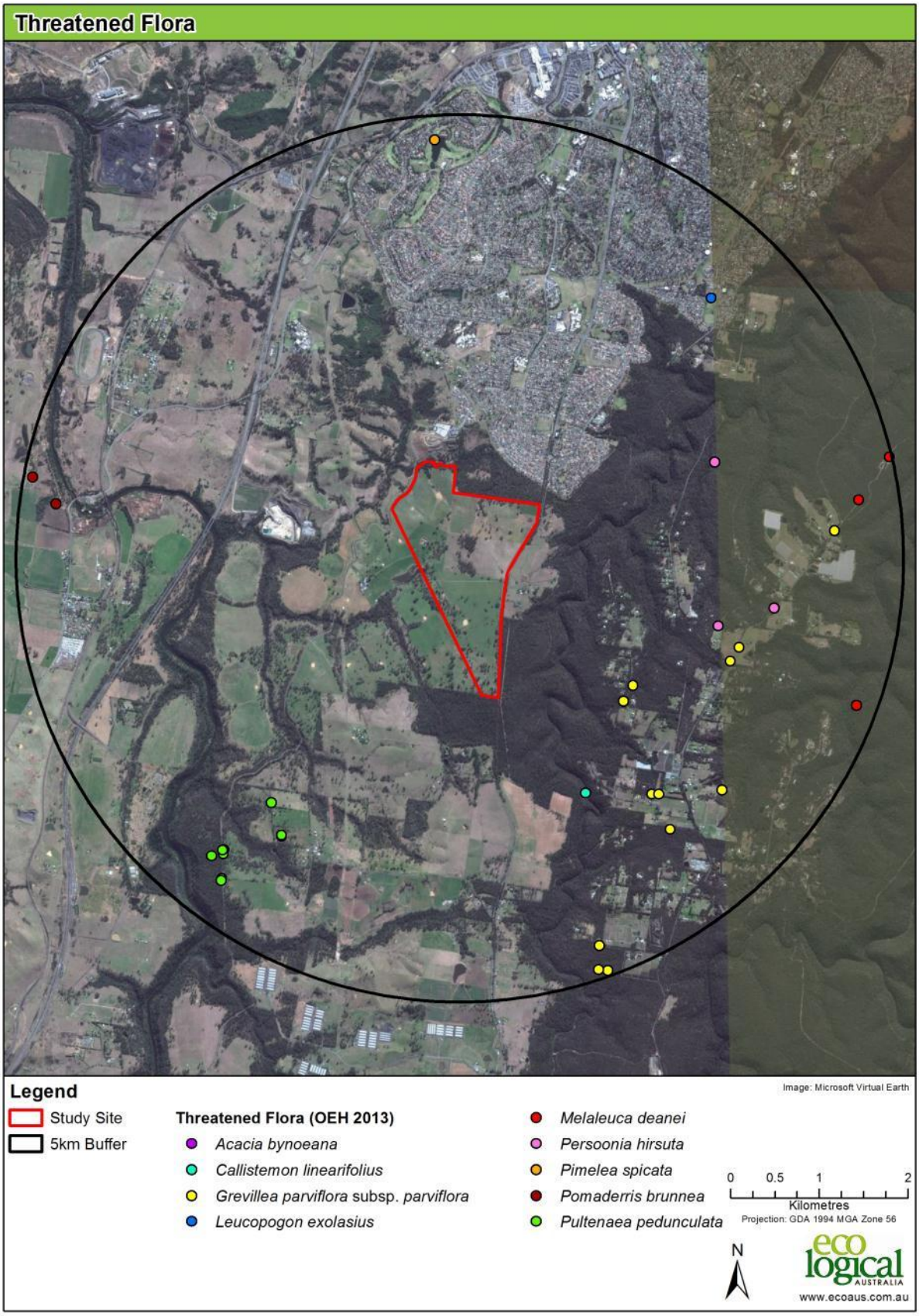



**Figure 5: Atlas of NSW Wildlife records of threatened flora within 5 km of the study site**

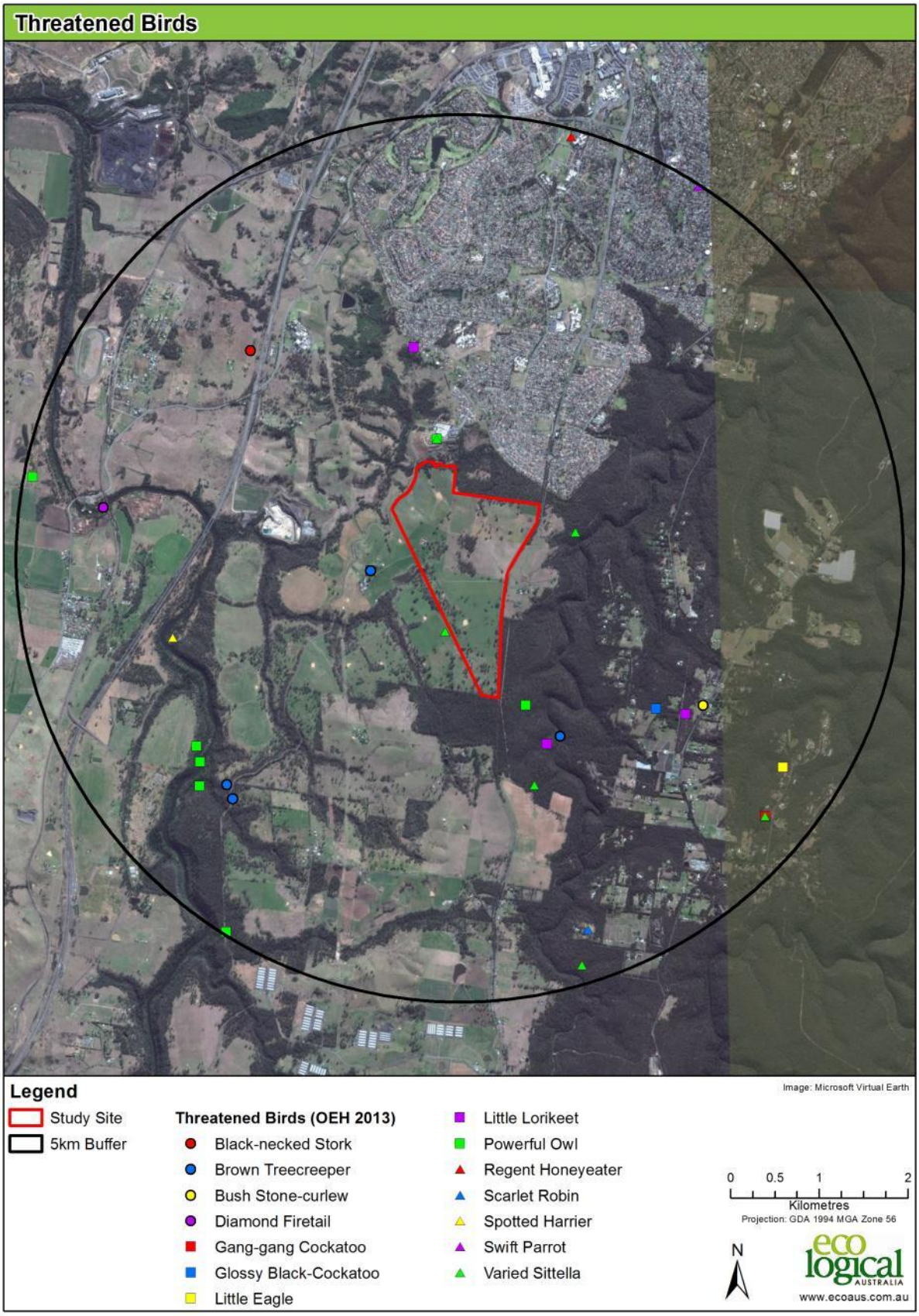



**Figure 6: Atlas of NSW Wildlife records of threatened birds within 5 km of the study site**

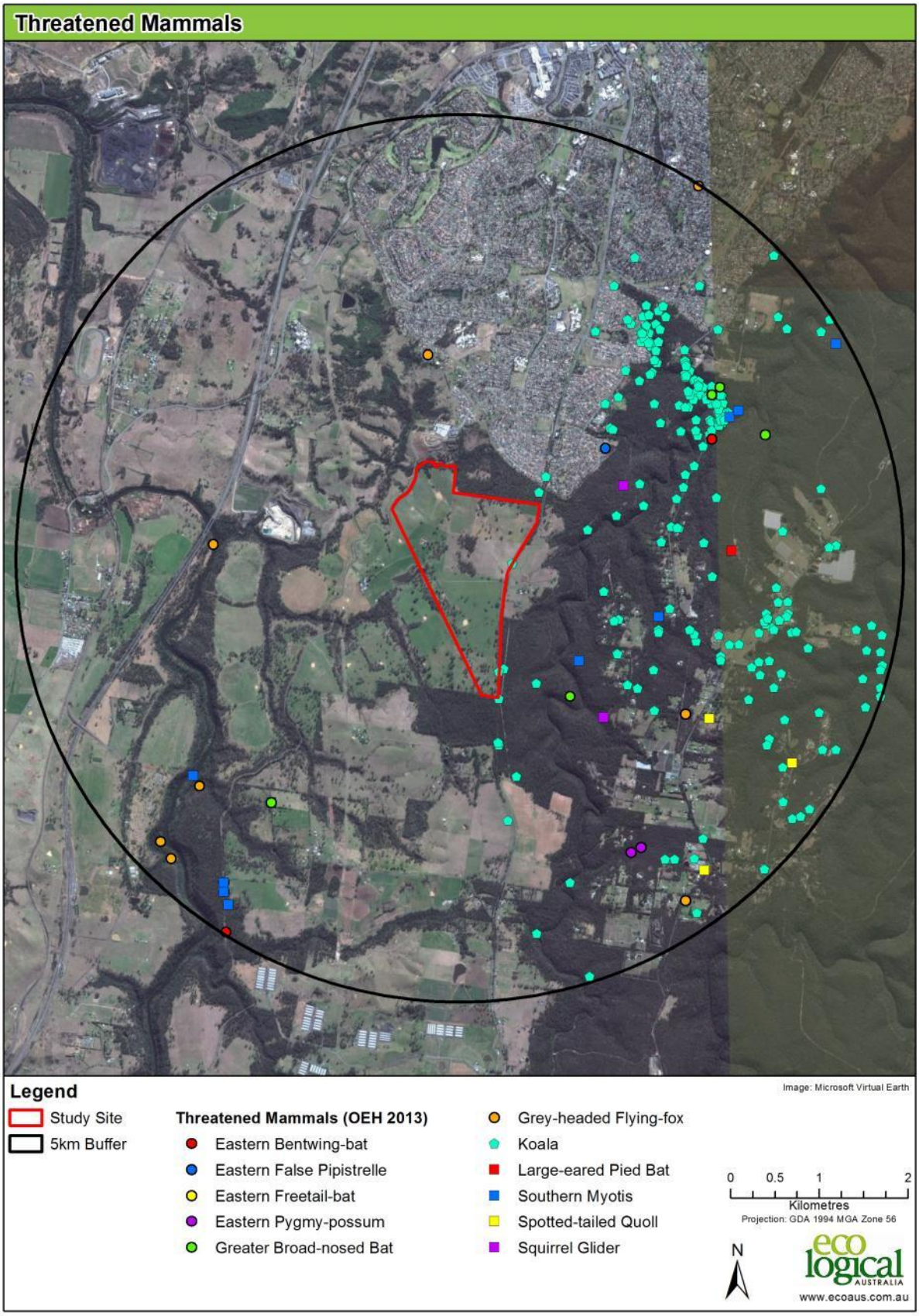



**Figure 7: Atlas of NSW Wildlife records of threatened mammals within 5 km of the study site**

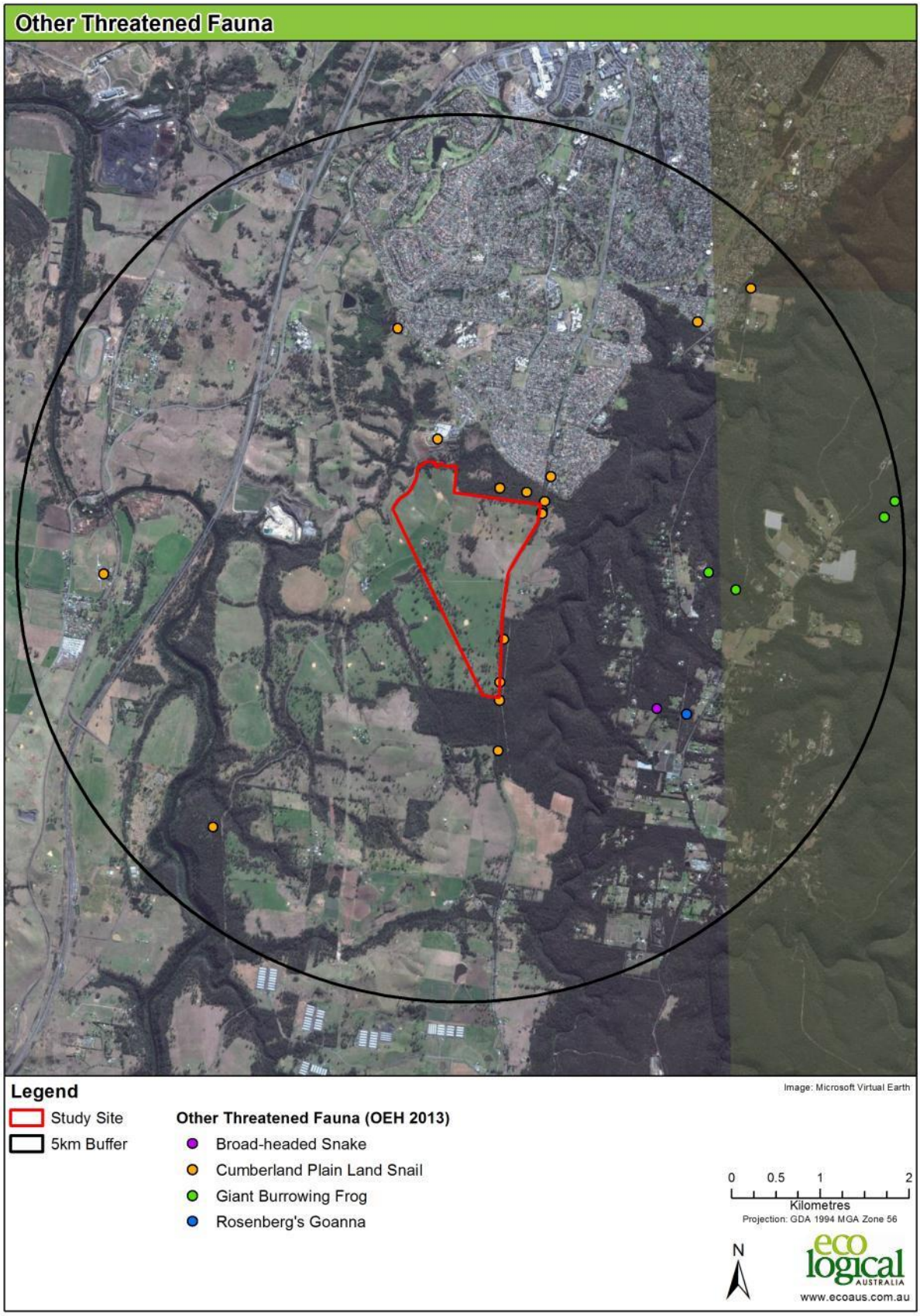



**Figure 8: Atlas of NSW Wildlife records of threatened frogs, reptiles and invertebrates within 5 km of the study site**

### 4.2.1 Cumberland Plain Woodland (CPW)

The corresponding Biometric vegetation type for this community is '*Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain*'.

A long history of grazing, pasture improvement and weed invasion has fragmented and modified vegetation of this community. Three localised clumps of CPW are located along the northern and western borders of the study site (**Figure 12**). These patches are generally found on clay soils in lower topography within Mt Gilead. It contains several large remnant trees including: *Eucalyptus tereticornis* (Forest Red Gum), *E. moluccana* and *E. crebra* (Narrow-leaved Ironbark). The shrub layer is absent throughout most of the site and ground cover diversity is poor. Some resilience is present within the soil seed bank with evidence of some native ground cover species present including: *Microlaena stipoides* (Weeping Grass), *Chloris truncata* (Windmill Grass) and *Aristida ramosa* (Purple Wiregrass). The majority of the vegetation community is dominated by exotic groundcover of *Pennisetum clandestinum* (Kikuyu) and *Ehrharta erecta* (Panic Veldtgrass). Native resilience is particularly prominent within the biobanking plot (B04) (**Figure 9**), adjacent to the Noorumba Reserve. This patch contained a shrub layer of *Bursaria spinosa* (Blackthorn) and diversity of native forbs and herbs not located in other areas: *Ajuga australis* (Austral Bugle), *Asperula conferta* (Common Woodruff) and *Hypericum gramineum* (Small St John).

One aquatic weed species *Myriophyllum aquaticum* (Parrot's feather) is located in a deep pool along the constructed canal which flows into the Noorumba Reserve. Small infestations of this weed were also observed downstream. Other noxious weeds occurred in low densities, with the exception of *Xanthium spinosum* (Bathurst Burr) which was widely distributed over the entire study site and *Lycium ferocissimum* (African Boxthorn) which was only recorded in one location. Refer to section 4.3 for more information on noxious weeds.

Erosion has occurred near the drainage lines to the north-east and north-western boundaries. Compaction of soils is present near dams and areas where livestock congregate under trees these areas are also prone to erosion.

Patches of this community are considered to be part of the TSC listed community fewer areas conform to the EPBC listing criteria (**Figure 12**).

