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Environmental Impact Statement – Appendix F2: Downstream Ecological Assessment

Warragamba Dam Raising

Reference No. 30012078
Prepared for WaterNSW
10 September 2021

Environmental & Social Consultants

SMEC INTERNAL REF. 30012078

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Abbreviations and acronyms

ABBREVIATION / ACRONYM	DESCRIPTION
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AWS	Automatic Weather Station
BC Act	*Biodiversity Conservation Act 2016* (NSW)
CEEC	Critically Endangered Ecological Community
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DoEE	Commonwealth Department of the Environment and Energy (former)
DPIE	NSW Department of Planning, Industry and Environment
EEC	Endangered Ecological Community
EES	Environment, Energy and Science Group (within DPIE)
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994* (NSW)
FMZ	Flood Mitigation Zone
FSL	Full supply level
GBMWHA	Greater Blue Mountains World Heritage Area
GDE	Groundwater dependent ecosystem
GIS	Geographic Information System
GL	gigalitres
GWMA	Groundwater management area
IBRA	Interim Biogeographic Regionalisation for Australia
INSW	Infrastructure New South Wales
LEP	Local Environmental Plan
LGA	Local Government Area
ML	megalitres
MNES	Matter(s) of National Environmental Significance
NSW	New South Wales
PCT	Plant Community Type
PMF	Probable Maximum Flood
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SMEC	SMEC Australia Pty Ltd

ABBREVIATION / ACRONYM	DESCRIPTION
SSI	State Significant Infrastructure
TEC	Threatened Ecological Community
the Project	Warragamba Dam Raising
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
Umwelt	Umwelt (Australia) Pty Limited
WNSW	WaterNSW

Definitions

Abundance: the quantification of the population of the species or community.

Annual Exceedance Probability (AEP): An indicator of flood probability. The probability of a flood event being equalled or exceeded within a year. The probability is expressed as a percentage as outlined below:

- 10% AEP = 1 in 10 chance in a year flood event
- 5% AEP = 1 in 20 chance in a year flood event
- 1% AEP = 1 in 100 chance in a year flood event.

Benchmarks: the quantitative measures of the range of variability in vegetation condition in vegetation with relatively little evidence of modification by humans since European (post 1750) settlement.

Biodiversity values: has the same meaning as at section 4A of the TSC Act but excludes marine mammals, wandering sea birds and biodiversity that is endemic to Lord Howe Island. Biodiversity values include the composition, structure and function of ecosystems, and includes (but is not limited to) threatened species, populations and ecological communities, and their habitats.

Broad condition state: areas of a PCT that are in relatively homogenous condition. Broad condition is used for stratifying areas of the same PCT into a vegetation zone for the purpose of determining the site value score.

Clearing Native Vegetation: has the same meaning as section 60C of the *Local Land Services Act 2013*:

any one or more of the following:

(a) cutting down, felling, uprooting, thinning or otherwise removing native vegetation,

(b) killing, destroying, poisoning, ringbarking or burning native vegetation.

Connectivity: the measure of the degree to which an area(s) of native vegetation is linked with other areas of vegetation

Conservation status: is regarded as the degree of representation of a species or community in formal conservation reserves

Critical habitat: has the same meaning as the TSC Act

Critically Endangered Ecological Community: an ecological community specified in Part 2 of Schedule 1A of the TSC Act and/or listed under Part 13, Division 1, Subdivision A of the EPBC Act.

Direct impact: impacts that directly affect the habitat and individuals. They include, but are not limited to, death through predation, trampling, poisoning of the animal/plant itself and the removal of suitable habitat.

Ecological Impact Assessment: report prepared in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities, working draft (DEC, 2004)* and the requirements of the SEARs which assesses the ecological impacts of the Project within the downstream operational area.

EIS: an environmental impact statement referred to in sections 78A, 112 or 155Y of the EP&A Act

Expert: a person who is accredited by the Chief Executive under section 142B(1)(b) of the TSC Act, or if arrangements of accreditation under Section 142B(1)(b) are not in place, a person who has the relevant experience and/or qualifications to provide an expert opinion in relation to the biodiversity values to which an expert report relates

Exotic plant cover: exotic plants are vascular plants not native to Australia. Exotic plant cover is measured as total percentage foliage cover of all exotics in all strata

Floodplain: alluvial plain characterised by frequently active erosion and aggradation by channelled or overbank stream flow.

Flood Mitigation Zone (FMZ) discharge area: the downstream area that would be affected by temporary inundation during the discharge of the Flood Mitigation Zone.

Framework for Biodiversity Assessment (FBA): Underpins the Biodiversity Offsets Policy for Major Projects. It contains the assessment methodology that is adopted by the policy to quantify and describe the impact assessment requirements and offset guidance that apply to Major Projects (note that this definition is provided due to various references in this report to the FBA, however, it should be noted that this biodiversity assessment has not been prepared in accordance with the FBA; the reasons for this are provided in Section 3.

Habitat: an area or areas occupied, or periodically or occasionally occupied by a species, population, or ecological community, including any biotic or abiotic component

Habitat component: the component of habitat that is used by a species for either breeding, foraging, or shelter

Hollow bearing tree: a living or dead tree that has at least one hollow. A tree is considered to have a hollow if:

(a) the entrance can be seen

(b) the minimum entrance width is at least 5 centimetres across

(c) the hollow appears to have depth

(d) the hollow is at least 1 metre above the ground.

IBRA region: a bioregion identified under the Interim Biogeographic Regionalisation for Australia (IBRA) system, which divides Australia into bioregions on the basis of their dominant landscape-scale attributes

IBRA subregion: a subregion of a bioregion identified under the IBRA system

Important wetland: a wetland that is listed in the Directory of Important Wetlands of Australia (DIWA), or is a wetland mapped under State Environmental Planning Policy (Coastal Management) 2018

Indirect impact on biodiversity values: indirect impacts occur when project-related activities affect species, populations, or ecological communities in a manner other than direct loss (DECC 2007).

Individual: in relation to organisms, a single, mature organism that is a threatened species defined in section 491 of the TSC Act, or any additional threatened species listed under Part 13 of the EPBC Act

Life cycle: the series of reproduction, growth, development, aging, and death of an organism

Local population: the population the occurs within the study area (DECC 2007).

Local wetland: and wetland that is not identified as an important wetland

Major Project: State Significant Development or State Significant Infrastructure projects

Native ground cover: all native vegetation below 1 m in height, including all such species native to NSW (that is, not confided to species indigenous to the area)

Native vegetation: has the same meaning as section 60B of the *Local Land Services Act 2013*: (in part) native vegetation means any of the following types of plants native to New South Wales:

a) trees (including any sapling or shrub or any scrub),

b) understorey plants,

c) groundcover (being any type of herbaceous vegetation),

d) plants occurring in a wetland.

Percent foliage cover: the percentage of ground that would be covered by a vertical projection of the foliage and branches and trunk of a plant or plants.

Plant community type (PCT): a NSW plant community type identified using the PCT classification system. PCTs are the master community-level typology used in NSW's planning and assessment tools and vegetation mapping programs.

Plot: an area within a vegetation zone in which site attributes are assessed.

Regeneration: the proportion of over-storey species characteristic of the PCT that are naturally regenerating and have a diameter at breast height

Region has the same meaning as that contained within the TSC Act

Regionally significant biodiversity link: a biodiversity corridor that is important at a regional scale and is identified in a plan approved by the Chief Executive of OEH.

Remaining impact: an impact on biodiversity values after all reasonable measures have been taken to avoid and minimise the impacts of development.

Riparian buffer: a transition zone between the land - also known as the terrestrial environment - and the river or watercourse or aquatic environment.

Risk of extinction: the likelihood that the local population or CEEC or EEC will become extinct either in the short term or in the long term as a result of direct or indirect impacts on the viability of that population or CEEC or EEC.

Stream order: has the same meaning as in Appendix 2 of the FBA.

study area: the area of land within the existing PMF.

Subject species: means those threatened species that are known or considered likely to occur in the study area.

survey area: the area of land surveyed for this assessment. For this assessment, the survey area is land within the existing 10% AEP.

Threatening process: has the same meaning as that contained in the TSC Act; the definition is not limited to KTPs.

Threatened population: has the same meaning as in section 4(1) of the TSC Act.

Threatened species: critically endangered, endangered or vulnerable threatened species and populations as defined in section 4(1) of the TSC Act, or any additional threatened species listed under Part 13 of the EPBC Act as critically endangered, endangered or vulnerable.

Threatened Species Profile Database: is part the BIONET database, is maintained by OEH and can be accessed from the BIONET website at www.bionet.nsw.gov.au/.

Total length of fallen logs: the total length of logs presents in a vegetation zone that are at least 10 cm in diameter and at least 0.5 m long.

Transect: a line or narrow belt along which environmental data is collected.

Vegetation Benchmarks Database: a database of benchmarks for vegetation classes and some PCTs. The Vegetation Benchmarks Database is maintained by OEH and is part of the BioNet Classification Database. It is available at www.environment.nsw.gov.au/research/Visclassification.htm.

Vegetation class: a level of classification of vegetation communities defined in Keith (2004). There are 99 vegetation classes in NSW.

Vegetation formation: a broad level of vegetation classification as defined in Keith (2004). There are 12 vegetation formations in NSW.

Vegetation zone: a relatively homogenous area of native vegetation on a development site that is the same PCT and broad condition state.

VIS Classification Database (NSW Vegetation Information System Classification Database): the master vegetation community-level classification for use in vegetation mapping programs and regulatory biodiversity impact assessment frameworks in NSW. The VIS Classification Database is maintained by OEH and available at www.environment.nsw.gov.au/research/Visclassification.htm.

Viability: the capacity of a species to successfully complete each stage of its life cycle under normal conditions so as to retain long-term population densities.

Wetland: an area of land that is wet by surface water or ground water, or both, for long enough periods that the plants and animals in it are adapted to, and depend on, moist conditions for at least part of their life cycle. Wetlands may exhibit wet and dry phases and may be wet permanently, cyclically or intermittently with fresh, brackish or saline water.

Woody native vegetation: native vegetation that contains an over-storey and/or mid-storey that predominantly consists of trees and/or shrubs.

1 Introduction

1.1 Project application

WaterNSW, a New South Wales (NSW) state-owned corporation, is seeking planning approval for the Warragamba Dam Raising Project (the Project). The approval is sought under Part 5, Division 5.2 (section 5.12) (State Significant Infrastructure) of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

WaterNSW is proposing to raise the existing Warragamba Dam to facilitate flood mitigation and to install infrastructure to enable the release of downstream environmental flows. An Environmental Impact Statement (EIS) has been prepared to support the Project approval application. This report is part of the EIS and has been prepared to assess the Project's potential impacts on biodiversity within the downstream operational area of Warragamba Dam. The key objectives of this ecological assessment are to address the requirements of the biodiversity matters raised in in the Secretary's Environmental Assessment Requirements (SEARs). The SEARs that this report addresses are discussed in Section 1.3. The background to the Project is described in the following section. A more detailed description of the Project is contained in Section 1.4 of this report.

1.2 Project background

The Hawkesbury-Nepean Valley (the valley) in western Sydney has the highest flood risk in New South Wales, if not Australia. The potential for significant flooding of the Hawkesbury-Nepean Valley was known by the local Aboriginal community before the first European settlement of the area in the 1790s. In the early years of European settlement, the risk of flooding was recognised, and a series of proclamations were issued that warned of the risk of flooding. This high flood risk arises from the river being confined by narrow sandstone gorges, creating rapid deep backwater flooding over extensive floodplains. The floodplains are home to a large existing population who would be impacted in a major flood.

During the 1980s and 1990s updated flood investigation techniques and new geological evidence predicted that floods significantly larger than any historically recorded could occur in the Hawkesbury-Nepean Valley. The dam was raised by five metres in the late 1980s to meet modern dam safety requirements. Further investigations into flooding and flood mitigation were undertaken and culminated in 1995 in a proposal to raise Warragamba Dam by 23 metres primarily for dam safety but also to provide for flood mitigation. The 1995 proposal did not proceed. In the late 1990s, major upgrades of Warragamba Dam were undertaken to prevent dam failure during extreme flooding events, to protect Sydney's water supply, and to prevent catastrophic downstream floods from dam failure. This resulted in the construction of the auxiliary spillway. However, these works only dealt with dam safety issues and did not address the major flood risks to the people and businesses in the Hawkesbury-Nepean Valley and the NSW economy.

In 2011, an approximately 1 in 100 chance in a year flood impacted Brisbane, resulting in significant damage, economic costs, and social disruption. The substantial impacts of the 2011 Brisbane flood led the NSW Government to recommence investigations into flood mitigation options for the Hawkesbury-Nepean Valley.

In 2013, the NSW Government in response to the State Infrastructure Strategy and community concerns, initiated the Hawkesbury-Nepean Valley Flood Management Review to consider flood planning, flood mitigation and flood response in the Hawkesbury-Nepean Valley. The review found that current flood management and planning arrangements could be improved, and no single mitigation option could address all the flood risks present in the Hawkesbury-Nepean Valley (Department of Primary Industries (DPI) 2014a). The review concluded that raising Warragamba Dam to capture inflows is the most effective infrastructure measure that could have a major influence on flood levels during those events, when most of the damages occur. Other complementary and non-infrastructure options were also identified to mitigate flood risks (DPI 2014a).

Under the direction of Infrastructure NSW (INSW), the Hawkesbury-Nepean Valley Flood Management Taskforce was established to investigate feasible flood options to reduce overall risk to the Hawkesbury-Nepean Valley. In June 2016, the former Premier and Minister for Western Sydney, Mike Baird MP, announced the NSW Government plan to raise Warragamba Dam to significantly reduce the risk of flooding in the Hawkesbury-Nepean Valley. The cost-benefit analysis demonstrated that the Warragamba Dam Raising would provide a 75 percent reduction in flood damages on average and reduce current levels of flood damages from $5 billion to $2 billion (2016 dollars).

Raising Warragamba Dam would significantly reduce flood risk; however, it would not eliminate the risk completely. Regardless of the increase in the dam's height, flooding can be generated from catchments other than Warragamba Dam. The raising of Warragamba Dam would therefore be complemented with other non-infrastructure and policy actions. In May 2017, INSW released *Resilient Valley, Resilient Communities*, which outlines the Hawkesbury-Nepean

Valley Flood Risk Management Strategy (the Flood Strategy) (INSW 2017). The Flood Strategy covers the geographic region between Bents Bridge and the Brooklyn Bridge, encompassing areas within the Local Government Areas (LGAs) of Liverpool City, Penrith City, Hawkesbury City, The Hills Shire Blacktown City, Central Coast and Hornsby Shire.

The Flood Strategy's objective is to reduce flood risk to life, property and social amenity from floods in the Hawkesbury-Nepean Valley. The strategy includes nine key outcomes; a combination of infrastructure and non-infrastructure initiatives to mitigate the flood risk to the Hawkesbury-Nepean Valley floodplain downstream of Warragamba Dam. Actions include:

- coordinated flood risk management across the Hawkesbury-Nepean Valley now and in the future
- strategic and integrated consideration of flood risk in land use and emergency planning
- engaging and providing flood risk information for an aware, prepared and responsive community.

The Flood Strategy provides the context and policy impetus to mitigate flood risk in the Hawkesbury-Nepean Valley.

A description of alternatives considered as feasible flood options to reduce risk to the Hawkesbury-Nepean Valley, as well as alternatives considered for the Warragamba Dam Raising Project, are provided in Chapter 4 of the EIS.

This report has been prepared to assess the Project's impact on biodiversity within the downstream operational area of Warragamba Dam only. Separate biodiversity assessment reports have been prepared to address the upstream and construction impacts of the Project (provided as Appendices F1 and F3 to the EIS respectively).

1.3 Purpose of the report

This ecological assessment has been jointly prepared by Umwelt (Australia) Pty Limited (Umwelt) and SMEC Australia Pty Limited (SMEC) on behalf of WaterNSW (the Proponent).

As outlined above, the assessment of potential biodiversity impacts of the Project has been divided into three areas based upon the different types of impacts and different assessment methodologies applied in each area. These are:

- Upstream of Warragamba Dam – some areas upstream of Warragamba Dam are predicted to experience an increase in the extent and duration of temporary inundation during the flood mitigation operations of the Project.
- At Warragamba Dam – the area in and around the existing dam would be subject to clearing, disturbance and other indirect impacts to allow for the construction of the Project.
- Downstream of Warragamba Dam (the subject of this assessment) – some areas downstream of Warragamba Dam would experience a decrease in the extent and duration of flooding during the flood mitigation operations of the Project. Other areas would experience an increase in the duration of temporary flooding due to the discharge of water from the FMZ after the flood peak had passed.

The key objective of this ecological assessment is to meet the requirements of the biodiversity matters raised in Section 6.2 and Attachment B of the SEARs (see Table 1-1). The Department of Planning, Industry and Environment (DPIE) has been extensively consulted during the assessment process through direct meetings and teleconferences. This report aims to conform to the requirements of DPIE and the relevant guidance documents. Matters relating to aquatic ecology are addressed separately in Appendix F4.

Table 1-1. SEARs relevant to biodiversity assessment

Desired performance outcomes	Secretary's Environmental Assessment Requirements	Where addressed
6. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.	2. The Proponent must assess the downstream impacts on threatened biodiversity, native vegetation and habitats resulting from any changes to hydrology and environmental flows. This assessment should address the matters in **Attachment B**.	Section 6 Appendix F2
	4. The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process in accordance with the listings in the *Threatened Species Conservation Act 1995* (TSC	Section 6.10 Appendix F4 EIS Chapter 12

Desired performance outcomes	Secretary's Environmental Assessment Requirements	Where addressed
	Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).	
ATTACHMENT B[1]		
6. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.	A field survey of the potentially impacted areas downstream should be conducted and documented in accordance with relevant guidelines.	Section 4
	The assessment should contain the following information as a minimum:	
	(a) The requirements set out in the *Guidelines for Threatened Species Assessment* (Department of Planning, July 2005).	Section 4
	(b) Description and geo-referenced mapping of study area (and spatial data files), for example, overlays on topographic maps, satellite images and /or aerial photos, including details of map datum, projection and zone, all survey locations, vegetation communities (including classification and method used to classify), key habitat features and reported locations of threatened species, populations and ecological communities present in the subject site and study area.	Section 2 Figures are provided in the body of this report or within Appendix I.
	(c) Description of survey methods used, including timing, location and weather conditions.	Section 4
	(d) Details, including qualifications and experience of all staff undertaking the surveys, mapping and assessment of impacts as part of the assessment.	Appendix H
	(e) Identification of national and state listed threatened biota known or likely to occur and their conservation status.	Appendix A.
	(f) Description of the likely impacts of the Project on downstream biodiversity and wildlife corridors, including direct, indirect, construction and operation impacts. Wherever possible, quantify these impacts such as the amount of each vegetation community or species habitat to be cleared or impacted, or any fragmentation of a wildlife corridor.	Section 6
	(g) Identification of the avoidance, mitigation and management measures that will be put in place as part of the Project to avoid or minimise impacts, including details about alternative options considered and how long-term management arrangements will be guaranteed.	Section 7 EIS Chapter 4
	(h) Description of the residual impacts of the Project. If the Project cannot adequately avoid or mitigate impacts on downstream biodiversity, then a biodiversity offset package is expected.	Section 6
	(i) Provision of specific Statement of Commitments relating to biodiversity.	Section 7

Desired performance outcomes	Secretary's Environmental Assessment Requirements	Where addressed
	Where an offsets package is proposed by a proponent for any downstream impacts to biodiversity this package should: (a) Meet OEH's Principles for the use of biodiversity offsets in NSW, which are available at: www.environment.nsw.gov.au/biocertification/offsets.htm. (b) Identify the conservation mechanisms to be used to ensure the long-term protection and management of the offset sites. (c) Include an appropriate Management Plan (such as vegetation or habitat) that has been developed as a key amelioration measure to ensure any proposed compensatory offsets, retained habitat enhancement features and/or impact mitigation measures (including proposed rehabilitation and/or monitoring programs) are appropriately managed and funded.	Section 1
	Where appropriate, likely impacts (both direct and indirect) on any downstream OEH estate reserved under the *National Parks and Wildlife Act 1974* should be considered.	Section 6.9

[1.] SEARs requirements have been summarised.

1.4 Project description

Warragamba Dam Raising is a project to provide flood mitigation to reduce the significant existing risk to life and property in the Hawkesbury-Nepean Valley downstream of the dam. This would be achieved through raising the level of the central spillway crest by around 12 metres and the auxiliary spillway crest by around 14 metres above the existing full supply level for temporary storage of inflows. The spillway crest levels and outlets control the extent and duration of the temporary upstream inundation. There would be no change to the existing maximum volume of water stored for water supply.

The NSW Government announcement in 2016 proposed that the dam wall be raised by 14 metres. Subsequently, the NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs) required the project to be designed, constructed and operated to be resilient to the future impacts of climate change and incorporate specific adaptation actions in the design.

Peer reviewed climate change research found that by 2090 it is likely an additional three metres of spillway height would be required to provide similar flood mitigation outcomes as the current flood mitigation proposal. Raising the dam side walls and roadway by an additional three metres may not be feasible in the future, both in terms of engineering constraints and cost. The current design includes raising the dam side walls and roadway by 17 metres now to enable adaptation to projected climate change. Any consideration of raising spillway heights is unlikely before the mid to late 21st century and would be subject to a separate planning approval process.

The 17 metre raising height of the dam abutments (side walls) and roadway have been considered and accounted for in the EIS and design. The potential maximum height and duration of upstream inundation remains consistent with what was originally proposed in 2016.

The Project also includes providing infrastructure to facilitate variable environmental flows to be released from Warragamba Dam.

The Project would include the following main activities and elements:

- demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates,

- thickening and raising of the dam abutments
- thickening and raising of the central spillway
- new gates or slots to control discharge of water from the flood mitigation zone (FMZ)
- modifications to the auxiliary spillway
- operation of the dam for flood mitigation
- environmental flow infrastructure.

The Project would take the opportunity, during the construction period for the dam raising, to install the physical infrastructure to allow for management of environmental flows as outlined in the NSW Government, 2017 Metropolitan Water Plan. However, the actual environmental flow releases themselves do not form part of the Project and are subject to administration under the *Water Management Act 2000*.

A detailed description of the Project including key elements of construction and operation for flood mitigation is provided in Chapter 5 of the EIS.

The location of the downstream operational area is shown on Figure 1-1.

1.5 Operation of the dam for flood mitigation

Operational objectives in order of priority are to:

- maintain the structural integrity of the dam
- minimise risk to life
- maintain Sydney's water supply
- minimise downstream impact of flooding to properties:
- minimise environmental impact
- minimise social impact.

There would be two different modes of operation for the Project: normal and flood operations. In both modes Warragamba Dam would continue to store and supply up to 80 percent of Sydney's drinking water. The storage capacity, which is the dam's full supply level (FSL), would not change. The current and future operation of the dam is shown on Figure 1-2 and Figure 1-3 respectively.

1.5.1 Normal operations

Normal operations would occur when the dam storage level is at or lower than FSL.

Normal operations mode for the modified dam would be essentially the same as current operations, apart from environmental flow releases. Inflows would be captured up to FSL, after which environmental flows releases would cease and flood operation procedures would be implemented.

The capacity created by the FMZ will allow for around two Sydney Harbours of water to be held back temporarily during a large rainfall event to reduce flooding downstream.

1.5.2 Flood operations

During large rainfall events when the storage level rises above FSL, flood operations mode would commence. In this mode, inflows to Lake Burragorang would be captured and temporarily stored (increasing water levels in Lake Burragorang and upstream tributaries). The raised dam would provide capacity (i.e. the FMZ) to capture temporarily around 1,000 gigalitres of water during a flood event.

Water would be discharged in a controlled manner via the gated conduits or slots until the dam level returns to FSL. FMZ operating protocols would guide this process and be developed for approval by the relevant regulatory authorities.

The raised dam would not be able to fully capture inflows from all floods. For floods that exceed the capacity of the FMZ, water would spill firstly over the central spillway and then, depending on the size of the flood, the auxiliary spillway.

Figure 1-1. Location of the downstream operational area

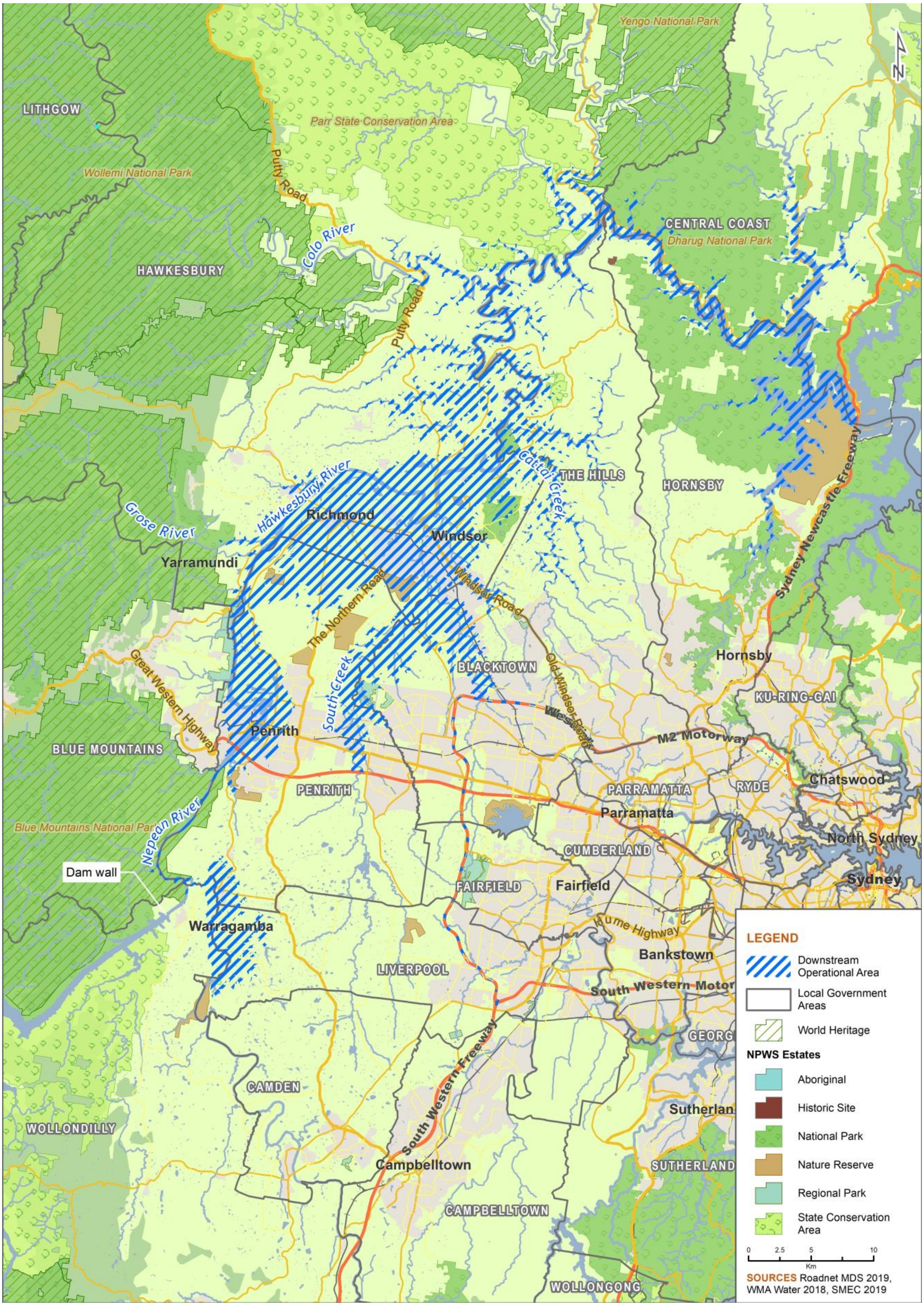


Figure 1-2. Existing operation of the dam

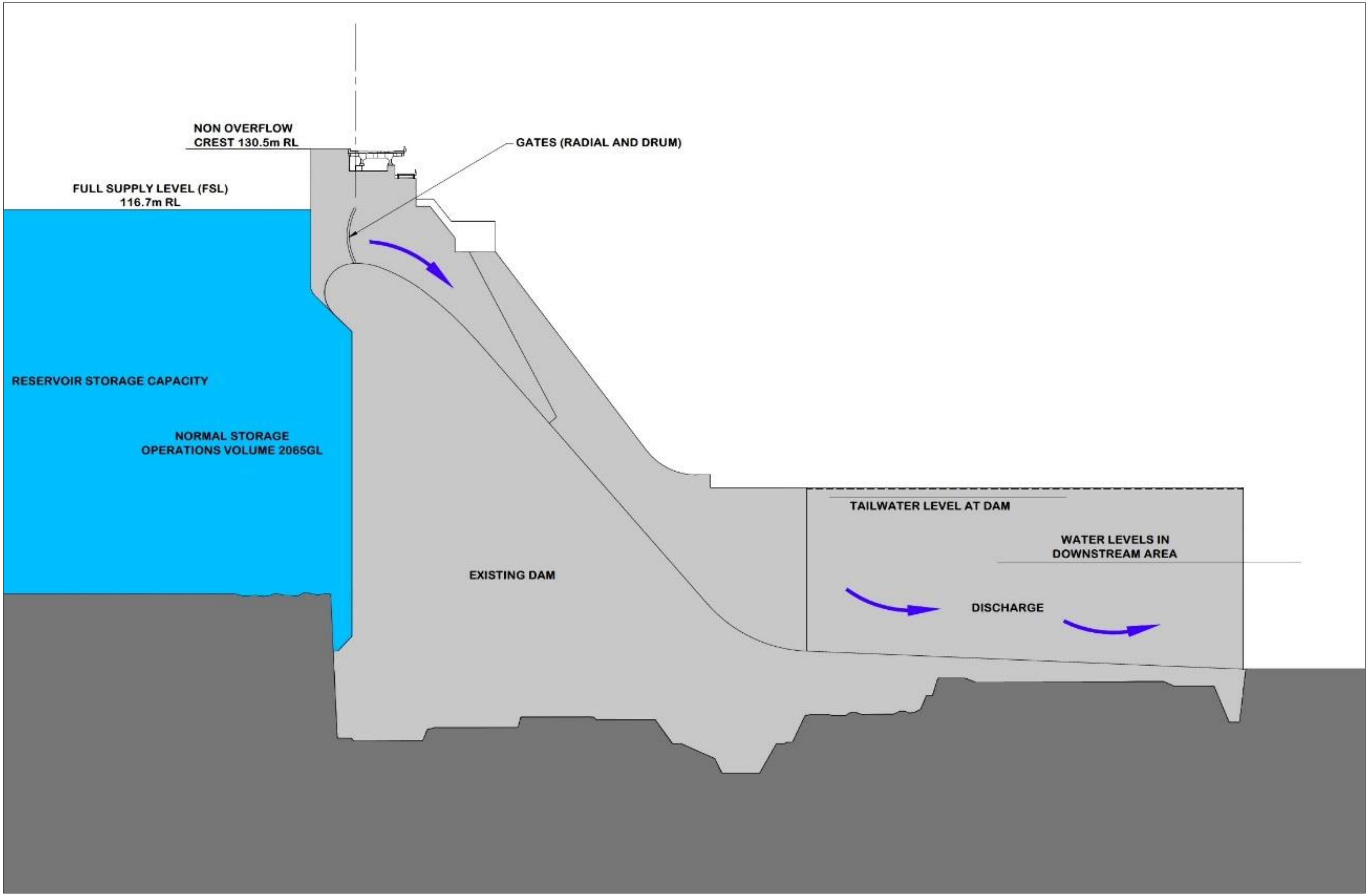
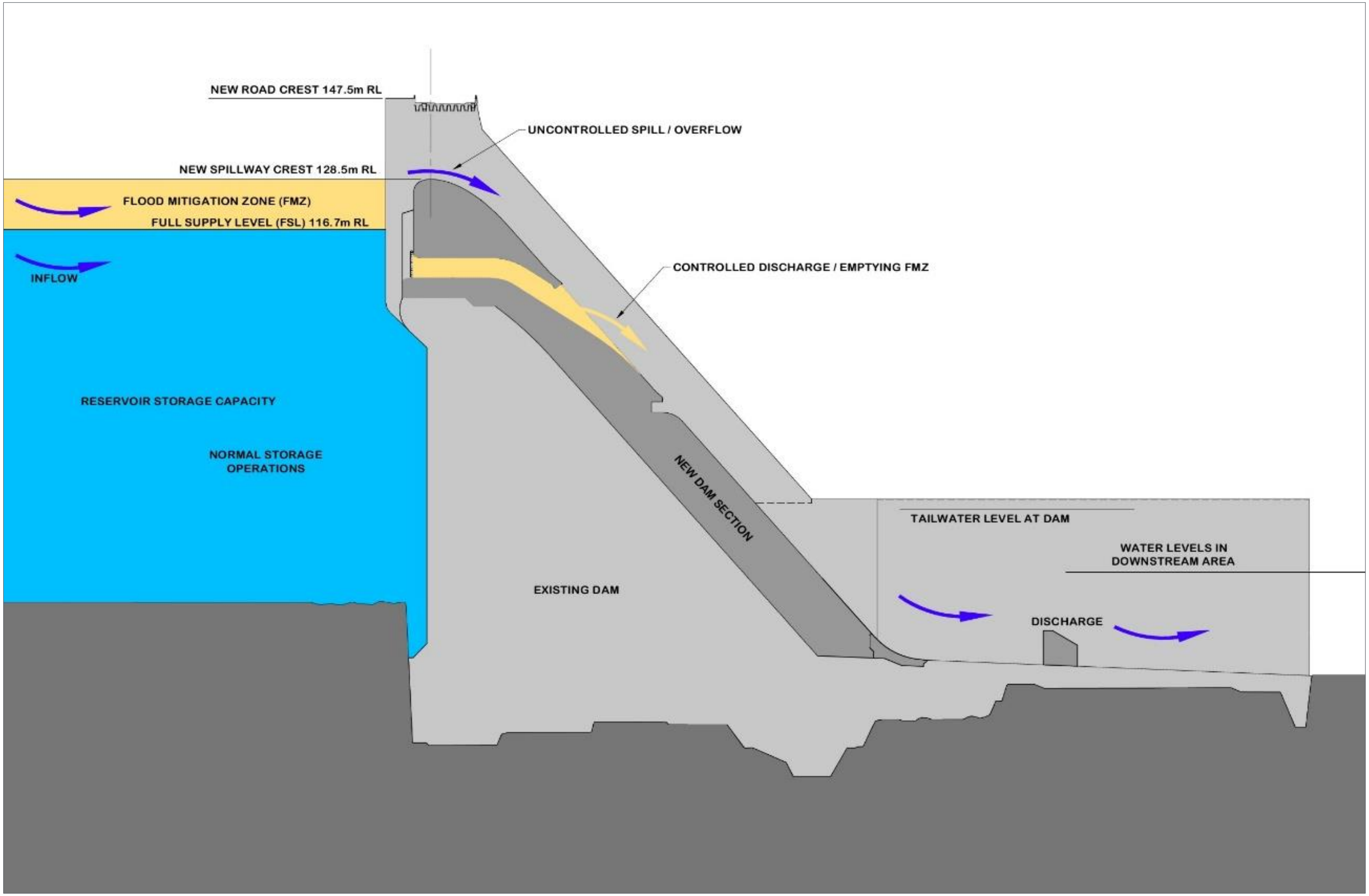


Figure 1-3. Future operation of the dam



Minor flood releases

The FMZ would typically have sufficient capacity to temporarily capture up to around 1,000 gigalitres of water during a flood event. If the water level in the dam at the beginning of the rainfall event was below FSL, the size of the event able to be fully captured would be larger. The long-term average water level in the dam is about 75 percent, which would provide an additional 500 gigalitres of flood mitigation capacity.