**Figure 9: Cumberland Plain Woodland. These patches meet EPBC criteria**

### 4.2.2 Shale Sandstone Transition Forest (SSTF)

The corresponding Biometric vegetation type for this community is '*Narrow-leaved Ironbark-Broad-leaved Ironbark- Grey Gum open forest'.*

This vegetation community is the most common native vegetation community within the study site. *Corymbia maculata* (Spotted Gum) is the dominant species within the southern corner of the study site. Ironbark species, *Eucalyptus crebra* (Narrow-leaved Ironbark) and *E. fibrosa* (Red Ironbark) are more frequent in the northern patches of this community (**Figure 12**).

The main extent of this vegetation community is represented by two pockets of vegetation in the middle of the study site (**Figure 10**). A dense canopy of Ironbark species is supported by a rich assemblage of native shrubs (*Bursaria spinosa*) and a diversity of native ground cover species. Exotic species densities are lower in this area.

The remaining patches of this vegetation community have much thinner canopies or occur as scattered trees over a predominantly exotic understory. However, there are small patches where the native grass *Microlaena stipoides* dominates, along with the occasional herbs/twiner, such as *Glycine clandestina* and *Dichondra repens* (Kidney Weed). Exotic species form a dominant ground cover through most of these low quality patches. Species include *Tagetes minuta* (Stinking Roger) and *Senecio madagascariensis* (Fireweed); the latter is listed as a Weed of National Significance (WoNS). Two other weed species located in this vegetation community have been listed as noxious in the LGA *Xanthium spinosum* and *Rubus fruticosus* agg. (Blackberry). Refer to section 4.3 for more information on weeds.

Vegetation has been disturbed through clearing, prolonged grazing, fertilizer application and weed establishment. Farm dams also are well represented within this vegetation community.

Parts of this vegetation community considered to be part of the TSC and EPBC Act listed endangered ecological community are illustrated in **Figure 12**.

**Figure 10: Examples of SSTF in moderate to good condition, and low condition**

### 4.2.3 River-flat Eucalypt Forest (RFEF)

The corresponding Biometric vegetation type is '*Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plains, Sydney Basin'*.

This vegetation community is poorly represented within the study site. A small patch is located along a tributary to the north-east corner of the study site (**Figure 12**). It contains an intermittent tributary which flows into Menangle Creek. The community is represented by an exotic midstorey of *Olea europaea* subsp. *cuspidata* (African Olive) interspersed by a sparse canopy of *Eucalyptus moluccana*, E. *tereticornis* and several stags (**Figure 11**). Groundcover is very patchy and contains a similar ratio of native to exotic groundcover species and native shrubs are absent, however, diversity and cover is very low beneath olive infestations.

Four weed species listed as noxious within the Campbelltown LGA were recorded in this vegetation community, of which two were also listed as WoNS, *Asparagus asparagoides* (Bridal Creeper) and *Opuntia* sp. (Prickly Pear). *Olea europaea* subsp. *cuspidate* is not listed as noxious or a WoNS, although, it is considered a significant threat on the condition of this community. Refer to section 4.3 for more information on weeds.

The creek banks varied from steep banks with active erosion to areas of gentle slope with accumulation of leaf litter and logs within a dry creek bed. Woody weed infestation and erosion are key issue within this vegetation community.

**Figure 11: River-flat Eucalypt Forest**

### 4.2.4 Exotic pasture

The remaining lands have been cleared and exist as exotic pastures and are not considered part of a native vegetation community. These areas are cleared of native vegetation and subject to intense grazing and/or regular fertilisation. Exotic woody herbs *Bidens pilosa* (Cobblers Pegs), *Carthamus lanatus* (Saffron Thistle) and *Galinsoga parviflora* (Potato Weed) and perennial grasses *Pennisetum clandestinum* (Kikuyu) and *Axonopus fissifolius* (Carpet Grass) dominate the ground layer.

A few scattered native herbs and grasses were represented within cleared areas. These include *Erodium crinitum* (Blue Storksbill), *Oxalis perennans*, *Rumex brownii* (Swamp Dock) and *Microlaena stipoides* (Weeping Grass).

Exotic pasture was mapped on a variety of terrains including upper and lower slopes and around constructed dams. These areas contain very limited fauna habitat features.

### 4.2.5 Extent of vegetation communities

A summary of the extent of vegetation communities within the study site is listed in **Table 6**.

**Table 6: Approximate vegetation community areas within Mt Gilead**

| Vegetation Community | Biometric Condition class | Ancillary code | Approximate area (ha) |
|---|---|---|---|
| Cumberland Plain Woodland | Low | Moderate | 5.5 |
| | Low | Scattered paddock trees | 3.5 |
| **Total** Cumberland Plain Woodland | | | **9** |
| Shale Sandstone Transition Forest | Low | Moderate | 15 |
| | Low | Scattered paddock trees | 4.5 |
| | Moderate to good | Good | 5 |
| **Total** Shale Sandstone Transition Forest | | | **24.5** |
| River-flat Eucalypt Forest | Moderate to good | Moderate | 1 |
| **Total** River-flat Eucalypt Forest | | | **1** |
| Exotic pasture/cleared | Low | Poor | 174.5 |
| **Total** | | | **210** |

Note: CPW corresponds to Biometric vegetation type Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, SSTF corresponds to Biometric vegetation type Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, RFEF corresponds to Biometric vegetation type Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain.

## 4.3 FLORA SPECIES

A total of 154 flora species were identified within the study site during vegetation survey. Of these, 67 were native and 87 species were introduced. Nine weed species listed as noxious in Campbelltown LGA and four WoNS (**Table 7**). A full list of flora species is in **Appendix B**.

As most of the study site has been subject to pasture improvement and fertiliser application, the targeted flora search was limited to areas that had a higher cover of native species. No threatened flora were recorded during the targeted survey.

**Table 7: Noxious weeds within study site**

| Scientific Name | Common Name | WoNS | Control Class | Legal Requirements |
|---|---|---|---|---|
| *Senecio madagascariensis* | Fireweed | √ | - | |
| *Sporobolus fertilis* | Giant Parramatta Gras | | Class 3 | The plant must be fully and continuously suppressed and destroyed |
| *Echium plantagineum* | Paterson's Curse | | Class 4 | The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction |
| *Asparagus asparagoides* | Bridal Creeper | √ | Class 4 | |
| *Ligustrum lucidum* | Broad-leaved Privet | | Class 4 | |
| *Ligustrum sinense* | Small-leaved Privet | | Class 4 | |
| *Lycium ferocissimum* | African Boxthorn | √ | Class 4 | |
| *Opuntia* sp. | Prickly Pear | | Class 4 | |
| *Rubus fruticosus* aggregate species | Blackberry | √ | Class 4 | |
| *Xanthium spinosum* | Bathurst Burr | | Class 4 | |

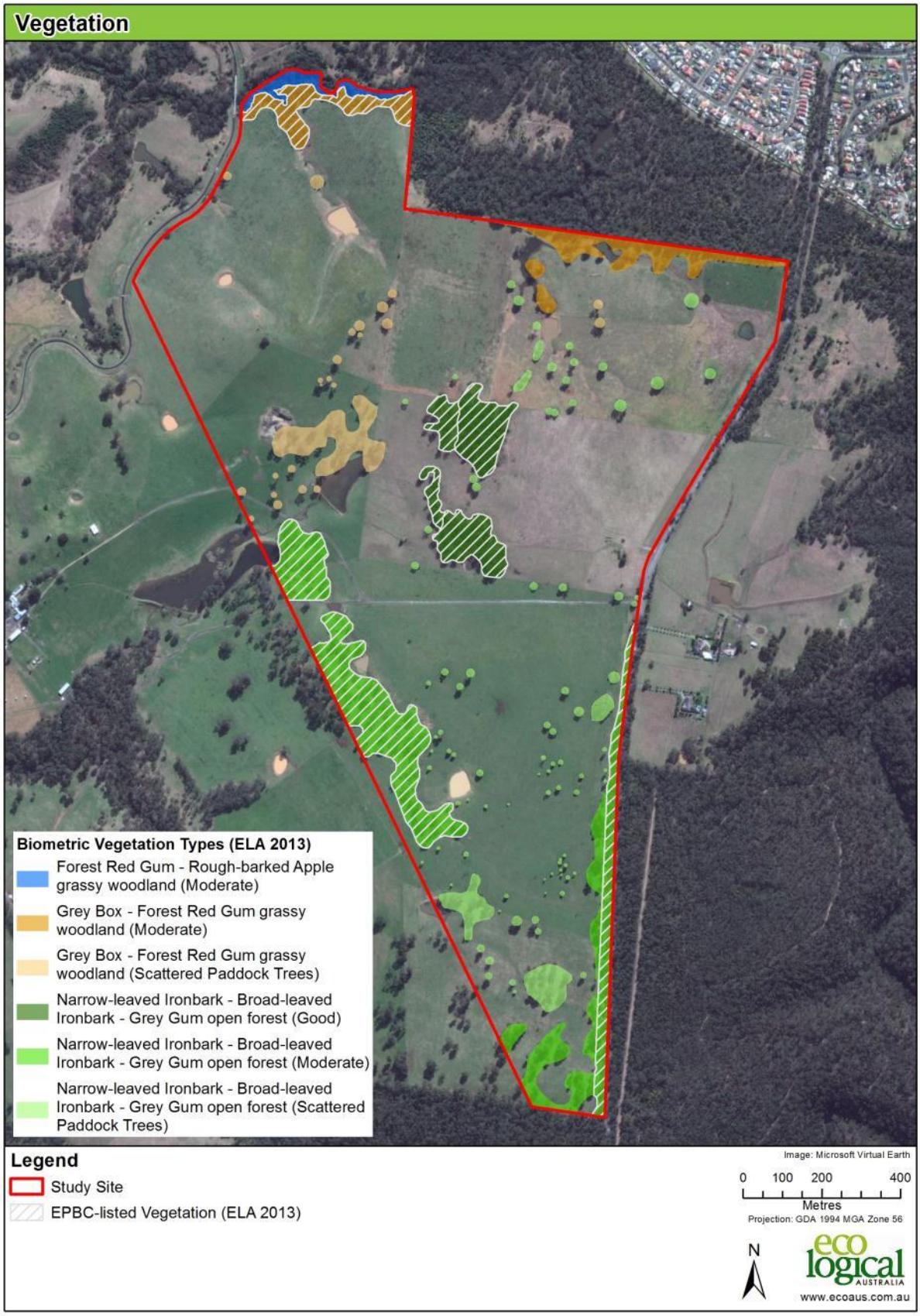



**Figure 12: Biometric vegetation types and ancillary condition codes on Mt Gilead**

## 4.4 FAUNA SPECIES

### Birds

A total of 58 bird species were recorded during bird census and opportunistic observations within the study site of which three were introduced species. One vulnerable species, *Glossopsitta pusilla* (Little Lorikeet), and one migratory species, *Ardea ibis* (Cattle Egret), were recorded during the survey.

No evidence of nocturnal bird activity was recorded within the study site during general traverse of the site.

### Mammals

Over 400 sequences were recorded from Anabat detectors placed at three separate locations on 10 to 11 April, and 17 to 18 July 2013 within the study site at Mt Gilead. Approximately 64% of sequences submitted were able to be identified to species in the first survey period and 18% of sequences in the second survey, with the remainder being too short or of low quality preventing positive identification of species. During the first survey period, general microbat activity was moderate with calls recorded more often than every ten minutes but less often than every two minutes. Feeding buzzes and foraging activity were occasionally recorded. During the second survey, activity was low.

There were 13 species identified including six vulnerable species: *Miniopterus australis* (Little Bentwing Bat), *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat), *Mormopterus norfolkensis* (East-coast Freetail Bat), *Falsistrellus tasmaniensis* (Eastern False Pipistrelle), *Saccolaimus flaviventris* (Yellow-bellied Sheathtail Bat), *Myotis macropus* (Southern Myotis) and *Scoteanax rueppellii* (Greater Broad-nosed Bat) listed under the NSW TSC Act. The most commonly recorded species were the threatened East-coast Freetail Bat and *Chalinolobus gouldii* (Gould's Wattled Bat), accounting for over 66% of positively identified sequences. Only East-coast Freetail Bat was found at every Anabat location surveyed. In addition, East-coast Freetail Bat was one of the first species to be recorded at each Anabat location and on three out of four evenings, also the last species to be recorded. These results are indicative of a nearby roost for East-coast Freetail Bat.

Only one other native mammal was observed during diurnal survey of the study site. *Wallabia bicolor* (Swamp Wallaby) was noted along the eastern boundary adjacent to native vegetation.

Domestic livestock, *Bos taurus* (European Cow) and *Equus ferus* subsp*. caballus* (Ponies) were grazing throughout the property. One feral mammal, *Vulpes vulpes* (European Fox), was recorded within the study site.

A full inventory of fauna is included in **Appendix B**.

### Fauna habitat

Large remnant trees scattered throughout the study site contain few hollows and potential flowering opportunities including winter flowering species *Eucalyptus tereticornis*.

Ironbark species *E. fibrosa* and *E. crebra* provide suitable flowering resources for threatened birds and arboreal mammals although contain limited supply of hollows.

Large woody debris was recorded within the study site, although this was in limited supply in open grassland areas. Terrestrial termite mounds including scratch marks were also observed.

Several constructed dams are dispersed throughout the study site that provide a source of water for livestock and native fauna.

The highly managed nature of the study site and continuous grazing regimes has affected litter build up at the base of trees in CPW. Consequently, habitat for Cumberland Plain Land Snail was scant to absent.

Seven threatened fauna species were recorded during the site survey, as discussed above. Depending on the approval pathway selected for the proposal, further surveys may be required for some ecosystem credit species.

The study site does not contain any contiguous vegetated corridors to patches of vegetation off site. At best, the patches of vegetation on the study site form stepping stones. The primary corridor linking vegetation located north and south of the study site is east of Appin Rd.

## 4.5 KOALA HABITAT

Koala food tree species have been identified on the study site. These species are *Eucalyptus tereticornis* and *E. punctata* at low numbers in some patches of SSTF, with *E. tereticornis* more common in patches of CPW. However, the number of these trees does not exceed the 15% threshold for the study site to be considered "potential Koala habitat".

Most historic Koala records are along and east of Appin Rd (**Figure 7**). There are no records on the study site or west of Appin Rd. Therefore, the site should not be considered core Koala habitat.

## 4.6 RIPARIAN ZONES

Mt Gilead is situated between two large catchment areas the George's River Catchment in the south-east and Hawkesbury – Nepean Catchment to the north-west. The topography gently undulates across the study site. The landscape slopes down towards the north-west and south-west study site boundary. Several unnamed tributaries eventually flow into Menangle Creek. Menangle Creek continues to flow west where it converges with the Nepean and Woodhouse Creeks outside the study site and then into the Nepean River. An open water canal runs west of the study site as part of Sydney water's supply to Prospect Reservoir (ELA 2006). The mapping of TofB and stream order is presented in **Figure 13**. This provides the required vegetative buffers for each riparian corridor. The results of the aquatic assessment are available in **Appendix D**. Three watercourses did not contain a defined channel.

The majority of the watercourses in the study site are considered substantially to slightly modified. Clearing of vegetation within the catchment and along TofB is noted along watercourses. Creek width varied between 1 to 10 metres and generally steep maximum recording was over 70 degree slope. Slumping and erosion (sheet, gully and undercut) are key impacts as a result of steep creek banks.

Aquatic habitat is limited due to the modification to watercourses. Even in areas of unmodified watercourse the aquatic vegetation is marginal over much of the study site. In areas where vegetation is available it provides suitable habitat for amphibians, birds and fish. Fish barriers are also noted throughout much of the study site.

The overall rating of the riparian and aquatic condition varied from degraded to moderate.

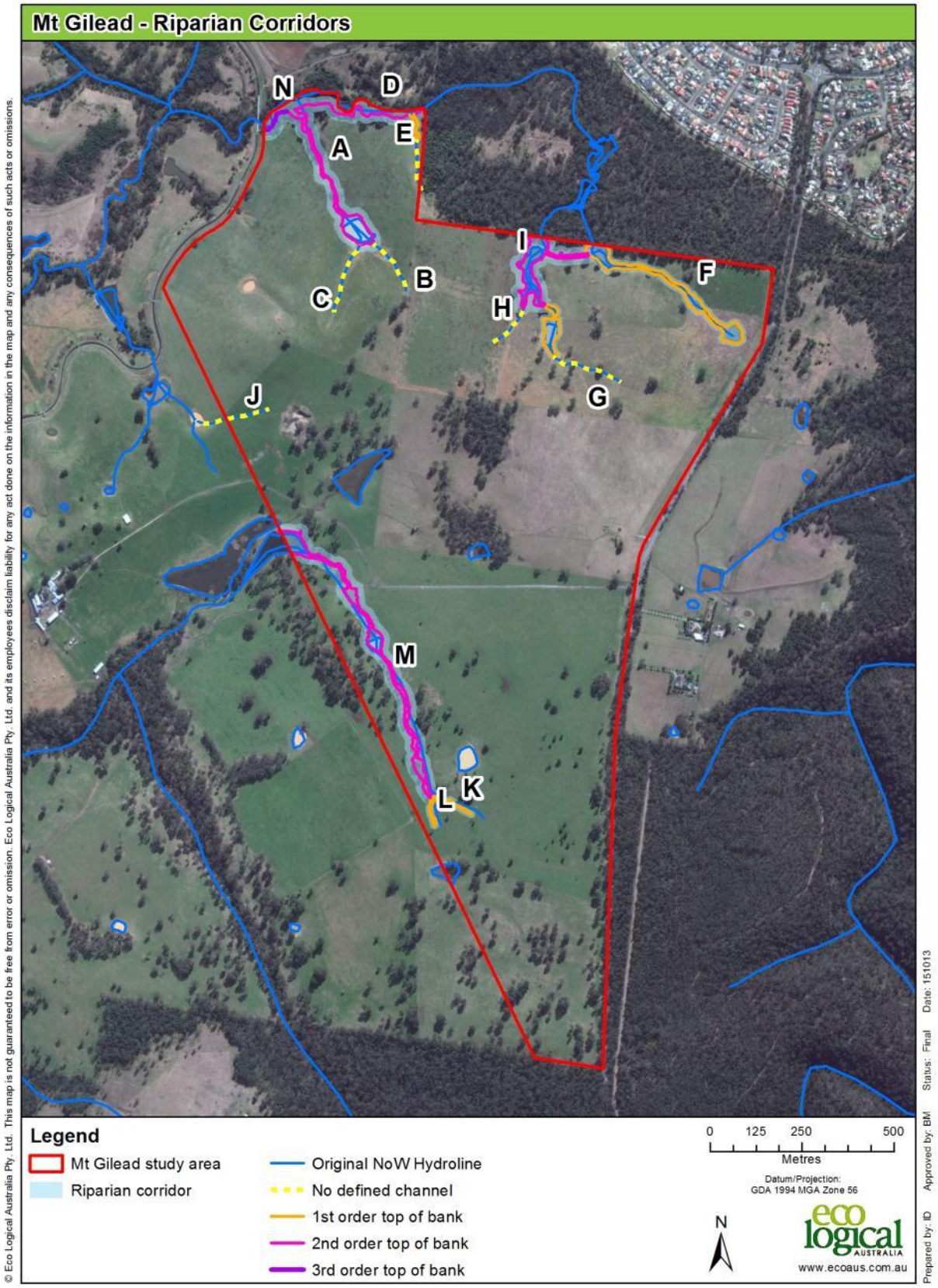



**Figure 13: Top of Bank, Vegetated Riparian Zones and Reach number**

## 4.7 BIODIVERSITY CERTIFICATION ASSESSMENT RESULTS

An assessment consistent with the BCAM was conducted to determine whether the proposed rezoning met the 'improve or maintain' test required by the methodology. In conducting the assessment the areas to be rezoned were assigned one of three proposed land uses to be assessed:

- Land proposed for biodiversity certification (development) - requires biodiversity credits
- Land proposed for offsets (including conservation areas and riparian corridors) - generates biodiversity credits
- Lands where the current land use will be retained (rural) - neither requires nor generates biodiversity credits.

The footprint proposed for biodiversity certification (development and detention basins) is 158.46 ha (**Table 8** and **Figure 2**). The land proposed for offset (conservation and riparian areas) is approximately 24.18 ha. Finally, approximately 26.94 ha of land has been identified as maintaining its current land use (rural), and has, therefore, been assessed as retained land (i.e. credits are neither required nor generated). The development footprint will impact 1.89 ha of one endangered ecological community which is 'red flagged' (SSTF in good condition) (**Figure 15**) under the BCAM which means an 'improve or maintain' outcome is not possible unless a red-flag variation is obtained from OEH. It is expected that a red-flag variation would be viewed favourably.

**Table 8: Land use breakdown**

| Development Footprint | Area (ha) |
|---|---|
| Land proposed for Biodiversity Certification (development and detention basins) | 158.46 |
| Land proposed for offset (conservation) | 24.18 |
| Retained land (land excluded from this assessment) | 26.94 |
| **Total** | **209.58** |

The results from the BCAM calculator provides the credits required for impact areas and the credits generated from land subject to conservation measures under three scenarios of protection. Areas that are managed and funded in perpetuity (i.e. Biobank sites or national parks) - 100% credit entitlement. Areas that are managed in perpetuity (such as Land subject to a Plan of Management under the Local Government Act Conservation Agreements or Biodiversity Certification Agreements) - 90% credit entitlement. A combination of managed and funded (Biobank sites) and managed (Council reserves) offset areas are proposed to be established as part of Biodiversity Certification of the proposal (refer to **Table 9** and **Figure 14**).

**Table 9: Approximate areas and credits required and generated for each vegetation type. Credits generated are presented under the two different protection scenarios.**

| | | | Offset areas | | | |
|---|---|---|---|---|---|---|
| | | | Funded and managed (Biobank site*) | | Managed (Council reserve**) | |
| **Vegetation Type** | **Area to be certified (ha)** | **Credits required** | **Area of offset (ha)** | **Credits generated** | **Area of offset (ha)** | **Credits generated** |
| River-flat Eucalypt Forest (RFEF) | | | | | 1.16 | 9 |
| Cumberland Plain Woodland (CPW) | 1.71 | 18 | 0.02 | 0 | 6.87 | 64 |
| Shale / Sandstone Transition Forest (SSTF) | 11.18 | 157 | 12.54 | 115 | 3.58 | 34 |
| | **12.89** | **175** | **12.56** | **115** | **11.61** | **107** |

*Biobank sites are managed and funded and qualify for 100% of the credit entitlement

**Council reserves are managed and qualify for 90% of the credit entitlement. The numbers presented are the 90% credit entitlement.

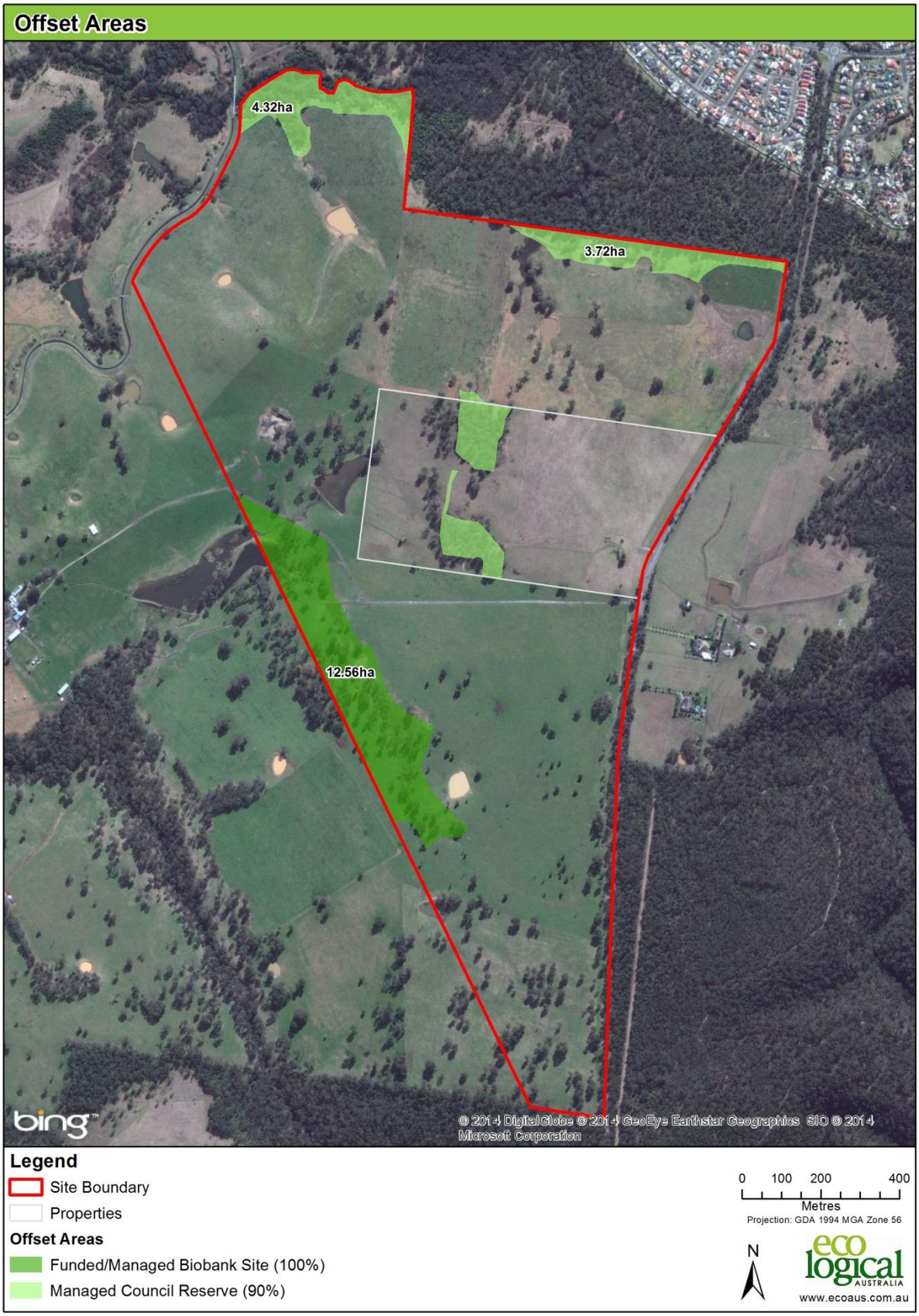



**Figure 14: Proposed conservation areas to the "funded and managed" and "managed".**

# 5 Impact assessment

This section discusses the potential impacts on vegetation communities, threatened species and migratory species based on the proposed footprint of developed, conserved and retained lands (**Figure 2**). **Table 10** summarises the area of each vegetation community to be developed and retained.

## 5.1 VEGETATION COMMUNITIES

The impact on vegetation within the proposed rezoning and subsequent development is centred on exotic pastures with scattered paddock trees providing limited canopy cover and areas where the existing vegetation has been identified as 'poor condition'. Both these vegetation classes are characterised by an understorey dominated by exotic species. However, there is some vegetation in biometric moderate to good condition in the centre of the site that will be removed.

The proposed impact on SSTF, CPW and RFEF as defined under the TSC and/or EPBC Acts, with detail about the impact to the various condition states for each community is shown in **Table 10**.

**Table 10: Impact and retained (conserved and retained) native vegetation communities**

| Vegetation Community | Ancillary Code | Area (ha) | | % Retained |
|---|---|---|---|---|
| | | Impact | Retained | |
| Cumberland Plain Woodland | Moderate * | 0.10 | 5.41 | 98.2 |
| | Scattered trees # | 1.61 | 1.94 | 54.6 |
| | **Total CPW** | **1.71** | **7.35** | **81.1** |
| Shale-Sandstone Transition Forest | Good * | 1.88 | 3.46 | 64.8 |
| | Moderate * | 4.97 | 10.2 | 67.2 |
| | Scattered trees | 4.33 | 0.13 | 3.1 |
| | **Total SSTF** | **11.18** | **13.79** | **55.3** |
| River-flat Eucalypt Forest (EEC) | Moderate # | 0 | 1.16 | 100 |
| | **Total RFEF** | **0** | **1.16** | **100** |
| **Total Vegetation** | | **12.89** | **22.3** | |

* = Listed as a Critically Endangered Ecological Community under both the TSC Act and EPBC Act
# = Listed as a Critically Endangered Ecological Community under the TSC Act only

## 5.2 CONNECTIVITY

Connectivity to areas of vegetation north and south of the site currently exists as a fragmented series of "stepping stones" through the study site. While the proposed rezoning will remove some areas of scattered trees, the fragmented patches of vegetation are likely to be consolidated through improved management and revegetation.

However, at a broader, landscape scale, connectivity between Noorumba Reserve and Beulah is via vegetation east of Appin Rd. This provides a contiguous linkage, with the exception of Appin Rd, in which the vegetation is in a very good condition with low disturbance.

## 5.3 THREATENED FLORA

The field survey included numerous biometric plots and targeted survey in areas of potential habitat for threatened flora, yet none were identified. Accordingly the proposal is unlikely to affect any threatened flora.

## 5.4 FAUNA

Seven threatened fauna species and one migratory species were identified on site (Little Lorikeet, *Mormopterus norfolkensis, Miniopterus schreibersii oceanensis, Myotis macropus, Falsistrellus tasmaniensis, Scoteanax rueppellii* and *Saccolaimus flaviventris*). Hollow bearing trees may act as roost sites for hollow dependant bat species, and should be retained, wherever possible, on site. Otherwise, the site does not offer substantial fauna habitat other than occasional foraging habitat as majority of the site is substantially modified for agriculture. Proximity to managed patches of vegetation (Beulah and Noorumba Reserve) in good condition provides a potential source of fauna for the site.

Survey for threatened birds and bats was undertaken in accordance with the BCAM methodology. Habitat for threatened microbats is present in the form of hollow bearing trees and water sources. Most potential habitat for threatened fauna will be retained and enhanced. Retaining trees within the development area as street trees or within open space would be beneficial to these fauna.

## 5.5 KOALA HABITAT

No records of Koala are known from the study site. The proposed rezoning will remove some scattered trees comprising *Corymbia maculata* and *Eucalyptus crebra*. Trees that are the preferred feed tree of Koala should be retained, wherever possible, and patches of retained remnant vegetation will be enhanced. The preferred feed trees are contained within SSTF along the south western boundary and in CPW which are in zones identified to be retained.

Rezoning will introduce domestic pets into the region which often present a threat to Koala. Management of the site and particularly the conservation areas, should seek to reduce the potential for threatening processes to impact Koala, should they occur on site.

## 5.6 RIPARIAN ZONES

Wherever possible, development and subsequent asset protection zones (APZ) should not occur in areas mapped as Riparian Corridor or Vegetated Riparian Zone (VRZ).

Advice from the NOW agrees with the determination in this assessment that some channels no longer meet the definition of “waterfront land” (**Figure 13**).

The NOW *Guidelines for riparian corridors on waterfront land* (**Appendix E**) and other written advice regarding future development of the site, advise that:

- All first order streams including those that have been determined not to be 'waterfront land' must be used in determination of stream ordering downstream
- Riparian Corridor widths should be consistent with NSW Office of Water Guidelines for the corresponding stream order
- Riparian corridors should be maintained or rehabilitated with fully structured native vegetation
- Vegetated Riparian Zones are to be fully vegetated in accordance with riparian corridor matrix rules
- The upper section of reach F proposed for residential development must be offset within the lower part of reach F or in the proposed open space above the dam in reach G

- Where existing dams are to be removed post development the riparian corridor should be measured from the top of bank of the proposed new constructed channel. The channel width should be consistent with the existing channel up and or downstream
- Cycleways and paths are permitted within the outer VRZ, however, the total disturbance footprint must not exceed 4 m. This impact does not require offsetting
- Detention basins are permitted within the outer VRZ. However, an equivalent area connected to the riparian corridor is required to offset that part of the detention basin that occurs within the VRZ.

Should future development of the site require roads to be constructed across a stream impacting on the Riparian Zone, it will be deemed a controlled activity under the WM Act and an approval will be required under Section 91 (2) of the WM Act. The preparation of a vegetation management plan is also required.

## 5.7 ASSESSMENT USING BIODIVERSITY CERTIFICATION ASSESSMENT METHOD

To quantify the development and conservation outcome, ELA used the Biodiversity Certification Assessment Methodology (DECCW 2011). It is the intent of the major landowner (Mt Gilead Pty Ltd holding 84% of the study area) will pursue Biodiversity Certification of the land through Campbelltown City Council. This will occur after the rezoning process.

The BCAM calculates the impact (described in terms of Biobanking credits required) and the conservation benefits (described as Biobanking credits generated) for each ecosystem type in the study site. If more credits are generated than are required for each ecosystem type, and areas of high biodiversity value (e.g. EECs in moderate-good condition) are avoided, the Improve or Maintain test is met and the Minister for the Environment may confer biocertification over land proposed for development.

There are two points that are acknowledged when using the BCAM for this project. Firstly, the project is not currently being proposed for Biodiversity Certification, but it is intended that Biodiversity Certification will be pursued after rezoning. The BCAM is being used in this report to give a broad indication of the conservation impacts and benefits of the planning proposal only so that impacts to threatened species and EECs can be assessed at an early stage in the planning process. Secondly, the development footprint will impact 1.89 ha of one endangered ecological community which is 'red flagged' (SSTF in moderate to good condition) (**Figure 15** depicts all red flag areas on the study site).

The existence of red flags within the study site means that Biocertification of the land cannot be conferred, unless a Red Flag Variation is granted by the Director General of OEH. In order to apply for a red flag variation a request to OEH is required satisfying Section 2.4 of the BCAM (DECCW 2011).

Section 2.4 of the BCAM outlines the criteria to be considered for a proposal to be regarded as improving or maintaining biodiversity values, even if a red flag has been triggered. The following criteria will need to be addressed:

1. Feasibility of options to avoid impacts on red flag area(s) where biodiversity certification is conferred

2. Viability must be low or not viable. The application for biodiversity certification must demonstrate to the satisfaction of the Director General that the viability of biodiversity values in the red flag area is low or not viable. The viability assessment of the red flagged vegetation should consider such factors as condition, patch size and isolation, current or proposed tenure

and surrounding land use, whether mechanisms and funds are available to manage low viability sites such that their viability is improved over time.

3. Contribution to regional biodiversity values must be low. The application for biodiversity certification must demonstrate to the satisfaction of the Director General that the contribution of the red flag area to regional biodiversity values is low. This includes an assessment of relative abundance of the impacted vegetation type in the region, the proportion of the vegetation type remaining in the region and the percent native vegetation (by area) remaining in the region.

Given that only part of the red flag area is likely to be removed, and the area of EEC proposed to be protected, it is considered that a red flag variation request will be considered favourably.