Generally, once the peak flood level has passed downstream, discharge of the FMZ would commence. Example hydrographs showing flood frequency distribution of dam outflows from the dam for the 20% AEP (1 in 5 chance in a year), 10% AEP (1 in 10 chance in a year) and 5% AEP (1 in 20 chance in a year) events for both existing conditions and with the Project are shown on Figure 1-4, Figure 1-5 and Figure 1-6, respectively, with the modelled flood extents for each event shown in Figure 1-7, Figure 1-8, and Figure 1-9 respectively.

Figure 1-4. Outflows and discharge from Warragamba Dam for the 20% AEP (1 in 5 chance in a year) event

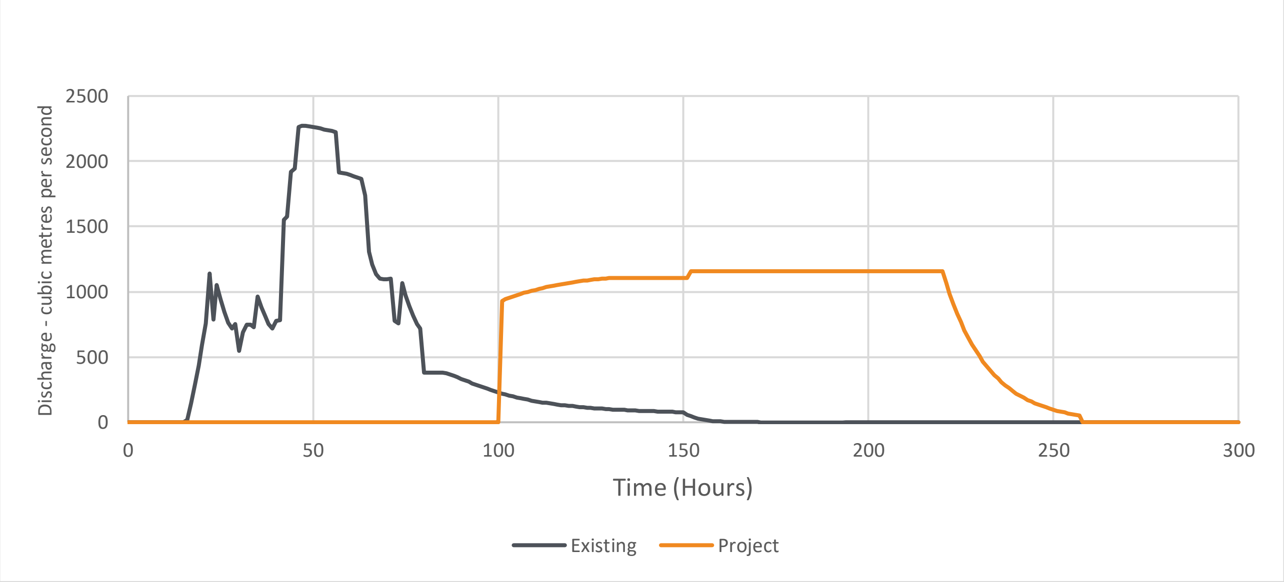


Figure 1-5. Outflows and discharge from Warragamba Dam for the 10% AEP (1 in 10 chance in a year) event

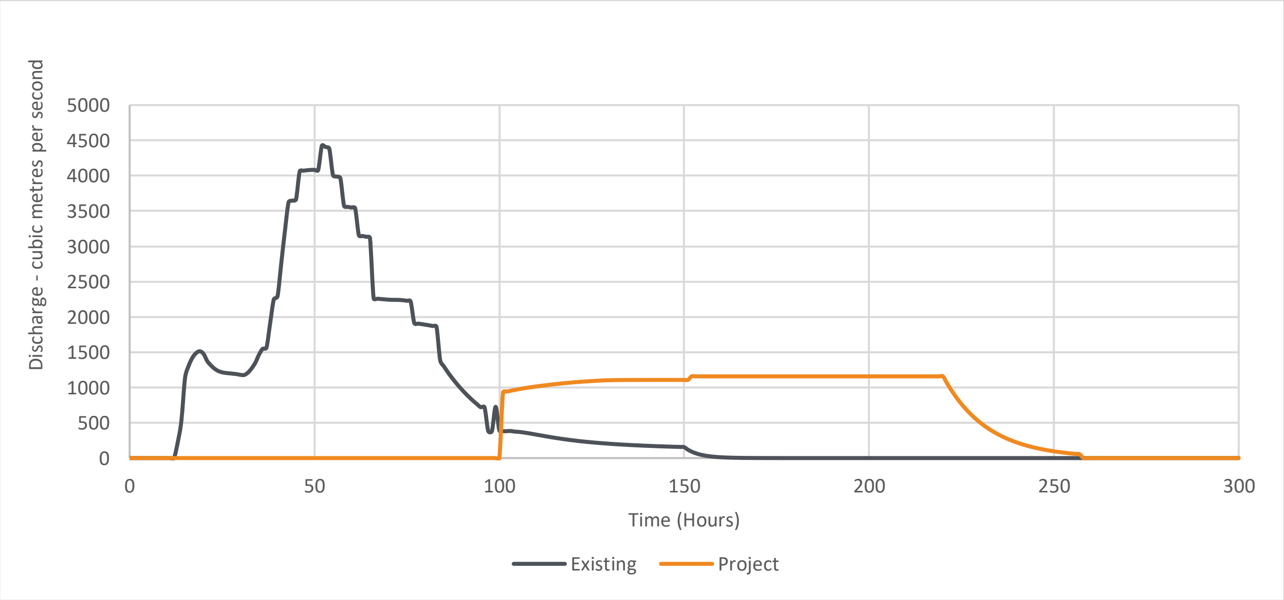


Figure 1-6. Outflows and discharge from Warragamba Dam for the 5% AEP (1 in 20 chance in a year) event

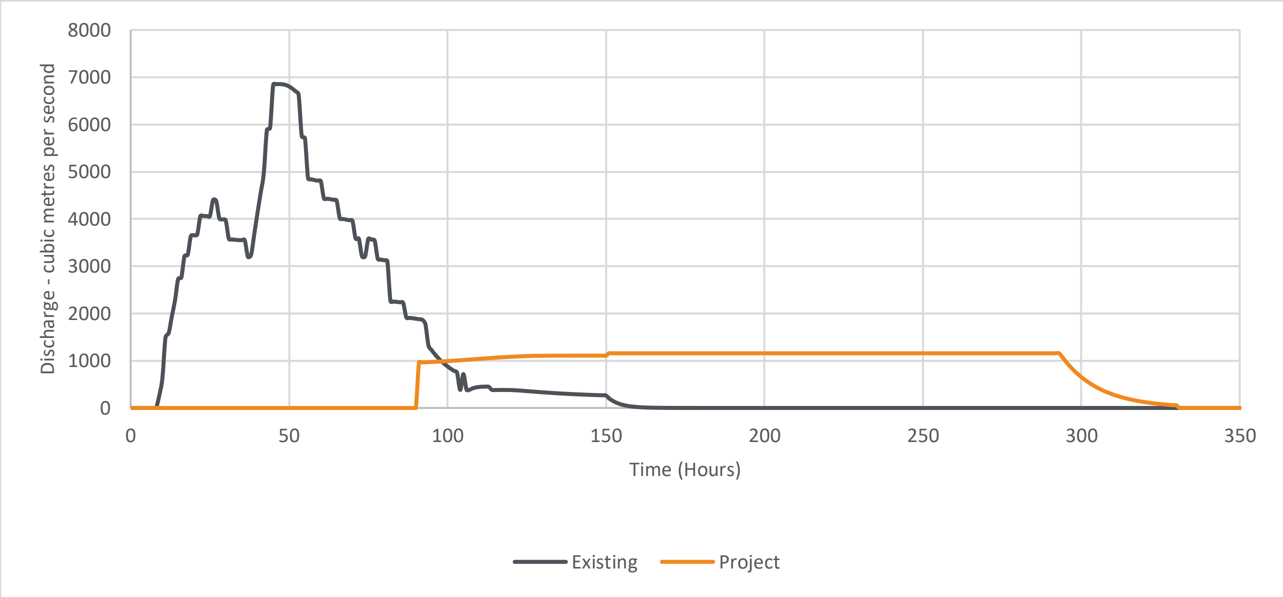


Figure 1-7. Existing and with Project 20% AEP (1 in 5 chance in a year) events

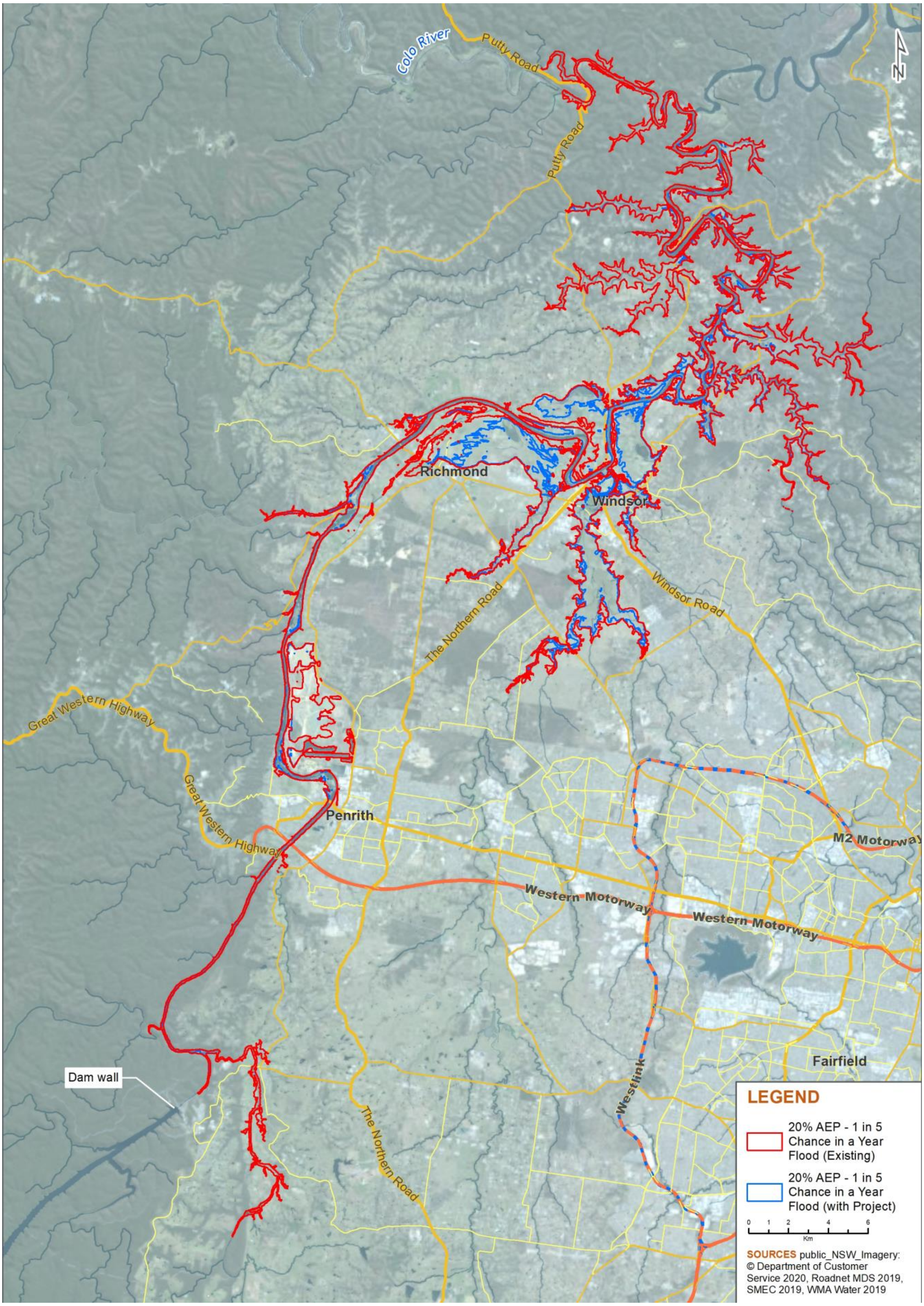


Figure 1-8. Existing and with Project 10% AEP (1 in 10 chance in a year) events

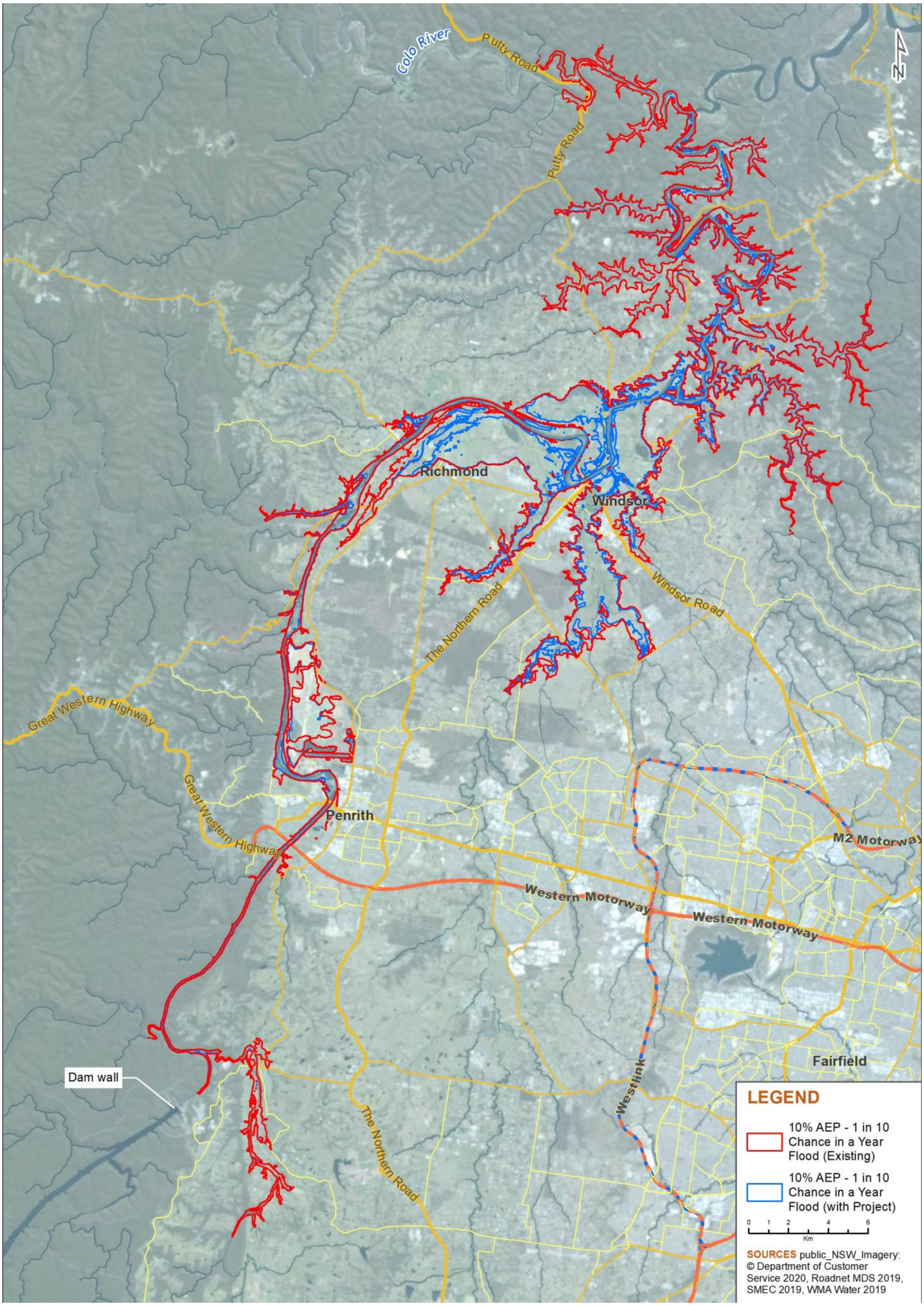
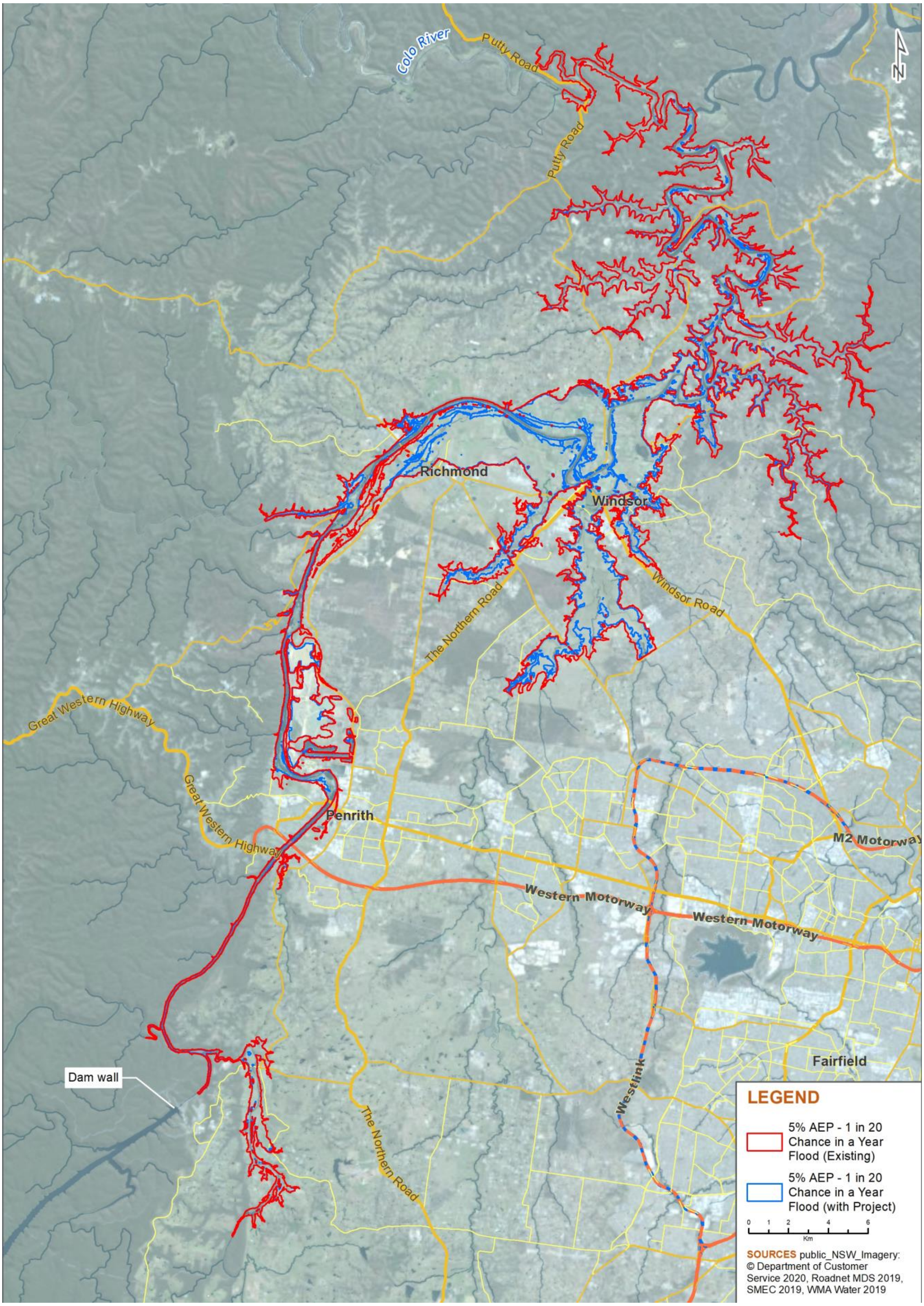


Figure 1-9. Existing and with Project 5% AEP (1 in 20 chance in a year) events



Major flood releases

Figure 1-10 and Figure 1-11 show hydrographs for outflows from Warragamba Dam for the 1% AEP (1 in 100 chance in a year) event and the probable maximum flood (PMF) for both the existing situation and with the Project. The modelled flood extents for the two flood events are shown in Figure 1-12 and Figure 1-13.

It should be noted that the PMF is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. It represents a notional upper limit of flood magnitude and no attempt is made to assign a probability of exceedance to such an event (Ball *et al*. 2019). The PMF is unlikely to occur in nature given the size of the Warragamba Dam catchment but has been included in this report for the sake of completeness in describing the hydrological changes associated with the Project.

For major rainfall events, the FMZ would capture the initial inflows until the capacity was reached and would then spill over the spillways. As the downstream levels would be higher, there is the opportunity to initially discharge water from the FMZ at a higher rate without increasing the extent of flooding (that is, piggy back releases). Generally, these higher discharge rates would occur for approximately two to three days before the FMZ discharge rate would be reduced to the same discharge rate as for minor flood releases, namely about 1,150 cubic metres per second or around 100 gigalitres per day.

Figure 1-10. Outflows and discharge from Warragamba Dam for the 1% AEP (1 in 100 chance in a year) event

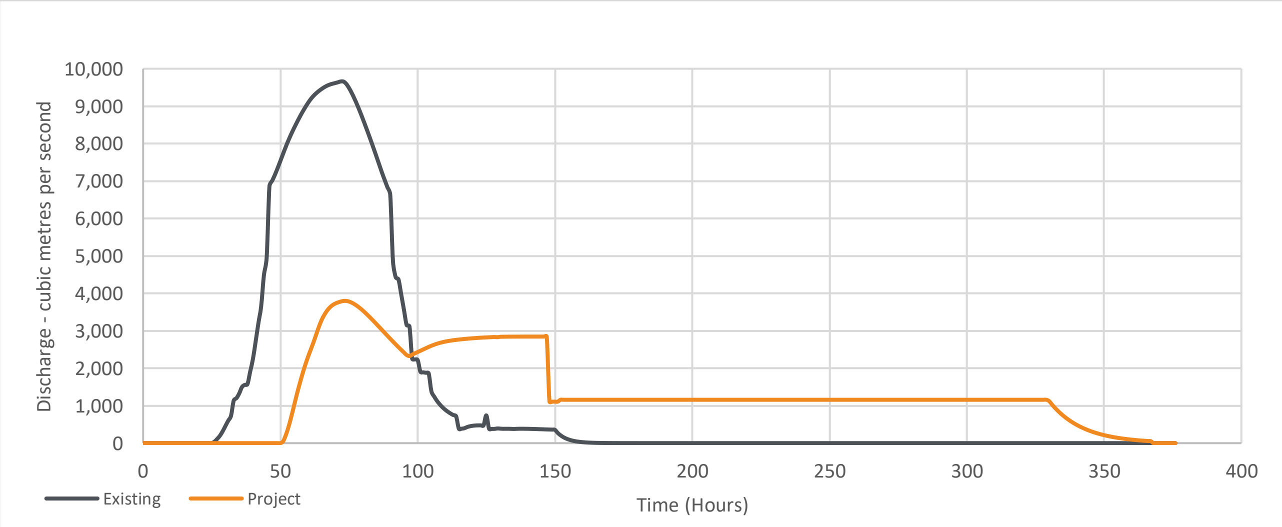


Figure 1-11. Outflows and discharge from Warragamba Dam for the PMF event

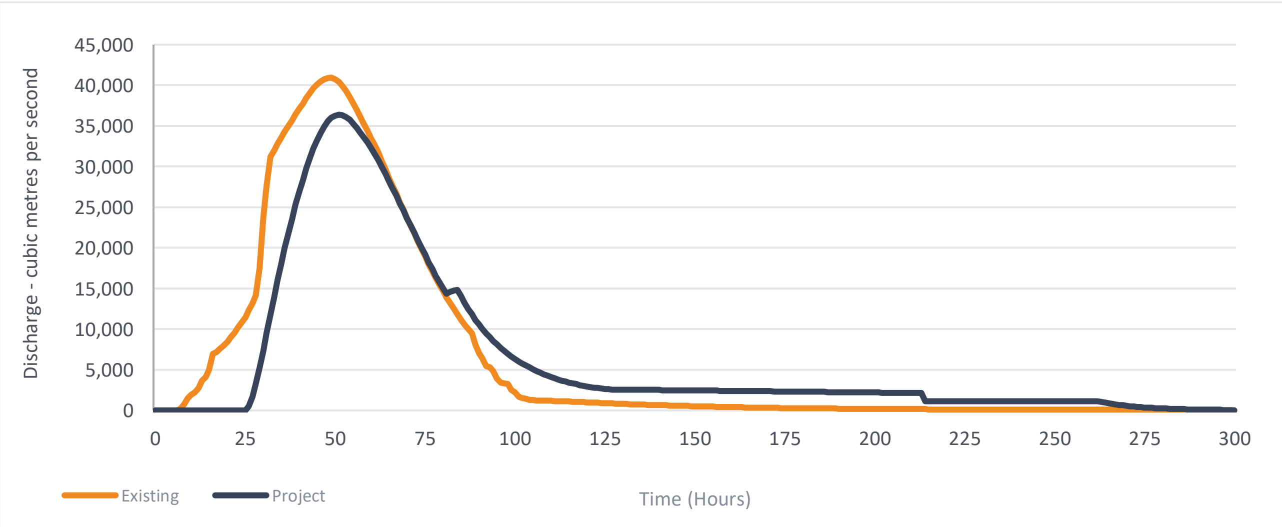


Figure 1-12. Existing and with Project 1% AEP (1 in 100 chance in a year) events

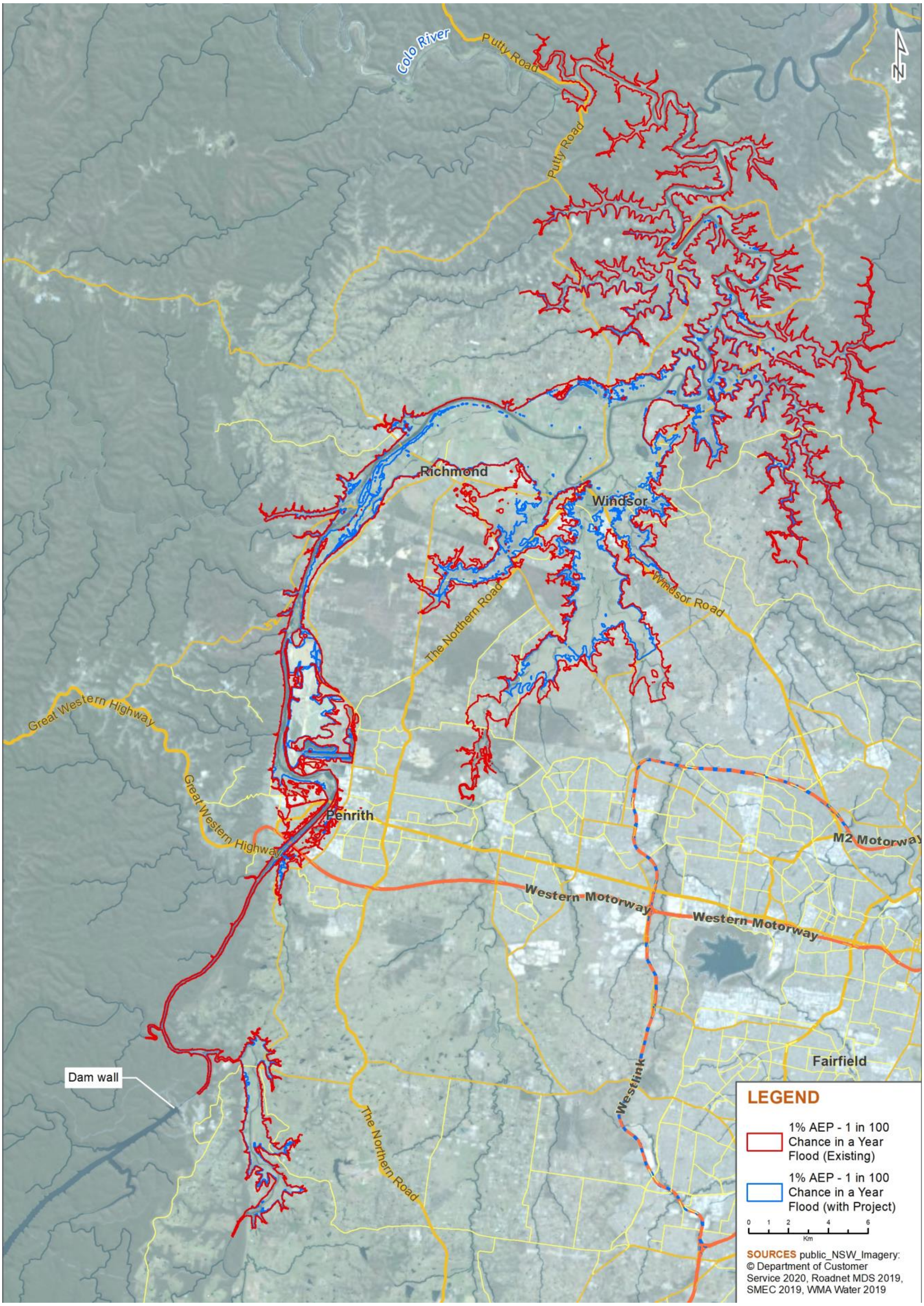
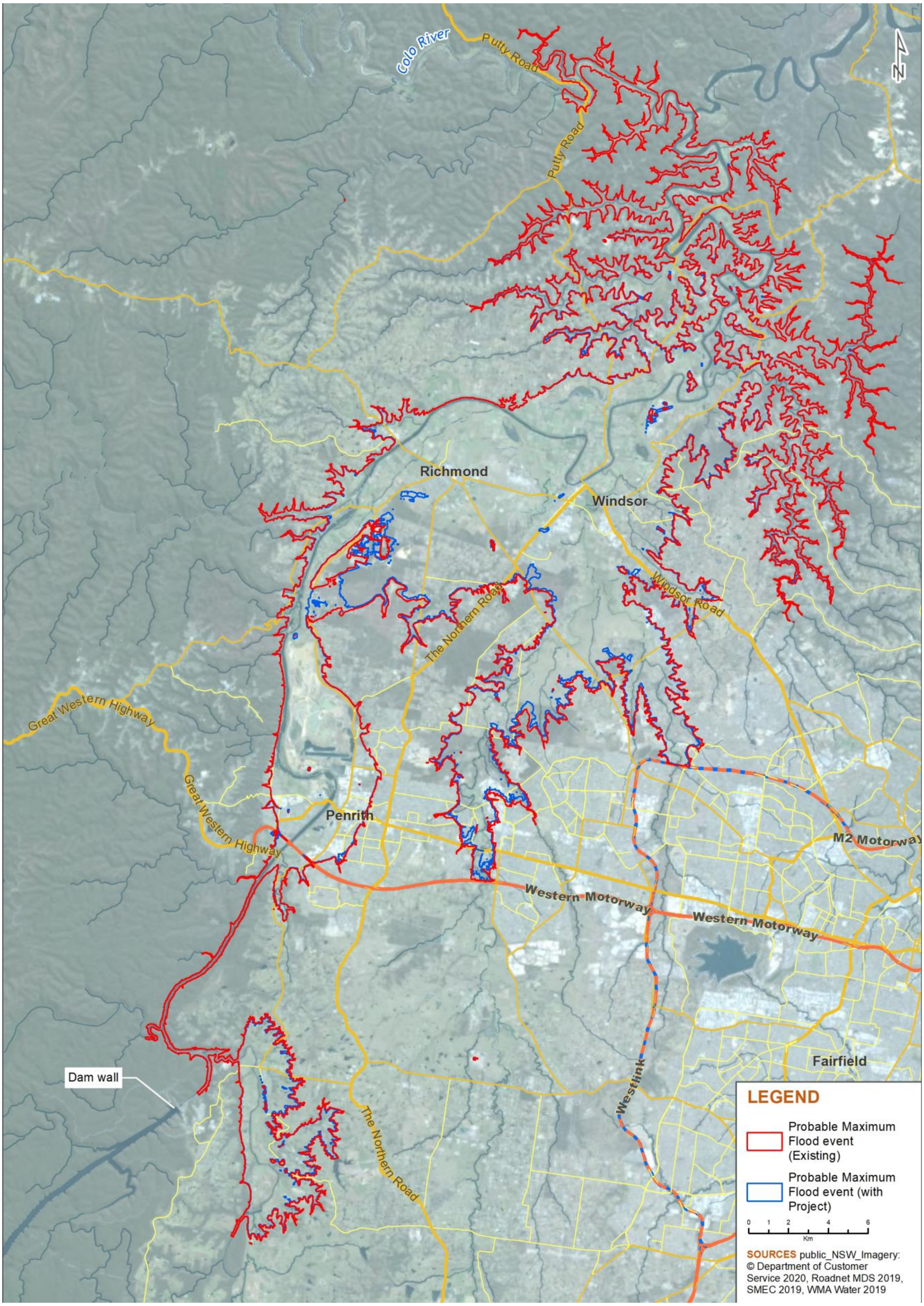


Figure 1-13. Existing and with Project PMF events



1.6 Project and assessment area definitions

Based on hydrological modelling it is predicted that the 10% AEP (1 in 10 chance in a year) event would likely have the greatest change in extent as a result of differences between the existing and with Project flood extent scenarios. The existing 10% AEP event downstream extent represents the larger boundary scenario (compared to the 10% AEP event with Project) and it was agreed with the former Office of Environment and Heritage (OEH[1]) that this would comprise the targeted survey area for the downstream assessment, hereafter referred to as the 'survey area'.