The assessment made the following assumptions regarding development and conservation outcomes:

- That all vegetation within the areas proposed to be zoned residential (development) would be cleared of vegetation. In reality, many of the scattered paddock trees may remain – especially in the larger lots, however, for the purposes of BCAM they were assumed to be lost.
- Vegetation within the conservation lands would be protected via either:
    - Permanently managed and funded conservation measures – such as registration of a Biobank Agreement over some areas proposed for conservation; or
    - Permanently managed conservation measures – such as transfer of the northern retained area adjacent to Noorumba Reserve to Council

Discussions with Council and NSW OEH regarding these mechanisms will be undertaken at rezoning.

BCAM requires assessment to be undertaken using Biometric Vegetation Types (BVT). ELA has converted the vegetation communities to the closest BVT match. The results of the assessment are provided in **Table 11**. The credit requirement is met for all of the BVTs

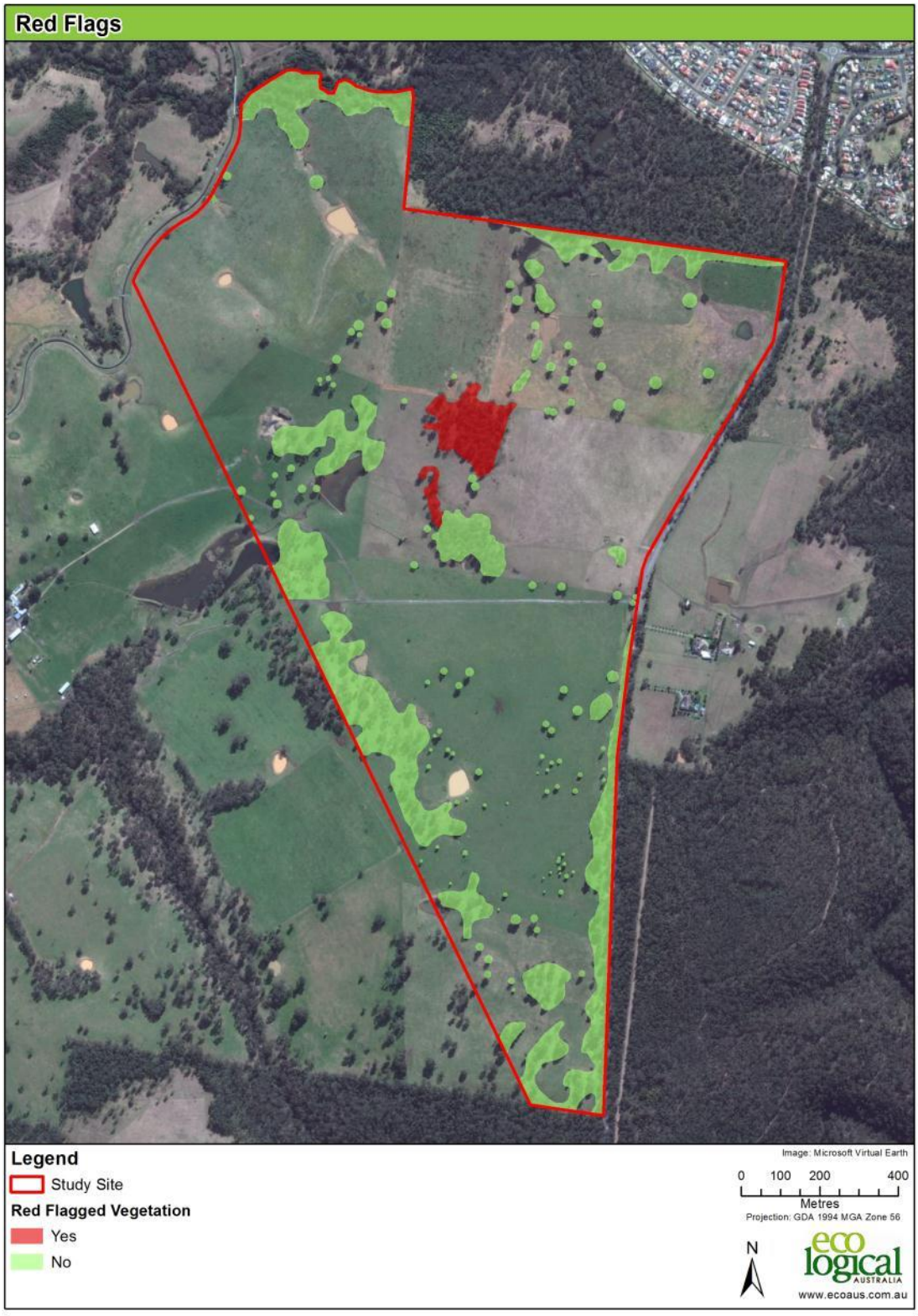



**Figure 15: Red Flag areas**

**Table 11: BCAM results under the highest protection scenario**

| Vegetation Community | Biometric Vegetation Type | Credits Required | Credits Generated | | Difference |
|---|---|---|---|---|---|
| | | | Biobank* | Council** | |
| Cumberland Plain Woodland | Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin | 18 | 0 | 64 | 46 surplus |
| Shale Sandstone Transition Forest | Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin | 157 | 115 | 34 | 8 deficit |
| River-flat Eucalypt Forest | Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin | 0 | 0 | 9 | 9 surplus |

* Biobank sites are managed and funded and qualify for 100% of the credit entitlement

**Council reserves are managed and qualify for 90% of the credit entitlement. The numbers presented are the 90% credit entitlement.

## 5.8 EPBC ACT

Vegetation communities, threatened species and migratory species listed under the EPBC Act are considered Matters of National Environmental Significance (MNES). Where an action may have a significant impact on MNES, the Commonwealth recommends referral of the action for consideration of whether it should be considered a Controlled Action under the EPBC Act.

Planning proposals do not constitute an 'action' under the EPBC Act and, therefore, referral of the planning proposal to the Commonwealth is not required. However, future subdivision and earthworks for development will be considered an 'action' and based on the proposed area of vegetation to be cleared, a referral is likely to be required. This section provides a preliminary review of the impacts to MNES.

**Table 12: EPBC Threatened Ecological Communities**

| Vegetation Community | Ancillary Condition | Area (ha) | | % retained |
|---|---|---|---|---|
| | | Impact | Retained | |
| EPBC Cumberland Plain Woodland (CEEC) | Moderate | 0.1 | 5.41 | **100** |
| EPBC Shale-Sandstone Transition Forest (EEC) | Good | 1.89 | 3.46 | **64.8** |
| | Moderate | 4.97 | 10.2 | **67.3** |
| | **Total SSTF** | **6.86** | **13.66** | **66.6** |

# 6 Conclusion

The proposed rezoning of property owned by Mt Gilead Pty Ltd and S and A Dzwonnik, referred to as Mt Gilead MDP Area, has been designed to focus future subdivision and development in areas with generally lower habitat value, lower condition of vegetation and higher exotic species density. While this report provides information to inform a rezoning, Mt Gilead Pty Ltd intend to pursue Biocertification through Council after rezoning.

The proposed rezoning includes approximately 158.46 ha for residential development, 24.18 ha for offsets (conservation and riparian) and 26.94 ha will be retained. Areas set aside for offsets could be afforded appropriate protection if zoned RE1 – Public Recreation Zone or RU2 – Rural Zone with a terrestrial biodiversity overlay clause included in the LEP. Streams that are Strahler 3 or higher will be zoned RU2 or RE1, while Strahler 1 and 2 streams can adopt an equivalent zoning to adjoining land.

A long history of grazing and pasture improvement has resulted in the majority of vegetation on site having a high cover of exotic species. Nevertheless, there are examples of endangered ecological communities, some of which possess distinctive upper, middle and lower strata dominated by native vegetation. These communities are Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), and their various condition states were mapped.

The proposed rezoning will remove 1.71 ha of CPW (principally occurring as scattered trees) and 11.18 ha of SSTF (mostly occurring as scattered trees or in moderate condition). Based on the areas to be impacted for future development, the BCAM was used to calculate the quantum of offset required. This determined that there is sufficient area of vegetation remaining within the proposed conservation areas to satisfy offset requirements under the managed and funded scenario and the managed scenario (**Table 9**).

No threatened flora were identified on site, and prolonged grazing and pasture improvement renders most of the site unsuitable for threatened flora.

One vulnerable species (Little Lorikeet) and one migratory species (Cattle Egret) were recorded on site. The proposal is unlikely to have a deleterious impact on these species in the area.

The majority of the watercourses in the study site are considered substantially to slightly modified. ELA identified that some streams no longer had a defined channel, and sought and received agreement on this assessment from the NOW. Should development of the site require roads or stormwater detention basins to be constructed within the riparian corridor, the area lost must be offset within riparian corridor.

The proposed residential development of Mt Gilead presents a plan that can achieve an “improve or maintain” outcome under BCAM, however, a red-flag variation would be required to remove 1.89 ha of SSTF in moderate to good condition.

# References

Allison, F.R. and Hoye, G.A. 1998. 'Eastern Freetail-bat', In: Strahan, R. (Ed.) *The Mammals of Australia*, pp. 484-485, Australian Museum/ Reed Publications, Sydney.

Australian Museum Business Services 1995. *Fauna impact statement for proposed forestry activities in the Urbenville Management Area*., Report prepared for State Forests of New South Wales. Australian Museum Business Services, Sydney.

Benson, D. and McDougall, L. 1992. 'Ecology of Sydney plants 2', Cunninghamia, 3(4): 709- 1004.

Benson, D. & McDougall, L. 1998. Ecology of Sydney plant species Part 6: Dicotyledon family Myrtaceae. Cunninghamia 5(4): 808-987.

Bell, S. 2001. 'Notes on population size and habitat of the vulnerable Cryptostylis hunteriana (Orchidaceae) from the Central Coast of New South Wales', Cunninghamia 7(2): 195-204.

Blakers, M., Davies, S., and Reilly, P.N 1984. *The Atlas of Australian Birds*. RAOU Melbourne University Press.

Churchill, S. 1998. *Australian Bats*, Reed New Holland, Sydney.

Debus, S.J.S. and Chafer, C.J. 1994. 'The Powerful Owl *Ninox strenua* in New South Wales', *Australian Birds*. 28:s21-s38.

DEC, 2004, Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft), New South Wales Department of Environment and Conservation, Hurstville, NSW.

DECC 2008 Vegetation Types Database. Accessed at: http://www.environment.nsw.gov.au/biobanking/VegTypeDatabase.htm

DECC 2009 BioBanking Assessment Methodology and Credit Calculator Operation Manual. Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change NSW 2007. Threatened Species Profiles http://www.threatenedspecies.environment.nsw.gov.au/index.aspx

DECCW 2011. Biodiversity Certification Assessment Methodology. DECCW, Sydney.

Department of Environment and Heritage NSW 2012. Threatened Species Profiles http://www.threatenedspecies.environment.nsw.gov.au/index.aspx Accessed November 2012

DLWC 2000. *Geomorphic Categorisation of Streams in the Hawkesbury Nepean Catchment.* Department of Land and Water Conservation

Department of Sustainability Environment Water Population and Communities 2012. Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from http://www.environment.gov.au/sprat

Dwyer, P.D. 1995. 'Common Bent-wing Bat (Miniopterus schreibersii)', In: R. Strahan (Ed.) *The Australian Museum Complete Book of Australian Mammals*, pp494-495, Angus and Robertson Publishers, Sydney.

Eby, P. 1998. 'An analysis of the diet specialisation in frugivorous *Pteropus_poliocephalus* in Australian subtropical rainforest', *Austral Ecology*, 23:443-456

Ehmann, E. 1997. *Threatened Frogs of New South Wales: Habitats, status and conservation*, Frog and Tadpole Study Group, Sydney.

ELA 2006. Mt Gilead Flora and Fauna Assessment – stage 2. Prepared for Australand

Environment Australia 2000. *Comprehensive and Regional Assessments for North-East NSW*. Report to National Parks and Wildlife Service.

Forshaw, J.M. and Cooper, W.T. 1981. Australian Parrots, (2nd Ed.). Lansdowne Press, Melbourne.

Garnett, S. (Ed) 1993. *Threatened and extinct birds of Australia. Royal Australian Ornithologists Union and Australian NPWS*, Royal Australian Ornithologists Union Report, No. 82.

Harden, G.J., McDonald, W.J.F. and Williams, J.B. 2006. *Rainforest Trees and Shrubs; A field guide to their identification.* Gwen Harden Publishing.
Hoye, G. and Richards, G. 1998. 'Greater Broad-nosed Bat', In: Strahan, R. (ed.) *The Australian Museum Complete Book of Australian Mammals*, Angus and Robertson Publishers, Sydney.

Kushlan, J.A. & J. Hancock 2005. *Herons*. Oxford, United Kingdom: Oxford University Press.

Law, B. S., Anderson, J., and Chidel, M. 1999. Bat communities in a fragmented forest landscape on the south-west slopes of New South Wales, Australia. *Biological Conservation 88, 333-345*.

Lloyd, A.M., Law, B.S., and Goldingay, R. 2006. Bat activity on riparian zones and upper slopes in Australian timber production forests and the effectiveness of riparian buffers. *Biological Conservation 129, 207-220*.

Mansergh, I. M. 1984.The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia with particular reference to Victoria, *Australian Zoolology*, 21(2):109-22.

Marchant and Higgins 1993. *Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

Martínez-Vilalta, A. & A. Motis 1992. Family Ardeidae (Herons). **In:** del Hoyo J., A. Elliott & J. Sargatal, eds. *Handbook of the Birds of the World*. Page(s) 376-42. Barcelona: Lynx Edicions.

McKenzie, N. L., Stuart, A. N., and Bullen, R. D. 2002. 'Foraging ecology and organisation of a desert bat fauna.' *Australian Journal of Zoology 50, 529-548.*

McKilligan, N. 2005. *Herons, Egrets and Bitterns*, CSIRO Publishing.

Menkhorst, P. and Knight, F. 2004. *A Field Guide to the Mammals of Australia*, 2nd Edn., Oxford University Press, South Melbourne.

Menkhorst, P. and Seebeck, J.1990. 'Distribution and Conservation Status of Bandicoots in Victoria', In: Seebeck, J., Brown, P., Wallis, R. and Kemper, C. (Eds.) *Bandicoots and Bilbies*, Surrey Beatty and Sons, Sydney.

Mills, D. J., Norton, T. W., Parnaby, H. E., Cunningham, R. B., and Nix, H. A. 1996. 'Designing surveys for microchiropteran bats in complex forest landscapes - a pilot study from south-east Australia.' Special issue*: Conservation of biological diversity in temperate and boreal forest ecosystems 85, 149-161*.

Morcombe, M. 2004. *Field Guide to Australian Birds*, Steve Parish Publishing.

NSW National Parks and Wildlife Service 1995. Endangered Fauna of Western New South Wales, NSW National Parks and Wildlife Service, Hurstville.

New South Wales National Parks and Wildlife Service 2002. *Interpretation Guidelines for the Native Vegetation Maps of the Cumberland Plain, Western Sydney*, Final Edition NSW NPWS, Hurstville.

New South Wales National Parks and Wildlife Service 2004a. *Cumberland Plain Woodland Endangered Ecological Community Information* Feb. 2004

New South Wales National Parks and Wildlife Service 2004b. *Shale Sandstone Transition Forest Endangered Ecological Community Information* Feb. 2004

National Parks and Wildlife Service 1997. Urban Bushland Biodiversity Study - Western Sydney, National Parks and Wildlife Service.

NSW Scientific Committee 2000. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm accessed 26/11/2012

NSW Scientific Committee 2001. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm accessed 28/11/2012

NSW Office of Water (NoW) 2012. *Controlled Activities on Waterfront Land. Guidelines for riparian corridors on waterfront land.* NSW Department of Primary Industries Office of Water. www.water.nsw.gov.au

Parnaby, H. 1992. *An interim guide to identification of insectivorous bats of south-eastern Australia.* Technical Reports of the Australian Museum Number 8.

Payne, R. 1991. 'New findings of the rare tree Syzygium paniculatum (Myrtaceae) in the Wyong area, NSW, Cunninghamia, 2(3):495-498.

Payne, R. 1997. The Distribution and Reproductive Ecology of Syzygium paniculatum and Syzygium australe (Myrtaceae) in the Gosford-Wyong Region. Unpublished Thesis prepared for the award of Masters of Natural Resources, University of New England, Armidale NSW.

Pennay, M., Law, B., and Rhinhold, L. (2004). *Bat calls of New South Wales: Region based guide to echolocation calls of Microchiropteran bats.* NSW Department of Environment and Conservation, Hurstville.

Pyke, G.H and White, A.W. 1996. Habitat requirements for the Green and Golden Bell Frog *Litoria aurea* (Anura:Hylidae), *Australian Zoologist*, 30(2):177-189.

PlantNET 2012. Persoonia hirsuta
http://plantnet.rbgsyd.nsw.gov.au/cgibin/NSWfl.pl?page=nswfl&lvl=sp&name=Persoonia~hirsuta
accessed 26/11/2012

Quinn, D.G. 1995. 'Population ecology of the Squirrel Glider and the Sugar Glider at Limeburners Creek, on the Central North Coast of NSW', Wildlife Research. 22: 471-505.

Reed, P.C., Lunney, D. and Walker, P. 1990. 'A 1986-7 survey of the Koala Phascolarctos cinereus in NSW and an ecological interpretation of its distribution', In: *Biology of the Koala*, pp: 55-74

Reinhold, L., Law, B., Ford, G., and Pennay, M*. Key to the bat calls of south-east Queensland and north-east New South Wales. 2001.* Queensland, DNR.

Richards, G.C. 1988. 'Large-footed Mouse-eared Bat (*Myotis adversus*)', In: Strahan, R (Ed.) *The Australian Museum Complete Book of Australian Mammals*, Angus and Robertson Publishers, Sydney.

Rudman, W. B. 1999. Threatened and Endangered Landsnail species – *Meridolum corneovirens*

Schodde, R. and Tidemann, S. (Eds) 1986. *Readers Digest complete book of Australian Birds*, 2nd Edn., Reader's Digest Services Pty Ltd, Sydney.

Sheilds, J. and Chrome, F. 1992. *Parrots and Pigeons of Australia*, Angus and Robinson, Sydney.

Simpson, K. and Day, N. 1999. *Field guide to the birds of Australia 6th edn.,* Penguin Books Australia Ltd, Ringwood Victoria.

Simpson, K. and Day, N. 2004. *Field guide to the birds of Australia 7th edn.,* Penguin Books Australia Ltd, Ringwood Victoria.

Strahan, R. (Ed.) 1998. *The Australian Museum Complete Book of Australian Mammals*, Angus and Robertson Publishers, Sydney.

Turner, V. and Ward, S. 1995. 'Eastern Pygmy Possum *Cercartetus nanus*', In: Strahan, R. (Ed.) *The Mammals of Australia*, pp 217-218, Reed Books, Sydney

Webb J.K. and Shine R. 1998. Ecological characteristics of a threatened snake species *Hoplocephalus bungaroides* (Serpentes: Elapidae), *Animal Conservation*, 1: 185-193

# Appendix A: Threatened species likelihood of occurrence

**Summary of initial assessment to determine the likelihood of occurrence of threatened species, populations and ecological communities in the proposal site.**

An assessment of likelihood of occurrence was made for threatened and migratory species identified from the database search. Five terms for the likelihood of occurrence of species are used in this report. This assessment was based on database or other records, presence or absence of suitable habitat, features of the proposal site, results of the field survey and professional judgement. The terms for likelihood of occurrence are defined below:

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

| Common Name | TSC Act | EPBC Act | Likelihood of Occurrence |
|---|---|---|---|
| **THREATENED ECOLOGICAL COMMUNITIES** | | | |
| Cumberland Plain Woodland / Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest | CEEC | CEEC | Yes |
| Shale/Sandstone Transition Forest | EEC | EEC | Yes |
| Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion | EEC | EEC | No |
| River-flat Eucalypt Forest | EEC | | Yes |
| Western Sydney Dry Rainforest and Moist Woodland on Shale | CEEC | CEEC | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| **FLORA** | | | | | |
| *Acacia bynoeana* | Bynoe's Wattle | E | V | Acacia bynoeana is found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains, and has recently been found in the Colymea and Parma Creek areas west of Nowra. It is found in heath and dry sclerophyll forest, typically on a sand or sandy clay substrate, often with ironstone gravels (OEH 2012). | No |
| *Acacia pubescens* | Downy Wattle | V | V | *Acacia pubescens* occurs on the NSW Central Coast in Western Sydney, mainly in the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. It is associated with Cumberland Plains Woodlands, Shale / Gravel Forest and Shale / Sandstone Transition Forest growing on clay soils, often with ironstone gravel (NPWS 1997; Benson and McDougall 1998). | No |
| *Allocasuarina glareicola* | | - | E | *Allocasuarina glareicola* is primarily restricted to the Richmond district on the north-west Cumberland Plain, with an outlier population found at Voyager Point. It grows in Castlereagh woodland on lateritic soil (DECC 2007). | No |
| *Asterolasia elegans* | | E | E | *Asterolasia elegans* is restricted to a few localities on the NSW Central Coast north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby LGAs. It is found in sheltered forests on mid- to lower slopes and valleys, in or adjacent to gullies (OEH 2012). | No |
| *Caladenia tessellata* | Thick Lip Spider Orchid | E | V | *Caladenia tessellata* occurs in grassy sclerophyll woodland, often growing in well-structured clay loams or sandy soils south from Swansea, usually in sheltered moist places and in areas of increased sunlight (OEH 2012). It flowers from September to November (OEH 2012). | No |
| *Callistemon linearifolius* | Nettled Bottlebrush | - | - | *Callistemon linearifolius* has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW, growing in dry sclerophyll forest (DECC 2007). For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (DECC 2007). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Clematis fawcettii* | Stream Clematis | | V | *Clematis fawcettii* occurs north from Cambridge Plateau (north west of Casino), on the NSW North Coast. It usually grows in subtropical or dry rainforest (Harden et al. 2006). | No |
| *Cryptostylis hunteriana* | Leafless Tongue Orchid | V | V | *Cryptostylis hunteriana* is known from a range of vegetation communities including swamp-heath and woodland (OEH 2012). The larger populations typically occur in woodland dominated by Scribbly Gum (*Eucalyptus sclerophylla*), Silvertop Ash (*E. sieberi*), Red Bloodwood (*Corymbia gummifera*) and Black Sheoak (*Allocasuarina littoralis*); where it appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid (*C. subulata*) and the Tartan Tongue Orchid (*C. erecta*) (OEH 2012). Bell (2001) has identified Coastal Plains Scribbly Gum Woodland and Coastal Plains Smoothed-barked Apple Woodland as potential habitat on the Central Coast. Flowers between November and February, although may not flower regularly (OEH 2012; Bell 2001). | No |
| *Cynanchum elegans* | White-flowered Wax Plant | E | E | *Cynanchum elegans* is a climber or twiner with a variable form, and flowers between August and May, peaking in November (OEH 2012). It occurs in dry rainforest gullies, scrub and scree slopes, and prefers the ecotone between dry subtropical rainforest and sclerophyll woodland/forest (NPWS 1997). The species has also been found in littoral rainforest; *Leptospermum laevigatum – Banksia integrifolia* subsp. *integrifolia* coastal scrub; *Eucalyptus tereticornis* open forest/ woodland; *Corymbia maculata* open forest/woodland; and *Melaleuca armillaris* scrub to open scrub (OEH 2012). | No |
| *Eucalyptus benthamii* | Camden White Gum | V | V | *Eucalyptus benthamii* occurs in wet open forest on well drained sandy alluvial soils along stream channels, small terraces and alluvial flats on valley floors (DECC 2007). | No |
| *Genoplesium baueri* | Bauer's Midge Orchid | V | - | Known from coastal areas from northern Sydney south to the Nowra district. Previous records from the Hunter Valley and Nelson Bay are now thought to be erroneous. Grows in shrubby woodland in open forest on shallow sandy soils (OEH 2012). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Grevillea parviflora* subsp. *parviflora* | Small-flower Grevillea | V | V | *Grevillea parviflora* subsp. *parviflora* is sporadically distributed throughout the Sydney Basin mainly around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie and Cessnock and Kurri Kurri. It grows in sandy or light clay soils over thin shales, often with lateritic ironstone gravels. It often occurs in open, slightly disturbed sites such as tracks (OEH 2012). | No |
| *Lepidium hyssopifolium* | Aromatic Peppercress | E | E | *Lepidium hyssopifolium* occurs near Bathurst, near Bungendore, near Crookwell and near Armidale, occurring in a variety of habitats including woodland with a grassy understorey and grassland (OEH 2012). | No |
| *Leucopogon exolasius* | Woronora Beard-heath | V | V | *Leucopogon* exolasius is found along the upper Georges River area and in Heathcote National Park (OEH 2012). It is associated with Sydney Sandstone Gully Forest on rocky hillsides and creek banks (NPWS 1997). | No |
| *Melaleuca deanei* | Deane's Paperbark | V | V | Found in heath on sandstone (OEH 2012), and also associated with woodland on broad ridge tops and slopes on sandy loam and lateritic soils (Benson and McDougall 1998). | Unlikely |
| *Pelargonium* sp. *Striatellum* | Omeo's Stork's Bill | E | E | The species is known to occur in habitat usually located just above the high water level of irregularly inundated or ephemeral lakes. During dry periods, the species is known to colonise exposed lake beds. It is not known if the species' rhizomes and/or soil seedbank persist through prolonged inundation or drought (SEWPaC 2012). | No |
| *Persoonia bargoensis* | Bargo Geebung | E | V | Associated with woodland to dry sclerophyll forest, on sandstone and clayey laterite on heavier, well-drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale in the catchments of the Cataract, Cordeaux and Bargo Rivers (NSW Scientific Committee 2000). | Unlikely |
| *Persoonia hirsuta* | Hairy Geebung | E | E | *Persoonia hirsuta* occurs from Singleton in the north, south to Bargo and the Blue Mountains to the west (OEH 2012). It grows in dry sclerophyll eucalypt woodland and forest on sandstone (PlantNet 2012). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Persoonia nutans* | Nodding Geebung | E | E | Associated with dry woodland, Castlereagh Scribbly Gum Woodland, Agnes Banks Woodland and sandy soils associated with tertiary alluvium, occasionally poorly drained (Benson and McDougall 1998). Endemic to the Western Sydney (Benson and McDougall 1998). | Unlikely |
| *Pimelea curviflora* var. *curviflora* | | V | V | *Pimelea curviflora var. curviflora* is confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. It grows on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands (OEH 2012). | No |
| *Pimelea spicata* | Spiked Rice-flower | E | E | In western Sydney, *Pimelea spicata* occurs on an undulating topography of well structured clay soils, derived from Wianamatta shale (OEH 2012). It is associated with Cumberland Plains Woodland (CPW), in open woodland and grassland often in moist depressions or near creek lines (Ibid.). Has been located in disturbed areas that would have previously supported CPW (Ibid.). | Unlikely |
| *Pomaderris brunnea* | Rufous Pomaderris | V | V | *Pomaderris brunnea* occurs in a limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden. It also occurs near Walcha on the New England tablelands and in far eastern Gippsland in Victoria It grows in moist woodland or forest on clay or alluvial soils of floodplains and creek lines (OEH 2012). | No |
| *Pterostylis saxicola* | Sydney Plains Greenhood | E | E | Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where *Pterostylis saxicola* occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils. Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated (OEH 2012). | No |
| *Pultenaea aristata* | | V | V | *Pultenaea aristata* is restricted to the Woronora Plateau, in a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong (DECC 2007). It is associated with scrub and heath on sandstone ridge tops and upper slopes of large upland swamps on shallow sandy loams. | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Pultenaea pedunculata* | Matted Bush-pea | E | - | In NSW, *Pultenaea pedunculata* is known from three disjunct populations, in the Cumberland Plains in Sydney, the coast between Tathra and Bermagui and the Windellama area south of Goulburn. It grows in woodland vegetation but plants have also been found on road batters and coastal cliffs. It is largely confined to loamy soils in dry gullies in populations in the Windellama area (DECC 2007). | No |
| *Streblus pendulinus* | Siah's backbone | - | E | On the Australian mainland, Siah's Backbone is found in warmer rainforests, chiefly along watercourses. The altitudinal range is from near sea level to 800 m above sea level. The species grows in well developed rainforest, gallery forest and drier, more seasonal rainforest (SEWPaC 2012). | No |
| *Syzygium paniculatum* | Magenta Lily Pilly | V | V | This species occupies a narrow coastal area between Bulahdelah and Conjola State Forests in NSW. On the Central Coast, it occurs on Quaternary gravels, sands, silts and clays, in riparian gallery rainforests and remnant littoral rainforest communities (Payne 1997). In the Ourimbah Creek valley, *S. paniculatum* occurs within gallery rainforest with Alphitonia excelsa, *Acmena smithii*, *Cryptocarya glaucescens*, *Toona ciliata*, *Syzygium oleosum* with emergent *Eucalyptus saligna*. At Wyrrabalong NP, *S. paniculatum* occurs in littoral rainforest as a co-dominant with *Ficus fraseri*, *Syzygium oleosum*, *Acmena smithii*, *Cassine australe*, and *Endiandra sieberi*. Payne (1991) reports that the species appears absent from Terrigal formation shales, on which the gully rainforests occur. S. paniculatum is summer flowering (November-February), with the fruits maturing in May (DECC 2007). | |
| *Thelymitra* sp. *Kangaloon* | Kangaloon Sun-orchid | CE | CE | *Thelymitra sp*. Kangaloon is only known to occur on the southern tablelands of NSW in the Robertson / Kangaloon / Fitzroy Falls area at 550-700 m above sea level. It is thought to be a short-lived perennial, flowering in late October and early November. It is found in swamps in sedgelands over grey silty grey loam soils (OEH 2012). It is known to occur at three swamps that are above the Kangaloon Aquifer, and that are a part of the ecological community "Temperate Highland Peat Swamps on Sandstone" which is listed under the Environment Protection and Biodiversity Conservation Act 1999. | |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| **INVERTEBRATES** | | | | | |
| *Meridolum corneovirens* | Cumberland Plain Land Snail | E | - | Associated with open eucalypt forests, particularly Cumberland Plain Woodland described in Benson (1992). Found under fallen logs, debris and in bark and leaf litter around the trunk of gum trees or burrowing in loose soil around clumps of grass (NPWS 1997; Rudman 1998). Urban waste may also form suitable habitat (NSW NPWS 1997; Rudman 1998). | Unlikely |
| **FISH** | | | | | |
| *Macquarie australasica* | Macquarie Perch | E (under FM Act 1994) | E | Habitat for the Macquarie perch is bottom or mid-water in slow-flowing rivers with deep holes, typically in the upper reaches of forested catchments with intact riparian vegetation. Macquarie perch also do well in some upper catchment lakes. In some parts of its range, the species is reduced to taking refuge in small pools which persist in midland–upland areas through the drier summer periods. | No |
| *Prototroctes maraena* | Australian Grayling | - | V | The historic distribution of the Australian Grayling included coastal streams from the Grose River southwards through NSW, Vic. and Tas. On mainland Australia, this species has been recorded from rivers flowing east and south of the main dividing ranges. This species spends only part of its lifecycle in freshwater, mainly inhabiting clear, gravel-bottomed streams with alternating pools and riffles, and granite outcrops but has also been found in muddy-bottomed, heavily silted habitat. Grayling migrate between freshwater streams and the ocean and as such it is generally accepted to be a diadromous (migratory between fresh and salt waters) species. | No |
| **FROGS** | | | | | |
| *Heleioporus australiacus* | Giant Burrowing Frog | V | V | Forages in woodlands, wet heath, dry and wet sclerophyll forest (Ehmann 1997). Associated with semi-permanent to ephemeral sand or rock based streams (Ehmann 1997), where the soil is soft and sandy so that burrows can be constructed (Environment Australia 2000). | Unlikely |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Litoria aurea* | Green and Golden Bell Frog | E | V | This species has been observed utilising a variety of natural and man-made waterbodies (Pyke & White 1996) such as coastal swamps, marshes, dune swales, lagoons, lakes, other estuary wetlands, riverine floodplain wetlands and billabongs, stormwater detention basins, farm dams, bunded areas, drains, ditches and any other structure capable of storing water (DECC 2007). Preferable habitat for this species includes attributes such as shallow, still or slow flowing, permanent and/or widely fluctuating water bodies that are unpolluted and without heavy shading (DECC 2007). Large permanent swamps and ponds exhibiting well-established fringing vegetation (especially bulrushes–Typha sp. and spikerushes–*Eleocharis sp*.) adjacent to open grassland areas for foraging are preferable (Ehmann 1997; Robinson 1993). Ponds that are typically inhabited tend to be free from predatory fish such as Mosquito Fish (Gambusia holbrooki) (DECC 2007). | Unlikely |
| *Litoria littlejohnii* | Littlejohn's Tree Frog | V | V | Littlejohn's Tree Frog occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops. It appears to be restricted to sandstone woodland and heath communities at mid to high altitude (NSW Scientific Committee 2000). | Unlikely |
| *Litoria raniformis* | Southern Bell Frog | E | V | Relatively still or slow-flowing sites such as billabongs, ponds, lakes or farm dams, especially where *Typha* sp., *Eleocharis* sp. and *Phragmites* sp. (Bulrushes) are present (DECC 2007; Ehmann 1997). This species is common in lignum shrublands, black box and River Red Gum woodlands, irrigation channels and at the periphery of rivers in the southern parts of NSW (DECC 2007). This species occurs in vegetation types such as open grassland, open forest and ephemeral and permanent non-saline marshes and swamps (DECC 2007). Open grassland and ephemeral permanent non-saline marshes and swamps have also been associated with this species (Ehmann 1997). | No |
| *Mixophyes balbus* | Stuttering Frog | E | V | Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range (OEH 2012) that are generally characterised by deep leaf litter or thick cover from understorey vegetation (Ehmann 1997). Breeding habitats are streams and occasionally springs. Not known from streams disturbed by humans (Ehmann 1997). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Mixophyes iteratus* | Giant Barred Frog | E | E | Found on forested slopes of the escarpment and adjacent ranges in riparian vegetation, subtropical and dry rainforest, wet sclerophyll forests and swamp sclerophyll forest (DECC 2007; Ehmann 1997). This species is associated with flowing streams with high water quality, though habitats may contain weed species (Ehmann 1997). This species is not known from riparian vegetation disturbed by humans (NSW Scientific Committee 1999). During breeding eggs are kicked up onto an overhanging bank or the streams edge (DECC 2007). | No |
| **REPTILES** | | | | | |
| *Hoplocephalus bungaroides* | Broad-headed Snake | E | V | Typical sites consist of exposed sandstone outcrops and benching where the vegetation is predominantly woodland, open woodland and/or heath on Triassic sandstone of the Sydney Basin (OEH 2012). They utilise rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer (Webb & Shine 1998) | No |
| *Varanus rosenbergi* | Rosenberg's Goanna | V | - | Associated with Sydney sandstone woodland and heath land. Rocks, hollow logs and burrows are utilised for shelter (Environment Australia 2000). | No |
| **BIRDS** | | | | | |
| *Anthochaera phrygia* | Regent Honeyeater | E | E & M | Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of River Oak (*Casuarina cunninghamiana*) (Garnett 1993). Areas containing Swamp Mahogany (*Eucalyptus robusta*) in coastal areas have been observed to be utilised (NPWS 1997). The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000). | Unlikely |
| *Botaurus poiciloptilus* | Australasian Bittern | V | - | Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams, estuaries (Simpson & Day 1999). | Unlikely |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Burhinus grallarius* | Bush Stone-curlew | E | - | Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed in lightly disturbed. | No |
| *Callocephalon fimbriatum* | Gang-gang Cockatoo | V | - | During summer in dense, tall, wet forests of mountains and gullies, alpine woodlands (Morcombe 2004). In winter they occur at lower altitudes in drier more open forests and woodlands, particularly box-ironbark assemblages (Shields & Chrome 1992). They sometimes inhabit woodland, farms and suburbs in autumn/winter (Simpson & Day 2004). | No |
| *Calyptorhynchus lathami* | Glossy Black-Cockatoo | V | - | Associated with a variety of forest types containing Allocasuarina species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; NPWS 1997; OEH 2012). Intact drier forest types with less rugged landscapes are preferred (OEH 2012). Nests in large trees with large hollows (Environment Australia 2000). | No |
| *Circus assimilis* | Spotted Harrier | V | - | The Spotted Harrier is found in mainland Australia and Indonesia. It is widespread but sparsely distributed. The Spotted Harrier is found in open wooded country in tropical and temperate Australia, particularly in arid and semi-arid areas (BIB, 2006). | Unlikely |
| *Climacteris picumnus victoriae* | Brown Treecreeper (eastern subspecies) | V | - | Distributed through central NSW on the western side of the Great Dividing Range and sparsely scattered to the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys. The Brown Treecreeper occupies eucalypt woodlands, particularly open woodland lacking a dense understorey. It is sedentary and nests in tree hollows within permanent territories. (NSW Scientific Committee 2001). | Unlikely |
| *Daphoenositta chrysoptera* | Varied Sittella | V | - | Distribution includes most of mainland Australia except deserts and open grasslands. Prefers eucalypt forests and woodlands with rough-barked species, or mature smooth-barked gums with dead branches, mallee and Acacia woodland. Feeds on arthropods from bark, dead branches, or small branches and twigs. | Unlikely |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Dasyornis brachypterus* | Eastern Bristlebird | E | E | Habitat is characterised by dense, low vegetation and includes sedgeland, heathland, swampland, shrubland, sclerophyll forest and woodland, and rainforest, as well as open woodland with a heathy understorey. In northern NSW occurs in open forest with tussocky grass understorey. All of these vegetation types are fire prone, aside from the rainforest habitatas utilised by the northern population as fire refuge. Age of habitat since fires (fire-age) is of paramount importance to this species; Illawarra and southern populations reach maximum densities in habitat that has not been burnt for at least 15 years; however, in the northern NSW population a lack of fire in grassy forest may be detrimental as grassy tussock nesting habitat becomes unsuitable after long periods without fire; northern NSW birds are usually found in habitats burnt five to 10 years previously. | No |
| *Ephippiorhynchus asiaticus* | Black-necked Stork | E | - | Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; DECC 2007). | No |
| *Erythrotriochis radiatus* | Red Goshawk | E4A | V | Associated with forests and woodlands with a mosaic of vegetation types, an abundance of birds and permanent water. In NSW, this species is thought to favour mixed subtropical rainforest, Melaleuca Swamp Forest, and open eucalypt forest along rivers, often in rugged terrain (Marchant & Higgins 1993; OEH 2012). Across northern Australian south through eastern Queensland to far north-east NSW. The species is very rare in NSW. Most records are from the Clarence River Catchment, with a few about the lower Richmond and Tweed Rivers. (OEH 2012). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Glossopsitta pusilla* | Little Lorikeet | V | - | In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes. | Yes |
| *Hieraaetus morphnoides* | Little Eagle | V | - | Utilises open eucalypt, sheoak and acacia forest, woodland or open woodland. Uses tall trees for nesting, with a large stick nest being built. Lays eggs in spring, and young fledge in early summer. Preys on birds, reptiles and mammals, and occasionally feeds on large insects or carrion. | Potential |
| *Lathamus discolor* | Swift Parrot | E | E | Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts (Blakers et al. 1984; Schodde and Tidemann 1986; Forshaw and Cooper 1981). Hence, in this region, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Bloodwood (*C. gummifera*), Mugga Ironbark (*E. sideroxylon*), and White Box (*E. albens*) (OEH 2012) | Potential |
| *Ninox strenua* | Powerful Owl | V | - | The Powerful Owl is associated with a wide range of wet and dry forest types with a high density of prey, such as arboreal mammals, large birds and flying foxes (Environment Australia 2000, Debus & Chafer 1994). Large trees with hollows at least 0.5m deep are required for shelter and breeding (Environment Australia 2000). | Potential |
| *Petroica boodang* | Scarlet Robin | V | - | Occurs from the coast to the inland slopes in NSW. After breeding (July-Jan), some disperse to the lower valleys and plains of the tablelands and slopes. Primarily resides in dry eucalypt forests and woodlands, with usually open and grassy understorey, with scattered shrubs. Abundant logs and fallen timber are important habitat components. In autumn and winter many Scarlet Robins live in open grassy woodlands, and grasslands or grazed paddocks with scattered trees, and may join mixed flocks of other small insectivorous birds. | Unlikely |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Rostratula australis* | Painted Snipe (Australian subspecies) | E | V | Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (OEH 2012). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (ibid.). Breeding is often in response to local conditions; generally occurs from September to December (OEH 2012). Forages nocturnally on mud-flats and in shallow water (OEH 2012). Feeds on worms, molluscs, insects and some plant-matter (ibid.). | Unlikely |
| *Stagonopleura guttata* | Diamond Firetail | V | - | Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (OEH 2012). It is often found in riparian areas and sometimes in lightly wooded farmland (OEH 2012). Appears to be sedentary, though some populations move locally, especially those in the south (OEH 2012). | Unlikely |
| *Stictonetta naevosa* | Freckled Duck | V | - | Associated with a variety of plankton-rich wetlands, such as heavily vegetated, large open lakes and their shores, creeks, farm dams, sewerage ponds and floodwaters (DECC 2007). | Unlikely |
| **MAMMALS (EXCLUDING BATS)** | | | | | |
| *Cercartetus nanus* | Eastern Pygmy-possum | V | - | Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995). | No |
| *Dasyurus maculatus*<br>*Dasyurus maculatus maculatus* | Spotted-tailed Quoll<br>Spotted-tailed Quoll (SE mainland population) | V<br>- | -<br>E | The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; OEH 2012), more frequently recorded near the ecotones of closed and open forest. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites (OEH 2012). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000). | No |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Isoodon obesulus* | Southern Brown Bandicoot | E | E | This species is associated with heath, coastal scrub, heathy forests (Menkhorst & Knight 2004), shrubland and woodland on well drained soils. This species is thought to display a preference for newly regenerating heathland and other areas prone to fire (Menkhorst & Seebeck 1990). | No |
| *Petaurus norfolcensis* | Squirrel Glider | V | - | Associated with dry hardwood forest and woodlands (Quin 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species. The presence of hollow bearing eucalypts is a critical habitat value (Quin 1995). | No |
| *Petrogale penicillata* | Brush-tailed Rock-wallaby | E | V | Rocky areas in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1995). | No |
| *Phascolarctos cinereus* | Koala | V | V | Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred Eucalyptus species are: *Eucalyptus tereticornis*, *E. punctata, E. cypellocarpa, E. viminalis* | Potential |
| *Potorous tridactylus*<br>*Potorous tridactylus tridactylus* | Long-nosed Potoroo<br>Long-nosed Potoroo (SE Mainland Population) | V<br>- | -<br>V | Associated with dry coastal heath and dry and wet sclerophyll forests (Strahan 1998) with dense cover for shelter and adjacent more open areas for foraging (Menkhorst & Knight 2004). | No |
| *Pseudomys novaehollandiae* | New Holland Mouse | - | V | A small burrowing native rodent with a fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Inhabits open heathlands, open woodlands with a heathland understorey and vegetated sand dunes. A social animal, living predominantly in burrows shared with other individuals. The home range of the New Holland Mouse ranges from 0.44 ha to 1.4 ha and the species peaks in abundance during early to mid stages of vegetation succession typically induced by fire (SEWPaC 2012) | No |
| **MAMMALS (BATS)** | | | | | |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Chalinolobus dwyeri* | Large-eared Pied Bat | V | V | The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; OEH 2012). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998). Found in well-timbered areas containing gullies (OEH 2012). | Potential |
| *Falsistrellus tasmaniensis* | Eastern False Pipistrelle | V | - | Prefers moist habitats with trees taller than 20m (OEH 2012). Roosts in tree hollows but has also been found roosting in buildings or under loose bark (OEH 2012). | Yes |
| *Miniopterus schreibersii oceanensis* | Eastern Bent-wing Bat | V | - | Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (AMBS 1995, Dwyer 1995). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995). | Yes |
| *Mormopterus norfolkensis* | Eastern Freetail Bat | V | - | Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998). | Yes |
| *Myotis macropus* | Large-footed Myotis | V | - | The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Will occupy most habitat types such as mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland, close to water (Churchill 1998). While roosting (in groups of 10-15) is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, in clumps of Pandanus, under bridges, in mines, tunnels and stormwater drains (Churchill 1998), however with specific roost requirements (Richards 1998). Forages over streams and pools catching insects and small fish. In NSW females have one young each year usually in November or December (OEH 2012) | Yes |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Pteropus poliocephalus* | Grey-headed Flying-Fox | V | V | Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). Camps are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998). | Potential |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail Bat | V | - | Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies. Roosts in tree hollows; may also use caves; has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). The Yellow-bellied Sheathtail-bat is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000). | Yes |
| *Scoteanax rueppellii* | Greater Broad-nosed Bat | V | - | Associated with moist gullies in mature coastal forest, or rainforest, east of the Great Dividing Range (Churchill, 1998), tending to be more frequently located in more productive forests (Hoye & Richards 1998). Within denser vegetation types use is made of natural and man-made openings such as roads, creeks and small rivers, where it hawks backwards and forwards for prey (Hoye & Richards 1998). | Yes |
| **INVERTEBRATES** | | | | | |
| *Meridolum corneovirens* | Cumberland Plain Land Snail | E | - | This species is found only within Cumberland Plain Woodland. It resides in the soil and litter layers, and can be found under woody debris and dumped building rubble. The species forages on fungi that grows around the roots of eucalypts, particularly, *Eucalyptus tereticornis.* | Potential |
| **MIGRATORY MARINE SPECIES LISTED UNDER EPBC ACT** | | | | | |
| *Apus pacificus* | Fork-tailed Swift | - | M | Sometimes travels with Needletails. Varied habitat with a possible tendency to more arid areas but also over coasts and urban areas (Simpson & Day 1999). | Potential |
| **MIGRATORY TERRESTRIAL SPECIES LISTED UNDER EPBC ACT** | | | | | |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Haliaeetus leucogaster* | White-bellied Sea-Eagle | - | M | Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993). | Potential |
| *Hirundapus caudacutus* | White-throated Needletail | - | M | Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993). | Potential |
| *Merops ornatus* | Rainbow Bee-eater | - | M | Resident in coastal and subcoastal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March, some occasionally present April to May. Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs . Nest is a chamber a the end of a burrow, up to 1.6 m long, tunnelled in flat or sloping ground, sandy back or cutting. | Likely |
| *Monarcha melanopsis* | Black-faced Monarch | - | M | Rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984). | Unlikely |
| *Myiagra cyanoleuca* | Satin Flycatcher | - | M | Wetter, denser forest, often at high elevations (Simpson & Day 2004). | Unlikely |
| *Rhipidura rufifrons* | Rufous Fantail | - | M | The Rufous Fantail is a summer breeding migrant to southeastern Australia (Morcombe, 2004). The Rufous Fantail is found in rainforest, dense wet eucalypt and monsoon forests, paperbark and mangrove swamps and riverside vegetation (Morcombe, 2004). Open country may be used by the Rufous Fantail during migration (Morcombe, 2004). | Unlikely |
| *Xanthomyza phrygia* | Regent Honeyeater | E | E, M | SEE BIRDS ABOVE | Unlikely |
| **MIGRATORY WETLAND SPECIES LISTED UNDER EPBC ACT** | | | | | |