It was also agreed that the survey and assessment within the downstream operational area of the Project would be truncated to the confluence of the Hawkesbury and Colo Rivers. Subsequent hydrological modelling and assessment of water quality impacts identified the Project's influence was minimal past Wisemans Ferry, refer to Section 1.2.5.3 in Appendix F4 (Aquatic ecology assessment report). The Hawkesbury River is largely confined in gorge country between the Colo River and Wisemans Ferry, and impacts on biodiversity would be largely confined to riparian vegetation and associated habitats. This supports the initial definition of the area for survey and assessment.

During consultation with the former Commonwealth Department of the Environment and Energy (DoEE)[2], it was agreed that matters of national environmental significance (MNES) would be assessed to the impact footprint of the larger flooding potential of the PMF. Impacts to MNES resulting from the Project are summarised in a separate matters of national environmental significance assessment report, refer to Appendix F5 of the EIS.

Consequently, the following definitions with regard to this assessment have been adopted:

- **study Area** – the land within the **existing** PMF from Warragamba Dam to the confluence of the Colo River and Hawkesbury River, which is the maximum scope of this ecological assessment
- **survey area** - land within the **existing** 10% AEP (1 in 10 chance in a year) flood inundation extent from Warragamba Dam to the confluence of the Colo River and Hawkesbury River, which was the focus of on-ground biodiversity surveys.

This biodiversity assessment focuses on the following impact zones as appropriate within the survey area and study area:

- **Reduced flooding extent for 10% AEP (1 in 10 chance in a year) event** – the areas subject to reduced inundation events between the existing 10% AEP event and the predicted 10% AEP event scenario following the commencement of the Project.
- **FMZ discharge area** - the downstream area that would be affected by inundation during flood mitigation operations.
- **PMF** – this area represents the largest flood that could conceivably occur and defines the maximum extent of land liable to flooding. It should be noted that this is highly unlikely to occur in nature given the collective area of the upstream catchments.

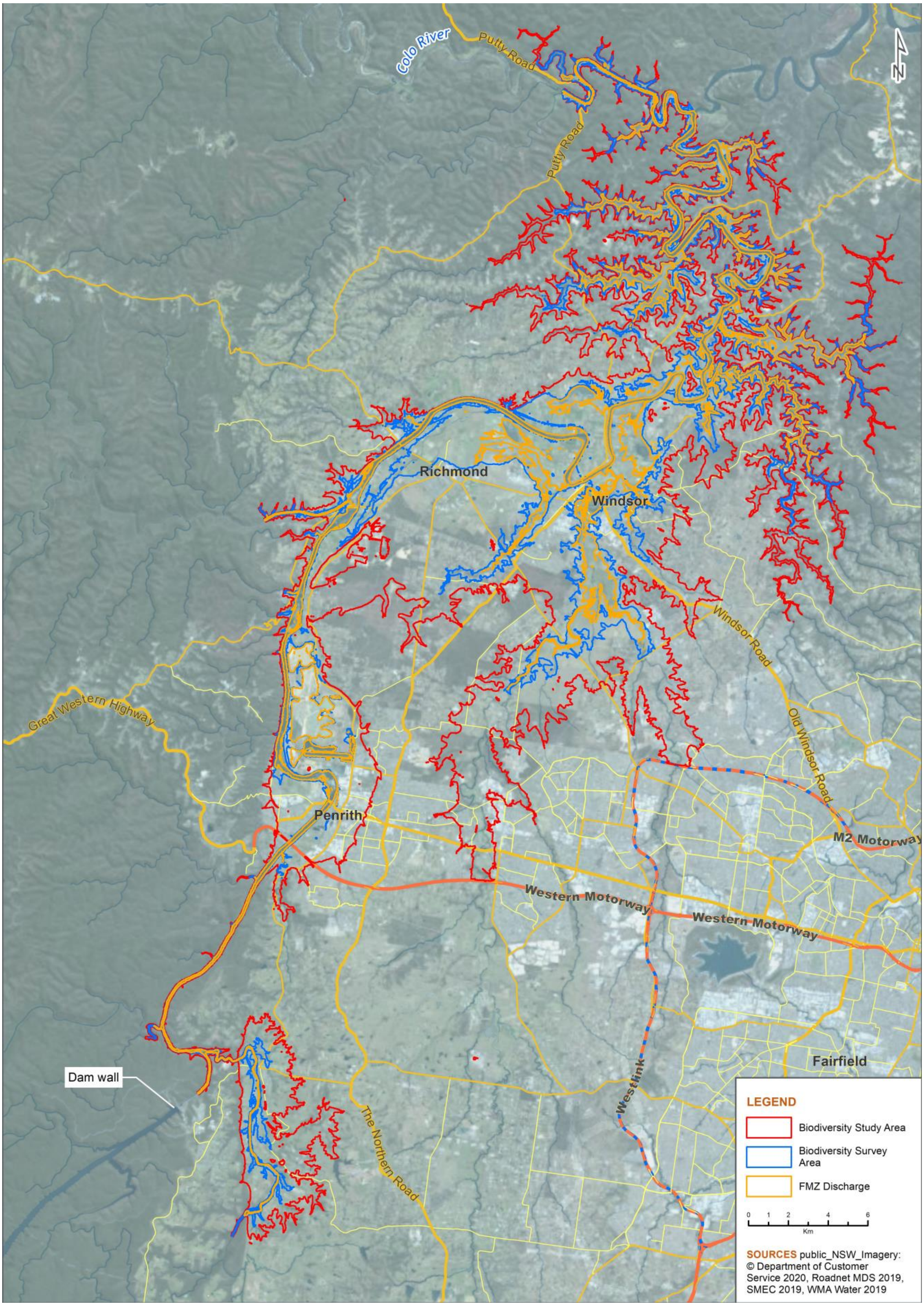
The extents of these areas are shown on Figure 1-14. A detailed multipage figure showing these areas is provided in Appendix I of this report.

Subsequent to commencement of field survey activities for the downstream biodiversity assessment, further investigation into potential changes to downstream hydrology and water quality from the Project identified that the influence of the Project was negligible beyond Wisemans Ferry.

[1] The assessment for the Warragamba Dam Raising formally commenced in 2017 with the issue of the SEARs for the Project. On 1 July 2019 OEH was dissolved, with its biodiversity related functions transferred to a group within DPIE. For the sake of convenience 'OEH' is used to refer to OEH in the historic context unless otherwise specifically noted.

[2] Now the Department of Agriculture, Water and the Environment (DAWE) which commenced operation on 1 February 2020, incorporating the Environment portfolio within DoEE.

Figure 1-14. Biodiversity study area and survey area



2 Local and regional context

2.1 Catchment characteristics and hydrology

2.1.1 Hawkesbury-Nepean catchment

The study area occurs entirely within the Hawkesbury-Nepean catchment as shown on Figure 2-1. The Hawkesbury-Nepean River system covers approximately 21,400 square kilometres, from Lithgow in the west, Goulburn in the south, south-east at the Illawarra escarpment and north to Gosford (DPIE n.d.).

The Hawkesbury-Nepean is also a catchment of biological diversity and World Heritage significance. The region includes a variety of natural landscapes, from rainforests to open woodlands, grasslands to wetlands, and a river system that flows from highland freshwater streams to the Hawkesbury River estuary at Broken Bay. Although many of these landscapes have been altered due to development and agriculture, almost half of the catchment is protected in over one million hectares of national parks and reserves.

Specifically, the study area occurs within varying landforms, from the Cumberland lowlands, north to the foot slopes of the Hornsby Plateau and Blue Mountains Plateau, and the Macdonald Ranges. Within the majority of the study area, the landform is relatively uniform, with undulating rises and alluvial flats. The topography is relatively flat, with highest elevations within the study area of 88 metres AHD and the lowest point of the study area being approximately 50 metres AHD.

The mean rainfall for the general locality around the study area is:

- Warragamba: 541.5 millimetres per year (BOM 2018c)
- Richmond – University of Western Sydney Hawkesbury: 799.4 millimetres per year (BOM 2018b)
- Sackville (Hawkesbury River): 627.9 millimetres per year (BOM 2018a)
- Lower Portland (Hawkesbury River): 751.4 millimetres per year (BOM 2018d).

The highest rainfall generally occurs in the warmer months, particularly during February.

The study area occurs within three IBRA subregions within the Sydney Basin Bioregion:

- Cumberland
- Yengo
- Wollemi.

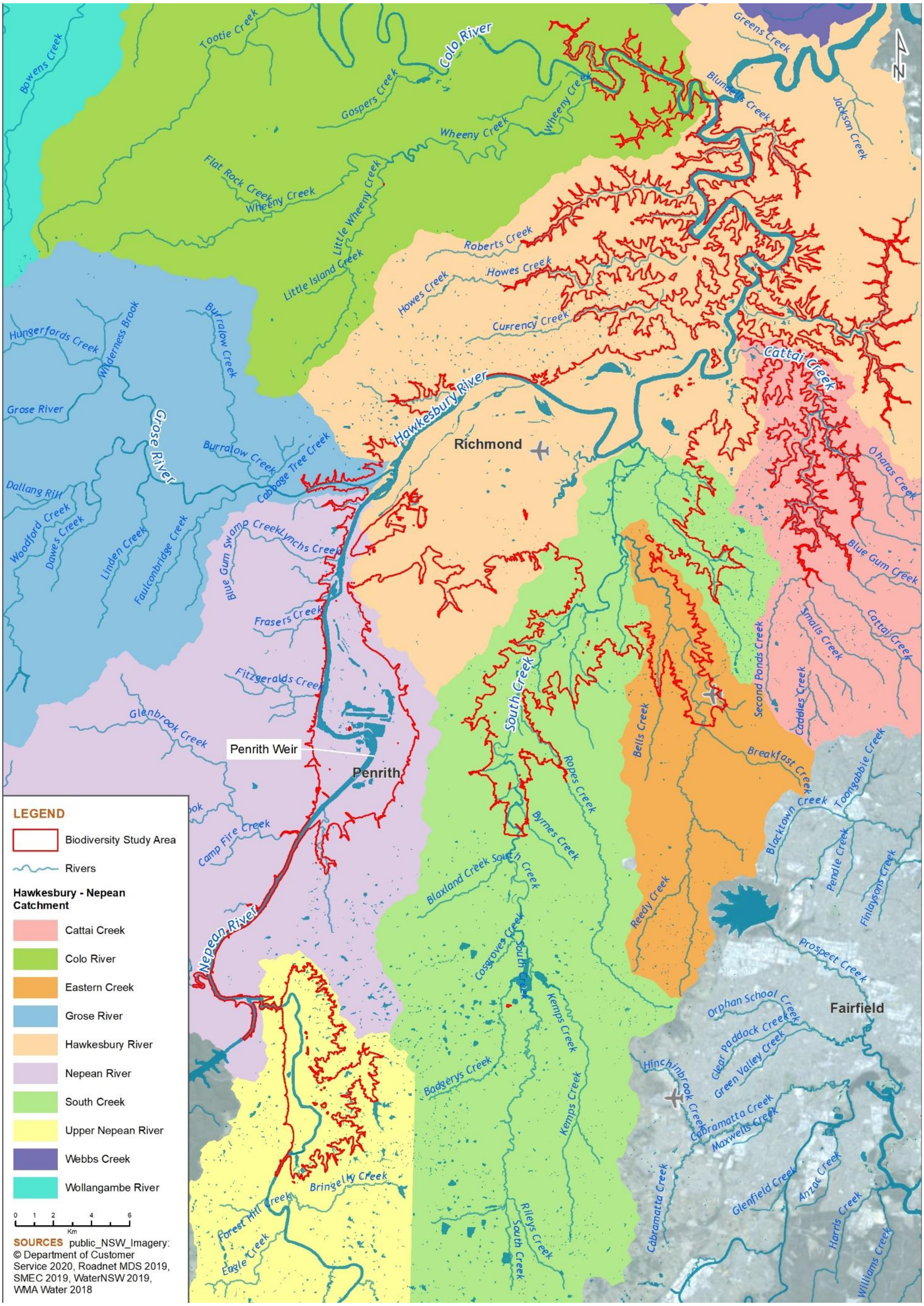
2.1.2 Hydrology

The hydrology of the Hawkesbury-Nepean River system within the study area is highly regulated due to the construction and operation of water supply dams including major dams such as Warragamba Dam, Avon Dam, Cordeaux Dam, Nepean Dam, Cataract Dam and weirs. These dams capture the majority of inflows, however, apart from Warragamba Dam, all of them contribute variable daily environmental flow releases for improved downstream river health.

The Hawkesbury-Nepean River downstream of the Warragamba River confluence has also been significantly modified with the building of Penrith Weir and subsequent weir pool, extensive historical sand and gravel extraction from the river bed and surrounding areas and clearing of riparian vegetation (BMT WBM Pty Ltd 2016). This has resulted in the river geomorphically readjusting and, as such, there are localised areas of bank instability. This has been exacerbated by human activity, particularly from waves generated by recreational water activities and inconsistent measures to stabilise banks that redistribute the flow energy (BMT WBM Pty Ltd 2016). This is discussed in Appendix N2 (Geomorphology assessment report).

The study area covers three main floodplains: Wallacia, Penrith/Emu Plains, and Richmond/Windsor (including areas affected by backwater flooding in South Creek and Eastern Creek). Downstream of the Richmond/Windsor floodplain, the Hawkesbury River winds its way through around 100 kilometres of confined, sandstone gorges all the way to Brooklyn. Numerous small floodplains occur in the narrow areas between the river and the steep valley sides along this reach.

Figure 2-1. Hawkesbury-Nepean catchment and hydrology



Flooding within the Hawkesbury-Nepean Valley is described in EIS Chapter 15 (Flooding and hydrology). Floodwaters come from several different river catchments. The largest of these is the Warragamba River catchment, which drains into Lake Burragorang and represents approximately 80 percent of the catchment at Penrith and 70 percent of the catchment at Windsor. Further inflows downstream of the dam originate from the Nepean River (up to 37 percent), the Grose River (up to 11 percent), South and Eastern Creeks (up to 7 percent), and other tributaries (up to 12 percent). While floods can occur without contribution from the Warragamba catchment, larger floods (above the 1 in 100 chance in a year flood) would include significant floodwater inflows from the Warragamba River catchment. However, each flood event is unique due to the timing of rainfall across the Hawkesbury-Nepean catchment.

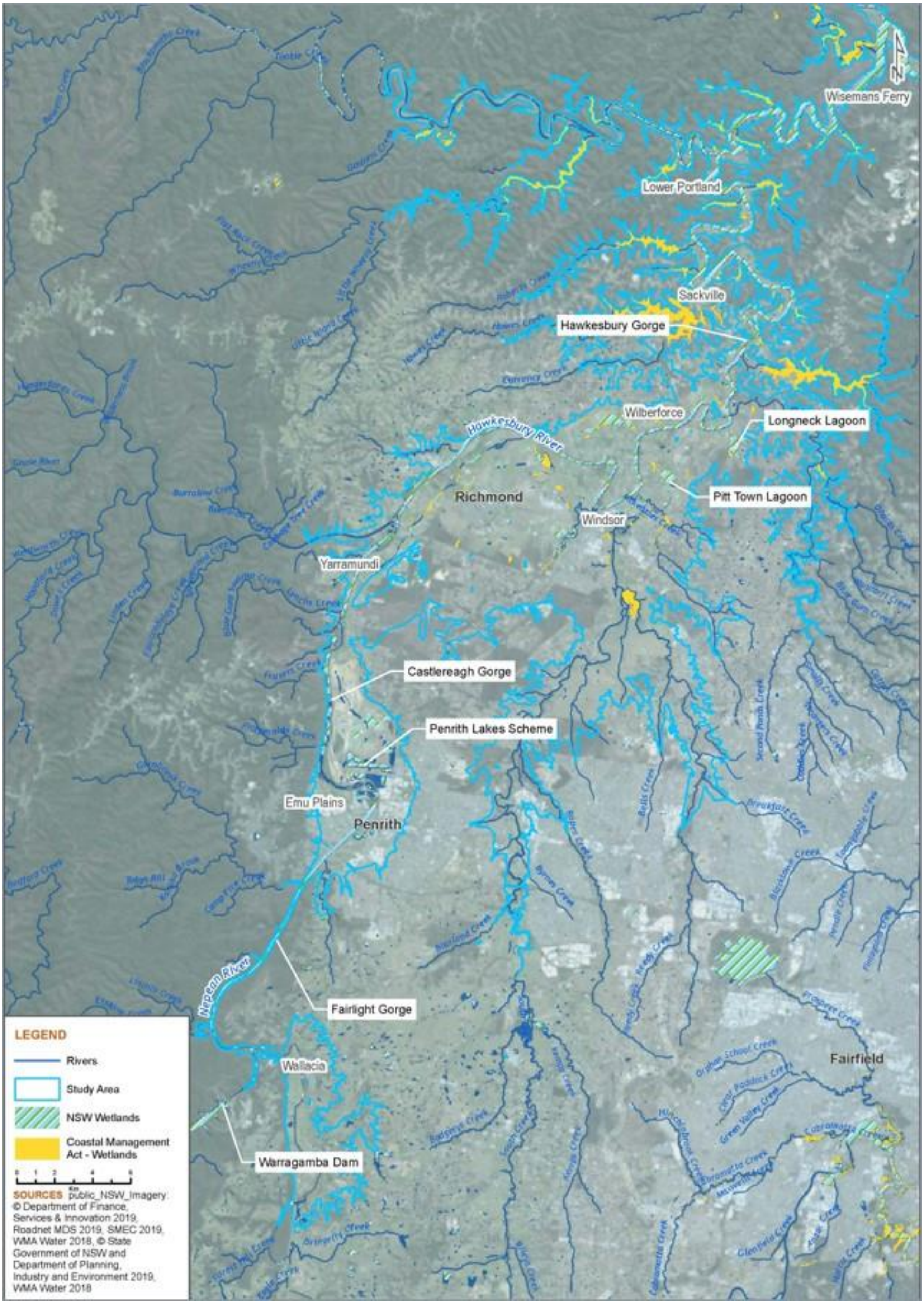
The inundation extent is controlled by the topography across the floodplain, with floodwaters primarily contained within the channel and highly incised valley floor for some reaches, and widespread inundation in other sections of the floodplain. There are also significant step changes in inundation extents between flood events, for example the reach of the Nepean River from the dam wall to immediately upstream of Penrith is characterised by steep terrain with a highly incised channel, resulting in a narrow flood extent, while near the regional localities of Penrith, Windsor, and Richmond the floodplain is notably flatter and wider, and flood inundation extends over a greater area.

The rate of rise of floodwaters is a function of the dam outflow and local topography. The rate of rise differs depending on the distance downstream of Warragamba Dam, with the peak water levels typically occurring about 40 to 60 hours after the initial response. The duration of inundation will also vary depending on location within the receiving environment, with water levels typically returning to standard/pre-response levels within six to eight days after the initial response.

A number of ‘coastal wetlands areas’ and areas mapped as ‘proximity to coastal wetlands’ protected under the *Coastal Management Act 2016* and State Environmental Planning Policy (Coastal Management) 2018 occur within the study area, north from Agnes Banks.

The hydrology of the study area is shown on Figure 2-2.

Figure 2-2. Local hydrology



2.2 Physiography, geology, and soils

Underlying substrates that occur in the study area are:

- Hawkesbury sandstone
- Ashfield shale
- Bringelly shale
- Narrabeen Group rocks
- Berry siltstone.

Alluvial deposits occur along the valleys, creeks and floodplains of the Nepean and Hawkesbury rivers. These deposits are generally shallow, forming unconfined aquifers that are responsive to rainfall and streamflow. Water movement in these deposits occurs as intergranular flow through the preferential pathways provided by interconnected, higher permeability sand and gravel lenses.[3]

The Soil Landscapes layer on eSPADE (OEH 2019) has mapped 17 soil landscapes within the study area, as outlined in Table 2-1. A multipage figure of the soil landscapes is provided in Appendix I of this report.

Table 2-1. Soil landscape description

SOIL LANDSCAPE	DESCRIPTION
Agnes Banks	Low parallel sand dunes deposited on a flat Tertiary terrace. Local relief to 7 m, slopes generally <5%. Low woodland vegetation. Deep acid sandy soils strongly leached overlying yellow sandy clays with coffee-coloured iron and organic rich layer.
Bakers Lagoon	Swamp depressions on floodplains of the Hawkesbury and Nepean Rivers; permanently or periodically waterlogged. Peaty topsoils overlying greyed or black plastic clays or dark or gleyed sandy clay loams. Open sedge land vegetation.
Berkshire Park	Gently undulating low rises on the Tertiary terraces of the Hawkesbury-Nepean River system in a dissected landscape. Soils are weakly pedal orange heavy clays and clayey sands, often mottled.
Blacktown	Gently undulating rises on Wianamatta Group shales. Local relief to 30 m, slopes usually >5%. Broad rounded crests and ridges with gently inclined slopes. Cleared eucalypt woodland and tall open-forest (dry sclerophyll forest).
Burralow Swamp	Large flat areas of alluvial deposits, hanging swamps, valley flats and scattered undulating sandstone benches. Local relief <10 m, slopes <10%. Tall eucalypt open woodland with grass understorey and swamp grasses and bracken fern.
Disturbed Terrain	The topography varies from level plains to undulating terrain, and has been disturbed by human activity to a depth of at least 100 cm. Most of these areas have been levelled to slopes of <5%. The original vegetation has been completely cleared.
Falconbridge	Level to gently undulating crests and ridges on plateau surfaces of the Hawkesbury Sandstone. Local relief <20 m, slopes <5%. Infrequent rock outcrop. Partially cleared Eucalypt woodland.
Freemans Reach	Current active floodplain of the Nepean River. Level with minor (<10 m) relief to meander scrolls, levees and back swamps. Deep brown sands and loams, apedal to moderately structured, usually friable. Extensively cleared open forest (dry sclerophyll).
Gymea	Undulating to rolling rises and low hills on Hawkesbury Sandstone. Local relief 20 - 80 m, slopes 10 - 25%. Rock outcrop <25%. Broad convex crests, moderately inclined side slopes with wide benches, localised rock outcrop on low broken scarps. Extensively cleared open forest (dry sclerophyll forest) and eucalypt woodland.

[3] https://www.bioregionalassessments.gov.au/assessments/11-context-statement-sydney-basin-bioregion/114-hydrogeology-and-groundwater-quality

SOIL LANDSCAPE	DESCRIPTION
Hawkesbury	Rugged, rolling to very steep hills on Hawkesbury Sandstone. Local relief 40 - 200 m, slopes >25%. Rock outcrop >50%. Narrow crests and ridges, narrow incised valleys, steep side slopes with rocky benches, broken scarps and boulders. Mostly uncleared eucalypt open-woodland (dry sclerophyll forest) and tall open-forest (wet sclerophyll forest).
Lucas Heights	Gently undulating crests and ridges on plateau surfaces of the Mittagong Formation (alternating bands of shale and fine-grained sandstones). Local relief to 30 m, slopes <10%. Rock outcrop is absent. Low open-forest and woodland (dry sclerophyll).
Luddenham	Undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone. Local relief 50 - 80 m, slopes 5 - 20%. Narrow ridges, hillcrests and valleys. Extensively cleared tall open forest (wet sclerophyll forest).
Richmond	Quaternary terraces of the Nepean and Georges Rivers. Mainly flat (slopes <1%). Splays and levees provide local relief (<3 m). Poorly structured orange to red clay loams, clays and sands. Texture may increase with depth. Tree cover, now almost completely cleared, was formerly a low open woodland (dry sclerophyll).
South Creek	Floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. Usually flat with incised channels; mainly cleared. Soils are often very deep layered sediments over bedrock or relict soils. The vegetation of this soil landscape reflects its frequent inundation.
Upper Castlereagh	Terraces of the Nepean and Hawkesbury Rivers. Relief <10 m, slopes <5%. Soils are deep (>150 cm) yellow podzolic soils and yellow brown earths. Soils locally have seasonal waterlogging. Almost completely cleared of original vegetation.
Wisemans Ferry	Narrow to moderately broad (<100 - 300 m), level to gently undulating floodplains, levee banks, back plains and back swamps adjacent to the Hawkesbury, Macdonald and Colo Rivers and their tributaries in the Hawkesbury Valleys. Local relief <5 m; slopes are generally <5%. Elevation <40 m. Extensively cleared open-forest.
Woodlands	Very broad benches and drainage lines in the passage beds of the Mittagong Formation (alternating bands of shale and fine-grained sandstones). Rock outcrop is minimal. Local relief up to 20 m. Slope <10%. Extensively to completely cleared low eucalypt open-forest and low eucalypt woodland with a sclerophyll shrub understorey.

2.3 Vegetation and habitats

The vegetation and habitat across the study area varies significantly in its structure, floristics, and condition. Within the Cumberland lowlands, much of the vegetation has been subject to clearing and disturbance as a result of historical land use practices such as agriculture and, more recently, urban development. As a result, the majority of the intact native vegetation is found within national parks, conservation reserves, council managed land and small remnant patches in farm paddocks. Approximately 73 percent of the study area is previously cleared, disturbed, or dominated by exotic vegetation.

As a consequence of these highly cleared landscapes, the majority of the remaining native vegetation on the floodplain is listed as a Threatened Ecological Community (TEC) under NSW and/or Commonwealth legislation. Much of the vegetation within the floodplain shows evidence of disturbance such as weed invasion resulting in alterations to vegetation structure and floristics. However, some intact areas do exist in small pockets. The vegetation communities present on the floodplain are varied, which is primarily driven by substrate and landform/drainage patterns. Grassy woodlands dominated by *Eucalyptus tereticornis* and *Eucalyptus moluccana* are typically found on clay substrates on rolling hills above the water table. The Tertiary Alluvium soil landscapes of varying drainage support the Castlereagh Woodland Communities. River-flat forests occur on the alluvial soils adjacent to creek lines, while small pockets of aeolian sands support *Banksia* dominated heath communities, which are typical of coastal areas. Gullies have historically contained dry rainforest, however, much of this vegetation type has been cleared.

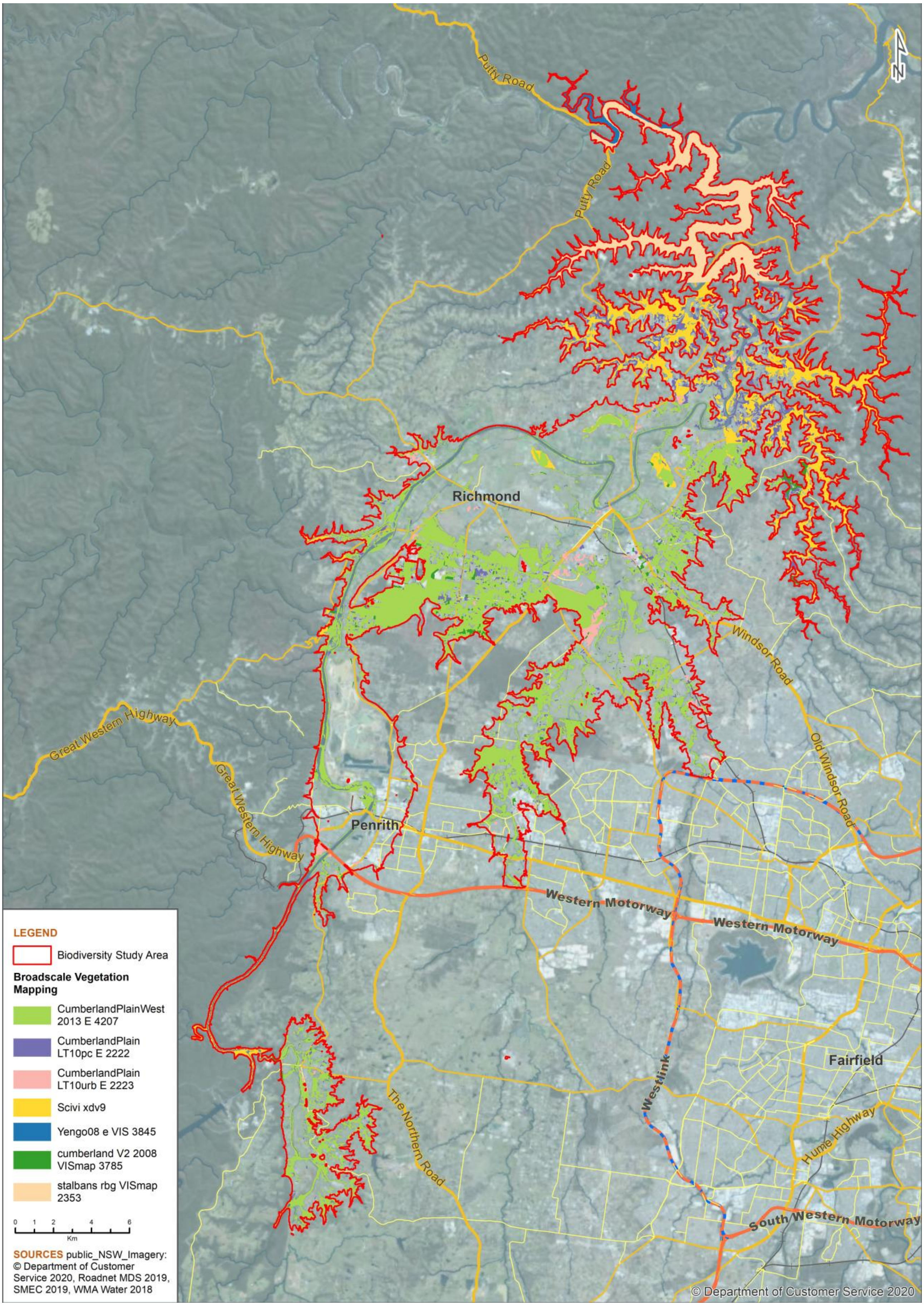
As the landscape rises towards the Hornsby Plateau and Blue Mountains Plateau, transitional communities such as Shale-Sandstone Transition Forest (SSTF) CEEC and Sydney Turpentine-Ironbark Forest (STIF) are found on transitional soils where Wianamatta shale grades into Hawkesbury Sandstone. These communities contain a mix of species typically found on either sandstone substrates or clay substrates. As such, the composition and structure of these communities can differ significantly depending on the proportions of clay-sandstone in the area. Where the landscape is comprised of sandstone, sandstone heath, woodland, and forest communities are present. Species composition and structure within these communities are driven by exposure, aspect, and landscape position. Sheltered forests typically occur on south facing slopes and within gullies, while woodland and heath generally occur closer or on top of ridges where the soils are shallow and the landscape position more exposed.

The Hawkesbury-Nepean catchment supports a substantial range of fauna species and exhibits some of the highest levels of species diversity in Australia, largely as a result of the variety of rock types, topography, and climates in the region. The broad fauna habitat types of grassland, riparian, and woodland and forest found within the study area are representative of the broad habitat types within the surrounding region. Many of these habitats, particularly on the floodplain, have been extensively cleared or modified for agriculture.

In intact vegetated areas, habitat is provided by woodland, forest, and heath communities. Where habitats have been modified or disturbed, a range of native and naturalised perennial grasses and forbs are generally present. The grass and forb-dominated groundcover includes log and stump cover that provides habitat for grassland mammals (small and large), birds, and terrestrial reptile species. Scattered trees throughout grasslands provide potential nesting, roosting and perching habitat for bird species, roosting habitat for some micro-bat species and shade for larger grazing mammal species.

Areas of intact native vegetation using broadscale vegetation mapping for the study area are shown on Figure 2-3.

Figure 2-3. Broadscale mapping of intact vegetation within the study area



2.4 Conservation areas and connectivity

The following lands listed under the *National Parks and Wildlife Act 1974* occur, in part, within the study area (refer to Figure 2-4):

- Blue Mountains National Park
- Yellomundee Regional Park
- Gulguer Nature Reserve
- Windsor Downs Nature Reserve
- Agnes Banks Nature Reserve
- Scheyville National Park
- Pitt Town Nature Reserve
- Cattai National Park
- Wollemi National Park
- Parr State Conservation Area
- Wianamatta Regional Park
- Bents Basin State Conservation Area
- Castlereagh Nature Reserve
- Maroota Ridge State Conservation Area
- Mulgoa Nature Reserve.

Additionally, the Greater Blue Mountains World Heritage Area occurs either side of the Warragamba River, immediately downstream of Warragamba Dam, and stretches across the western boundary of the study area along the Colo River and Wheeny Creek.

Vegetation and habitat connectivity surrounding the study area is mainly characterised by extensive and intact vegetation associated with the Blue Mountains National Park, Wollemi National Park and Parr State Conservation Area occurring on the western and northern edges of the study area, respectively. In the highly cleared landscapes of the floodplain, strip corridors and stepping stone habitats occur along riparian zones and retained vegetation on private properties and conservation areas including Agnes Banks Nature Reserve, Windsor Downs Nature Reserve, and Cattai National Park. Of particular importance is the ability of these remnants to support a range of species whose occurrence is limited by the need for a large area of contiguous habitat. These remnants are threatened by ongoing disturbance and isolation due to the expansion of agriculture, rural residential development, and other suburban developments.