| Scientific Name | Common Name | TSC Act | EPBC Act | Habitat Associations | Likelihood of Occurrence |
|---|---|---|---|---|---|
| *Ardea alba* | Great Egret | - | M | The Great Egret is common and widespread in Australia (McKilligan, 2005). The Eastern Great Egret has been reported in a wide range of wetland. These include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs (Kushlan & Hancock 2005; Marchant & Higgins 1993; Martínez-Vilalta & Motis 1992). The species usually frequents shallow waters. It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats (McKilligan, 2005). | Potential |
| *Ardea ibis* | Cattle Egret | - | M | Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan, 2005). Some individuals stay close to the natal heronry from one nesting season to the next, but the majority leave the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recovered west of the Great Dividing Range (McKilligan, 2005). | Yes |
| *Gallinago hardwickii* | Latham's Snipe | - | M | A variety of permanent and ephemeral wetlands, preferring open fresh water wetlands with nearby cover (Marchant and Higgins 1993). | Unlikely |

*E = Endangered; E2 = Endangered Population; V = Vulnerable; M = Migratory.*

# Appendix B: Species lists

**Flora**

| Scientific Name | Common Name | Native / Exotic |
|---|---|---|
| *Carex* sp. | | |
| *Alternanthera* sp. | | E |
| *Amaranthus* sp. | | E |
| *Anagallis arvensis* | Scarlet Pimpernel | E |
| *Araujia sericifera* | Moth Vine | E |
| *Arctotheca calendula* | Capeweed | E |
| *Asparagus asparagoides* | Bridal Creeper | E |
| *Axonopus fissifolius* | Narrow-leafed Carpet Grass | E |
| *Bidens bipinnata* | Bipinnate Beggar's Ticks | E |
| *Bidens pilosa* | Cobblers Pegs | E |
| *Briza subaristata* | | E |
| *Bromus catharticus* | Prairie Grass | E |
| *Capsella bursa-pastoris* | Shepherd's Purse | E |
| *Carthamus lanatus* | Saffron Thistle | E |
| *Cerastium glomeratum* | Mouse-eared Chickweed | E |
| *Chenopodium murale* | Nettle-leaf Goosefoot | E |
| *Cirsium vulgare* | Spear Thistle | E |
| *Conyza* sp. | | E |
| *Cynodon dactylon* | Couch | E |
| *Dactylis glomerata* | Cocksfoot | E |
| *Digitaria sanguinalis* | Summer Grass | E |
| *Digitaria* sp. | | E |
| *Echinochloa crus-galli* | Barnyard Grass | E |
| *Echinochloa esculenta* | Japanese Millet | E |
| *Echinochloa* sp. | | E |
| *Echium plantagineum* | Paterson's Curse | E |
| *Ehrharta erecta* | Panic Veldtgrass | E |
| *Eleusine indica* | Indian Goosegrass | E |
| *Eleusine tristachya* | Goose Grass | E |
| *Eragrostis curvula* | African Lovegrass | E |
| *Eragrostis* sp. | | E |
| *Facelis retusa* | Annual Trampweed | E |
| *Galinsoga parviflora* | Potato Weed | E |

| Scientific Name | Common Name | Native / Exotic |
|---|---|---|
| *Gomphocarpus physocarpus* | Balloon Cotton Bush | E |
| *Gomphrena celosioides* | | E |
| *Hypochaeris radicata* | Catsear | E |
| *Lepidium africanum* | | E |
| *Lepidium* sp. | | E |
| *Ligustrum lucidum* | Large-leaved Privet | E |
| *Ligustrum sinense* | Small-leaved Privet | E |
| *Linum trigynum* | | E |
| *Lolium rigidum* | Wimmera Ryegrass | E |
| *Lycium ferocissimum* | African Boxthorn | E |
| *Malva parviflora* | Small-flowered Mallow | E |
| *Medicago polymorpha* | Burr Medic | E |
| *Medicago* sp. | | E |
| *Modiola caroliniana* | Red-flowered Mallow | E |
| *Olea europaea* subsp. *cuspidata* | African Olive | E |
| *Opuntia* sp. | Prickly Pear | E |
| *Oxalis* sp. | | E |
| *Paronychia brasiliana* | Chilean Whitlow Wort | E |
| *Paspalum dilatatum* | Paspalum | E |
| *Pennisetum clandestinum* | Kikuyu | E |
| *Petrorhagia nanteuilii* | | E |
| *Phytolacca octandra* | Inkweed | E |
| *Picris* sp. | | N |
| *Plantago lanceolata* | Lamb's Tongues | E |
| *Polygonum aviculare* | Wireweed | E |
| *Portulaca oleracea* | Pigweed | E |
| *Romulea rosea* | Onion Grass | E |
| *Rubus fruticosus* agg. | Blackberry | E |
| *Rumex crispus* | Curled Dock | E |
| *Senecio madagascariensis* | Fireweed | E |
| *Setaria parviflora* | | E |
| *Setaria pumila* | Slender Pigeon Grass | E |
| *Setaria* sp. | | E |
| *Sida rhombifolia* | Paddy's Lucerne | E |
| *Silene* sp. | | E |
| *Solanum nigrum* | Black-berry Nightshade | E |
| *Solanum* sp. | | E |
| *Sonchus asper* | Prickly Sowthistle | E |
| *Sonchus oleraceus* | Common Sowthistle | E |

| Scientific Name | Common Name | Native / Exotic |
|---|---|---|
| *Sporobolus fertilis* | Giant Parramatta Grass | E |
| *Sporobolus indicus* | Parramatta Grass | E |
| *Stachys arvensis* | Stagger Weed | E |
| *Stellaria media* | Common Chickweed | E |
| *Tagetes minuta* | Stinking Roger | E |
| *Taraxacum officinale* | Dandelion | E |
| *Trifolium dubium* | Yellow Sucking Clover | E |
| *Trifolium glomeratum* | | E |
| *Trifolium repens* | White Clover | E |
| *Trifolium* sp. | | E |
| UNKNOWN Brassiceae | | E |
| *Urtica urens* | Small Nettle | E |
| *Verbena bonariensis* | Purpletop | E |
| *Verbena officinalis* | Common Verbena | E |
| *Veronica plebeia* | Trailing Speedwell | N |
| *Xanthium spinosum* | Bathurst Burr | E |
| *Ajuga australis* | Austral Bugle | N |
| *Alternanthera denticulata* | Lesser Joyweed | N |
| *Aristida ramosa* | Purple Wiregrass | N |
| *Arthropodium milleflorum* | Pale Vanilla-lily | N |
| *Asperula conferta* | Common Woodruff | N |
| *Astroloma humifusum* | Native Cranberry | N |
| *Austrostipa elegantissima* | | N |
| *Bothriochloa macra* | Red Grass | N |
| *Brunoniella australis* | Blue Trumpet | N |
| *Bursaria spinosa* | Blackthorn | N |
| *Calotis lappulacea* | Yellow Burr-daisy | N |
| *Carex inversa* | | N |
| *Cassinia* sp. | | N |
| *Cheilanthes sieberi* | | N |
| *Chloris* sp. | | N |
| *Chloris truncata* | Windmill Grass | N |
| *Chloris ventricosa* | Plump Windmill Grass | N |
| *Chrysocephalum apiculatum* | Common Everlasting | N |
| *Clematis aristata* | Old Man's Beard | N |
| *Corymbia maculata* | Spotted Gum | N |
| *Cotula australis* | Common Cotula | N |
| *Cymbopogon refractus* | Barbed Wire Grass | N |
| *Cyperus gracilis* | Slender Flat-sedge | N |

| Scientific Name | Common Name | Native / Exotic |
|---|---|---|
| *Daviesia ulicifolia* | Gorse Bitter Pea | N |
| *Desmodium brachypodum* | Large Tick-trefoil | N |
| *Desmodium varians* | | N |
| *Dianella longifolia* | Blueberry Lily | N |
| *Dichelachne* sp. | | N |
| *Dichondra repens* | Kidney Weed | N |
| *Digitaria parviflora* | Small-flowered Finger Grass | N |
| *Dodonaea viscosa* | Sticky Hop-bush | N |
| *Dysphania pumilio* | Small Crumbweed | N |
| *Echinopogon caespitosus* | Bushy Hedgehog-grass | N |
| *Echinopogon ovatus* | Forest Hedgehog Grass | N |
| *Einadia hastata* | Berry Saltbush | N |
| *Einadia nutans* | Climbing Saltbush | N |
| *Einadia trigonos* | Fishweed | N |
| *Eragrostis leptostachya* | Paddock Lovegrass | N |
| *Erodium crinitum* | Blue Storksbill | N |
| *Eucalyptus crebra* | Narrow-leaved Ironbark | N |
| *Eucalyptus fibrosa* | Red Ironbark | N |
| *Eucalyptus moluccana* | Grey Box | N |
| *Eucalyptus tereticornis* | Forest Red Gum | N |
| *Euchiton sphaericus* | | N |
| *Glycine clandestina* | | N |
| *Glycine tabacina* | | N |
| *Hypericum gramineum* | Small St. John's Wort | N |
| *Juncus* sp. | | N |
| *Juncus usitatus* | | N |
| *Lagenophora stipitata* | Blue Bottle-daisy | N |
| *Lomandra filiformis* | Wattle Mat-rush | N |
| *Ludwigia peploides* | Water Primrose | N |
| *Lythrum hyssopifolium* | Loosestrife | N |
| *Mentha satureioides* | Creeping Mint | N |
| *Microlaena stipoides* | Weeping Grass | N |
| *Opercularia diphylla* | | N |
| *Oplismenus aemulus* | Australian Basket Grass | N |
| *Oxalis perennans* | | N |
| *Panicum simile* | Two-colour Panic | N |
| *Paspalidium distans* | | N |
| *Persicaria decipiens* | Slender Knotweed | N |
| *Phyllanthus virgatus* | | N |

| Scientific Name | Common Name | Native / Exotic |
|---|---|---|
| *Pratia purpurascens* | Whiteroot | N |
| *Rumex brownii* | Swamp Dock | N |
| *Rytidosperma racemosum* | | N |
| *Rytidosperma* sp. | | N |
| *Rytidosperma tenuius* | | N |
| *Schoenus apogon* | Common Bog-rush | N |
| *Sida corrugata* | Corrugated Sida | N |
| *Sigesbeckia orientalis* | | N |
| *Solanum prinophyllum* | Forest Nightshade | N |
| *Sporobolus creber* | Western Rat-tail Grass | N |
| *Themeda australis* | Kangaroo Grass | N |
| *Tricoryne elatior* | Yellow Autumn-lily | N |
| *Vittadinia* sp. | | N |
| *Wahlenbergia* sp. | | N |
| *Zornia* sp. | | N |
| *Stenotaphrum* sp. | Buffalo Grass | E |

**Fauna**

| Common Name | Scientific Name |
|---|---|
| **FROGS** | |
| Common Eastern Froglet | *Crinia signifera* |
| Eastern Dwarf Tree Frog | *Litoria fallax* |
| Smooth Toadlet | *Uperoleia laevigata* |
| **BIRDS** | |
| King Parrot | *Alisterus scapularis* |
| Grey Teal | *Anas gracilis* |
| Pacific Black Duck | *Anas superciliosa* |
| Red Wattlebird | *Anthochaera carunculata* |
| Australasian Pipit | *Anthus novaeseelandiae* |
| White-necked Heron | *Ardea pacifica* |
| Hardhead | *Aythya australis* |
| Sulphur-crested Cockatoo | *Cacatua galerita* |
| Little Corella | *Cacatua sanguinea* |
| European Goldfinch | *Carduelis carduelis* |
| Australian Wood Duck | *Chenonetta jubata* |
| Golden-headed Cisticola | *Cisticola exilis* |
| Grey Shrike-thrush | *Colluricincla harmonica* |

| Common Name | Scientific Name |
|---|---|
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* |
| White-winged Chough | *Corcorax melanorhamphos* |
| Australian Raven | *Corvus coronoides* |
| Australian Magpie | *Cracticus tibicen* |
| Grey Butcherbird | *Cracticus torquatus* |
| Black Swan | *Cygnus atratus* |
| White-faced Heron | *Egretta novaehollandiae* |
| Black-fronted Dotterel | *Elseyornis melanops* |
| Galah | *Eolophus roseicapillus* |
| Nankeen Kestrel | *Falco cenchroides* |
| Eurasian Coot | *Fulica atra* |
| Bar-shouldered Dove | *Geopelia humeralis* |
| Musk Lorikeet | *Glossopsitta concinna* |
| Little Lorikeet | *Glossopsitta pusilla* |
| Magpie-lark | *Grallina cyanoleuca* |
| Welcome Swallow | *Hirundo neoxena* |
| Wonga Pigeon | *Leucosarcia picata* |
| Yellow-faced Honeyeater | *Lichenostomus chrysops* |
| Superb Fairy-wren | *Malurus cyaneus* |
| Noisy Miner | *Manorina melanocephala* |
| Bell Miner | *Manorina melanophrys* |
| Lewin's Honeyeater | *Meliphaga lewinii* |
| Restless Flycatcher | *Myiagra inquieta* |
| Red-browed Finch | *Neochmia temporalis* |
| Crested Pigeon | *Ocyphaps lophotes* |
| Spotted Pardalote | *Pardalotus punctatus* |
| Striated Pardalote | *Pardalotus striatus* |
| Noisy Friarbird | *Philemon corniculatus* |
| Crimson Rosella | *Platycercus elegans* |
| Eastern Rosella | *Platycercus eximius* |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* |
| Purple Swamphen | *Porphyrio porphyrio* |
| Red-rumped Parrot | *Psephotus haematonotus* |
| Eastern Whipbird | *Psophodes olivaceus* |
| Satin Bowerbird | *Ptilonorhynchus violaceus* |
| Grey Fantail | *Rhipidura albiscapa* |
| Willie Wagtail | *Rhipidura leucophrys* |
| Pied Currawong | *Strepera graculina* |
| Common Myna | *Sturnus tristis* |

| Common Name | Scientific Name |
|---|---|
| Common Starling | *Sturnus vulgaris* |
| Australasian Grebe | *Tachybaptus novaehollandiae* |
| Australian White Ibis | *Threskiornis molucca* |
| Straw-necked Ibis | *Threskiornis spinicollis* |
| Sacred Kingfisher | *Todiramphus sanctus* |
| Rainbow Lorikeet | *Trichoglossus haematodus* |
| Cattle Egret^ | *Ardea ibis* |
| Yellow-tailed Black Cockatoos | *Calyptorhynchus funereus* |
| Masked Lapwing | *Vanellus miles* |
| **MAMMALS** | |
| Domestic Cattle* | *Bos primigenius* |
| Gould's Wattled Bat | *Chalinolobus gouldii* |
| Chocolate Wattled Bat | *Chalinolobus morio* |
| Domestic Horse* | *Equus ferus caballus* |
| Eastern False Pipistrelle | *Falsistrellus tasmaniensis* |
| Eastern Bentwing Bat | *Miniopterus schreibersii oceanensis* |
| East-coast Freetail Bat | *Mormopterus norfolkensis* |
| Eastern Freetail Bat | *Mormopterus* sp2 |
| Large-footed Myotis | *Myotis macropus* |
| Long-eared Bat | *Nyctophilus* spp. |
| European Rabbit* | *Oryctolagus cuniculus* |
| Yellow-bellied Sheathtail Bat | *Saccolaimus flaviventris* |
| Greater Broad-nosed Bat | *Scoteanax rueppellii* |
| White-striped Freetail Bat | *Tadarida australis* |
| Eastern forest Bat | *Vespadelus regulus* |
| Little Forest Bat | *Vespadelus vulturnus* |
| European Red Fox* | *Vulpes vulpes* |
| Swamp Wallaby | *Wallabia bicolor* |
| **REPTILES** | |
| Eastern Water Skink | *Eulamprus quoyii* |
| **FISH** | |
| Common Carp* | *Cyprinus carpio* |
| Eastern Gambusia* | *Gambusia holbrooki* |

# Appendix C: Anabat method details

Bat calls were analysed using the program AnalookW (Version 3.8 25 October 2012, written by Chris Corben, www.hoarybat.com). Call identifications were made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from north-eastern NSW. Available: (http://www.forest.nsw.gov.au/research/bats/default.asp).

Bat calls are analysed using species-specific parameters of the call profile such as call shape, characteristic frequency, initial slope and time between calls (Reinhold et al. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd et al. 2006) were followed:

- Search phase calls were used in the analysis, rather than cruise phase calls or feeding buzzes (McKenzie et al. 2002)
- Recordings containing less than three pulses were not analysed and these sequences were labelled as short (Law et al. 1999)
- Four categories of confidence in species identification were used (Mills et al. 1996):
  - definite – identity not in doubt
  - probable – low probability of confusion with species of similar calls
  - possible – medium to high probability of confusion with species with similar calls
  - unidentifiable – calls made by bats which cannot be identified to even a species group.
- *Nyctophilus* spp. are difficult to identify confidently from their calls and no attempt was made to identify this genus to species level (Pennay et al. 2004)
- Sequences not attributed to microbat echolocation calls were labelled as junk or non-bat calls and don't represent microbat activity at the site
- Sequences labelled as low were of poor quality and therefore not able to be identified to any microbat species, they can however be used as an indicator of microbat activity at the site.

# Appendix D: Description of riparian and aquatic habitat

**Table 13: Riparian and aquatic condition within study site**

| Reach No. | Hydrology | Streamside Vegetation | Physical Form | Water Quality and Aquatic Habitat | Overall Rating |
|---|---|---|---|---|---|
| Reach A | 2nd order stream (Strahler). Mostly modified channel. One low flow barrier. Mostly cleared catchment. | Substantially modified. Width reduced by up to 1/3 and/or some breaks in continuity. More than one stratum completely altered from reference (lost or <10% remaining). Reduced cover (75-50%) of dominant strata, and only one age class present. About 50% of the native vegetation remains, either in strips or patches. Quantities and/or cover of debris 50% higher or lower than reference. | Average channel width = 2 m. Bank slope = 30-70 degrees. Gully erosion = 10%. Slumping erosion = 10%. Sheet erosion = 10%. Undercut erosion = 0%. | Velocity = Stagnant. Riffle = 0%. Run = 90%. Pool = 10%. Depth (creek) = < 10 cm. Turbidity = Very turbid. Dominant substrate = Clay. Sub-dominant substrate = Clay. Aquatic vegetation richness = 1 species. Native aquatic vegetation abundance = Absent. Instream woody debris = Rare. Fish habitat = Class 3 - Minimal fish habitat. Bird habitat = Good. Frog habitat = Poor. | Degraded-Moderate |
| Reach B | No defined channel. | | | | |
| Reach C | No defined channel. | | | | |
| Reach D | 2nd order stream (Strahler). Unmodified channel. No barriers. Partially cleared catchment. | Slightly modified. Width reduced by up to 1/3 and/or some breaks in continuity. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Width reduced by up to 1/3 and/or some breaks in continuity. Quantities and cover of debris similar to reference. | Average channel width = 4 m. Bank slope = >70 degrees. Gully erosion = 5%. Slumping erosion = 20%. Sheet erosion = 0%. Undercut erosion = 20%. | Velocity = Slow (<0.1 m/s). Riffle = 5%. Run = 35%. Pool = 60%. Depth (creek) = 20-30 cm. Turbidity = Moderate. Dominant substrate = Clay. Sub-dominant substrate = Gravel. Aquatic vegetation richness = 4 species. Native aquatic vegetation abundance = Common. Instream woody debris = Abundant. Fish habitat = Class 2 - Moderate fish habitat. Bird habitat = Excellent. Frog habitat = Excellent. | Moderate |

| Reach No. | Hydrology | Streamside Vegetation | Physical Form | Water Quality and Aquatic Habitat | Overall Rating |
|---|---|---|---|---|---|
| Reach E | 1st order stream (Strahler). Unmodified channel. No barriers. Mostly cleared catchment.<br><br>No defined channel in upper section. | Substantially modified. Only small patches of well-separated native vegetation remain. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Reduced cover (<50%) of dominant strata, and only one age class present. About 50% of the native vegetation remains, either in strips or patches. Quantities and/or cover of debris 50% higher or lower than reference. | Average channel width = 1 m. Bank slope = >70 degrees. Gully erosion = 5%. Slumping erosion = 10%. Sheet erosion = 0%. Undercut erosion = 0%. | Velocity = Dry. Riffle = 50%. Run = 50%. Pool = 0%. Depth (creek) = Dry. Turbidity = Dry. Dominant substrate = Clay. Sub-dominant substrate = Boulder. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Instream woody debris = Abundant. Fish habitat = Class 4 - Unlikely fish habitat. Bird habitat = Excellent. Frog habitat = Good. | Degraded-Moderate |
| Reach F | 1st order stream (Strahler). Heavily modified channel. Numerous low flow barriers without fish passage. Mostly cleared catchment.<br><br>Lower dam receives diverted water from Reach I. | Severely modified. Little or no remaining native vegetation. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Dominant strata mostly absent. Little or no remaining native vegetation. Some evidence of unnatural loss of debris (e.g. through collection of firewood, trampling of leaf litter by stock). | Average channel width = 8 m. Bank slope = <30 degrees. Gully erosion = 5%. Slumping erosion = 0%. Sheet erosion = 5%. Undercut erosion = 0%. | Velocity = Stagnant. Riffle = 0%. Run = 80%. Pool = 20%. Depth (creek) = < 10 cm. Turbidity = Turbid. Dominant substrate = Clay. Sub-dominant substrate = Silt. Aquatic vegetation richness = 3 species. Native aquatic vegetation abundance = Common. Instream woody debris = Rare. Fish habitat = Class 3 - Minimal fish habitat. Bird habitat = Moderate. Frog habitat = Good. | Degraded |
| Reach G | 1st order stream (Strahler). Partially modified channel. Numerous low flow barriers without fish passage. Mostly cleared catchment. | Severely modified. Width reduced by up to 1/3 and/or some breaks in continuity. Structure completely altered from reference (e.g. grassland shrubland, forest pasture). Dominant strata mostly absent. Only small patches of well-separated native vegetation remain. Very small quantities of debris present. | Average channel width = 6 m. Bank slope = <30 degrees. Gully erosion = 5%. Slumping erosion = 5%. Sheet erosion = 15%. Undercut erosion = 0%. | Velocity = Stagnant. Riffle = 0%. Run = 20%. Pool = 80%. Depth (creek) = 30-100 cm. Turbidity = Turbid. Dominant substrate = Clay. Sub-dominant substrate = Silt. Aquatic vegetation richness = 3 species. Native aquatic vegetation abundance = Rare. Instream woody debris = Rare. Fish habitat = Class 3 - Minimal fish habitat. Bird habitat = Moderate. Frog habitat = Good. | Degraded |