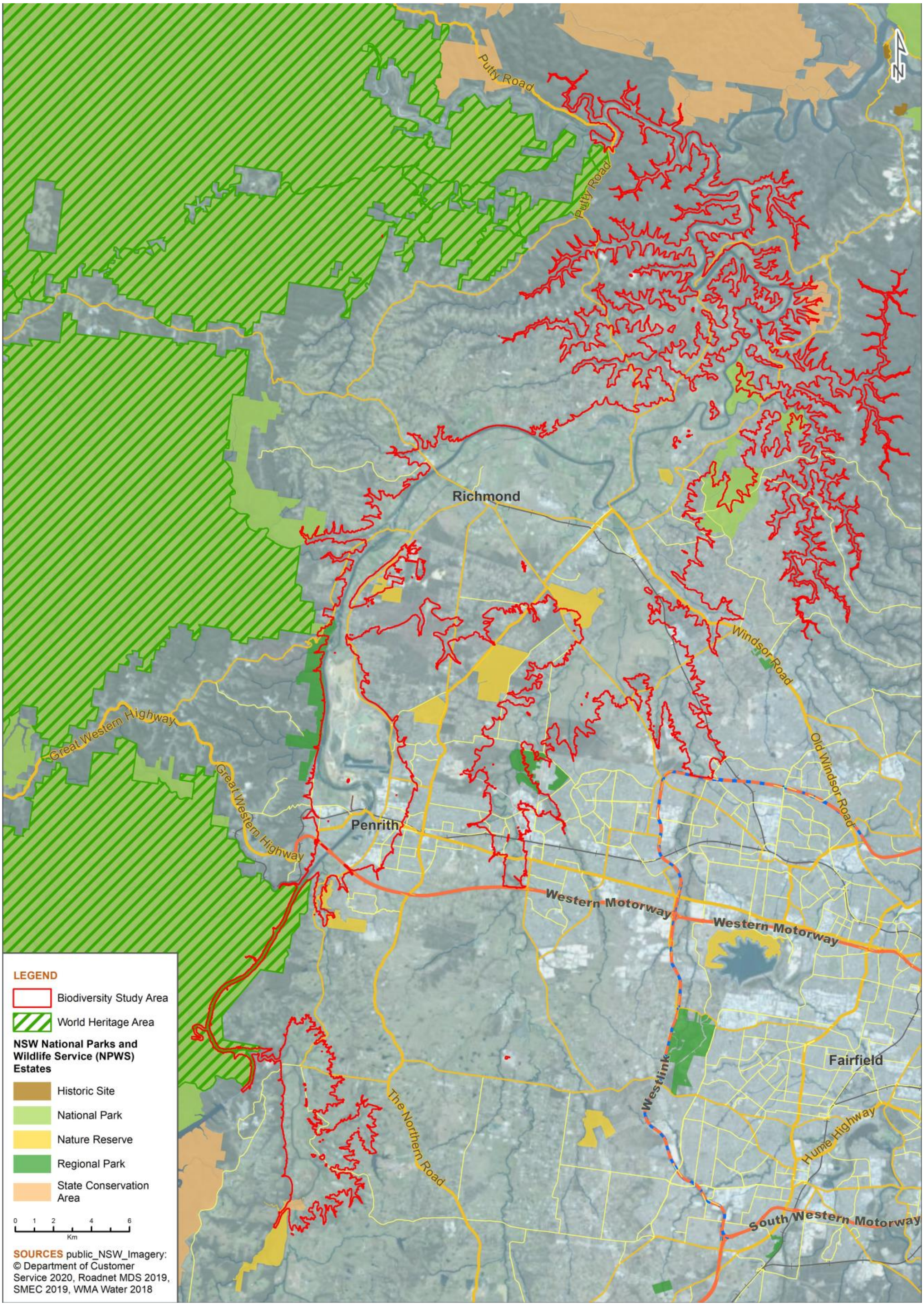
2.5 Land use

The study area encompasses many different types of land uses including agriculture, suburban and residential development and land protected for conservation purposes. Land zonings in the area (under Camden, Blue Mountains, Penrith, Blacktown, The Hills, and Hawkesbury LEPs) include:

- RU2 Rural landscape
- E1 National parks and nature reserves
- E3 Environmental conservation
- R5 Large lot residential
- RE2 Private recreation.

The study area includes the townships of North Richmond, Windsor and Wisemans Ferry, which have low to high density residential areas. The remainder of the downstream valley is made up of agricultural land and reserves, though some areas have been marked for future medium to high density residential development (BMT WBM Pty Ltd 2016).

Figure 2-4: Conservation areas within and surrounding the study area



3 Legislation and policies

The legislative instruments and policies outlined in Table 3-1 are applicable to the ecological assessment of the Project.

Table 3-1. Relevant legislation and policies

Name	Description	Applicability to the Project
Commonwealth legislation		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Designed to protect national environmental assets, known as matters of national environmental significance (MNES), which include threatened species of flora and fauna, endangered ecological communities, and migratory species, as well as other protected matters. Among other things, it defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna, and communities. MNES identified in the EPBC Act are: ▪ World Heritage properties ▪ national heritage places ▪ Ramsar wetlands ▪ nationally threatened species and communities ▪ migratory species protected under international agreements ▪ the Commonwealth marine environment ▪ the Great Barrier Reef Marine Park ▪ nuclear actions ▪ a water resource in relation to coal seam gas development and large coal mining development.	The Project was deemed a controlled action (ref 2017/7940) due to potential significant impact on MNES. In accordance with the bilateral agreement reached between the NSW and Commonwealth Governments, an EIS under the EP&A Act for State Significant Infrastructure (SSI) can be used for an EIS under the EPBC Act for a controlled action, where directed by the Commonwealth Minister. The direction was given for the Project to be assessed under the bilateral agreement on 17 July 2017. The Project will be assessed under the NSW process which will then be used to inform a recommendation to the Commonwealth Environment Minister. Where relevant, this assessment refers to impacts on biodiversity-related MNES, however a separate assessment specifically for biodiversity-related MNES is provided in Appendix F5 to the EIS.
EPBC Act Environmental Offsets Policy	This policy came into force in October 2012 and provides guidance on the role of offsets in environmental impact assessments and how DoEE (now DAWE) considers the suitability of a proposed offset package. According to the policy, an offsets package is a "suite of actions that a proponent undertakes in order to compensate for the residual significant impact of a project". It can comprise a combination of direct offsets and other compensatory measures.	As the Project will be assessed under the Bilateral Agreement, the proposed offsets package will be prepared in accordance with NSW offset policies, however the Commonwealth Minister will also need to approve the outcome.
NSW legislation		
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is the overarching planning legislation in NSW that provides for the creation of planning instruments that guide land use. The EP&A Act also provides for the protection of the environment, including the protection and conservation of native animals and plants. This includes threatened species, populations and ecological communities, and their habitats of biodiversity values.	The Project comes under Part 5 of the EP&A Act through the effect of Division 24 (Water supply systems), clause 125 of *State Environmental Planning Policy (Infrastructure) 2007*. Section 5.12 of the EP&A Act provides for development to be SSI through a Ministerial Order or through a SEPP. Clause 14 of *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) provides for development specified in

Name	Description	Applicability to the Project
		Schedule 3 to the SRD SEPP to be SSI. The Project meets the criteria identified in clause 4(1) in Schedule 3. Accordingly, the Project is subject to assessment under Division 5.2 of the EP&A Act and requires the approval of the NSW Minister for Planning and Public Spaces under section 5.14 of Division 5.2. Updated SEARs for the Project were issued by the then NSW Department of Planning and Environment (DPE) on 13 March 2018, which are outlined in Table 1-1.
Biodiversity Conservation Act 2016 (BC Act)	The *Biodiversity Conservation Act 2016* (BC Act) and its supporting regulations commenced on 25 August 2017. The BC Act repeals the *Threatened Species Conservation Act 1995* (TSC Act) along with other natural resource management legislation, while retaining the TSC Act species list. The BC Act sets out the environmental impact assessment framework for threatened species, threatened ecological communities and Areas of Outstanding Biodiversity Value (formerly critical habitat) for Major Projects and local development.	The transitional provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 apply to this Project as the SEARs for the Project were issued prior to the commencement of the new BC Act. Consequently, the Project has been assessed in accordance with the requirements of the former TSC Act. Updated SEARs for the Project were issued on 13 March 2018 confirming the assessment in accordance with the TSC Act.
Threatened Species Conservation Act 1995 (TSC Act)	The TSC Act was repealed when the BC Act commenced on 25 August 2017. However, as outlined above, transitional arrangements allow SSI projects to be considered under previous legislation if the SEARs were issued before 25 August 2017. Initial SEARs for the Project were issued in June 2017 and consequently the TSC Act applies to the Project. Updated SEARs for the Project, confirming this position, were reissued on 13 March 2018. The TSC Act was the key piece of legislation in NSW relating to the protection and management of biodiversity and threatened species. The schedules of the TSC Act identify endangered or vulnerable subjects and the processes likely to be affecting them. This is achieved through the declaration and mapping of habitats that are critical to the survival of the relevant species, populations and ecological communities (critical habitats). Further, the TSC Act also sets out the methods of assessment, management and regulation of actions that may damage critical or other habitat or otherwise significantly affect threatened species, populations and ecological communities. Provision is made for the preparation of recovery plans to mitigate and manage key threatening processes.	The TSC Act requires consideration of whether a development (Part 4) or an activity (Part 5) is likely to significantly impact threatened species, populations, communities or their habitat. The potential impacts of any developments, land use changes or activities do not need to undergo an 'Assessment of Significance' under section 5A of the EP&A Act as the Project has been declared SSI, and therefore Framework for Biodiversity Assessment applies. However, the FBA does not assess downstream impacts on hydrology and environmental flows on surface vegetation. As such, the SEARs have determined that impacts downstream of the dam wall should be assessed via an 'Assessment of Significance'.

Name	Description	Applicability to the Project
Fisheries Management Act 1994 (FM Act)	The objectives of the FM Act are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. More detailed objectives relevant to the Project are: ▪ to conserve fish stocks and key fish habitats ▪ to conserve threatened species, populations and ecological communities of fish and marine vegetation ▪ to promote ecologically sustainable development, including the conservation of biological diversity.	As SSI, certain approvals under the FM Act are not required for the Project, these being permits under sections 201, 205 and/or 219. A separate aquatic ecology impact assessment (Appendix F4 to the EIS) assesses these issues.
Coastal Management Act 2016 (CM Act)	The objective of the *Coastal Management Act 2016* (CM Act) is to manage the coastal environment in a manner consistent with the principles of ecologically sustainable development for the social, cultural and economic well-being of the people of NSW. The study area contains areas mapped in the Coastal Management SEPP as 'coastal wetland area' and 'proximity to coastal wetlands'. This legislation establishes clear outcome-orientated management objectives for each area to ensure councils apply appropriate management tools and development controls. The management objectives for the coastal wetlands area are as follows: ▪ to protect coastal wetlands and littoral rainforests in their natural state, including their biological diversity and ecosystem integrity, ▪ to promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests, ▪ to improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration, ▪ to support the social and cultural values of coastal wetlands and littoral rainforests, ▪ to promote the objectives of State policies and programs for wetlands or littoral rainforest management.	The Project could potentially impact upon land mapped as 'coastal wetlands, and 'proximity area to coastal wetlands'. Development within coastal wetlands is classed as 'designated development' and requires a higher order of assessment regarding potential environmental impacts. Designated development includes development that has a high potential to have adverse impacts because of their scale or nature or because of their location in sensitive environmental areas, such as wetlands (DPE, 2015). Designated development does not include SSI proposals such as the Project.
State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP)	The CM SEPP commenced on 3 April 2018. It aims to promote an integrated and coordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the *Coastal Management Act 2016*. Development in coastal wetlands and littoral rainforests, regardless of land zoning, has been controlled since the 1980s. The CM SEPP largely carries forward pre-existing controls from the now repealed SEPP 14 (Coastal Wetlands) and SEPP 26 (Littoral Rainforests). The CM SEPP identifies development controls to help protect and manage sensitive coastal environments, manage risks from coastal	The Project could potentially impact upon land mapped as 'coastal wetlands, and 'proximity area to coastal wetlands'. Development within coastal wetlands is classed as 'designated development' and requires a higher order of assessment regarding potential environmental impacts. Designated development includes development that has a high potential to have adverse impacts because of their scale or nature or because of their location in sensitive environmental areas, such as wetlands (DPE, 2015). Designated development does not include SSI proposals such as the Project.

Name	Description	Applicability to the Project
	hazards and support appropriate development (DPE, 2015). The CM SEPP imposes targeted development controls for these areas, to guide appropriate development within the coastal zone. The CM Act and CM SEPP apply to land that is mapped within one or more of the four coastal management areas, which are not mutually exclusive. Where a site is mapped as more than one coastal management area, the development controls for each of those coastal management areas will apply.	The CM SEPP applies to development requiring consent under Part 4 of the EP&A Act. As the Project is being assessed under Division 5.2 of the EP&A Act (Part 5), the provisions of the CM SEPP do not apply.
National Parks and Wildlife Act 1974 (NPW Act)	The NPW Act provides for the conservation of NSW's natural and cultural heritage, including habitat, ecosystems, biological diversity, landforms and landscapes of significance, and places/objects/features of significance to Aboriginal peoples. The NPW Act also aims to foster public appreciation, understanding and enjoyment of natural and cultural heritage and promote its conservation.	The Project would not have any direct impacts on land which is protected under the NPW Act downstream of the dam. Consequently, no permit or other approval is required in relation to any National Park, State Conservation Area or Regional Park as no works are planned within these areas.
Wilderness Act 1987	The objectives of the *Wilderness Act 1987* are: ▪ to provide for the permanent protection of wilderness areas ▪ to provide for the proper management of wilderness areas ▪ to promote the education of the public in the appreciation, protection and management of wilderness.	Activities or impacts on declared wilderness areas require consent under section 15 from the Minister administering the Act. No declared wilderness areas in the downstream area would be directly or indirectly impacted by the Project and therefore consent is not required.
State Environmental Planning Policy (Koala Habitat Protection) 2020 (Koala SEPP)	This SEPP aims to encourage the conservation and management of areas of natural vegetation that provide habitat for koalas to support a permanent free-living population over their present range and reverse the current trend of koala population decline.	As the Project is declared SSI, the provisions of the SEPP do not apply to the proposed activity.
Principles for the use of biodiversity offsets in NSW	These principles have been developed to provide a useful framework when considering biodiversity impacts and appropriate offset requirements. The principles include: 1. Impacts must be avoided first by using prevention and mitigation measures. 2. All regulatory requirements must be met. 3. Offsets must never reward ongoing poor performance. 4. Offsets will complement other government programs. 5. Offsets must be underpinned by sound ecological principles. 6. Offsets should aim to result in a net improvement in biodiversity over time. 7. Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs. 8. Offsets should be agreed prior to the impact occurring.	In accordance with the SEARs, the Project was assessed by determining the residual impacts that require offsetting using an 'Assessment of Significance' in accordance with the EP&A Act (specifically the former 'Seven-part test' under the now repealed section 5A).

Name	Description	Applicability to the Project
	9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated. 10. Offsets must be targeted. 11. Offsets must be located appropriately. 12. Offsets must be supplementary. 13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or contracts.	
NSW Biodiversity Offsets Policy for Major Projects	The NSW Biodiversity Offsets Policy for Major Projects was adopted in September 2014 and applies to SSI designated under the EP&A Act. The policy provides a standard method for assessing impacts of major projects on biodiversity and determining offsetting requirements (OEH 2014). The policy is underpinned by six principles, which must be considered when assessing offsets for major projects. These principles are: ▪ before offsets are considered, the impacts must first be avoided, and unavoidable impacts minimised through mitigation measures. only then should offsets be considered for the remaining impacts ▪ offset requirements should be based on reliable and transparent assessment of losses and gains ▪ offsets must be target by the biodiversity values being lost or to higher conservation priorities ▪ offsets must be additional to other legal requirements ▪ offsets must be enduring, enforceable and auditable ▪ supplementary measures can be used in lieu of offsets.	Section 6.2 of the SEARs requires that the downstream assessment be carried out in accordance with *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft* (DEC, 2004). WaterNSW would deliver a compensatory package targeting entities deemed at most risk. The offset strategy would broadly adhere the principles outlined within the Major Projects Offset Policy and Principles for Biodiversity Offsets in NSW. Please refer to Section 8.1 and Appendix F6 of the EIS (Biodiversity offset strategy) for more details.

4 Methodology

4.1 Literature review and database analysis

4.1.1 Review of existing data

The following data sources were searched and reviewed as part of a desktop assessment of the biodiversity features within the study area:

- BioNet Vegetation Classification System (OEH 2017b)
- Spatial Information eXchange (Department of Finance and Services 2017)
- NSW OEH Atlas of NSW Wildlife Database (OEH 2017a)
- Atlas of Living Australia (CSIRO n.d.)
- The Australian Virtual Herbarium (Council of Heads of Australasian Herbaria n.d.)
- Department of the Environment and Energy Protected Matters Search Tool (DoEE 2015)
- DoEE Species Profiles and Threats database (SPRAT) (DoEE n.d.)

The following reports were also reviewed:

- *Blue Mountains National Park Plan of Management* (NPWS 2001)
- *Castlereagh, Agnes Banks and Windsor Downs Nature Reserves Plan of Management* (NPWS 1999)
- *Cattai National Park Plan of Management* (NPWS 1997)
- *Scheyville National Park Conservation Management Plan* (NPWS 2009a)
- *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 - Background Report* (DECC 2007)
- *Warragamba Dam Raising Preliminary Environmental Assessment* (BMT WBM Pty Ltd 2016)
- *Yellomundee Regional Park Plan of Management* (NPWS 2009b).

4.1.2 Likelihood of occurrence of species and communities

Prior to the field surveys, a search of relevant databases was undertaken to obtain records on all threatened species, populations, and ecological communities previously recorded within a two-kilometre buffer search (from the edge of the study area). Furthermore, a database search of additional listed areas of ecological importance, key habitat features, vegetation communities and aquatic habitat was undertaken. All current and preliminary listings under the BC Act, FM Act and EPBC Act were considered.

The full list of potentially occurring threatened entities was then reviewed with species, populations, and communities discounted if no suitable habitat was present within the study area. Species with no nearby records and no clear vector of propagation or travel (for example, purely pelagic species) were then discounted and an assessment of the likelihood of occurrence table was then prepared. The likelihood of occurrence table includes consideration of the proximity and age of the records, and the suitability of habitat in the study area for each species. Five likelihood ratings were used, as defined in Table 4-1.

Table 4-1. Likelihood of occurrence table

Likelihood rating	Rating criteria
Recorded	The species was observed during the recent surveys or has been previously recorded in the survey area.
High	It is likely that a species inhabits or utilises habitat within the survey area.
Moderate	Potential habitat for a species occurs within the survey area.
Low	It is unlikely that the species inhabits the survey area.
None	The species has not been recorded within the survey area and no suitable habitat occurs survey area.

The assessments of likelihood of occurrence are provided in Appendix A to this report.

4.2 Vegetation mapping and flora surveys

4.2.1 Vegetation mapping and threatened flora species searches

Prior to the commencement of vegetation surveys, a comprehensive review of previously conducted vegetation mapping was undertaken (refer Figure 2-3). The majority of the relevant mapping comprised the following three projects covering different parts of the downstream study area:

- *Remnant Vegetation of the western Cumberland subregion, 2013 Update. VIS_ID 4207* (OEH 2015): this mapping project covers the Western Sydney portion of the study area that occurs from the Warragamba Dam wall in the south-west, to Sackville in the north-east
- *The natural vegetation of the St Albans 1:100,000 map sheet* (OEH 2018): this mapping project covered the study area north of Sackville and along the Colo River
- *The Native Vegetation of Yengo and Parr Reserves and Surrounds* (OEH 2009): this mapping project covers the area north of the Colo River.

Vegetation mapping projects had a number of limitations requiring validation in order to confirm vegetation polygon accuracy, alignment to equivalent plant community types (PCTs), and the different condition classes of each PCT. The approach to the vegetation validation involved the following stages, which are described in detail below:

1. Preliminary vegetation analysis/desktop mapping
2. Field verification (floristic plots and transects)
3. Refinement and finalisation of vegetation mapping.

4.2.2 Preliminary vegetation analysis/desktop mapping

Vegetation mapping projects were overlaid onto aerial imagery and clipped to an outline of the survey area. Vegetation polygons were re-sized to match the aerial imagery where noticeable errors in the size and shape of mapped vegetation patches occurred. Units that were assigned as 'unclassified' in the NPWS (2002)/OEH (2015) vegetation mapping were assigned to a best fit vegetation community based on adjacent polygons, landscape position, soil type and aerial interpretation. Similarly, areas of vegetation that were not assigned a vegetation unit were attributed to a best fit vegetation community. The vegetation communities were then aligned to an equivalent PCT.

Based on aerial interpretation and landscape position, polygons were assigned to preliminary condition classes. Preliminary vegetation area calculations were produced for the survey area to inform the anticipated survey effort. The locations of vegetation plots/transects were placed (where possible) in national parks, conservation reserves and public land, to limit access issues to private land.

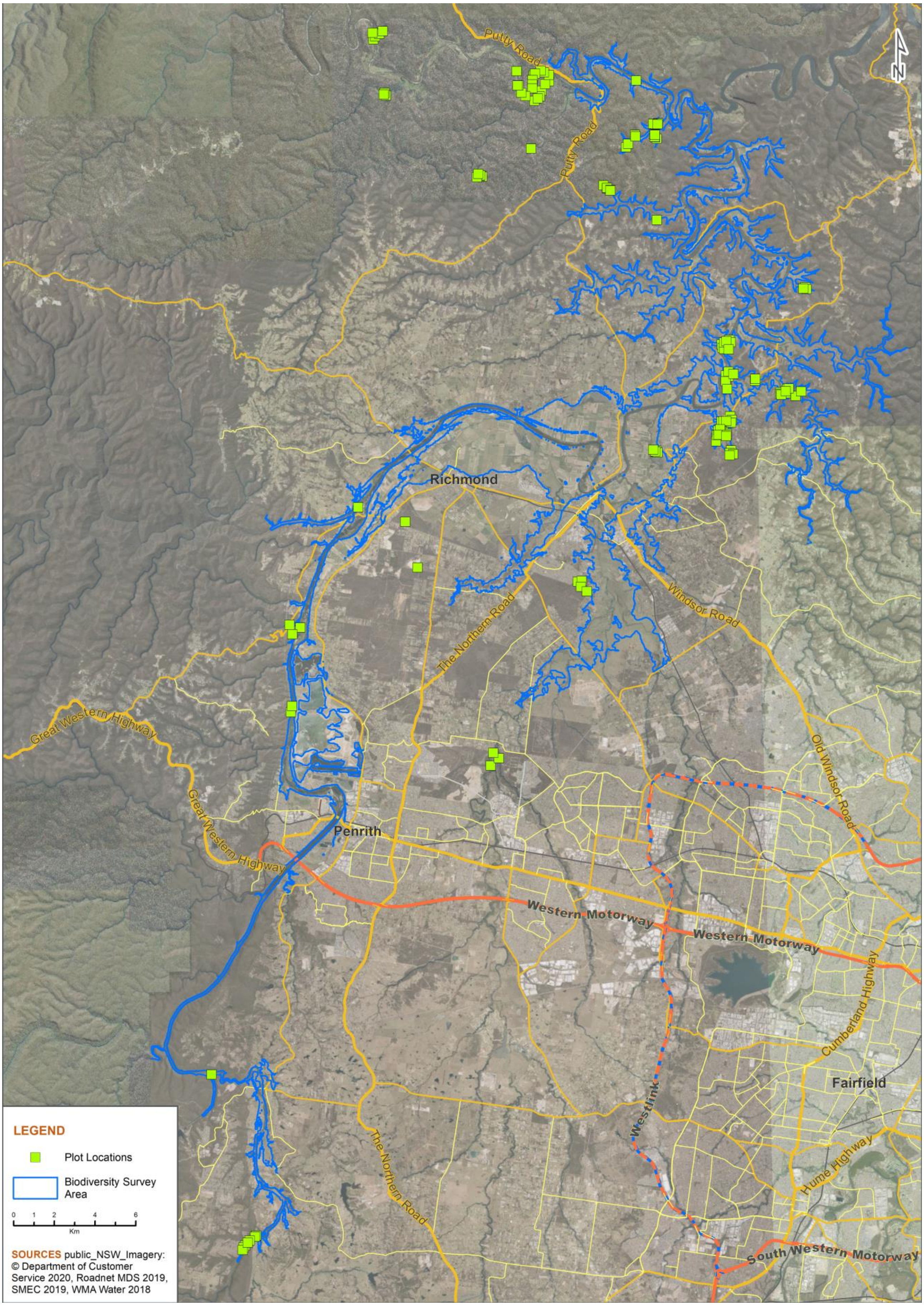
4.2.3 Field verification (floristic plots and transects)

The field surveys were undertaken in accordance with the *NSW Guide to Surveying Threatened Plants* (OEH 2016) and/or the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* (DEC 2004). Surveys involved the collection of full floristic data within each preliminary PCT and condition class (vegetation zones). A total of 101 plot/transects were completed across the survey area, as shown on Figure 4-1. The following information was collected at each of the 20 x 20 metre full floristic plots:

- **stratum (and layer)**: stratum and layer in which each species occurs
- **growth form**: growth form for each recorded species
- **species name**: scientific name and common name
- **cover**: a measure or estimate of the appropriate cover measure for each recorded species; recorded from 1–5% and then to the nearest 5%. If the cover of a species is less than one percent and the species is considered important, then the estimated cover should be entered (for example, 0.4)
- **abundance rating**: a relative measure of the number of individuals or shoots of a species within the plot. Uses the following intervals (numbers above 20 are estimates only): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 50, 100, 500, or 1,000, or specify a number greater than 1,000 if required.

The plot and transect surveys primarily focussed on locations within the survey area which were readily accessible, such as NPWS estate and council-managed lands. Consequently, plots were generally clustered within these accessible lands, but the exact locations randomly selected within each PCT. The location of each plot and transect considered

Figure 4-1. Location of plot/transect surveys



areas that were considered unsuitable for assessment, including ecotones, vehicle tracks and disturbed areas that were readily distinguishable from the broad condition state of the vegetation zone.

The following biometric data was collected from each plot and transect location:

- native species richness recorded within each stratum of a 20 x 20-metre sub-plot
- native overstory cover recorded at 10 points along a 50-metre transect
- native midstorey cover recorded at 10 points along a 50-metre transect
- native ground cover recorded at 50 points along a 50-metre transect for three life forms (shrubs, grasses and other)
- exotic plant cover expressed as a total percentage cover across all strata (each stratum measured using the same method for native overstory, midstorey and ground cover)
- number of trees with hollows visible from the ground within the 20 x 50-metre plot
- the total length of fallen logs > 10 centimetres in diameter within the 20 x 50-metre plot
- the proportion of regenerating overstory species within the vegetation zone.

4.2.4 Refinement and finalisation of vegetation mapping

Based on the results of the field survey, the preliminary vegetation mapping was amended where required. Amendments were made to the size, shape and locations of polygons as well as changing the mapped PCT based on the recorded floristic assemblage. The finalised vegetation mapping identifies 21 PCTs that are stratified across six different condition classes within the survey area. Stratification into different condition classes occurred when significant differences in patch structure and quality were observed. Where applicable, PCTs were matched to corresponding threatened ecological communities.

A description of the finalised vegetation condition classes is provided below:

- **Moderate/Good_good:** Native vegetation comprised of relatively intact stratum layers (canopy, sub-canopy, shrub layer and groundcover). A diversity and abundance of species occurs within the groundcover. Some weeds can occur scattered throughout the area of vegetation.
- **Moderate/Good_medium:** A canopy dominated by locally native species occurs. The lower stratum layers are comprised of a mix of locally native and non-native species.
- **Moderate/Good_low:** Remnant native trees and locally non-native species occur in the canopy and sub-canopy. The shrub layer and groundcover are dominated by locally non-native species however locally native species do occur.
- **Moderate/Good**: Native vegetation that is not defined as 'low condition' as per the FBA.
- **Derived grassland:** Native vegetation that has changed to an alternative stable state because of the removal of one or more structural components of the original vegetation (for example, removal of the canopy and shrub layer assemblages).
- **Other:** Areas that do not conform to any of the above condition classes such as residential gardens.

4.2.5 Targeted threatened flora surveys

Targeted threatened flora surveys were conducted with reference to the *NSW Guide to Surveying Threatened Plants* (OEH 2016) and/or the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* (DEC 2004). Specifically, the survey effort entailed the following:

- walking meanders through habitat types and PCTs associated with threatened species within the survey area, targeting the following species:
  - *Acacia pubescens*
  - *Dillwynia tenuifolia*
  - *Cynanchum elegans*
  - *Epacris purpurascens var. purpurascens*
  - *Grevillea juniperina subsp. juniperina*
  - *Marsdenia viridiflora subsp. viridiflora*
  - *Micromyrtus minutiflora*
  - *Persoonia hirsuta*

  - *Persoonia nutans*
  - *Pimelea spicata*
- threatened flora population counts for *Acacia pubescens*
- recording of *Dillwynia tenuifolia* individuals.

In total, over 200 hours of threatened flora transects and random meanders were completed within the survey area. The threatened flora surveys were conducted by two botanists between the following dates in 2017 and 2018:

- 20–24 November 2017
- 27 November–1 December 2017
- 4–8 December 2017
- 11–15 December 2017
- 20–23 December 2017
- 23–25 January 2018
- 29–30 January 2018
- 1–2 February 2018
- 6–10 February 2018
- 12–13 February 2018.

The majority of species fall within the recommended survey times as per BioNet with the exception of *Dillwynia tenuifolia* (August to October inclusive) and *Epacris purpurascens* var. *purpurascens* (September to October inclusive).

4.2.6 Preparation of expert report

An expert report was prepared to assess potential habitat suitability and impacts of the Project on *Pterostylis saxicola,* which has been assessed as having a moderate likelihood of occurring within the study area. The expert report has been prepared by Dr Peter Weston and is presented in Appendix J of this report. No other expert reports were considered necessary.

4.3 Fauna survey

Initial fauna habitat assessments were conducted by SMEC (in January - April 2018) to assist in determining the likelihood of presence of threatened fauna species. Habitat characteristics considered included (but were not limited to) the presence of hollow bearing trees, fallen logs, leaf litter and other ground debris, drainage lines, ponds, the structure of vegetation communities and the presence of fruiting/flowering plant species. Searches were carried out for signs of fauna activity such as tracks, scats, scratches, and notches on trees, as well as any opportunistic sightings, to identify the presence of fauna species. While it was presumed that anthropogenic habitat features occur widely throughout the study area (such as culverts, bridges, derelict buildings), along with natural caves, these structures were not specifically assessed due to limitations including access constraints. Habitat information recorded at each sampling site included: height and density of vegetation layers, leaf litter, fallen timber, tree hollows (position on tree and size), stags, rock shelves, soil type, presence of water and any anthropogenic habitats.

Targeted fauna surveys were conducted within the survey area between January and June 2018 and comprised:

- infrared cameras
- hair funnels
- ultrasonic call detection
- diurnal bird surveys
- call playback and spotlighting
- koala spot assessment technique.

Fauna field surveys were based on the survey effort recommendations of the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft* (DEC, 2004), and relevant Commonwealth survey guidelines, with particular reference to the size of the survey sites, broad scale vegetation communities and major sampling stratification units.

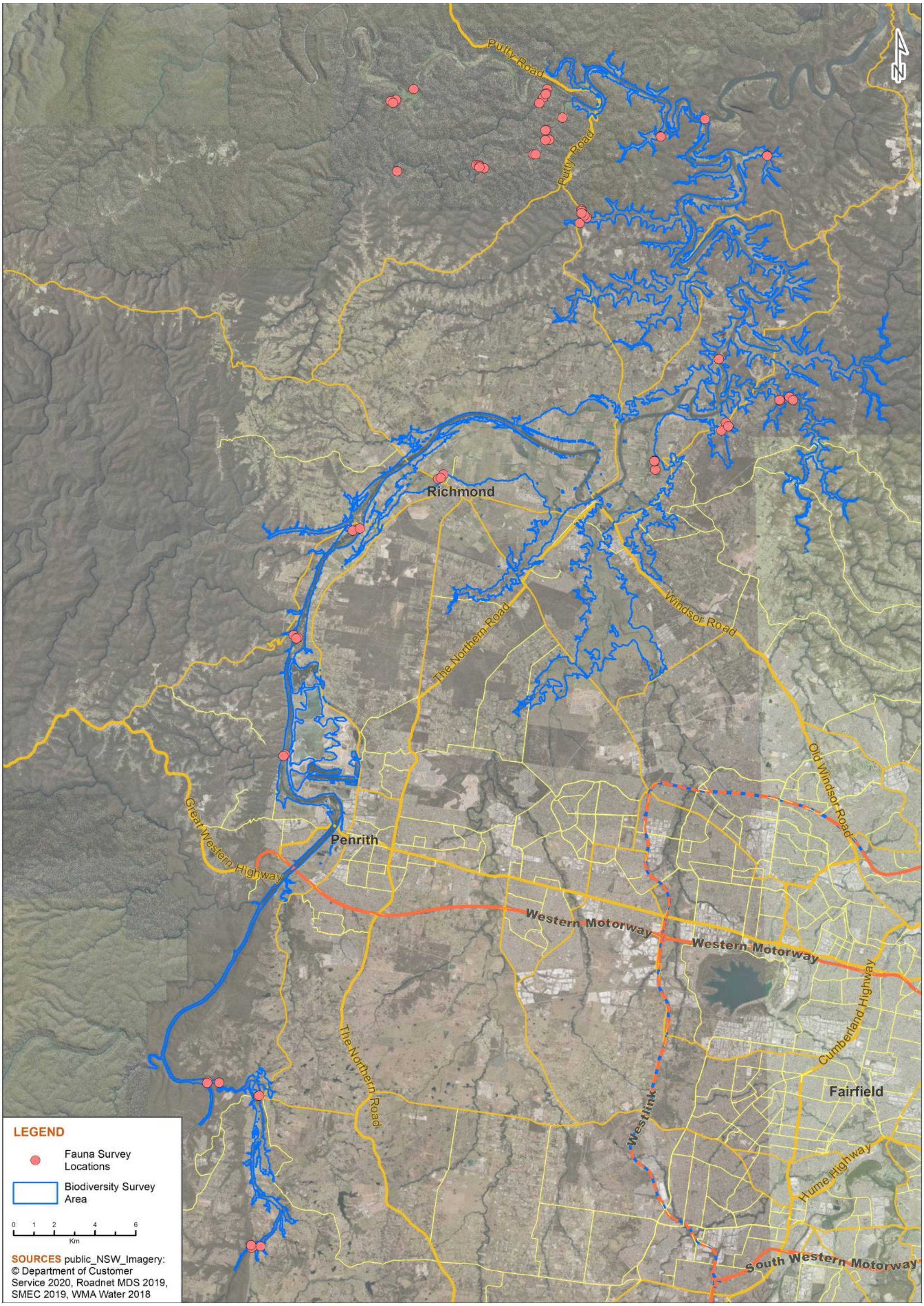
The locations of threatened fauna surveys are shown on Figure 4-2. Fauna survey methods, dates and survey effort are outlined in Table 4-2.

Table 4-2. Summary of targeted fauna survey effort

Survey type	Target species	Dates	Survey effort	Description
Infrared cameras	Spotted-tail Quoll Southern Brown Bandicoot	11/4/18 - 1/6/18	408 trap nights	Four infrared camera traps were placed in two locations to target nocturnal and diurnal ground-dwelling mammalian fauna (Figure 4-2). Cameras (PC900 Hyperfire, Reconyx, USA) were placed 1 m from bait stations which consisted of a PVC pipe containing rolled oats and peanut butter staked to the ground.
Hair funnels	Southern Brown Bandicoot	11/4/18 - 1/6/18	112 trap nights	Next to each camera described above, a single hair funnel was placed using the same bait. This was to aid in the identification of species that are difficult to distinguish in a grey-scale image, should they be detected. Hair samples collected were sent to Barbara Triggs, a recognised expert on the identification of mammalian traces, for identification.
Ultrasonic call detection	Threatened microchiropteran bats with a moderate or high likelihood of occurrence.	17/1/18 - 12/4/18	30 nights	Ultrasonic call detectors (SongMeter4BAT FS, Wildlife Acoustics, USA) were deployed all night (minimum eight hours) for at least two nights per site at six sites to record the echolocation calls of microchiropteran bats (microbats). Locations were chosen as having suitable flyways to maximise the potential for bat detection (Figure 4-2). Recorded calls were converted to zero crossing using Kaleidoscope (Version 4.1.0a, Wildlife Acoustics, USA), sorted and sent to Dr Brad Law (Principal Research Scientist, NSW Primary Industries) for analysis
Diurnal bird surveys	Threatened wetland birds with a moderate or high likelihood of occurrence.	17/1/18 - 10/4/18	24 hours, 48 mins	Surveys were undertaken for both woodland and wetland birds, targeted wetlands, and vegetation along the Hawkesbury River. Dawn and dusk bird surveys were undertaken within three hours of sunrise and sunset, respectively, by two observers. Eleven sites were surveyed, with most sites being surveyed twice on two separate days (Figure 4-2). Surveys lasted at least 30 minutes and involved a random meander from the start point where suitable habitat occurred within a two-hectare area. Species were identified visually or by vocalisations using *The Morcombe and Stewart Guide to Birds of Australia* (Cool Ideas LLC, 2014) as a reference guide.
Call playback and spotlighting	Eastern Grass Owl Australasian Bittern	9/4/18 - 13/4/18	14 hours	Call playback was undertaken at three sites in the Colo River catchment (Figure 4-2). The sites were chosen based on the presence of intact wetland vegetation. The survey included at least two call playback events at each location on separate nights and was preceded by a 10-minute listening period. Recorded calls were then broadcast for five minutes using an MP3 player and megaphone, followed by a 10-minute period of listening for a response. This was followed by localised spotlight searches and subsequent intermittent call playback to check for individuals that may have moved closer to investigate but had not audibly responded.

Survey type	Target species	Dates	Survey effort	Description
				Calls played during the survey included the Australasian Bittern (*Botaurus poiciloptilus*) and Eastern Grass Owl (*Tyto longimembris*).
KSAT	Koala	11/4/18 - 12/4/18	3 sites (90 trees)	30 trees were sampled at each KSAT site. Three sites that provided suitable feed trees for the koala or had historical records of the species' occurrence and were not overgrown by exotic vegetation were surveyed on 11 and 12 April 2018. The following methods from Phillips and Callaghan (2011) were adopted: 4. Locate and mark with flagging tape one tree (the focal tree) that meets one or more of the following selection criteria: (a) a tree of any species, beneath which, one or more koala faecal pellets has been observed (b) a tree in which a koala has been observed; and/or (c) any other tree known to be potentially important for the koala (for example, recognised koala food trees). 5. Identify and uniquely mark the 29 nearest koala habitat trees to this tree. 6. Undertake a search for koala faecal pellets beneath each of the 30 marked trees, based on a cursory inspection of the undisturbed ground surface within a distance of 100 centimetres around the base of each tree, followed (if no faecal pellets are initially detected) by a more thorough inspection involving disturbance of the leaf litter and ground cover within the prescribed search area. Only trees greater than ten centimetres diameter at breast height (DBH) or four metres in height were selected. As no previous koala records were known, or evidence of scats observed upon commencement of the survey, a tree recognised as a koala feed tree (as described by 1 (c) above) was utilised as the focal tree. A maximum of two person-minutes per tree was dedicated to the faecal pellet search. The search concluded either once a faecal pellet was found or when the two person-minutes were expired, whichever came first. A brief search of each tree was also made to determine the presence or absence of Koalas. Scat samples collected were sent to Barbara Triggs, a recognised expert on the identification of mammalian traces, for identification.

Figure 4-2. Fauna survey locations



4.4 Weather conditions

Long-term weather conditions for Penrith Lakes Automatic Weather Station (AWS) and Richmond Royal Australian Air Force (RAAF) are illustrated in Figure 4-3 and Figure 4-4, respectively. The figures show that temperatures during the summer of 2017/2018 were generally higher than the recorded averages. Rainfall was lower than the monthly averages in the beginning of 2018.

Figure 4-3. Long-term weather conditions recorded at Penrith Lakes

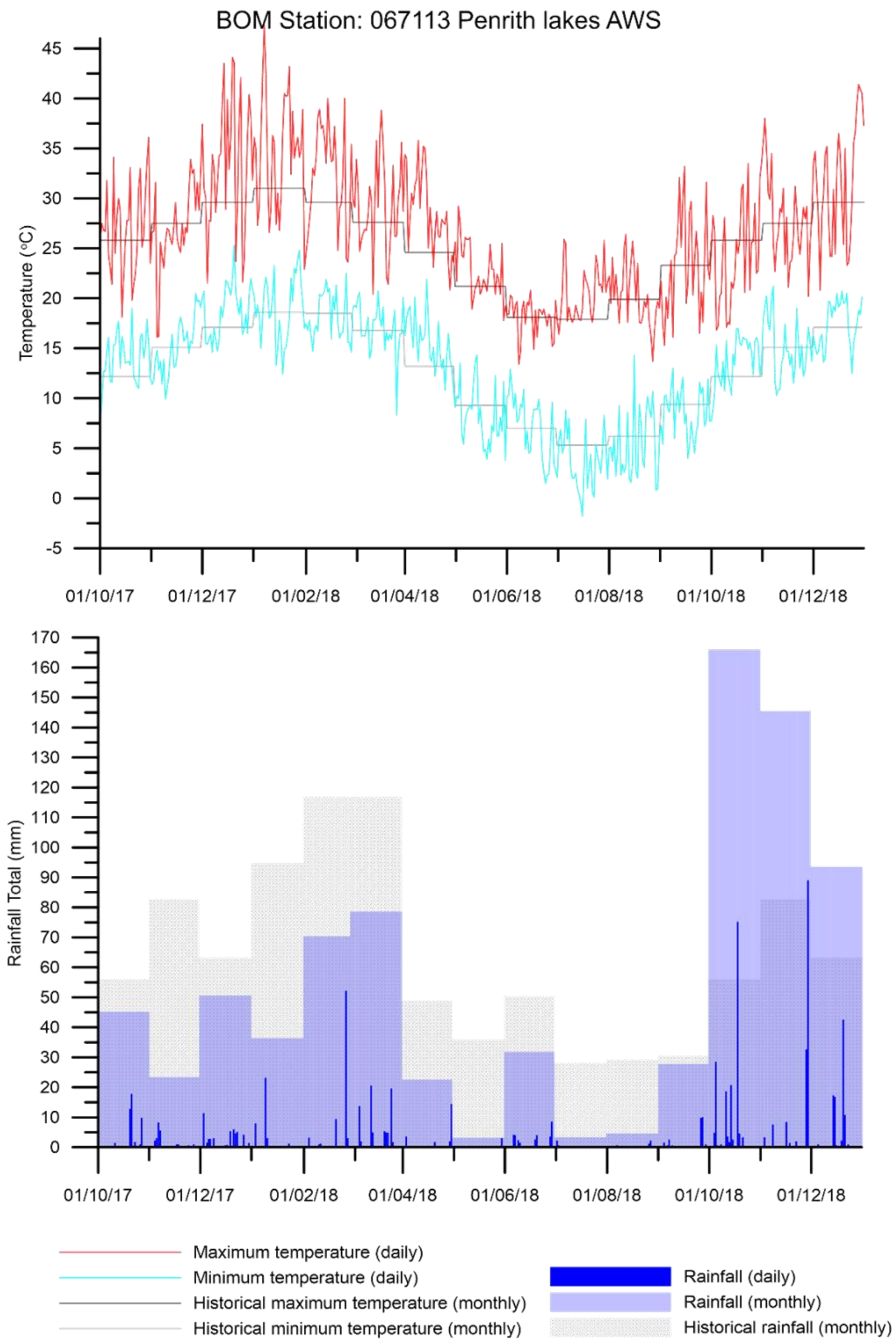
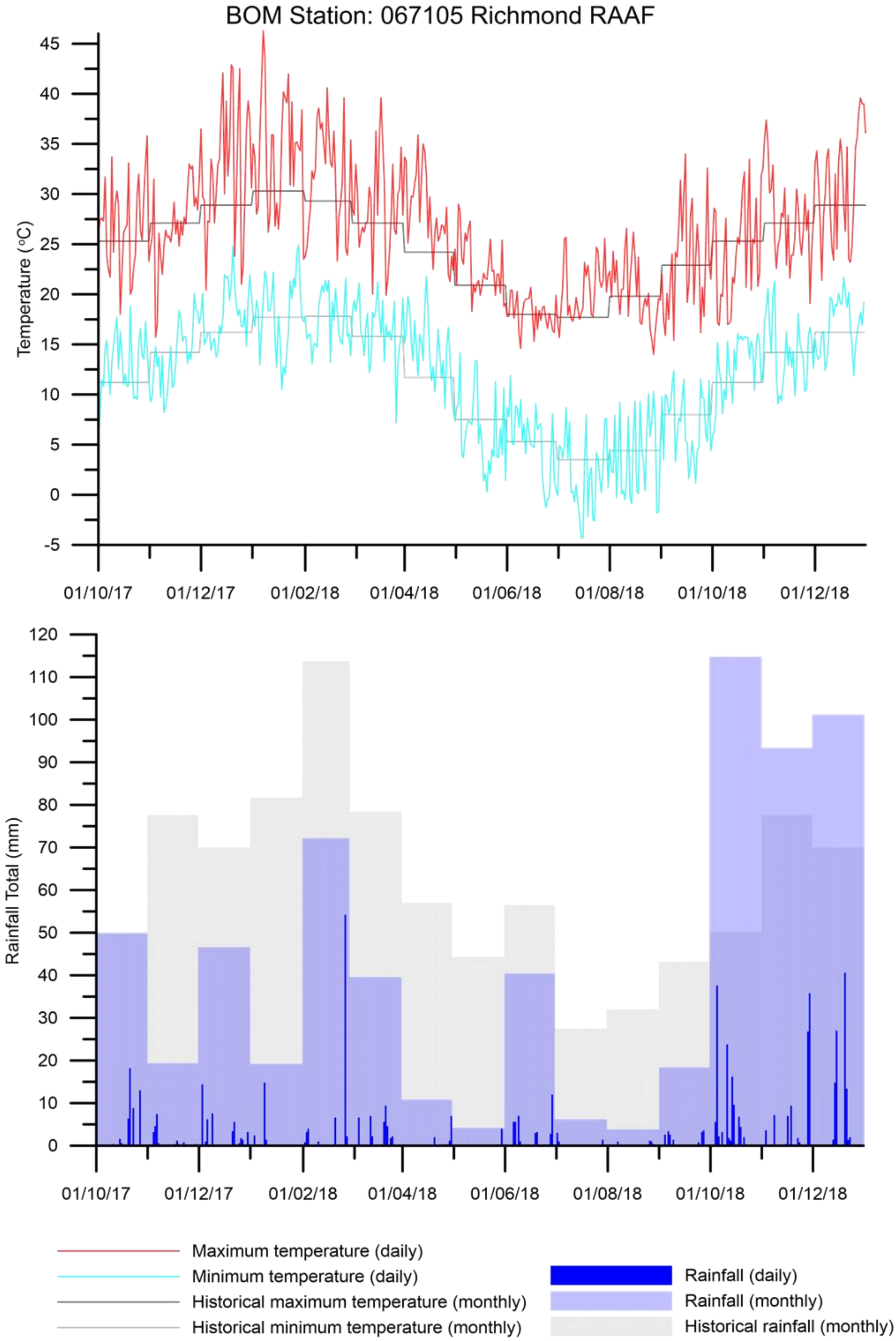


Figure 4-4. Long-term weather conditions recorded at Richmond RAAF



4.5 Limitations

The field survey was limited, in the first instance, to areas that were publicly accessible (for example, national parks and state conservation areas). Given the survey area encompassed hundreds of private lots, obtaining permission to access these lots presented a significant limitation. As such, field validation across the Cumberland Plain and the Colo region (from Warragamba Dam to Lower Colo) concentrated on publicly accessible land to inform vegetation mapping validation and fauna habitat assumptions. While access to a number of private lots was obtained by SMEC, many landholdings were inaccessible for verification assessments of the vegetation across the survey area.

As not all of the survey area could be ground-truthed, aerial photographic interpretation coupled with the interpretation of soil profiles and existing vegetation mapping products were used to extrapolate the final vegetation mapping and understanding of fauna habitat. Using aerial photography to determine the condition classes of each PCT was restricted due to the inability to determine the weed coverage. For such vegetation, a conservative approach was taken to capture all potential floristic and structural value with the potential to occur with or without the presence of weeds, with such vegetation assigned to the 'Moderate/good' condition class. In assessing the extent of TECs and threatened fauna habitat, this approach was used to ensure all the biodiversity and conservation value of the assessed vegetation and habitat was captured.

Not all of the vegetation occurring within the PMF boundaries (the existing PMF and the PMF after raising Warragamba Dam Wall) could be mapped to a PCT. The areas that could not be mapped to a PCT primarily occurred in the north west of the study area. This vegetation could not be mapped to a PCT because it could not be ground-truthed (primarily because of private property access constraints) or because it was not covered by a previous mapping project that identified vegetation to the PCT level. This is not considered to be a material issue for the assessment given the PMF event is unlikely to occur in nature.

The surveys and vegetation mapping have been conducted within the survey area described in Section 1.6.

5 Existing environment

5.1 Vegetation communities

Identification of the PCTs occurring within the survey area was guided by the review of the existing data and the vegetation surveys. The data collected during the surveys was analysed in conjunction with a review of the PCTs described within the VIS Classification Database and previously published vegetation mapping. Consideration was given to the following:

- occurrences within the Cumberland, Wollemi and Yengo IBRA subregions
- vegetation formation
- landscape position
- soil type and edaphics
- the dominant upper, mid and ground cover taxa.

Twenty-one PCTs were identified within the survey area. These PCTs occur as large vegetated remnants of the Cumberland Plain forests and woodlands, as scattered fragments of native vegetation and as protected national parks and state conservation areas. The condition of these PCTs varies from intact native vegetation to remnant stands of vegetation that are comprised of an understorey consisting of predominantly non-native invasive species. Large extents of the survey area have previously been cleared for agriculture and development creating large modified areas.

As outlined in Section 4.2.4, PCTs within the survey area were allocated to relevant condition classes. Each condition class and PCT combination was split into a vegetation zone. Due to a history of vegetation clearance, resource extraction and invasion of non-native invasive flora species, most of the recorded PCTs in the survey area occur in multiple condition classes. As such, the vegetation in the survey area has been stratified into 47 vegetation zones.

Table 5-1 lists the PCTs that have been identified within the survey area and the justification for their selection. Appendix B of this report includes detailed descriptions of each PCT in the survey area. Appendix C of this report includes all plot/transect data recorded from the floristic surveys.

Figure 5-1 shows the vegetation mapping in the survey area.

PCT and vegetation zone survey effort is shown in Table 5-2.

Table 5-1. Justification for PCT alignments within the survey area

PCT code/ BVT code	PCT name	Evidence used for identification	Characteristic species	Condition zones	Extent in the survey area (ha)
PCT 1067 HN562	Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Dry Sclerophyll Forest (Shrubby sub-formation) **Landscape position**: Windsor Downs and Shane's Park areas	**Upper stratum species**: *Eucalyptus parramattensis* subsp. *parramattensis* **Mid stratum species**: *Melaleuca decora, Melaleuca nodosa, Pultenaea villosa* **Ground stratum species**: *Juncus usitatus, Lobelia purpurascens, Themeda triandra*	**Moderate/good**	3.62
PCT 1106 NR223	River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	**IBRA Subregion**: Wollemi and Yengo **Vegetation formation**: Forested Wetland **Landscape position**: Along the waterways within the survey area.	**Upper stratum species**: *Casuarina cunninghamiana, Angophora floribunda, Angophora subvelutina.* **Mid stratum species**: *Backhousia myrtifolia, Tristaniopsis laurina.* **Ground stratum species**: *Microlaena stipoides* var. *stipoides* and *Cheilanthes sieberi* subsp. *sieberi.*	**Moderate/good** **Moderate/good_good** **Moderate/good_medium** **Moderate/good_low**	151.28
PCT 1181 HN586	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Dry Sclerophyll Forests (Shrubby sub-formation) **Landscape position**: Drier slopes	**Upper stratum species**: *Angophora costata, Corymbia gummifera* **Mid stratum species**: *Banksia serrata, Allocasuarina littoralis* **Ground stratum species**: *Entolasia stricta, Lepidosperma laterale*	**Moderate/good_good** **Moderate/good** **Moderate/good_medium** **Moderate/good_low**	385.81
PCT 1183 HN587	Smooth-barked Apple - Sydney Peppermint – Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion	**IBRA Subregion**: Yengo and Cumberland **Vegetation formation**: Dry Sclerophyll Forest (Shrubby sub-formation) **Landscape position**: Raised areas along the lower Colo and Hawkesbury Rivers	**Upper stratum species**: *Angophora costata, Eucalyptus piperita, Syncarpia glomulifera* **Mid stratum species**: *Pittosporum undulatum, Acacia elata, Allocasuarina torulosa* **Ground stratum species**: *Gonocarpus teucrioides, Lepidosperma laterale, Pteridium esculentum*	**Moderate/good** **Moderate/good_medium**	12.84
PCT 1284 HN606	Turpentine – Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion.	**IBRA Subregion**: Wollemi and Yengo **Vegetation formation**: Wet Sclerophyll Forests (Shrubby sub-formation)	**Upper stratum species**: *Syncarpia glomulifera subsp. glomulifera, Angophora costata* **Mid stratum species**: *Allocasuarina torulosa, Elaeocarpus reticulatus*	**Moderate/good** **Moderate/good_medium** **Moderate/good_low**	36.08

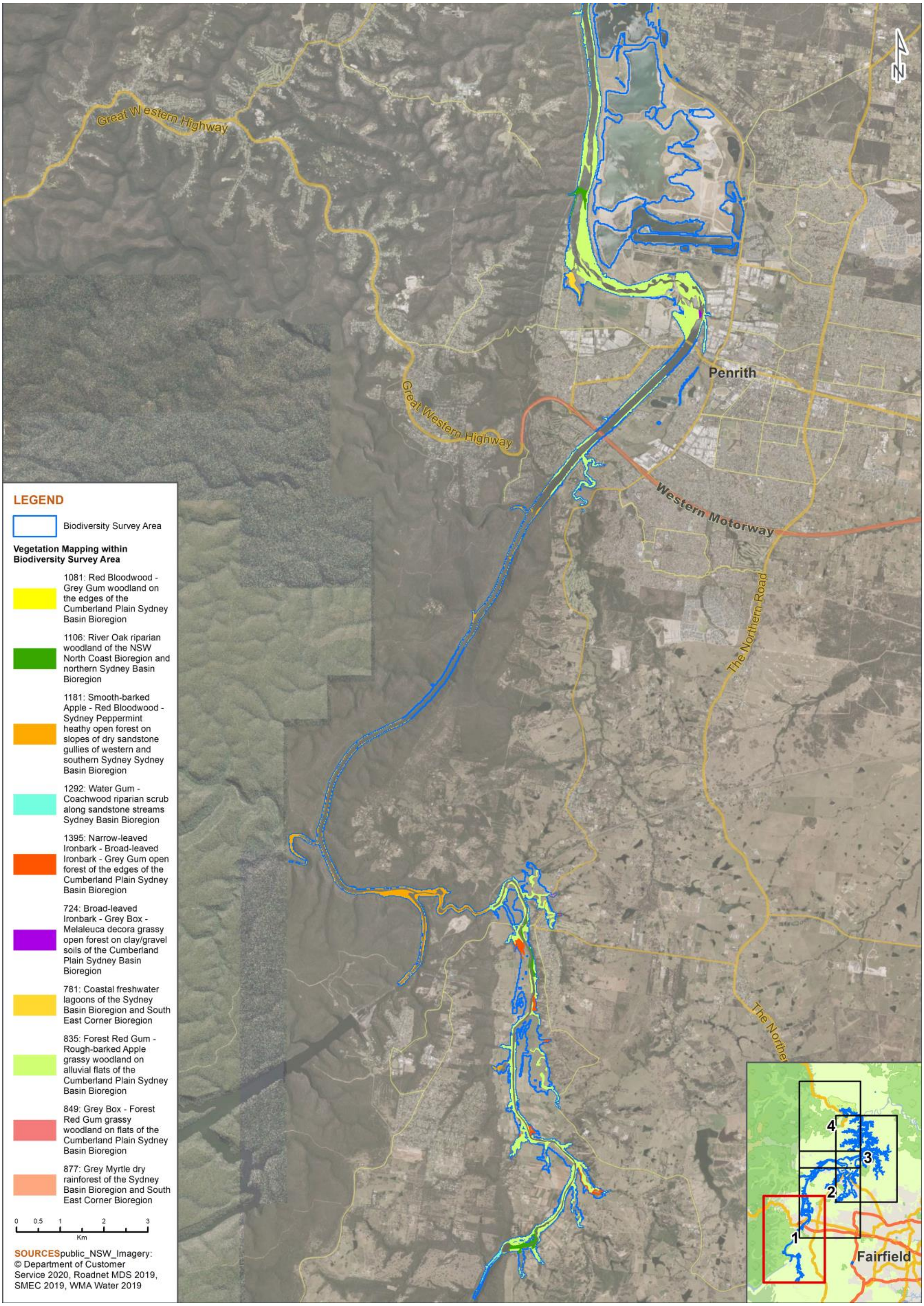
PCT code/ BVT code	PCT name	Evidence used for identification	Characteristic species	Condition zones	Extent in the survey area (ha)
		Landscape position: Slopes along the lower Colo River, lower Hawkesbury River and Wheeny Creek.	**Ground stratum species**: *Eustrephus latifolius, Geitonoplesium cymosum*		
PCT 1292 HN607	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Forested Wetland **Landscape position**: Bents Basin and Currency Creek	**Upper stratum species**: *Tristaniopsis laurina, Ceratopetalum apetalum* **Mid stratum species**: *Lomatia myricoides* **Ground stratum species**: *Lomandra longifolia, Entolasia stricta, Schoenus melanostachys; Sticherus flabellatus*	**Moderate/good**	7.14
PCT 1327 HN612	Yellow Bloodwood – Ironbark shrubby woodland of the dry hinterland of the Central Coast, Sydney Basin Bioregion	**IBRA Subregion**: Wollemi and Yengo **Vegetation formation**: Dry Sclerophyll Forests (Shrubby sub-formation) **Landscape position**: Two locations; lower Colo River and along Cattai Creek	**Upper stratum species**: *Corymbia eximia, Eucalyptus fibrosa* **Mid stratum species**: *Allocasuarina torulosa, Elaeocarpus reticulatus* **Ground stratum species**: *Hardenbergia violacea, Pomax umbellata*	**Moderate/good**	0.83
PCT 1328 HN613	Yellow Bloodwood – Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast, Sydney Basin Bioregion.	**IBRA Subregion**: Yengo **Vegetation formation**: Dry Sclerophyll Forest (Shrubby sub-formation) **Landscape position**: Rises along the Lower Colo and lower Hawkesbury Rivers	**Upper stratum species**: *Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata* **Mid stratum species**: *Acacia parramattensis, Allocasuarina littoralis* **Ground stratum species**: *Lepidosperma laterale, Cheilanthes sieberi* subsp. *sieberi*	**Moderate/good_good** **Moderate/good**	0.36
PCT 1385 HN577	Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast, Sydney Basin Bioregion	**IBRA Subregion**: Yengo **Vegetation formation**: Wet Sclerophyll Forest (Grassy sub-formation) **Landscape position**: Predominantly along the hills in the Lower Colo River area.	**Upper stratum species**: *Angophora floribunda, Eucalyptus punctata* **Mid stratum species**: *Jacksonia scoparia, Allocasuarina torulosa* **Ground stratum species**: *Lobelia purpurascens, Themeda triandra, Billardiera scandens*	**Moderate/good** **Moderate/good_medium** **Moderate/good_low**	35.83
PCT 1395 HN556	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Grassy Woodlands **Landscape position**: Dry slopes associated with the Hawkesbury River	**Upper stratum species**: *Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata* **Mid stratum species**: *Acacia parramattensis, Allocasuarina littoralis, Persoonia linearis*	**Moderate/good** **Moderate/good_medium** **Moderate/good_low** **Moderate/good_derived**	360.56

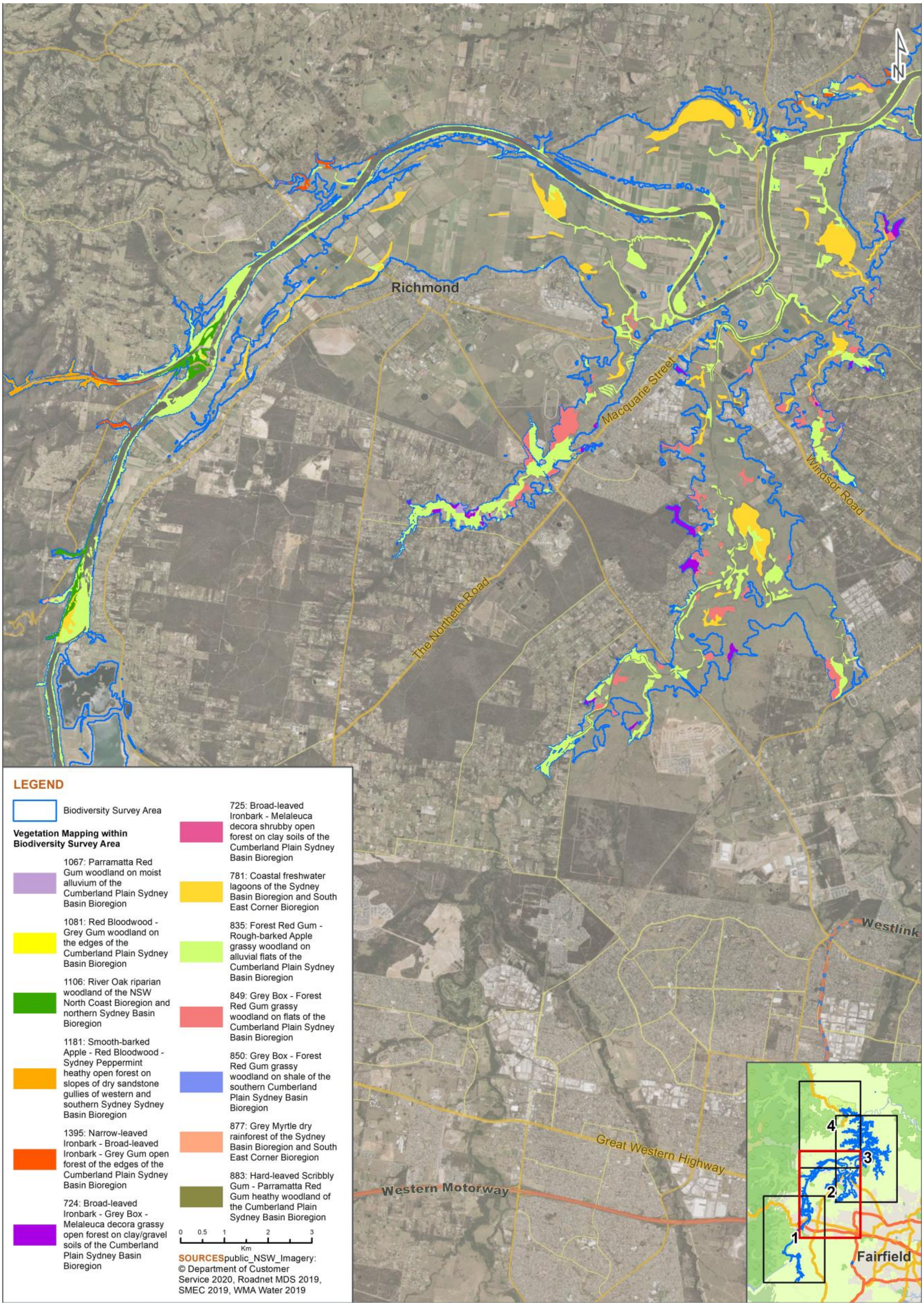
PCT code/ BVT code	PCT name	Evidence used for identification	Characteristic species	Condition zones	Extent in the survey area (ha)
			Ground stratum species: *Lepidosperma laterale, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans*		
PCT 1504 HN647	Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion	**IBRA Subregion**: Wollemi and Yengo **Vegetation formation**: Wet Sclerophyll Forest (Grassy sub-formation) **Landscape position**: River-flats associated with the Lower Colo and Hawkesbury Rivers.	**Upper stratum species**: *Eucalyptus saligna, Eucalyptus deanei, Eucalyptus elata* **Mid stratum species**: *Acmena smithii, Backhousia myrtifolia, Tristaniopsis laurina* **Ground stratum species**: *Lomandra longifolia, Microlaena stipoides* var. *stipoides*	**Moderate/good_good** **Moderate/good** **Moderate/good_medium** **Moderate/good_low** **Moderate/good_derived**	59.93
PCT 1557 HN665	Rough-barked Apple – Forest Oak – Grey Gum grassy woodland on sandstone ranges of the Sydney Basin	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Dry Sclerophyll Forest **Landscape position**: Sandstone ridges surrounding Cattai National Park.	**Upper stratum species**: *Eucalyptus punctata, Corymbia eximia, Angophora bakeri* **Mid stratum species**: *Allocasuarina littoralis, Leptospermum trinervium* **Ground stratum species**: *Lomandra filiformis, Lomandra longifolia, Lepidosperma laterale*	**Moderate/good**	0.52
PCT 1718 HU932	Swamp Mahogany – Flax-leaved paperbark swamp forest on coastal lowlands of the Central Coast	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Forested Wetland **Landscape position**: lowlands and swamps around Maroota Ridge SCA	**Upper stratum species**: *Eucalyptus robusta, Melaleuca linariifolia* **Mid stratum species**: *Pittosporum undulatum, Leptospermum polygalifolium, Glochidion ferdinandi* **Ground stratum species**: *Dianella revoluta, Dianella caerulea, Dichondra repens*	**Moderate/good_good** **Moderate/good**	4.08
PCT 724 HN512	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland **Vegetation formation**: Dry Sclerophyll Forest (Shrub/grass sub-formation) **Landscape position**: Low-lying and/or flat areas associated with the Cumberland Plain.	**Upper stratum species**: *Eucalyptus fibrosa, Melaleuca decora* **Mid stratum species**: *Acacia parramattensis, Lissanthe strigosa, Bursaria spinosa subsp. spinosa* **Ground stratum species**: *Microlaena stipoides var. stipoides, Cheilanthes sieberi subsp. sieberi, Aristida vagans*	**Moderate/good_good** **Moderate/good** **Moderate/good_medium** **Moderate/good_low**	62.29
PCT 725 HN513	Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the	**IBRA Subregion**: Cumberland and Yengo	**Upper stratum species**: *Eucalyptus fibrosa, Melaleuca decora*	**Moderate/good**	0.12