| Reach No. | Hydrology | Streamside Vegetation | Physical Form | Water Quality and Aquatic Habitat | Overall Rating |
|---|---|---|---|---|---|
| | No defined channel in upper section. | | | | |
| Reach H | No defined channel. | | | | |
| Reach I | 2nd order stream (Strahler). Mostly modified channel. One low flow barrier. Mostly cleared catchment.<br><br>Dam overflow diverted to Reach F. | Severely modified. Only small patches of well-separated native vegetation remain. Structure completely altered from reference (e.g. grassland shrubland, forest pasture). Reduced cover (<50%) of dominant strata, and only one age class present. Only small patches of well-separated native vegetation remain. Very small quantities of debris present. | Average channel width = 10 m. Bank slope = <30 degrees. Gully erosion = 5%. Slumping erosion = 10%. Sheet erosion = 20%. Undercut erosion = 0%. | Velocity = Stagnant. Riffle = 0%. Run = 15%. Pool = 85%. Depth (creek) = 30-100 cm. Turbidity = Turbid. Dominant substrate = Clay. Sub-dominant substrate = Silt. Aquatic vegetation richness = 3 species. Native aquatic vegetation abundance = Common. Instream woody debris = Rare. Fish habitat = Class 3 - Minimal fish habitat. Bird habitat = Moderate. Frog habitat = Good. | Degraded |
| Reach J | No defined channel. | | | | |
| Reach K | 1st order stream (Strahler). Unmodified channel. Numerous low flow barriers without fish passage. Mostly cleared catchment. | Severely modified. Little or no remaining native vegetation. Structure completely altered from reference (e.g. grassland shrubland, forest pasture). Dominant strata mostly absent. Little or no remaining native vegetation. Very small quantities of debris present. | Average channel width = 1 m. Bank slope = <30 degrees. Gully erosion = 0%. Slumping erosion = 0%. Sheet erosion = 0%. Undercut erosion = 0%. | Velocity = Dry. Riffle = 5%. Run = 80%. Pool = 5%. Depth (creek) = Dry. Turbidity = Dry. Dominant substrate = Clay. Sub-dominant substrate = Boulder. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Instream woody debris = Rare. Fish habitat = Class 4 - Unlikely fish habitat. Bird habitat = Poor. Frog habitat = Poor. | Degraded |

| Reach No. | Hydrology | Streamside Vegetation | Physical Form | Water Quality and Aquatic Habitat | Overall Rating |
|---|---|---|---|---|---|
| Reach L | 1st order stream (Strahler). Unmodified channel. Numerous low flow barriers without fish passage. Mostly cleared catchment. | Severely modified. Little or no remaining native vegetation. Structure completely altered from reference (e.g. grassland shrubland, forest pasture). Dominant strata mostly absent. Little or no remaining native vegetation. Very small quantities of debris present. | Average channel width = 3 m. Bank slope = <30 degrees. Gully erosion = 0%. Slumping erosion = 0%. Sheet erosion = 0%. Undercut erosion = 0%. | Velocity = Dry. Riffle = 5%. Run = 80%. Pool = 5%. Depth (creek) = Dry. Turbidity = Dry. Dominant substrate = Clay. Sub-dominant substrate = Boulder. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Instream woody debris = Occasional. Fish habitat = Class 4 - Unlikely fish habitat. Bird habitat = Poor. Frog habitat = Poor. | Degraded |
| Reach M | 2nd order stream (Strahler). Partially modified channel. Numerous low flow barriers without fish passage. Mostly cleared catchment. | Severely modified. Only small patches of well-separated native vegetation remain. More than one stratum completely altered from reference (lost or <10% remaining). Reduced cover (<50%) of dominant strata, and only one age class present. Only small patches of well-separated native vegetation remain. Very small quantities of debris present. | Average channel width = 4 m. Bank slope = <30 degrees. Gully erosion = 5%. Slumping erosion = 15%. Sheet erosion = 5%. Undercut erosion = 0%. | Velocity = Stagnant. Riffle = 20%. Run = 60%. Pool = 20%. Depth (creek) = < 10 cm. Turbidity = Very turbid. Dominant substrate = Clay. Sub-dominant substrate = Boulder. Aquatic vegetation richness = 1 species. Native aquatic vegetation abundance = Occasional. Instream woody debris = Occasional. Fish habitat = Class 3 - Minimal fish habitat. Bird habitat = Moderate. Frog habitat = Moderate. | Degraded |
| Reach N | 3rd order stream (Strahler). Unmodified channel. No barriers. Partially cleared catchment. | Slightly modified. Width reduced by up to 1/3 and/or some breaks in continuity. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Width reduced by up to 1/3 and/or some breaks in continuity. Quantities and cover of debris similar to reference. | Average channel width = 5 m. Bank slope = <30 degrees. Gully erosion = 0%. Slumping erosion = 0%. Sheet erosion = 0%. Undercut erosion = 0%. | Velocity = Slow (<0.1 m/s). Riffle = 0%. Run = 20%. Pool = 80%. Depth (creek) = 30-100 cm. Turbidity = Moderate. Dominant substrate = Clay. Sub-dominant substrate = Gravel. Aquatic vegetation richness = 4 species. Native aquatic vegetation abundance = Abundant. Instream woody debris = Abundant. Fish habitat = Class 2 - Moderate fish habitat. Bird habitat = Excellent. Frog habitat = Excellent. | Moderate |

# Appendix E: NOW Guidelines for riparian corridors on waterfront land

Department of Primary Industries
Office of Water

CONTROLLED ACTIVITIES ON WATERFRONT LAND

# Guidelines for riparian corridors on waterfront land

Controlled activities carried out in, on or under waterfront land are regulated by the *Water Management Act 2000* (WM Act). The NSW Office of Water administers the WM Act and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary.

This means that a controlled activity approval must be obtained from the Office of Water before commencing the controlled activity.

## What is a riparian corridor?

A riparian corridor (RC) forms a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment. Riparian corridors perform a range of important environmental functions such as:

- providing bed and bank stability and reducing bank and channel erosion
- protecting water quality by trapping sediment, nutrients and other contaminants
- providing diversity of habitat for terrestrial, riparian and aquatic plants (flora) and animals (fauna)
- providing connectivity between wildlife habitats
- conveying flood flows and controlling the direction of flood flows
- providing an interface or buffer between developments and waterways
- providing passive recreational uses.

The protection, restoration or rehabilitation of vegetated riparian corridors is important for maintaining or improving the shape, stability (or geomorphic form) and ecological functions of a watercourse.

## Changes to controlled activities within riparian corridors

On 1 July 2012 new rules commenced regarding controlled activities within riparian corridors. The new rules amend the riparian corridor widths that apply to watercourses, providing more flexibility in how riparian corridors can be used and making it easier for applicants to determine the Office of Water controlled activity approval requirements. Key aspects of the changes include:

- Provision of greater flexibility in the allowable uses and works permitted within riparian corridors.
- The core riparian zone and vegetated buffer have been combined into a single vegetated riparian zone (VRZ).
- The width of the VRZ within the riparian corridor has been pre-determined and standardised for first, second, third and fourth order and greater watercourses.
- Where suitable, applicants may undertake non-riparian corridor works or development within the outer 50 per cent of a VRZ, as long as they offset this activity by connecting an equivalent area to the RC within the development site.
- A new 'riparian corridors matrix' enables applicants to determine what activities can be considered in riparian corridors.

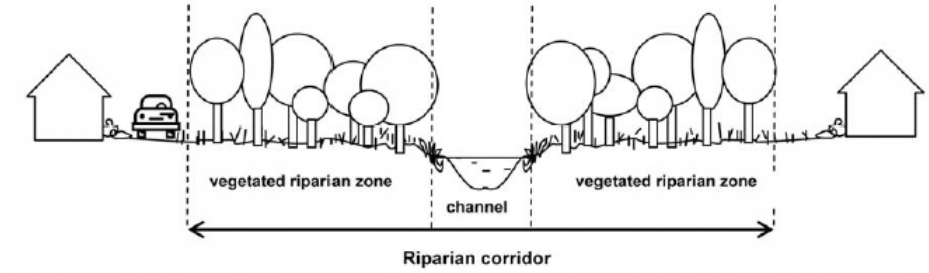
www.water.nsw.gov.au

These changes will simplify the controlled activities application and assessment process, provide greater flexibility, help make more land available for housing, support floodplain, stormwater and bush fire management, and allow riparian corridors to be used for public amenity whilst continuing to deliver environmental outcomes required under the WM Act.

The riparian corridor consists of:

- the channel which comprises the bed and banks of the watercourse (to the highest bank) and
- the vegetated riparian zone (VRZ) adjoining the channel.

**Figure 1. The riparian corridor**




## Riparian corridor widths

The Officer of Water recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps (see Figure 2 and Table 1). The width of the VRZ should be measured from the top of the highest bank on both sides of the watercourse.

**Figure 2. The Strahler System**

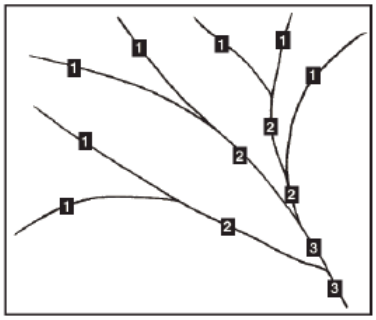


**Table 1. Recommended riparian corridor (RC) widths**

| Watercourse type | VRZ width (each side of watercourse) | Total RC width |
|---|---|---|
| 1st order | 10 metres | 20 m + channel width |
| 2nd order | 20 metres | 40 m + channel width |
| 3rd order | 30 metres | 60 m + channel width |
| 4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters) | 40 metres | 80 m + channel width |

Note: where a watercourse does not exhibit the features of a defined channel with bed and banks, the Office of Water may determine that the watercourse is not waterfront land for the purposes of the WM Act

## Objectives for riparian corridor management

The overarching objective of the controlled activities provisions of the WM Act is to establish and preserve the integrity of riparian corridors.

Ideally the environmental functions of riparian corridors should be maintained or rehabilitated by applying the following principles:

- Identify whether or not there is a watercourse present and determine its order in accordance with the Strahler System.
- If a watercourse is present, define the RC/VRZ on a map in accordance with Table 1.
- Seek to maintain or rehabilitate a RC/VRZ with fully structured native vegetation in accordance with Table 1.
- Seek to minimise disturbance and harm to the recommended RC/VRZ.
- Minimise the number of creek crossings and provide perimeter road separating development from the RC/VRZ.
- Locate services and infrastructure outside of the RC/VRZ. Within the RC/VRZ provide multiple service easements and/or utilise road crossings where possible.
- Treat stormwater run-off before discharging into the RC/VRZ.

The Office of Water however, does allow for a range of works and activities on waterfront land and in riparian corridors to better meet the needs of the community, so long as they cause minimal harm as outlined in the riparian corridor matrix below.

## Riparian corridor matrix

The riparian corridor matrix enables applicants to identify certain works and activities that can occur on waterfront land and in riparian corridors. Applicants should note that the matrix relates to controlled activity approvals under the WM Act only. They are still required to comply with other relevant government legislation, such as threatened species, flood planning levels and fisheries guidelines.

**Table 2. Riparian corridor matrix**

| Stream order | Vegetated Riparian Zone (VRZ) | RC off-setting for non RC uses | Cycleways and paths | Detention basins | | Stormwater outlet structures and essential services | Stream realignment | Road crossings | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Only within 50% outer VRZ | Online | | | Any | Culvert | Bridge |
| 1st | 10m | • | • | • | • | • | • | • | | |
| 2nd | 20m | • | • | • | • | • | | • | | |
| 3rd | 30m | • | • | • | | • | | | • | • |
| 4th + | 40m | • | • | • | | • | | | • | • |

### Key

**Stream order:** The watercourse order as classified under the Strahler System based on 1:25,000, 1:50,000 or 1:100,000 topographic maps whichever is the smallest scale available. A full list is provided at Part 2, Schedule 2 of the Water Management (General) Regulation 2011.

**Vegetated riparian zone (VRZ):** The required width of the VRZ measured from the top of the high bank on each side of the watercourse.

**Riparian corridor (RC) off-setting for non RC uses:** Non-riparian uses, such as Asset Protection Zones are allowed within the outer 50 per cent of the VRZ, so long as offsets are provided in accordance with the averaging rule as seen in Figure 3.

**Cycleways and paths:** Cycleways or paths no wider than four metres total disturbance footprint can be built in the outer 50 per cent of the VRZ.

**Detention basins:** Detention basins can be built in the outer 50 per cent of the VRZ or online where indicated. Refer to the Office of Water's *Controlled activities. Guidelines for outlet structures* and *Controlled activities. Guidelines for instream works*. Online basins must:

- be dry and vegetated
- be for temporary flood detention only with no permanent water holding
- have an equivalent VRZ for the corresponding watercourse order
- not be used for water quality treatment purposes.

**Stormwater outlet structures and essential services:** Stormwater outlets or essential services are allowed in the RC. Works for essential services on a fourth order or greater stream are to be undertaken by directional drilling or tied to existing crossings. Refer to the Office of Water's *Controlled activities. Guidelines for laying pipes and cables in watercourses* and *Controlled activities. Guidelines for outlet structures.*

**Stream realignment:** Indicates that a watercourse may be realigned. Refer to the Office of Water's *Controlled activities. Guidelines for instream works.*

**Road crossings:** Indicates permitted road crossing methods. Refer to the Office of Water's *Controlled activities. Guidelines for watercourse crossings* and NSW DPI policy and guidelines for fish friendly waterway crossings for Class 1 and 2 waterways.

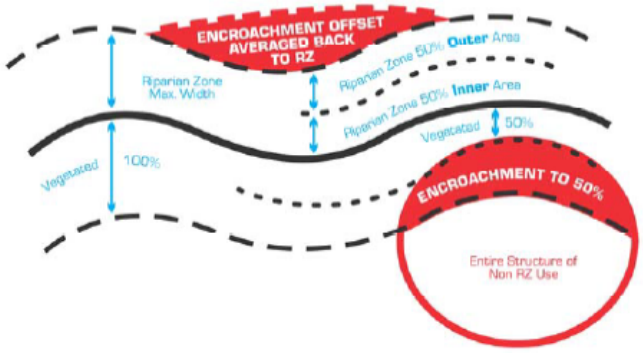
## What is the averaging rule?

Non riparian corridor works and activities can be authorised within the outer riparian corridor, so long as the average width of the vegetated riparian zone can be achieved over the length of the watercourse within the development site. That is, where appropriate 50 per cent of the outer vegetated riparian zone width may be used for non-riparian uses including asset protection zones, recreational areas, roads, development lots and infrastructure. However, an equivalent area connected to the riparian corridor must be offset on the site (see Figure 3) and the inner 50 per cent of the vegetated riparian zone must be fully protected and vegetated with native endemic riparian plant species.

Bridges, cycleways, paths, stormwater oulets and other essential services do not need to be offset, but must comply with the requirements set out in the riparian corridor matrix (Table 2) and other relevant Office of Water controlled activities guidelines. Offline detention basins do not need to be offset so long as there is an equivalent VRZ for the corresponding watercourse and they are built in compliance with the Office of Water's *Controlled activities: Guidelines for watercourse crossings* and *Controlled activities: Guidelines for in-stream works*. If a proposed basin will not have an equivalent VRZ for the corresponding watercourse, it may still be built in the outer 50 per cent of the VRZ but must be offset.

The averaging rule should generally be applied to cleared waterfront land. Development proposals involving waterfront lands that contain existing native vegetation should seek to preserve that riparian vegetation in accordance with the minimum riparian corridor requirements outlined in Table 1.

**Figure 3. Averaging rule**



## Applications for controlled activity approvals

Applications for controlled activities approvals should be informed by the riparian corridor matrix shown in Table 2 and prepared using the *Application for a Controlled Activity Approval for works on waterfront land* form and the *Guideline for completing an application for a Controlled Activity Approval*.

Other controlled activity guidelines are available on the Office of Water website and outline relevant considerations for applicants when proposing activities and works on waterfront lands.

### Streamlined assessment

Where applications are presented in accordance with the riparian corridor matrix (Table 2) and other Office of Water controlled activity guidelines, they will be assessed under a streamlined process. This may decrease the amount of time it takes the Office of Water to make a determination, saving applicants time and money.

Applications that do not conform to the matrix and/or relevant Office of Water controlled activity guidelines will continue to be subject to merit assessment to ensure that the proposals meet the requirements of the WM Act. All applications will still need to demonstrate that minimal harm will occur to waterfront land before a controlled activity approval will be issued.

### Where do I go for additional information?

Find out more about controlled activities at the Office of Water website www.water.nsw.gov.au.

### Contact us

Contact a water regulatory officer as listed on the Office of Water website www.water.nsw.gov.au, free call the licensing information on 1800 353 104 or email information@water.nsw.gov.au.



Published by the Department of Primary Industries, a division of NSW Department of Trade and Investment, Regional Infrastructure and Services.

NOW 12_136_e

ecological AUSTRALIA


**HEAD OFFICE**
Suite 4, Level 1
2-4 Merton Street
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

**SYDNEY**
Level 6
299 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9264 0717

**ST GEORGES BASIN**
8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

**CANBERRA**
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

**NEWCASTLE**
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

**NAROOMA**
5/20 Canty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

**COFFS HARBOUR**
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

**ARMIDALE**
92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

**MUDGEE**
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1230
F 02 6372 9230

**PERTH**
Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 08 9322 1358

**WOLLONGONG**
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 4268 4361

**GOSFORD**
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1220
F 02 4322 2897

**DARWIN**
16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601

**BRISBANE**
51 Amelia Street
Fortitude Valley QLD 4006
T 07 3503 7193

1300 646 131
www.ecoaus.com.au