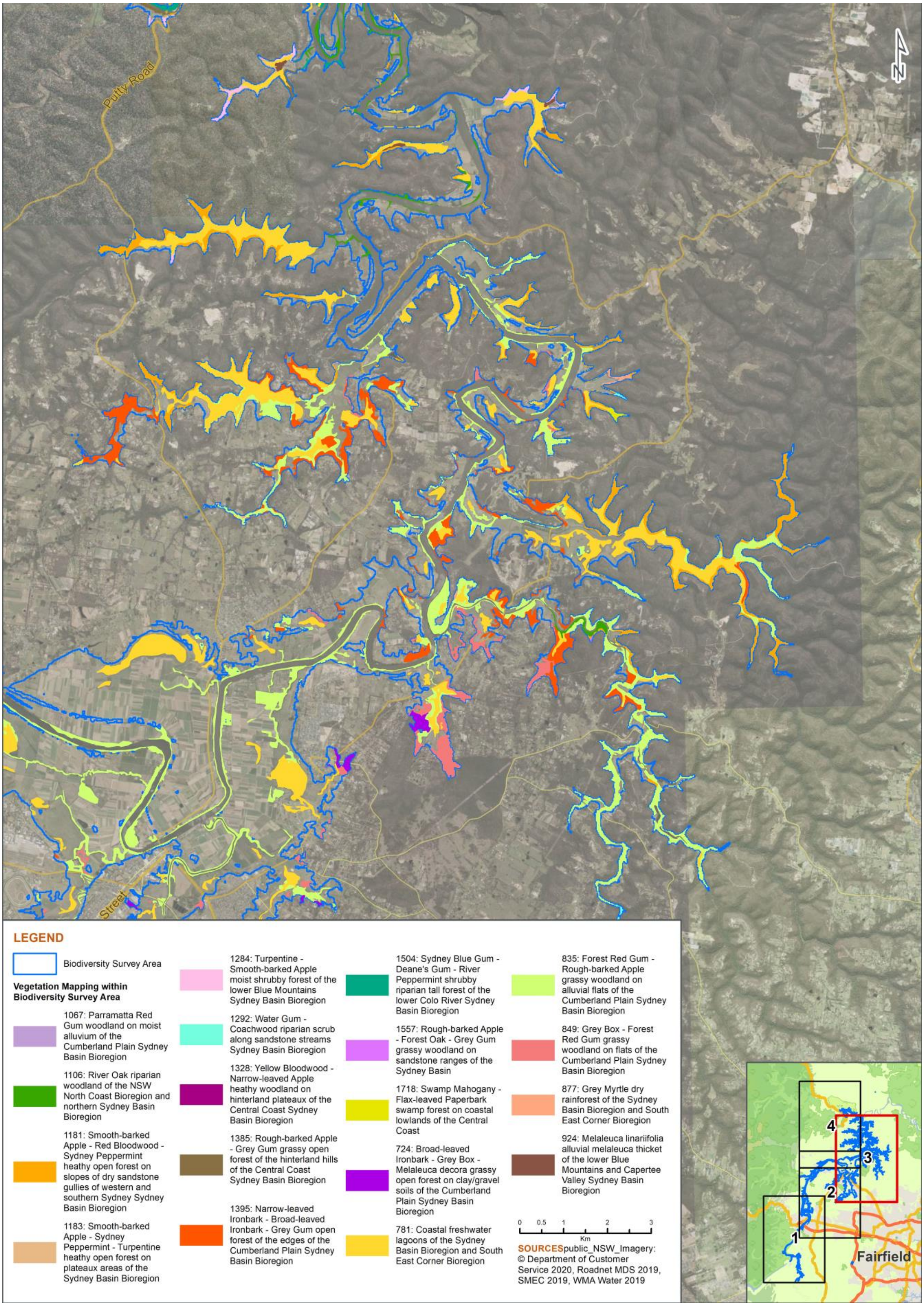
PCT code/ BVT code	PCT name	Evidence used for identification	Characteristic species	Condition zones	Extent in the survey area (ha)
	Cumberland Plain Sydney Basin Bioregion	**Vegetation formation**: Dry sclerophyll Forest **Landscape position**: lowlands and swamps around Maroota Ridge SCA	**Mid stratum species**: *Melaleuca nodosa, Acacia falcata, Bursaria spinosa* subsp. *spinosa, Ozothamnus diosmifolius* **Ground stratum species**: *Entolasia stricta, Microlaena stipoides* var. *stipoides, Cheilanthes sieberi* subsp. *sieberi, Lobelia purpurascens, Lomandra multiflora, Dianella caerulea, Lepidosperma laterale, Themeda triandra* **.**		
PCT 781 HN520	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	**IBRA Subregion**: Cumberland **Vegetation formation**: Freshwater Wetlands **Landscape position**: Low-lying areas throughout the survey area.	**Upper stratum species (occasional)**: *Casuarina glauca, Melaleuca ericifolia, Melaleuca decora* **Mid stratum species**: NA **Ground stratum species**: *Eleocharis sphacelata, Phragmites australis, Typha orientalis, Baumea rubiginosa*	**Moderate/good_good** **Moderate/good** **Moderate/good_medium** **Moderate/good_low** **Moderate/good_other** **Moderate/good_derived**	1,086.55
PCT 835 HN526	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland and Yengo **Vegetation formation**: Forested Wetlands **Landscape position**: Low-lying areas associated with the Hawkesbury and lower Nepean Rivers	**Upper stratum species**: *Eucalyptus tereticornis, Casuarina glauca, Angophora floribunda* **Mid stratum species**: *Acacia parramattensis, Lissanthe strigosa, Bursaria spinosa subsp. spinosa* **Ground stratum species**: *Microlaena stipoides* var. *stipoides, Oplismenus aemulus; Dichondra repens*	**Moderate/good_good** **Moderate/good** **Moderate/good_medium** **Moderate/good_low** **Moderate/good_derived**	1,903.59
PCT 849 HN528	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion**: Cumberland and Yengo **Vegetation formation**: Grassy Woodland **Landscape position**: Low-lying and/or flat areas associated with the Cumberland Plain	**Upper stratum species**: *Eucalyptus moluccana, Eucalyptus tereticornis* **Mid stratum species**: *Acacia parramattensis, Lissanthe strigosa, Bursaria spinosa* subsp. *spinosa* **Ground stratum species**: *Microlaena stipoides* var. *stipoides, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans*	**Moderate/good** **Moderate/good_medium** **Moderate/good_low**	275.67
PCT 866 HU554	Grey Gum - Smooth-barked Apple open forest of the dry	**IBRA Subregion**: Yengo and Cumberland **Vegetation formation**: Dry Sclerophyll Forest (Shrubby sub-formation)	**Upper stratum species**: *Eucalyptus punctata, Angophora costata, Syncarpia glomulifera*	**Moderate/good**	3.02

PCT code/ BVT code	PCT name	Evidence used for identification	Characteristic species	Condition zones	Extent in the survey area (ha)
	hinterland of the Central Coast, Sydney Basin Bioregion	**Landscape position**: Along the lower Colo and upper Hawkesbury Rivers	**Mid stratum species**: *Exocarpos strictus, Allocasuarina torulosa* **Ground stratum species**: *Goodenia heterophylla; Hardenbergia violacea, Pomax umbellata*		
PCT 877 HN538	Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	**IBRA Subregion**: Cumberland, Wollemi and Yengo **Vegetation formation**: Rainforests **Landscape position**: Sheltered slopes and gullies across the survey area	**Upper stratum species**: *Backhousia myrtifolia, Glochidion ferdinandi, Acmena smithii* **Mid stratum species**: *Notelaea longifolia, Breynia oblongifolia, Sigesbeckia orientalis* **Ground stratum species**: *Adiantum aethiopicum, Pellaea falcata, Dichondra repens*	**Moderate/good_good** **Moderate/good**	9.22
PCT 924 HN552	*Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion	**IBRA Subregion**: Wollemi and Yengo **Vegetation formation**: Forested Wetland **Landscape position**: Low-lying areas.	**Upper stratum species**: *Melaleuca linariifolia, Melaleuca decora* **Mid stratum species**: NA **Ground stratum species**: *Paspalum distichum, Phragmites australis, Typha orientalis*	**Moderate/good**	36.46

Figure 5-1. Plant community types (PCTs) in the survey area




Richmond
Macquarie Street
Windsor Road
The Northern Road
Westlink
Great Western Highway
Western Motorway
Fairfield
1
2
3
4
LEGEND
Biodiversity Survey Area
Vegetation Mapping within Biodiversity Survey Area
1067: Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion
1081: Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain Sydney Basin Bioregion
1106: River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Sydney Basin Bioregion
1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
725: Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
850: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
877: Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
883: Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain Sydney Basin Bioregion
0 0.5 1 2 3
Km
SOURCES public_NSW_Imagery: © Department of Customer Service 2020, Roadnet MDS 2019, SMEC 2019, WMA Water 2019


Putty Road
Street
LEGEND
Biodiversity Survey Area
Vegetation Mapping within Biodiversity Survey Area
1067: Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion
1106: River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Sydney Basin Bioregion
1183: Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion
1292: Water Gum - Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion
1328: Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast Sydney Basin Bioregion
1385: Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast Sydney Basin Bioregion
1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River Sydney Basin Bioregion
1557: Rough-barked Apple - Forest Oak - Grey Gum grassy woodland on sandstone ranges of the Sydney Basin
1718: Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
877: Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
924: Melaleuca linariifolia alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley Sydney Basin Bioregion
0 0.5 1 2 3
Km
SOURCESpublic_NSW_Imagery: © Department of Customer Service 2020, Roadnet MDS 2019, SMEC 2019, WMA Water 2019
1
2
3
4
Fairfield

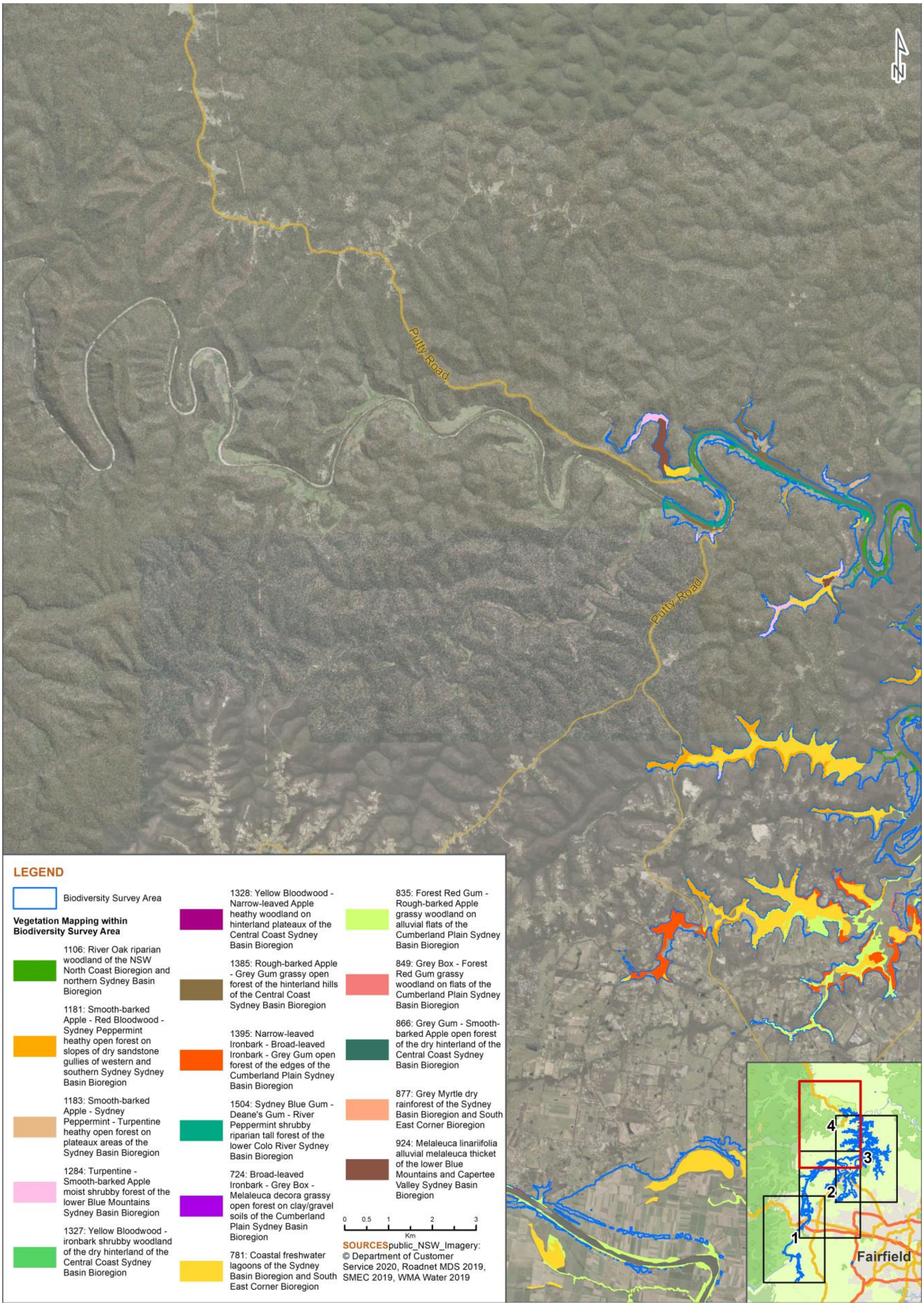

Putty Road
Putty Road
LEGEND
Biodiversity Survey Area
Vegetation Mapping within Biodiversity Survey Area
1106: River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Sydney Basin Bioregion
1183: Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion
1327: Yellow Bloodwood - ironbark shrubby woodland of the dry hinterland of the Central Coast Sydney Basin Bioregion
1328: Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast Sydney Basin Bioregion
1385: Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast Sydney Basin Bioregion
1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River Sydney Basin Bioregion
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
866: Grey Gum - Smooth-barked Apple open forest of the dry hinterland of the Central Coast Sydney Basin Bioregion
877: Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
924: Melaleuca linariifolia alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley Sydney Basin Bioregion
0 0.5 1 2 3
Km
SOURCESpublic_NSW_Imagery: © Department of Customer Service 2020, Roadnet MDS 2019, SMEC 2019, WMA Water 2019
4
3
2
1
Fairfield

Table 5-2. PCT and vegetation zone survey effort

PCT	Vegetation zone	Number of plots/transects*	Area in survey area (ha)
PCT 1067 (HN562)	Moderate/good	-	3.62
PCT 1106 (NR223)	Moderate/good_good	-	7.38
	Moderate/good	-	80.73
	Moderate/good_medium	3	38.46
	Moderate/good_low	-	24.71
PCT 1181 (HN586)	Moderate/good_good	1	2.41
	Moderate/good	5	349.92
	Moderate/good_medium	1	11.87
	Moderate/good_low	-	21.61
PCT 1183 (HN587)	Moderate/good	1	9.68
	Moderate/good_medium	-	3.16
PCT 1284 (HN606)	Moderate/good	5	30.95
	Moderate/good_medium	2	1.24
	Moderate/good_low	-	3.90
PCT 1292 (HN607)	Moderate/good	2	7.14
PCT 1327 (HN612)	Moderate/good	-	0.83
PCT 1328 (HN613)	Moderate/good	-	0.36
PCT 1385 (HN577)	Moderate/good	-	26.12
	Moderate/good_medium	3	5.48
	Moderate/good_low	-	4.23
PCT 1395 (HN556)	Moderate/good	3	89.90
	Moderate/good_medium	1	196.23
	Moderate/good_low	-	52.51
	Moderate/good_derived	1	21.92
PCT 1504 (HN647)	Moderate/good_good	1	31.39
	Moderate/good	5	9.28
	Moderate/good_medium	1	0.13
	Moderate/good_low	10	17.77
	Moderate/good_derived	2	1.35
PCT 1557 (HN665)	Moderate/good	-	0.52
PCT 1718 (HU932)	Moderate/good_good	1	4.08
	Moderate/good	-	-
PCT 724 (HN512)	Moderate/good_good	3	4.25
	Moderate/good	4	23.67
	Moderate/good_medium	-	29.80
	Moderate/good_low	1	4.58
PCT 725 (HN513)	Moderate/good	-	0.12
PCT 781 (HN520)	Moderate/good_good	1	11.68
	Moderate/good	11	602.07
	Moderate/good_medium	2	2.97
	Moderate/good_low	4	469.15
	Moderate/good_derived	-	-
	Moderate/good_other	1	0.68

PCT	Vegetation zone	Number of plots/transects*	Area in survey area (ha)
PCT 835 (HN526)	Moderate/good_good	2	5.58
	Moderate/good	3	230.24
	Moderate/good_medium	9	1,459.82
	Moderate/good_low	2	205.13
	Moderate/good_derived	-	2.82
PCT 849 (HN528)	Moderate/good_good	-	0.04
	Moderate/good	-	42.66
	Moderate/good_medium	-	163.62
	Moderate/good_low	2	69.35
PCT 866 (HN554)	Moderate/good	-	3.02
PCT 877 (HN538)	Moderate/good_good	2	0.46
	Moderate/good	-	8.76
PCT 924 (HN552)	Moderate/good	5	36.46

* plots not done due to access constraints (refer also Section 4.2.3)

5.2 Threatened ecological communities

A list of TECs occurring or potentially occurring (moderate or high likelihood of occurrence) within the study area, as generated from the database analysis, is provided in Appendix A of this report. The database analysis identified 13 TECs as occurring or potentially occurring within the study area.

Based on the results of the vegetation surveys, and a review of the Final Determination of potentially occurring TECs, 13 TECs have been assessed as occurring within the survey area (Table 5-3 and Figure 5-2). Sixteen of the PCTs assessed as occurring in the survey area are components of the identified TECs. The PCT/TEC associations relevant to the vegetation in the survey area are shown on Table 5-3 with regard to both the BC Act and EPBC Act (where equivalent).

Where the occurrence of a PCT could not be ground-truthed, it has been assumed that the PCT meets the Final Determination of the listed TEC.

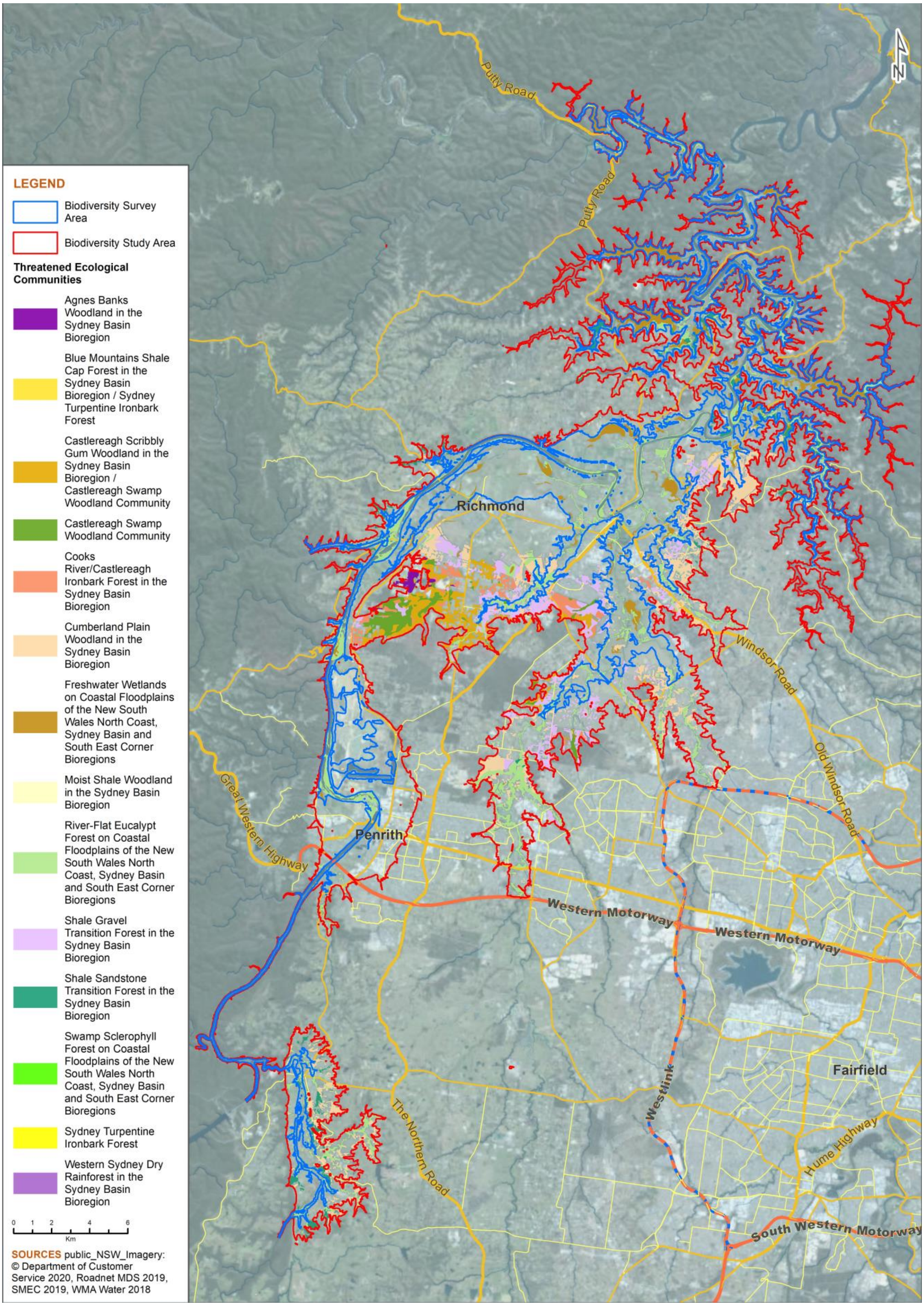
Table 5-3. PCT/TEC associations

BC Act status	EPBC Act status[3]	PCTs	Total area in survey area (ha)	Total area in study area (ha)
Shale Gravel Transition Forest in the Sydney Basin Bioregion EEC	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC*[1]	PCT 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	62.29	1,379.59
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC	Not listed	PCT 781 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	1,086.55	1,106.73
		PCT 924 - *Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion	36.46	36.63
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC	Preliminary determination for *Coastal Floodplain Eucalypt Forest of Eastern Australia*	PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	1,903.59	3,209.28
		PCT 1504 - Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion	59.93	60.94
		PCT 1106 - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	151.28	158.51
Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC*	PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	275.67	2,165.45
		PCT 850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	0.08	148.19
Western Sydney Dry Rainforest in the Sydney Basin Bioregion EEC	*Western Sydney Dry Rainforest and Moist Woodland on Shale CEEC*	PCT 877 - Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	9.22	19.54
Castlereagh Swamp Woodland Community EEC	Not listed	PCT 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	3.62	437.42

BC Act status	EPBC Act status[3]	PCTs	Total area in survey area (ha)	Total area in study area (ha)
Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC*	PCT 1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	360.56	708.78
Agnes Banks Woodland in the Sydney Basin Bioregion CEEC	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion EEC*[2]	PCT 958 - Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion	-	86.26
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion EEC	*Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion CEEC*	PCT 725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion	0.12	412.23
Moist Shale Woodland in the Sydney Basin Bioregion EEC	*Western Sydney Dry Rainforest and Moist Woodland on Shale CEEC*	PCT 830 - Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	-	6.86
Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion VEC	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion EEC*	PCT 883 - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	0.03	900.50
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC	Preliminary determination for *Melaleuca dominated Temperate Swamp Sclerophyll Forests on Coastal Floodplains of Eastern Australia*	PCT 1718 - Swamp Mahogany – Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast.	4.08	5.90
Blue Mountains Shale Cap Forest in the Sydney Basin Bioregion EEC (PCT 1284 is a potential equivalent to this TEC but this TEC is not considered present in the study area)	*Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC*	PCT 1284 - Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion	36.08	36.93
Sydney Turpentine Ironbark Forest CEEC				
Sydney Turpentine Ironbark Forest CEEC	*Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC*	PCT 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion	12.84	12.96

1. CEEC: Critically Endangered Ecological Community
2. EEC: Endangered Ecological Community
3. Detailed assessment of MNES provided in Appendix F5

Figure 5-2. Threatened ecological communities in the survey area



5.3 Groundwater dependent ecosystems

Two of the thirteen groundwater management areas (GWMAs) identified in the State of the Catchments 2010 report for the Hawkesbury-Nepean region[4] are relevant to the Project, these being the Hawkesbury Alluvium (alluvial GWMA) and the Sydney Basin–Central (porous rock GWMA).

The hydrogeological characteristics of the Sydney Basin bioregion has been described by Herron *et al*. (2018) as follows:

> *The alluvial deposits of the Hawkesbury River, extending downstream of Warragamba Dam to the township of Spencer, are referred to as the Hawkesbury Alluvium Groundwater Source. Alluvial deposits are broadest in the Windsor to Wilberforce area with most bores drilled in thinner alluvia of minor tributaries. … The Hawkesbury alluvium is a significant alluvial groundwater system with reasonable levels of storage.*

The main hydrogeological unit in the Sydney Basin–Central area is the Wianamatta Group. Two other hydrogeological units in this area are Quaternary-Cenozoic and Hawkesbury Sandstone. With regard to the Wianamatta Group, Herron *et al.* (2018) note:

> *The Wianamatta Group consists of three units: the Ashfield Shale, the Minchinbury Sandstone and the Bringelly Shale, with the Minchinbury Sandstone of negligible thickness (McNally, 2004). This group has a maximum thickness in western Sydney of up to 300 m, but with more typical thicknesses in the range of 100 to 150 m. The Wianamatta Group occurs as scattered remnant areas in the Southern Highlands, with major outcrops predominantly over the Cumberland Plain south-west of Richmond.*
>
> *In western Sydney, two aquifer systems are associated with the shale formations of the Wianamatta Group. The upper aquifer system comprises residual soils and colluvium derived from the shales, floodplain alluvium and the weathered saprolite, and typically has a depth of 3 to 10 m. Hydraulic conductivities show a large variability and range between 0.01 and 10-5 m/day, with the higher end suggesting the presence of open fractures in weathered shales or ferricrete bands. The lower aquifer system occurs below the base of the weathering and comprises fine-grained mudrocks. This aquifer shows some degree of fracturing thus allowing some groundwater flows. Despite its low transmissivities, McNally (2004) refers to this system as an aquifer because it discharges small volumes of saline water to the surface. Hydraulic conductivities range between 0.001 and 10-8 m/day, with the lower end reflecting the intrinsic impermeability of the unfractured shale.*
>
> *Both aquifers show limited storage and low bore yields, typically less than 0.1 ML/day (McNally, 2004; Parsons Brinckerhoff, 2013). Water-bearing fractures are widely spaced and sometimes poorly interconnected. This results in boreholes being dry when first drilled, then slowly filling with water over several weeks, causing substantial head and salinity variations in piezometers. Water within fractures is generally brackish to saline, especially in low relief areas, with typical values in the range of 5,000 to 50,000 mg/L TDS (McNally, 2004).*

The nature of groundwater recharge in the Sydney Basis is described as follows in Herron *et al*. (2018):

> *The dominant recharge mechanism in the geological Sydney Basin is likely to be infiltration of rainfall and runoff through alluvial deposits in valleys, particularly where they are incised into weathered Hawkesbury Sandstone (Parsons Brinckerhoff, 2011). Similarly, recharge through infiltration takes place where the underlying units of the Narrabeen Group outcrop. … Recharge for deeper sandstone aquifers comes mainly from infiltration of rainfall over outcropping areas and through inter-aquifer leakage (SCA, 2012). In the Southern Coalfields, the deeper aquifers occurring in the Bulgo and Scarborough sandstones (Narrabeen Group) outcrop in the valleys of the Cordeaux and Avon reservoirs and thus recharge is expected at times of higher water level (SCA, 2012).*

and

> *On a local scale, topography controls the groundwater flow near the ground surface in alluvial and shallow aquifers. In these systems, groundwater flow is likely to be localised and limited in extent, with occurrence of perched aquifers controlled by the presence of fine-grained materials. In general, these systems are responsive to rainfall and streamflow (SCA, 2012). On a regional scale, … groundwater flows for the geological Sydney Basin* [are] *controlled by the basin geometry, topography and major hydraulic boundaries.*

There are approximately 50 floodplain wetlands that are associated with the Hawkesbury-Nepean River downstream of Pheasants Nest and Broughtons Pass Weirs to the confluence of the Colo River, with the majority found between Richmond and Wisemans Ferry (Figure 2-2). Important wetlands include Pitt Town Lagoon and Longneck Lagoon,

[4] https://www.environment.nsw.gov.au/soc/sydneymetro.htm

which are examples of the Endangered Ecological Communities (EEC) Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions. There are no Ramsar listed wetlands, however some wetlands north of Agnes Banks are listed under State Environmental Policy (Coastal Management) 2018.

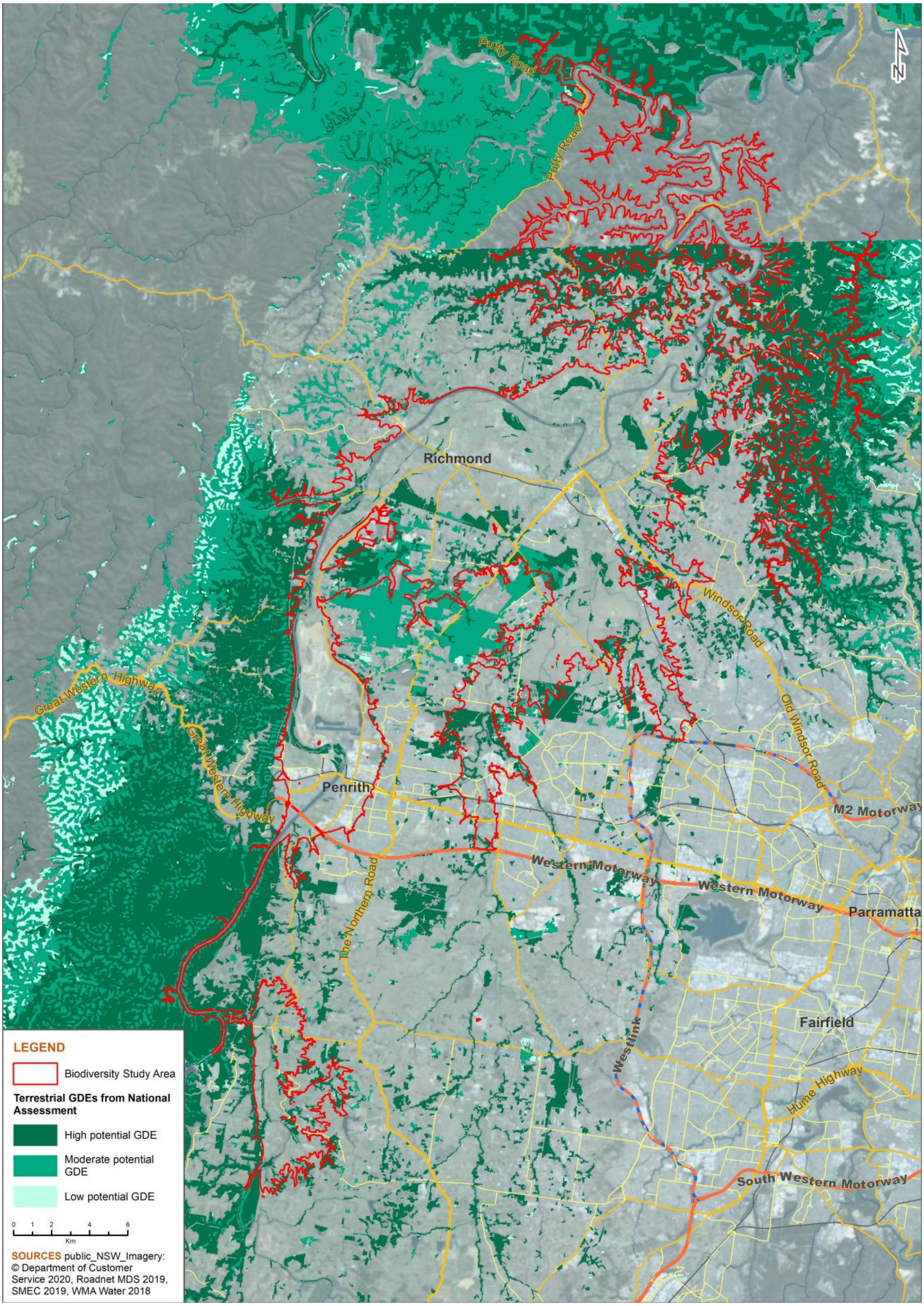
Groundwater dependent ecosystems (GDEs) have been classified to a corresponding vegetation type and mapped by the Bureau of Meteorology and Kuginis *et al.* in the Groundwater Dependent Ecosystems Atlas (BOM 2019). Sixty-two vegetation types were identified and classified according to their groundwater dependency potential, groundwater management area, position in the landscape and bioregion. This classification has been provided in Appendix G of this report. GDEs are shown on Figure 5-3.

Appendix 4 to the background document for the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (NSW Office of Water, 2011) lists identified high priority GDEs in the Greater Metropolitan Region. Of these, the following are relevant to the assessment:

- Pitt Town Lagoon (associated with the Hawkesbury Alluvium groundwater source)
- Long Swamp (associated with the Sydney Basin Central groundwater source)
- Longneck Lagoon (associated with the Sydney Basin Central groundwater source)
- O'Hares Creek (associated with the Sydney Basin Central groundwater source).

Downstream GDEs are considered to have limited reliance upon flows from the Warragamba catchment (Herron *et al*. (2018). Periodic inundation of floodplain areas under flood conditions represents only a minor contribution to groundwater, particularly compared with the contribution of infiltration from direct rainfall in the catchment. The recent flood in February 2020 demonstrated the extent of local flooding without flow contribution from the Warragamba Dam catchment.

Figure 5-3. Location of GDEs



5.4 Flora species

5.4.1 General species

A total of 101 floristic plots and transects were conducted across the study area recording a total of 422 species, of which 75 were identified as locally non-native.

5.4.2 Threatened flora species

Threatened flora records in the survey area are shown in Figure 5-4, comprising SMEC's survey results and NPWS historical records.

The review of existing studies and the database analysis identified 40 threatened flora species as having a moderate or high likelihood of occurring in the survey area, as shown in Appendix A of this report.

Targeted flora surveys were done for two of the 105 potentially occurring threatened flora species – *Acacia pubescens* and *Dillwynia tenuifolia*. Both species were recorded during the survey effort along with one incidental observation of a *Grevillea juniperina* subsp. *juniperina* population. Flora species lists by PCTs are provided in Appendix D of this report.

Further plot/transect surveys and vegetation mapping conducted by SMEC ecologists observed an additional four threatened flora species: *Eucalyptus benthamii, Persoonia nutans, Rhodamnia rubescens* and *Zieria involucrata*. All four threatened flora species had been previously recorded within a one kilometre radius of their observed locations.

The following flora species were recorded in the survey area as part of this assessment:

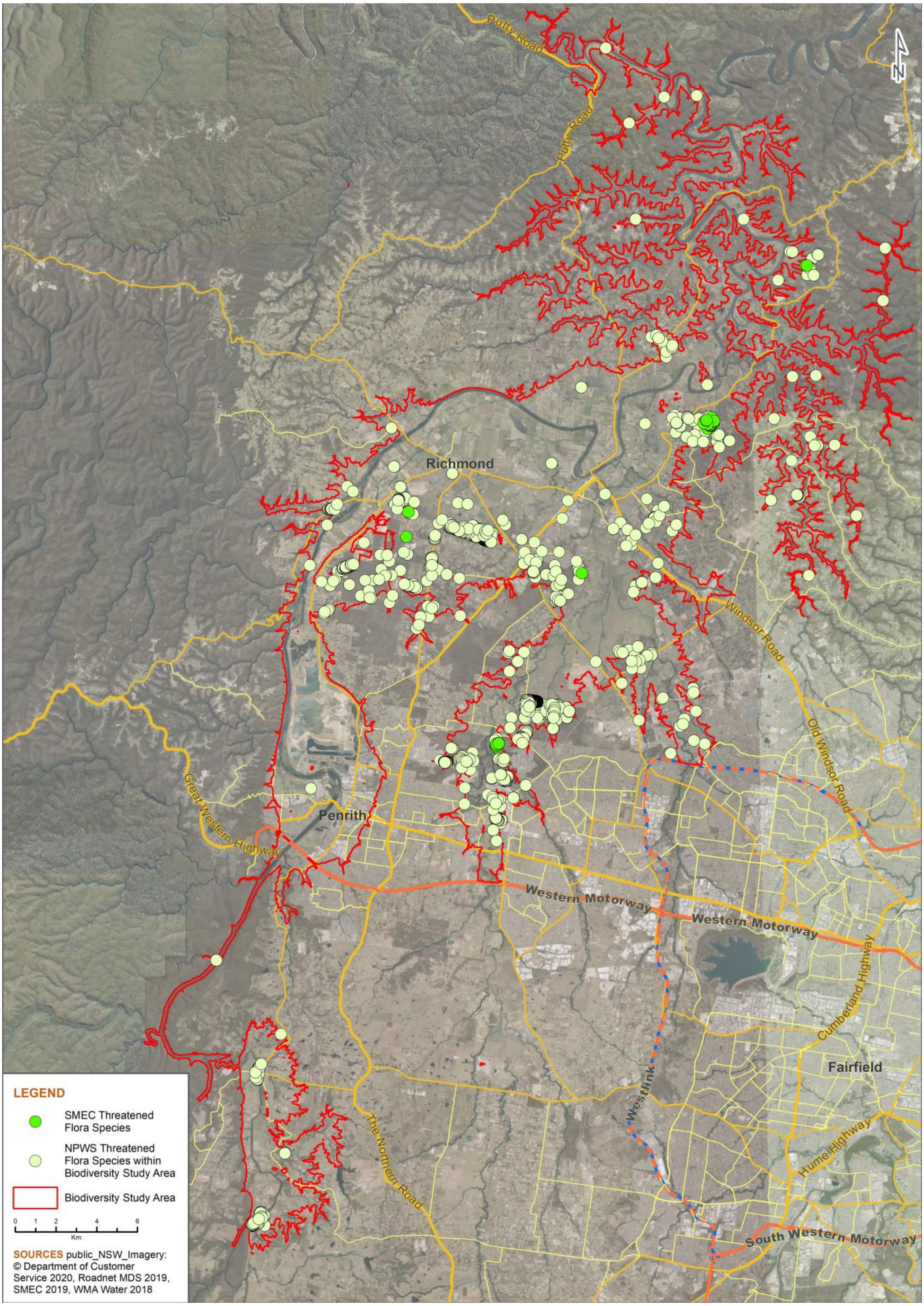
- *Acacia pubescens*
- *Dillwynia tenuifolia*
- *Eucalyptus benthamii*
- *Grevillea juniperina* subsp. *juniperina*
- *Persoonia nutans*
- *Rhodamnia rubescens*
- *Zieria involucrata.*

Comment on these records is provided in Table 5-4.

Table 5-4. Threatened flora species recorded during surveys

Species	BC Act	EPBC Act	Description
Downy wattle *Acacia pubescens*	V	V	A population of *A. pubescens* was recorded within the survey area at Longneck Lagoon – Scheyville National Park within PCTs 724 and 835. In total, based on a surveyed area of 6.9 hectares 1,054 individuals occur within the survey area.
Dillwynia tenuifolia	V	-	Eleven scattered *D. tenuifolia* individuals were identified near the *A. pubescens* population at Scheyville National Park in association with PCTs 1067, 724 and 835.
Camden white gum *Eucalyptus benthamii*	V	V	*E. benthamii* was observed in two locations during SMEC's plot-based surveys and vegetation mapping efforts; along the Nepean River at Bents Basin State Conservation Area and along the Nepean River at Wallacia.
Grevillea juniperina subsp. *juniperina*	V	-	*G. juniperina* subsp. *juniperina* was recorded along the access tracks within Wianamatta Regional Park during plot-based surveys and vegetation mapping efforts. The species is associated with PCTs 1064, 724, 835, and 1395.
Nodding geebung *Persoonia nutans*	E	E	*P. nutans* was recorded while conducting vegetation mapping at Wianamatta Regional Park. Three individuals were recorded.
Zieria involucrata	E	V	*Z. involucrata* was recorded while conducting vegetation mapping at Maroota Ridge State Conservation Area. This species has frequently been recorded within Maroota Ridge State Conservation Area.
Scrub turpentine *Rhodamnia rubescens*	CE	-	*R. rubescens* was recorded while conducting vegetation mapping at Maroota Ridge State Conservation Area. The species has previously been recorded within 500 metres of the edge of the State Conservation Area boundary, near the Hawkesbury River.

Figure 5-4. Threatened flora recorded within the study area



5.4.3 Previously recorded threatened flora species

The desktop and habitat assessment identified a further seven threatened flora species and one threatened flora population previously recorded in the survey area (refer Table 5-5). Many of these records are singular or have been recorded more than 10 years ago.

Further analysis of potentially occurring threatened flora species is provided in the likelihood of occurrence assessment in Appendix A of this report.

Table 5-5. Threatened fauna recorded in the survey area

Species name	Location in the survey area
Epacris purpurascens var. *purpurascens*	One record near Cattai in 2014 within the survey area.
Kunzea rupestris	One record from 1992 in Lower Portland.
Pimelea curviflora var. *curviflora*	One record from 2005 within Cattai National Park
Pomaderris brunnea	One record from 2005 at the junction of the Hawkesbury and Colo Rivers.
Pultenaea parviflora	One record from 2008 at Oakville.
Senna acclinis	Records from 2018 along the Colo River.
Seringia denticulata in the Hawkesbury LGA	Historic records from 1981 along the Colo River.
Tetratheca glandulosa	One record from 2000 near Wilberforce.

5.5 Fauna habitat

Most of the study area is highly disturbed by activities associated with cattle grazing and agriculture. Natural habitats are degraded and often unsuitable for native fauna species that are sensitive to disturbance. At the time of the survey 95.6 percent of the study area was exotic grassland based on GIS analysis.

The original native vegetation of the Cumberland Plain was comprised of various forms of open forest and woodland. The best remaining fauna habitats within the study area are associated with the remnant areas of forest and woodland with the highest quality habitat secured within national parks and reserves that occur across the study area. Outside of national parks and reserves, most remnants are largely comprised of young trees but do contain scattered occurrences of older individuals. Tree hollows – particularly large hollows – are generally rare.

Agricultural land usage and urbanisation have simplified and/or removed the majority of ground habitat features such as logs and rocks. The resultant landscape constitutes a simplified and fragmented habitat typical of many rural areas that support a subset of the pre-European fauna. The integrity of these habitats is further challenged by the abundance of feral animals such as foxes, pigs, and rabbits, which prey upon or compete with native fauna for resources.

Despite the modified nature, the study area still offers some broad habitat features for native fauna, including:

- regenerating woodland and scattered paddock trees that are likely to facilitate dispersal for woodland birds
- remnant open forest and woodland, and woodland margins that contain mixed age trees, deep litter, stags, tree hollows suitable as shelter and breeding habitat for a number of hollow-dependent fauna. These habitats also provide connectivity for woodland birds to the wider locality
- understorey vegetation and ground cover, leaf litter, fallen timber and rocky outcrops suitable as shelter for small terrestrial species
- blossom-producing trees suitable as forage habitat for a range of birds and Grey-headed Flying-foxes
- open grassland for foraging birds and microbats
- riparian vegetation along the Hawksbury-Nepean River, Colo River, and associated tributaries as well as small, ephemeral water bodies suitable for some common birds, frogs, reptiles and microbats
- farm dams suitable for some common birds, frogs and microbats.

5.5.1 Alluvial forests and woodlands

The woodland and open forest vegetation in the study area is predominantly contained within national parks and reserves. Outside of national parks and reserves, the woodland areas are relatively young and open with a grassy groundcover. For more mobile species, the woodland patches within the study area provide connectivity between the more intact woodlands within the national parks and reserves.

Fallen timber and woody debris occur within the alluvial forests and woodlands, and this is an important feature for many woodland birds. Fallen logs, leaf litter and ground vegetation provide habitat features that would provide shelter for many of the small to medium sized terrestrial fauna species known from the locality. In addition, some bush rock, particularly in sandstone derived areas provides habitat for small terrestrial fauna species such as small mammals and reptiles.

Many native woodland bird species are strongly associated with a shrub and tall tussock grass understorey. Understorey vegetation, and thus woodland structural complexity, provides nesting sites, refuge from predators and food. Understorey vegetation is at its most diverse within national parks, reserves and state conservation areas, providing nesting and foraging for many of the resident native fauna species. Outside of these areas, and for much of the study area, there is a general lack of a diverse understorey structure, and shrubs are uncommon, despite localised areas of shrubby understorey that is largely represented by exotic shrubs such as *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana).

Due to the disturbed nature of the study area, tree hollows occur in low densities throughout and are generally associated with large, mature box eucalypts (such as *Eucalyptus moluccana*) and angophoras (such as *Angophora costata*). The mature living trees and dead stags in the study area provide a limited number of small to medium-sized tree hollows for native fauna species dependent on this resource as shelter and breeding habitat. Most of the hollows recorded during fauna surveys were small, and large hollows in tall trees that provide breeding and shelter for large species such as forest owls were not frequently observed and likely to be scarce across much of the study area.

All forest and woodland vegetation communities within the study area would provide suitable foraging habitat for a range of nectivorous birds during blossom periods. Alluvial Forests and woodlands contain flowering eucalypts that blossom at different times of the year providing a year-round food resource to many resident native fauna species as well as migratory species that may use the study area. The tree species recorded, as well as mistletoe plants (*Amyema* sp.) are known to produce abundant flowers and nectar. Nectar-dependent bird species and Grey-headed Flying-foxes are expected to utilise these resources in the study area during blossoming periods.

5.5.2 Grassy box woodlands

Grassy Box Woodlands were considered to be very open forests with a grassy understorey on moderately fertile to fertile soils, lying within the major rain shadow valleys and coastal plains. These woodlands typically have an open canopy of Eucalypts that includes combinations of box, ironbark, red gum and stringybark species with a sparse shrub layer and a ground cover that is dominated by grasses.

Grassy Box Woodlands are particularly important for conserving declining woodland birds that are found in the region, including the Diamond Firetail, Brown Treecreeper, Hooded Robin, Restless Flycatcher and Speckled Warbler. This habitat type was once extensive in the Region, occurring on higher-fertility soils of the Cumberland Plain, Illawarra Coastal Plain and in the rain-shadow valleys of the Southern Blue Mountains such as in the Burragorang, Nattai and Wollondilly valleys.

The largest area of semi-intact Grassy Box Woodland occurs in the Burragorang Valley within the Warragamba Special Area upstream of the dam. Most Grassy Box Woodlands have experienced some degree of disturbance, and on the Cumberland Plain and Illawarra Coastal Plain they are heavily depleted and fragmented. In these areas, smaller isolated remnants are no longer utilised by species that are sensitive to fragmentation with this project highlighting that many Grassy Box Woodland species are locally extinct or close to extinction in the southern Cumberland Plain.

5.5.3 Grassland

Grassland habitat generally provides low fauna habitat value due to the lack of woody vegetation and ground debris for cover. Most native fauna species are found in treed habitats, however native tussock grasslands can provide sparse habitat for native fauna species because they provide a degree of groundcover complexity and seed resources, even where the grasslands are still used for light grazing.

Grassland vegetation is the most widespread habitat type in the study area. A range of native and naturalised grass and forb species dominate these communities, and upper stratum layers are generally non-existent except for a few scattered trees that do not conform to woodland. The composition and diversity of native species varies as a result of ongoing grazing; however, a large portion of grassland is derived from the understorey of woodland communities that have been cleared in the past and so still retain a proportion of native groundcover species. Some areas of grassland include woody debris and leaf litter cover; however, other areas that were cropped or grazed are devoid of such habitat features.

Open grasslands in the study area generally provide suitable foraging habitat for large mammals, including macropods like the Eastern Grey Kangaroo (*Macropus giganteus*). The grassland can also provide shelter and forage for small mammals in areas where there is an adequate layer of tussock grass, and microhabitats under timber and rocks for reptiles. Large open areas provide ample foraging habitat for insectivorous and granivorous birds, and hunting resources for raptors, owls, and some microbat species.

5.5.4 Aquatic habitat

Throughout the study area there are wetland areas that provide habitat for wetland birds and frogs. The most important wetlands in the study area for shorebirds and waterbirds are Bakers Lagoon, Broadwater Swamp, Bushells Lagoon, Hobartville Swamp, Little Cattai Creek, Longneck Lagoon, McGraths Hill, McKenzies Creek, Pitt Town Lagoon, Powells/Triangle Lane, Pughs Lagoon, Rickabys Creek, Wheeny Lagoon and Yarramundi Lagoon (Pressey 1979, Stricker and Wall 2000, Smith and Smith 1996). Most of the wetlands in the study area are either tributary wetlands or depositional flats adjacent to the main channel and major drowned tributaries (Taylor-Wood and Warner 2003).

Considerable changes to the wetlands of the Hawkesbury-Nepean River have occurred since European colonisation as a result of drainage, changes in land use, vegetation clearance and the construction of Warragamba Dam and the Upper Nepean dams. Today, most wetlands rely on their own, local catchments for water as the construction of levy banks and flood mitigation devices have reduced or removed their connectivity to the Hawkesbury-Nepean River, with only overbank flows reaching them (Taylor-Wood & Warner, 2003). Some wetlands have been partly drained and only hold water for short periods after flooding and heavy rain while others have been dammed and are now permanent swamps (NPWS 2000).

In addition, farm dams are present within the paddocks which also provide some habitat for invertebrates, fish species, amphibians, reptiles, and wetland birds. Some suitable habitat for Green and Golden Bell Frog occurs within the study area in and around wetland areas, particularly in areas containing reeds, bulrushes (*Typha* spp.) or spike rushes (*Eleocharis* spp.). Large dams and open waterways in the study area also provide foraging habitat for raptors such as the White-bellied Sea-eagle (*Haliaeetus leucogaster*).

5.5.5 Disturbed areas

The remaining terrestrial habitat in the study area is highly disturbed and includes suburban areas, turf farms, quarries and industrial areas. These areas provide very limited habitat for anything other than the most urban-tolerant species. Turf farms may provide some suitable foraging habitat for bird species; however, the rates of chemical use are likely to be higher than that of the surrounding natural environment.

5.6 Terrestrial fauna species

5.6.1 General species

One-hundred and three (103) species of birds, three reptiles, 31 mammals and three frogs were recorded in the survey area during recent surveys. Eleven of these species (five birds and six mammals) were introduced species, as shown in Appendix E of this report. The suite of species recorded varied greatly between habitat types. Threatened species that were recorded are discussed in more detail in the following sections.

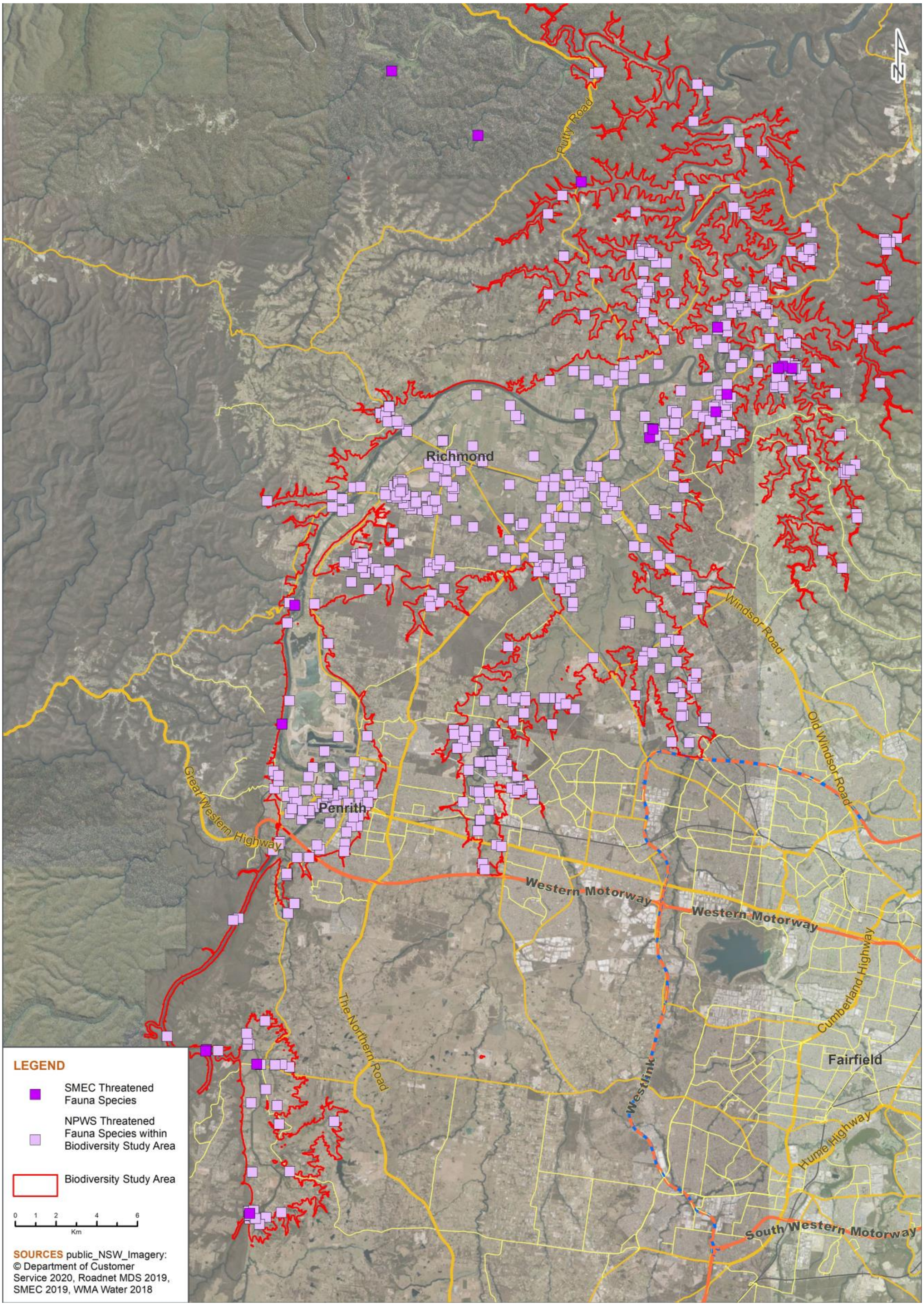
5.6.2 Threatened fauna species recorded in the survey area

Fifteen threatened fauna species were recorded during the surveys undertaken by SMEC. These threatened species were identified at a number of sites throughout the survey area. Table 5-6 provides details of the specific locations within the survey area where threatened species have been recorded (and which are shown in Figure 5-5).

Table 5-6. Locations of threatened species recorded in the survey area

Species name	Location in the survey area	Source
Cumberland Plain Land Snail (*Meridolum corneovirens*)	Incidentally recorded at Long Neck Lagoon during November 2018.	SMEC
Dural Land Snail (*Pommerhelix duralensis*)	Incidentally recorded at Mitchell Park and Maroota State Conservation Area during November 2018.	SMEC
Eastern Cave Bat (*Vespadelus troughtoni*)	Possible detection at Bents Basin and Cattai NP by SMEC in 2018	SMEC
Eastern Coastal Free-tailed Bat (*Mormopterus norfolkensis*)	Detected at Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP, Longneck Lagoon and Wheeny Creek by SMEC in 2018	SMEC
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	Detected at Bents Basin, Yellomundee NP and possibly Mitchell Park by SMEC in 2018	SMEC
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	Detected at Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP and Longneck Lagoon by SMEC in 2018	SMEC
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Recorded by SMEC on the Nepean River at Silverdale and Yarramundi	SMEC
Koala (*Phascolarctos cinereus*)	Recorded by SMEC at the Upper Colo Reserve and Blaxlands Ridge. Historical records from Lapstone north to the Colo River, predominantly to the west of the Nepean River. A record in South Windsor from 2014 and Wianamatta Regional Park from 2004 (*Robert Close, pers. Coms*).	SMEC NPWS database June 2018 DECCW 2011 Robert Close (UWS)
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	Detected at Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP, Longneck Lagoon and Wheeny Creek by SMEC in 2018	SMEC
Large-eared Pied Bat (*Chalinolobus dwyeri*)	Detected on the Hawkesbury River at Yellomundee NP and Cattai NP by SMEC in 2018	SMEC
Little Bentwing-bat (*Miniopterus australis*)	Detected at Mitchell Park by SMEC in 2018	SMEC
Red-crowned Toadlet (*Pseudophryne australis*)	Incidentally recorded in Maroota State Conservation Area during November 2018.	SMEC
Southern Myotis (*Myotis macropus*)	Detected at Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP and Longneck Lagoon by SMEC in 2018.	SMEC
Varied Sittella (*Daphoenositta chrysoptera*)	Recorded by SMEC in 2018 at Mitchell Park Yellomundee NP. Recorded in the study area adjacent to the Hawkesbury-Nepean River between Wallacia and Lower Portland.	SMEC
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Breeding resident in the study area. Nesting site identified at Pitt Town Nature Reserve in 2018. Also recorded at Nortons Basin and Gospers Lagoon. Occurs throughout the study area.	SMEC

Figure 5-5. Threatened fauna species recorded in the study area



5.6.3 Potential threatened fauna species

The desktop and habitat assessment identified a further 31 threatened fauna species being previously recorded in the survey area (refer Table 5-7). Further analysis of potentially occurring threatened fauna species is provided in the likelihood of occurrence assessment in Appendix A of this report.

Table 5-7. Threatened fauna previously recorded in the survey area

Species name	Location in the survey area
Australasian Bittern (*Botaurus poiciloptilus*)	Recorded occasionally, particularly between Richmond and Pitt Town Lagoon.
Australian Painted Snipe (*Rostratula australis*)	Recorded very occasionally at wetlands in the survey area, but not since 1985 in Bushells Lagoon.
Barking Owl (*Ninox strenua*)	Last recorded near Rickabys Creek in Windsor in 1994
Black Bittern (*Ixobrychus flavicollis*)	Recorded occasionally along the Colo and Hawkesbury-Nepean Rivers. Several records during the past decade in the Richmond/Agnes Bank area.
Black Falcon (*Falco subniger*)	Recorded occasionally, particularly in the Richmond/Windsor/Pitt Town area, but not since 1986.
Black-necked Stork (*Ephippiorhynchus asiaticus*)	Last recorded in the survey area in 1978 in McGraths Hill, Windsor.
Black-tailed Godwit (*Limosa limosa*)	Recorded very occasionally in the Richmond/Windsor/Pitt Town area. Not recorded since 1982.
Comb-crested Jacana (*Irediparra gallinacea*)	Last recorded in 1986 in Bushells Lagoon.
Curlew Sandpiper (*Calidris ferruginea*)	Recorded once in the survey area in the 1970s and in the 1980s around Bakers Lagoon, Bushells Lagoon and Pitt Town. Not recorded since 1986.
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	Recorded in the survey area near Cattai and Wallacia.
Flame Robin (*Petroica phoenicea*)	Recorded on one occasion in the survey area in 1981 near Bushells Lagoon.
Freckled Duck (*Stictonetta naevosa*)	Recorded at wetlands associated with the Hawkesbury-Nepean River, particularly Pitt Town Lagoon.
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	Recorded occasionally adjacent to the Colo and Hawkesbury Rivers.
Giant Burrowing Frog (*Heleioporus australiacus*)	A single record of the species exists in 2006 in swamp habitat in Cattai.
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	Recorded in the survey area around Cattai and Lower Portland.
Green and Golden Bell Frog (*Litoria aurea*)	Historically recorded in Longneck Lagoon and Pitt Town, however not since 1975.
Little Eagle (*Hieraaetus morphnoides*)	Recorded occasionally in the survey area around Pitt Town Lagoon, Bushells Lagoon and Long Neck Lagoon.
Little Lorikeet (*Glossopsitta pusilla*)	Scattered records in the survey area mostly upstream of Cattai along the Hawkesbury-Nepean River.
Masked Owl (*Tyto novaehollandiae*)	Recorded occasionally in the Richmond/Windsor/Pitt Town area.
Powerful Owl (*Ninox strenua*)	Recorded in the survey area around Maroota and Ebenezer.
Regent Honeyeater (*Anthochaera phrygia*)	Recorded in the survey area reasonably regularly until the late 1980s however there have been very few records from the survey area since.

Species name	Location in the survey area
Sooty Owl (*Tyto tenebricosa)*	Very rarely recorded in the survey area. Only record occurs in Cattai National Park in 2014.
Speckled Warbler (*Chthonicola sagittate)*	Recorded in the vicinity of Longneck Lagoon, Scheyville N.P. Not known to occur elsewhere in the survey area.
Spotted Harrier (*Circus assimilis)*	Occasionally recorded in the survey area, particularly over the floodplain in the vicinity of Richmond/Wilberforce/Cornwallis.
Spotted-tailed Quoll (*Dasyurus maculatus)*	Recorded on one occasion in the survey area in 1998 in Mitchell Park
Square-tailed Kite (*Lophoictinia isura)*	Recorded in the survey area along the Hawkesbury-Nepean River between Wallacia and Cattai. Most records from the past decade.
Squirrel Glider (*Petaurus norfolcensis)*	Recorded as recently as 2019 in Cattai.
Swift Parrot (*Lathamus discolor)*	Occasionally recorded in the survey area, most recently in 2016 in Richmond.
Turquoise Parrot (*Neophema pulchella)*	Last recorded near Castlereagh in 1977.
Yellow-bellied Glider (*Petaurus australis)*	Recorded within the survey area in Cattai National Park.
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris)*	Recorded in the survey area in 2013 near Wilberforce, Cattai and Ebenezer.

6 Impact assessment

The alteration of flow regimes of rivers, streams, and their associated floodplains and wetlands is documented as a key factor contributing to the loss of biological diversity and ecological function in aquatic and terrestrial ecosystems occurring on or immediately adjacent to floodplains (NSW Scientific Committee 2002).

The magnitude, frequency and duration of floods have been reduced since Warragamba Dam became fully operational in 1960 (Taylor-Wood and Warner 2003). As such, the flow regimes of the Hawkesbury-Nepean River are already subject to modified and controlled flows from the Warragamba Dam and the Upper Nepean dams. The Project proposes to raise Warragamba Dam for temporary storage to reduce downstream flooding impacts from its releases, which will further alter the flow regime albeit on a short term basis in the order of several weeks.

It should be noted that in the catchment downstream of Warragamba Dam there are numerous land uses and activities that already have an existing impact on the environment. For example, with regard to hydrology and water quality in the downstream catchment these include inflows from downstream catchments (for example, the Nepean River, Grose River, Macdonald River, and Colo River), runoff from rural and urban land uses, and discharges from sewage treatment plants. These will, to greater or lesser degrees, be occurring concurrent with the Project impacts and present practicable constraints to accurately apportioning impacts to the Project and to other sources. This uncertainty is likely to increase with increasing distance downstream, and this in turn presents challenges to practical management and offsetting of impacts associated with the Project.

This section outlines the key impact risks for biodiversity and provides an assessment for the impacts and biodiversity features most likely to be impacted by the proposed changes in hydrological flows due to the Project.

6.1 Impact and risk assessment methodology

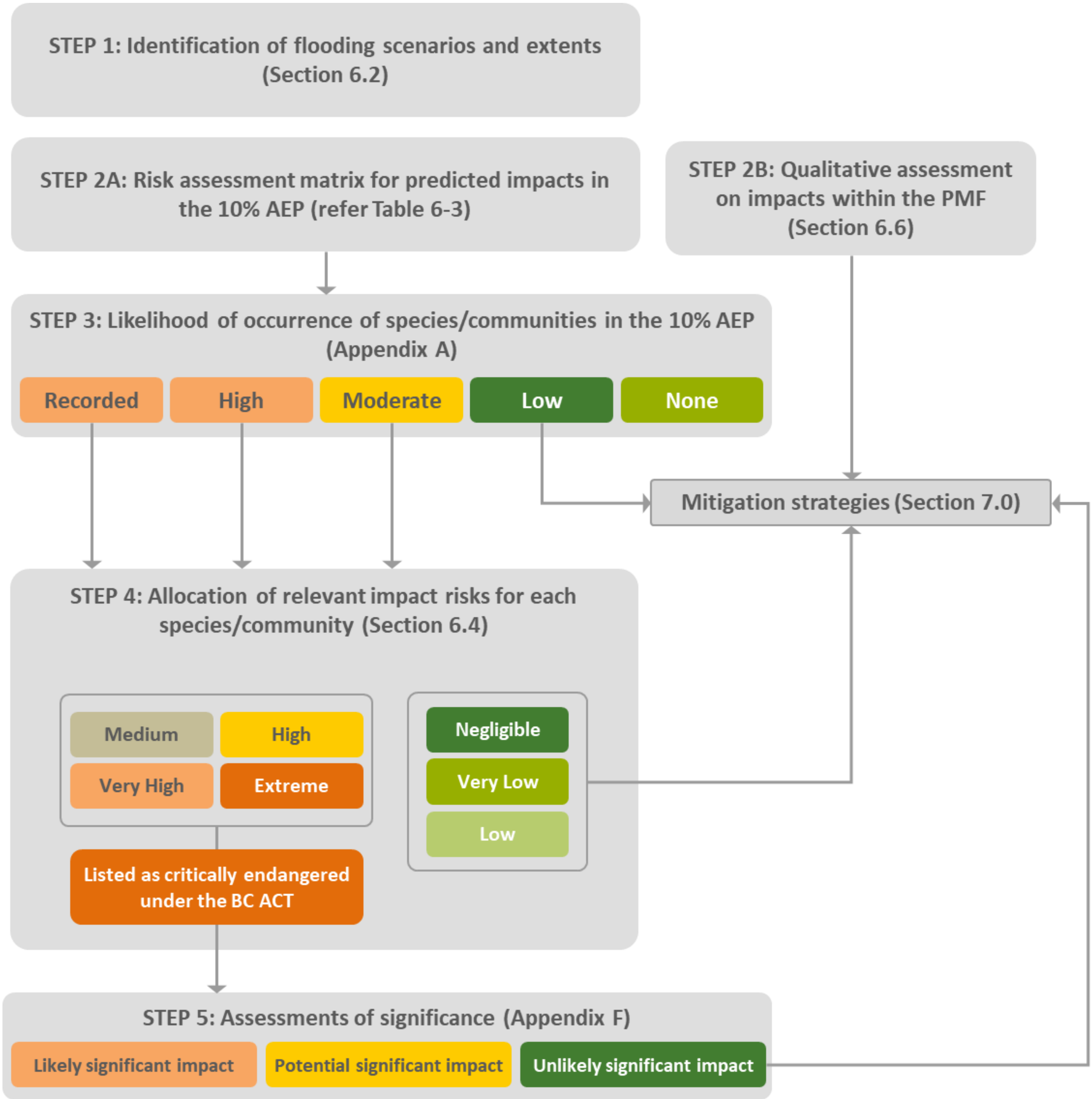
The focus of this biodiversity assessment is on the potential impacts associated with the changed outcomes of the survey area (10% AEP event) and the increased duration of temporary inundation of the FMZ discharge area. While these events are modelled based on the best available information, there remains a level of uncertainty on the frequency and extent of these flooding scenarios in the real world. Furthermore, the potential impacts on biodiversity may vary substantially depending on the frequency, duration and extent of flooding experienced following implementation of the Project and other stressors in the landscape.

In view of this, a risk assessment framework has been applied to determine the key likely impacts of the Project and the biodiversity features that are likely to be most sensitive to the predicted changes in hydrological conditions.

Figure 6-1 outlines the risk assessment process undertaken for this assessment. In summary, a risk assessment was undertaken on the key impacts relevant for biodiversity and cross-referenced with threatened species and communities that have potential to occur within the survey area. Those threatened entities that had a moderate or high potential to occur and were subject to 'Medium' or greater impact risk were further assessed using an Assessment of Significance under the TSC Act.

The wording of the matters in the Assessment of Significance uses the term 'likely' with regard to the manifestation of an impact, the obverse being 'unlikely'. However, in some instances while an impact may not have been considered 'likely', neither could it be categorically considered 'unlikely'. In view of this where an impact may not be likely but could conceivably occur, it has been treated as a 'potential' impact, reflecting a conservative position.

Figure 6-1. Impact and risk assessment methodology



6.2 Flooding scenarios and extents

The Project would delay and attenuate the progression of inflows coming from the upstream Warragamba catchment Operation of the FMZ would occur when inflows increase dam water levels above the FSL. Inflows would be temporarily stored in the FMZ and then progressively released when downstream flooding begins to recede. Rainfall events that do not increase Lake Burragorang levels above FSL would have no impact on downstream hydrology and flood behaviour. Flooding from downstream catchments such as the Nepean, Grose, Colo Rivers and South Creek can also contribute to downstream flooding.

The Project would:

- reduce peak outflow rates and flood levels for all flood scenarios; reduction in flood extents would be most prominent for higher frequency events up to about a 1% AEP (one in 100 chance in a year)

- increase flood durations within the FMZ discharge area, ranging from an additional five days for a 20% AEP (1 in 5 chance in a year) event, up to eight days for a 1% AEP (1 in 100 chance in a year) event
- change flood frequencies, with a lesser chance of occurrence for an outflow event of a specific magnitude; hence the existing 20% AEP (1 in 5 chance in a year) outflow event becomes a relatively less frequent event with the Project, having about a 1 in 60 chance in a year of occurring. Similarly, the existing 10% AEP (1 in 10 chance in a year) becomes a 0.5% AEP (1 in 200 chance in a year); and the 1% AEP (1 in 100 chance in a year) becomes a 0.07% AEP (1 in 1,500 chance in a year).

The Project would not directly impact on downstream floodplain connectivity, conveyance or flood storage areas as the Project does not involve construction in or modification of the floodplain topography. There may be some minor indirect geomorphological impacts associated with the Project (refer Appendix N2 - Geomorphology assessment report), however these impacts would not substantially alter local or regional flood conveyance and storage areas.

Project changes for various flood events are summarised in Table 6-1 and shown in Figure 6-2, Figure 6-3, Figure 6-4 and Figure 6-5. These changes are based on the dam being full before a rainfall event and widespread rainfall within the upstream catchment. However, as previously noted, rainfall can be localised and downstream flooding may be mainly due to flooding in local catchments. For example, recent flooding in the Hawkesbury-Nepean valley that occurred in February 2020 was estimated to be about a 20% AEP (1 in 5 chance in a year) event. At the time Warragamba Dam was less than 50 percent full, and all upstream inflow was trapped by the dam with no spill. Downstream flooding was therefore wholly a result of local flooding, with no contribution from the Warragamba dam catchment. This characterises the importance of local downstream flooding in contributing to existing landforms, biodiversity and groundwater characteristics.

Potential biodiversity impacts are principally related to:

- Reduction in flood frequency and extents resulting in reduced water availability to plants and wetland replenishment. As previously noted, the Project would have no impact on local flooding and any flood-dependent vegetation would be largely dependent on local catchment flows rather than overbank flooding from the Hawkesbury-Nepean River.
- Increase in flood durations within the FMZ discharge area. Once peak flood levels in the downstream river have decreased, the discharge of water from the FMZ would commence. Apart from some piggy-back discharges (or short duration higher discharges) for the first few days after a large flood event, the rate of discharge from the FMZ would be constant at around 100 gigalitres per day. There would be minimal overbank flows, however low level or backwater flooding would remain in some areas, such as the Penrith lakes area, due to the inability of tributaries to drain due to high main river water levels. This low-level flooding would persist for five to eight days longer than an existing flood event. Vegetation in these areas that is not tolerant of additional inundation may be adversely impacted.

Table 6-1. Project assessment of flooding scenarios

Scenario	Predicted changes	Project change in flood levels[1]	
		Location	metres
20% AEP event (1 in 5 chance in a year)	▪ Reduced frequency of peak outflow occurrence from 1 in 5 chance in a year to about 1 in 60 chance in a year with the Project ▪ Reduction in peak flow changes from 2,271 m^3/s to 810 m^3/s. ▪ Reduction of about 670 ha of native vegetation in the catchment previously subject to inundation in this event. ▪ Increased duration of inundation in FMZ discharge area of about 5 days instead of 2 days (that is an increase of 3 days). ▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area. ▪ The total volume of water discharged remains unchanged.	Nepean River Penrith Weir	-3.9
		South Creek Richmond Bridge	-2.1
		Hawkesbury River Windsor Bridge	-2.4
10% AEP event (1 in 10 chance in a year) **(survey area)**	▪ Reduced frequency of peak outflow occurrence from 1 in 10 chance in a year to about 1 in 200 chance in a year with the Project ▪ Reduction in peak flow changes from 4,430 m^3/s to 1,160 m^3/s. ▪ Reduction of about 955 ha of native vegetation in the catchment previously affected in this event. ▪ Increased duration of inundation in FMZ discharge area of about five days instead of 2.5 days (that is an increase of 2.5 days) ▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area. ▪ The total volume of water discharged remains unchanged.	Nepean River Penrith Weir	-5.3
		South Creek Richmond Bridge	-2.9
		Hawkesbury River Windsor Bridge	-3
5% AEP event (1 in 20 chance in a year)	▪ Reduced frequency of peak outflow occurrence from 1 in 20 chance in a year to about 1 in 500 chance in a year with the Project ▪ Reduction in peak flow changes from 6,860 m^3/s to 1,160 m^3/s ▪ Reduction of about 960 ha of native vegetation in the catchment previously affected in this event. ▪ Increased duration of inundation in FMZ discharge area of about 8 days instead of 3.5 days (that is an increase of 4.5 days) ▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area. ▪ The total volume of water discharged remains unchanged.	Nepean River Penrith Weir	-6.7
		South Creek Richmond Bridge	-3.5
		Hawkesbury River Windsor Bridge	-3.5
1% AEP event (1 in 100 chance in a year)	▪ Reduced frequency of peak outflow occurrence from 1 in 100 chance in a year to about 1 in 1500 chance in a year with the Project ▪ Reduction in peak flow changes from 9,660 m^3/s to 3,800 m^3/s. ▪ Reduction of about 1,180 ha of native vegetation in the catchment previously affected in this event. ▪ Increased duration of inundation in FMZ discharge area of about 11 days instead of 4 days (that is an increase of 7 days). ▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area. ▪ The total volume of water discharged remains unchanged.	Nepean River Penrith Weir	-5.2
		South Creek Richmond Bridge	-4.1
		Hawkesbury River Windsor Bridge	-4.1

1. Site locations and additional flood levels are provided in EIS Chapter 15 (Flooding and hydrology)

Figure 6-2. Existing and Project 20% AEP event scenarios and FMZ discharge area

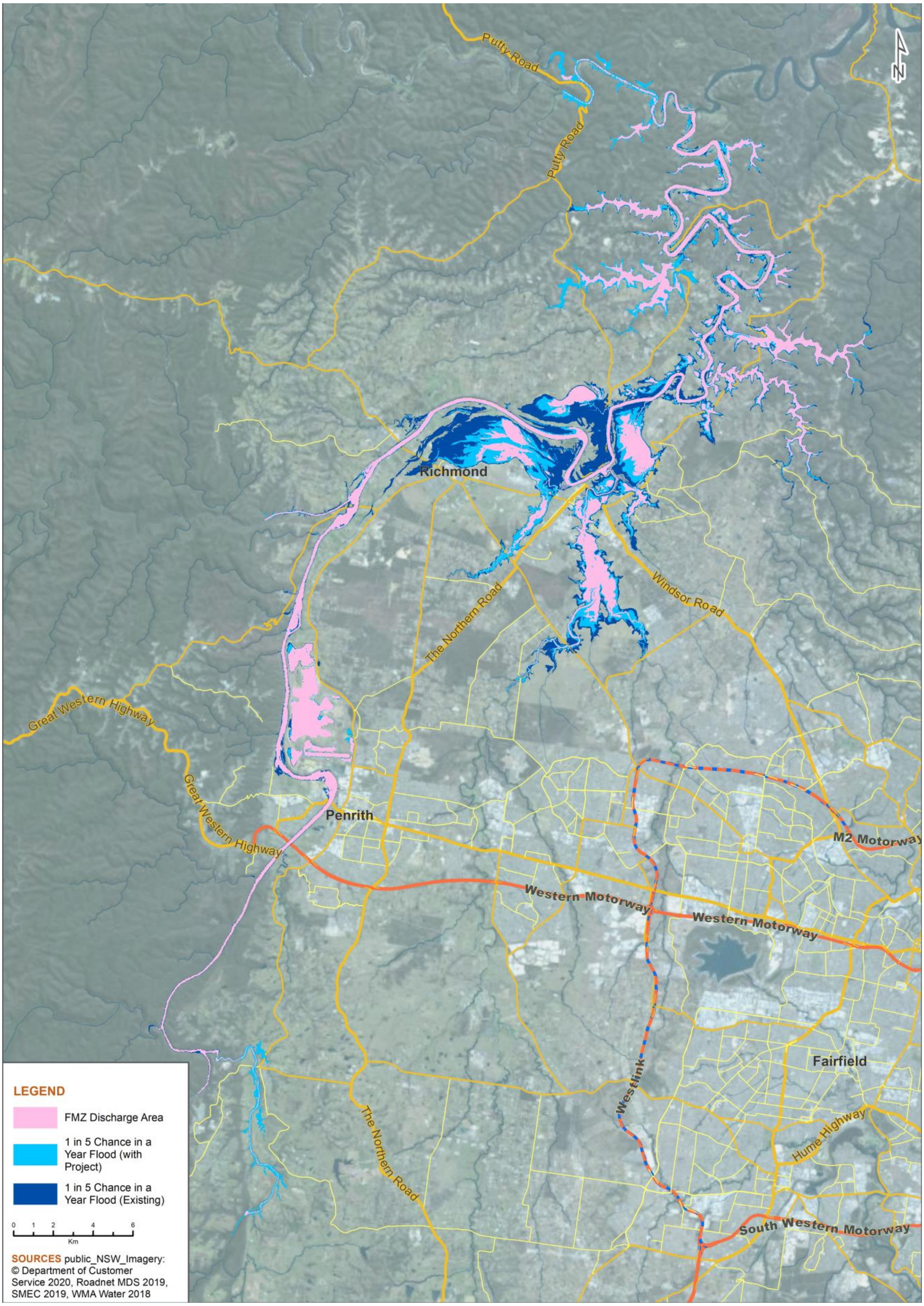


Figure 6-3. Existing and Project 10% AEP event scenarios and FMZ discharge area

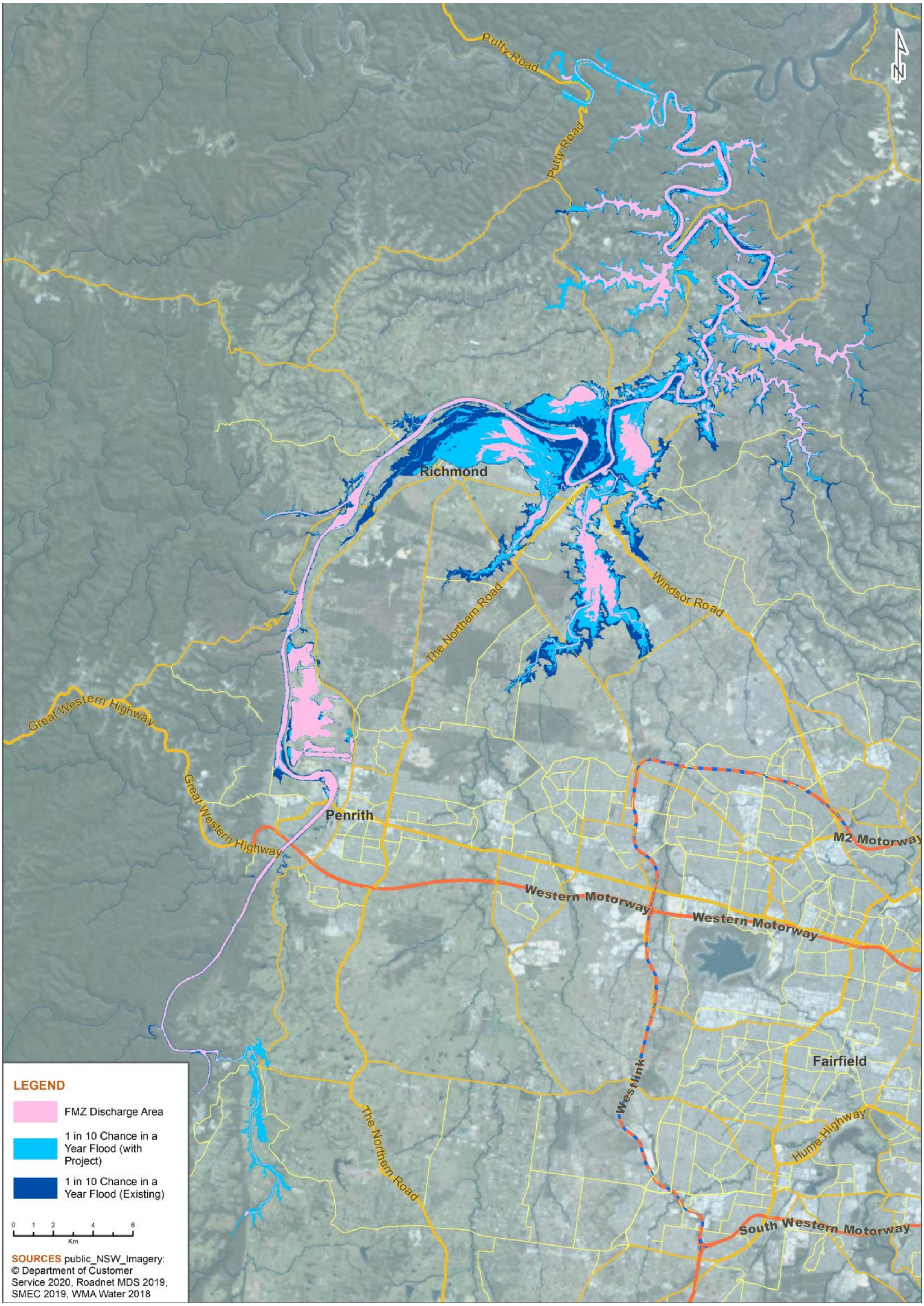


Figure 6-4. Existing and Project 5% AEP event scenarios and FMZ discharge area

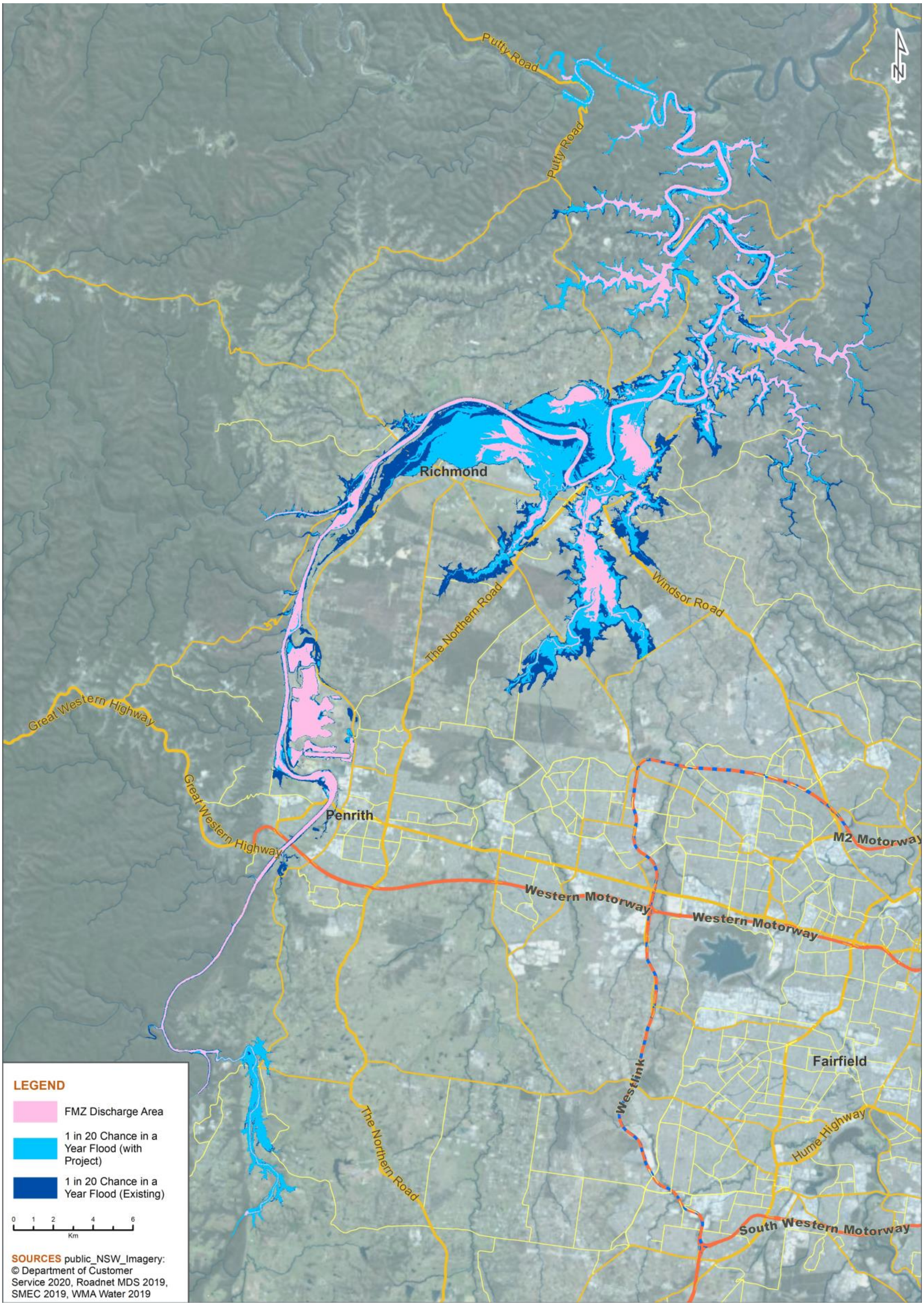
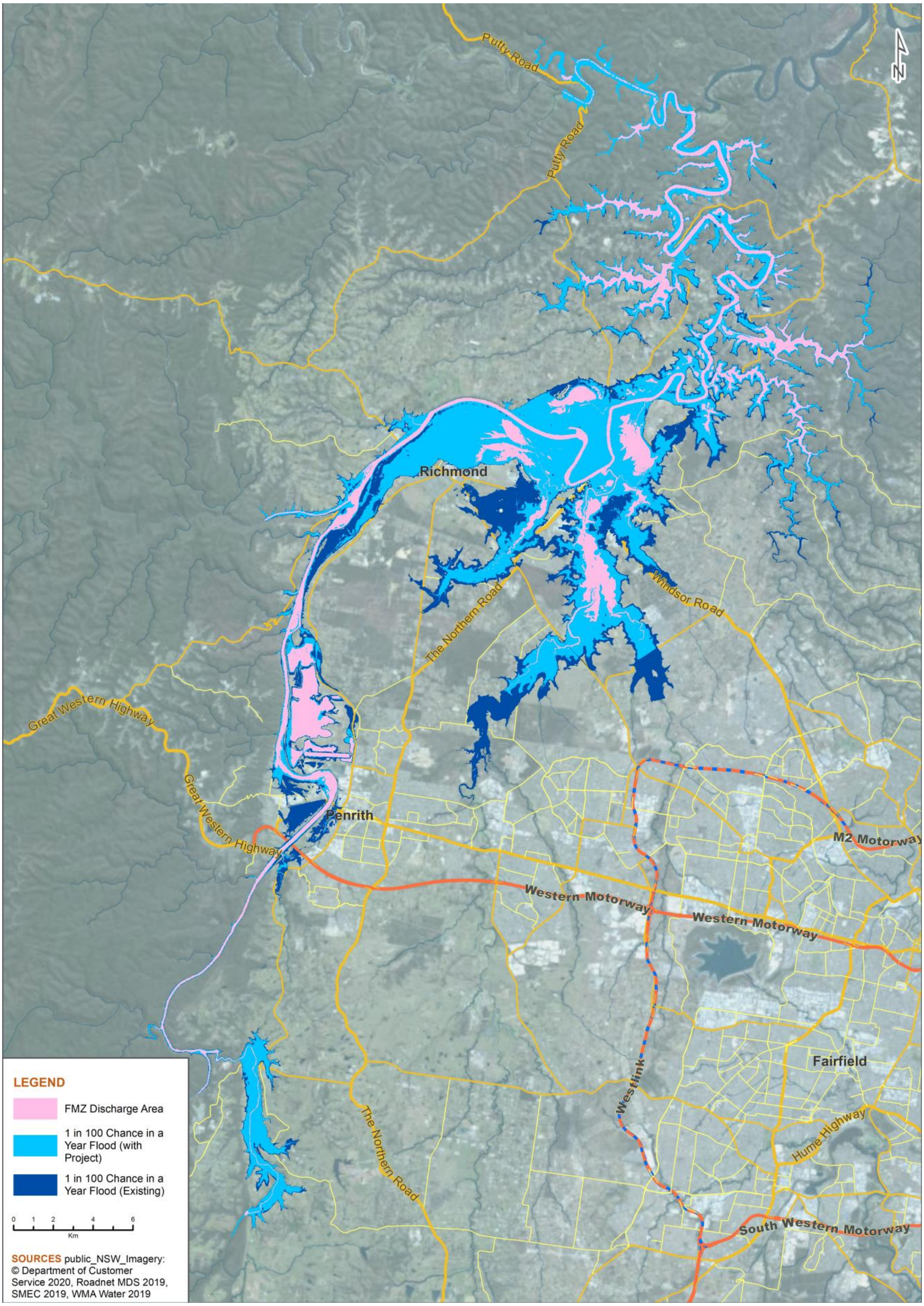


Figure 6-5. Existing and Project 1% AEP event scenarios and FMZ discharge area



6.3 Impact risk assessment for biodiversity

A reduction in the flood area and duration across floodplains and associated wetlands may result in a reduction of suitable habitat for organisms dependent on the distribution of organic matter through the river system. Altered flow patterns can contribute to the degradation of riparian zones, which may in turn reduce availability of suitable habitat for native species and increase available habitat for invasive species. For example, if the period between inundation events increases, this may provide sufficient time for some invasive species to become established.

Figure 6-1 outlines the impact risk framework guiding the assessment of the key impacts relevant for biodiversity.

The Project would result in two key changes to the downstream flooding regime, these being:

- a reduction in peak flood extents and durations and a reduction in peak flood flows across the floodplain
- an increase in low level flooding and flows during the discharge of the FMZ, principally around the Richmond Lowlands.

These changes may result in the following impacts:

- changes to wetland and floodplain vegetation communities and habitats
- changes to terrestrial woodland and forest communities and habitat
- bank erosion and slumping resulting in vegetation community and threatened species habitat degradation
- increased fine sediment deposits reducing water quality
- displacement of fauna habitat resources
- displacement of habitat for fauna dependent on riparian or wetland habitats
- spread of exotic species
- spread of disease and pathogens.

These potential impacts on biodiversity would vary depending on the type of impact, the duration and frequency of the impact and the ability of the biodiversity features to respond to these changes. A risk assessment matrix is shown in Figure 6-6 and definitions given in Table 6-2 (consistent with the methodology set out in Appendix C Environmental Risk Assessment Procedure) . These definitions guided the assessors to allocate a risk rating to impacts in the following sections. Impacts assessed with a risk score of 'Medium' or above are further discussed in the sections below.

Table 6-2. Risk assessment definitions

Definition	Description
Likelihood	
Expected	Very high or certain probability that impact will occur, or event is of a continuous nature.
May occur	Likely probability that impact will occur, or event is frequent (1-5 years).
Possible	Moderate probability that the impact will occur, or the event is infrequent (5-20 years).
Unlikely	Low probability that impact will occur, or event is very infrequent (100 + years).
Rare	Very low probability that impact will occur or may occur under extenuating circumstances. Event is very rare stochastic in nature (frequency 1,000+ years).
Consequence	
Extreme	An impact that is widespread, permanent and may result in large-scale loss of critical habitat[1].
Major	An impact that is widespread, long lasting and may result in large-scale loss of important habitat[2].
Moderate	Large-scale conversion of natural habitat or small-scale conversion of important habitat.
Minor	Incidental and localised impacts to natural habitat.
Negligible	No measurable impact.

1. As per definition in *Definitions*
2. Habitat that is important to the long-term survival of the species, population or ecological community in the locality (as per Matter d(iii) in Assessment of Significance, refer Appendix F)

Figure 6-6. Risk matrix

		CONSEQUENCE (C)				
		Insignificant (F)	Minor (I)	Moderate (D)	Major (J)	Significant (S)
LIKELIHOOD (L)	Remote (R)	Negligible (N)	Negligible (N)	Very Low (L)	Low (W)	Medium (M)
	Unlikely (U)	Negligible (N)	Very Low (L)	Low (W)	Medium (M)	High (H)
	Possible (P)	Very Low (L)	Low (W)	Medium (M)	High (H)	Very High (V)
	Likely (L)	Low (W)	Medium (M)	High (H)	Very High (V)	Extreme (E)
	Almost Certain (C)	Medium (M)	High (H)	Very High (V)	Extreme (E)	Extreme (E)

Table 6-3. Impact risk assessment for biodiversity in survey area

Potential impacts	Impact risk assessment			Description of change
	Likelihood	Consequence	Risk for biodiversity	
1. Reduction in peak flood extents and durations and a reduction in peak flood flows in the survey area (10% AEP) (includes FMZ discharge area)				
Reduction of flooding extent in wetland and floodplain vegetation communities and habitats	Possible	Moderate	**Medium**	The reduced extent of flooding in the survey area is expected to result in some areas of wetland and floodplain communities experiencing less frequent inundation. This may result in a gradual modification of community structure over time to be more representative of drier vegetation communities. These modifications may result from changes to dispersal patterns of some flora species that rely on flooding or an increase in survival of species less tolerant to flooding. However, because of the natural variability and stochastic nature of flooding and because there are other sources of flooding from catchments other than Warragamba it is expected that any change resulting from the Project is likely to be minor and gradual. The gradual nature of change would be difficult to measure and to accurately differentiate the impact of the Project from broader changes within the catchment.
Reduction of flooding extent in terrestrial woodland and forest communities and habitat	Unlikely	Minor	**Very Low**	The reduced extent of flooding in the survey area is expected to result in terrestrial woodland and forest habitats experiencing less frequent inundation. This reduced frequency of flooding is expected to have negligible impacts on these communities in the medium-long term, that do not typically depend on flooding events for their function. Increases in the condition of these area may occur over a long period of time if they are not subject to the damage caused by major flood events (such as weed and pest incursions).
Bank erosion and slumping resulting in vegetation community and habitat degradation	Likely	Minor	**Medium**	Appendix N2 of the EIS (Geomorphology assessment report) notes that the survey area is likely to result in increased bank erosion in discrete areas along the Nepean River and the Hawkesbury River. Changes to vegetation structure, composition, and condition would directly result from these changes to erosive processes for riparian, floodplain and wetland communities. However, it is also noted that bank erosion can be caused by a range of complex factors not associated with changing hydrological conditions including soil characteristics, land use modification and bank vegetation clearance. The highly cleared and modified landscapes of the Hawkesbury-Nepean catchment are already subject to erosion impacts and the increase in duration of inundation in wetland and floodplain zones is unlikely to substantially change the existing erosion condition in the broader landscape.
Increased fine sediment deposits reducing water quality	Possible	Minor	**Low**	Appendix N2 of the EIS (Geomorphology assessment report) predicted that minor turbidity increases in the catchment would not lead to a greater risk of sediment deposition, as the fine sediment would be suspended in the water column and the events would be relatively short-lived. Vegetation within these areas may temporarily decline, however this is not expected to result in long-term impacts to communities and habitats.
Displacement of terrestrial fauna habitat resources	Unlikely	Minor	**Very Low**	As the extent of flood inundation for the survey area is predicted to reduce due to the Project, (that is, it would not inundate some areas that are currently subject to flooding), an increase or changes to the displacement of fauna habitat resources (such as woody debris and litter) is not expected to occur.

Potential impacts	Impact risk assessment			Description of change
	Likelihood	Consequence	Risk for biodiversity	
Displacement of habitat for fauna dependent on riparian or wetland habitats	Possible	Moderate	**Medium**	The reduction in the frequency of flood events would likely result in fewer flushing flows though these wetland areas and may decrease water levels within wetlands which require overbank flooding to maintain their water budgets, resulting in habitat degradation and loss of resources. The effect of the Project would be offset to some extent through flooding due to inflows from local catchments as occurred in February 2020.
Spread of exotic species resulting in increased competition and predation on native species	Unlikely	Minor	**Very Low**	As the extent of flood inundation for the survey area is predicted to reduce due to the Project (that is, it would not inundate some areas that are currently subject to flooding), an increase in the spread of exotic species into unaffected areas is not expected to occur.
Spread of disease and pathogens	Unlikely	Minor	**Very Low**	As the extent of flood inundation for the survey area is predicted to reduce due to the Project (that is, it would not inundate some areas that are currently subject to flooding), an increase in the spread of disease and pathogens into unaffected areas is not expected to occur. Furthermore, increased dry periods may limit the spread of soil and water-borne diseases such as the root-rot fungus (*Phytophthora cinnamomi*) and the amphibian chytrid fungus.
2. An increase in low level flooding and flows within the FMZ discharge area				
Increased duration of inundation in wetland and floodplain vegetation communities and habitats	Likely	Insignificant	**Low**	For areas within the FMZ discharge area, prolonged periods of inundation may have negative impacts on natural successional processes on plant and sedentary fauna species through vegetation damage and bank stability in wetland and floodplain communities. This impact, however, is not expected to be permanent (up to an estimated 5 days) and is unlikely to result in significant modifications to the existing communities and habitats that are currently subject to wet periods and flooding events. Increased water flows into the Cumberland Plain's wetland and riparian habitats may potentially be beneficial for some aspects of wetland ecosystem health.
Increased duration of inundation in terrestrial woodland and forest communities and habitat	Possible	Minor	**Low**	Based on the predicted extent of the FMZ discharge area, very few areas of mapped terrestrial (that is, non-wetland and floodplain) communities and habitat occur within this zone. While no substantial increase in the duration of flood inundation is expected in terrestrial community and habitat types, in the areas where this occurs, the inundation may result in temporary restriction on access to those resources.
Bank erosion and slumping resulting in vegetation community and habitat degradation	Likely	Minor	**Medium**	Appendix N2 of the EIS (Geomorphology assessment report) notes that the survey area is likely to result in increased bank erosion in discrete areas along the main channel of the Nepean and Hawkesbury rivers. Riverbank erosion and bank slumping can be exacerbated by higher river flows and soil saturation during periods of extended inundation. Changes to vegetation structure, composition, and condition would directly result from these changes to erosive processes for riparian, floodplain, and wetland communities. The area potentially impacted would be small and confined to vegetated areas on alluvial soils immediately adjacent to the main river channel.

Potential impacts	Impact risk assessment			Description of change
	Likelihood	Consequence	Risk for biodiversity	
				However, it is also noted that bank erosion can be caused by a range of complex factors not associated with changing hydrological conditions including soil characteristics, land use modification and bank vegetation clearance. The highly cleared and modified landscapes of the Hawkesbury-Nepean catchment are already subject to erosion impacts and the increase in duration of inundation in wetland and floodplain zones is unlikely to substantially change the existing erosion condition in the broader landscape.
Increased fine sediment deposits reducing water quality	Possible	Minor	**Low**	Appendix N2 of the EIS (Geomorphology assessment report) predicted that minor turbidity increases in the catchment would not lead to a greater risk of sediment deposition, as the fine sediment would be suspended in the water column and the events would be relatively short-lived. Fringing aquatic vegetation within the FMZ discharge area may temporarily decline due to the increase in flooding duration, however this is not expected to result in long-term impacts to communities or habitats.
Displacement of fauna habitat resources	Possible	Minor	**Low**	Terrestrial habitat features provide essential habitat for a wide variety of native animals and are important to the functioning of many ecosystems. The removal or displacement of these features can have a range of environmental consequences, including the loss of shelter habitat, disruption of ecosystem process and soil erosion. An increase to the duration of flooding and inundation in the FMZ discharge area may result in the displacement of fauna habitat resources such as logs, woody litter, and bush rocks. These resources may be lost from the terrestrial environment to aquatic habitats or they may be moved into other areas following the receding of the flood waters. Conversely, the inundation of flood water may also increase the presence of woody debris in the environment following a flooding event, creating additional habitat for native species in the landscape. However, fauna habitat resources are currently already exposed to local catchment flooding and this situation is not expected to significantly change due to the Project.
Spread of exotic species resulting in increased competition and predation on native species	Possible	Minor	**Low**	The creation of deeper, more permanent pools of water in wetland zones may result in the spread of exotic flora and fauna species. Species favoured by deeper more permanent water include: Carp (*Cyprinus carpio*), Plague Minnow (*Gambusia holbrooki*), Water Hyacinth (*Eichhornia crassipes*), Salvinia (*Salvinia molesta*) and Cabomba (*Cabomba caroliniana*). The disturbance of floodplain and riparian zones by changes in water regime may permit establishment and spread of semi terrestrial species, for example willows (*Salix* spp.), Blackberry (*Rubus fruticosus*), Lippia (*Phyla canescens*) and Broad-leaved Privet (*Ligustrum lucidum*). However, the area of flooding in the FMZ discharge area is not more extensive than the current flooding extents and the increased duration of inundation in these areas is unlikely to introduce new or emerging weeds or pest animals into this catchment. The highly cleared landscapes typical of the floodplains in the Hawkesbury-Nepean catchment have been subject to extensive vegetation clearance and disturbance as a result of agriculture and suburban expansion and environmental weeds and pests are already part of the landscape.
Spread of disease and pathogens	Possible	Minor	**Low**	The increased duration of inundation of wetland and floodplain areas within the FMZ discharge area could result in the spread of aquatic and soil-borne diseases. The amphibian chytridiomycosis occurs in water and soil, is

Potential impacts	Impact risk assessment			Description of change
	Likelihood	Consequence	Risk for biodiversity	
				often fatal for infected frogs and is known to be present in habitats throughout eastern NSW. The root-rot fungus (*Phytophthora cinnamomi*) is soil-borne and known to spread in warm and moist conditions and cause dieback in native flora species. Infection by Myrtle Rust may be generally assisted, in part, by moist leaf surfaces. Prolonged inundation within the FMZ discharge area may support prolonged leaf surface moisture in these areas and immediate surrounds. While the increased inundation in the FMZ discharge area may result in the spread disease and pathogens, the effect of this is expected to be localised to wetland zones, riparian areas, and protected gullies and temporary following flood events. The pathogens listed above are known to occur in the Hawkesbury-Nepean catchment and the Project is not expected to introduce these pathogens into areas not already impacted by this threat. Some threatened entities, such as *Rhodamnia rubescens*, are known be more susceptible to certain pathogens and therefore at higher risk.

6.4 Risk of impacts to biodiversity features

6.4.1 Native vegetation and TECs

As outlined in Table 6-3, the following impacts were identified as a 'Medium' or greater risk to biodiversity:

- reduction of flooding extent in wetland and floodplain vegetation communities and habitats
- increased duration of inundation in terrestrial woodland and forest communities and habitat
- bank erosion and slumping resulting in vegetation community and habitat degradation.

'Low' risk impacts for native vegetation include:

- increased duration of inundation in wetland and floodplain vegetation communities and habitats
- spread of exotic species resulting in increased competition and predation on native species
- spread of disease and pathogens.

Table 6-4 outlines the areas of PCTs that would no longer be flooded during the 10% AEP and the areas of PCTs that would experience increased periods of inundation due to the FMZ discharge, including the areas affected. Where communities are listed as critically endangered under the BC Act, the impact risk is automatically allocated to 'High' to account for the increased risk to these CEECs inherent in their conservation status.

It should be noted these areas would still be subject to flooding from local catchments independent of contributions from the Warragamba Dam catchment. This constrains accurately apportioning the contribution of the Project to any changes to the composition and distribution of PCTs.

TECs in Table 6-4 with an impact risk of 'Medium' or greater have been further assessed through an Assessment of Significance in Appendix F of this report.

Notwithstanding the risk assessment process, TECs listed as critically endangered under the BC Act were assigned a 'High' risk rating for further assessment through an Assessment of Significance in Appendix F of this report.

Table 6-4. Potential impacts to plant community types and TECs within the changed flood extent of 10% AEP event area and the FMZ discharge area

Plant community type	Threatened ecological community	Area within changed 10% AEP flood extent (ha)	Area within FMZ discharge (ha)	Impact risk	Justification
Freshwater communities					
PCT 781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	*Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	43.07	864.35	**Medium**	This wetland community will be subject to extended inundation in the FMZ discharge area and some areas will experience reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 924: *Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley Sydney Basin Bioregion	*Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	0.29	10.02	**Medium**	This wetland community will be subject to extended inundation in the FMZ discharge area. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
TOTAL		**43.36**	**874.37**		
Floodplain and riparian communities					
PCT 724: Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion	*Shale Gravel Transition Forest in the Sydney Basin Bioregion EEC* under the BC Act *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC* under the EPBC Act	45.67	1.23	**Medium**	This floodplain community will be primarily subject to reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion	*River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	437.73	777.83	**Medium**	This floodplain community will be subject to extended inundation in the FMZ discharge area and some areas will experience reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion	*Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC* under the BC Act	157.61	24.95	**Medium**	Listed as critically endangered under the BC Act. This floodplain community will be subject to extended inundation in the FMZ discharge area and some areas will experience reduced flooding extents. Fringing vegetation and erosion impacts

Plant community type	Threatened ecological community	Area within changed 10% AEP flood extent (ha)	Area within FMZ discharge (ha)	Impact risk	Justification
	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC under the EPBC Act				may result in temporary modifications to the community.
PCT 1067: Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion	*Castlereagh Swamp Woodland Community EEC* under the BC Act	2.76	0.0	**Medium**	This floodplain community will be primarily subject to reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 1106: River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	*River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	22.66	65.88	**Medium**	This riparian community will be subject to extended inundation in the FMZ discharge area and some areas will experience reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 1292: Water Gum - Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion	Not listed	4.17	0.44	**Medium**	This riparian community will be subject to reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River Sydney Basin Bioregion	*River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	0.39	8.97	**Medium**	This riparian community will be subject to extended inundation in the FMZ discharge area and some areas will experience reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
PCT 1718: Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast	*Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act	1.96	0.43	**Medium**	This floodplain community will be primarily subject to reduced flooding extents. Fringing vegetation and erosion impacts may result in temporary modifications to the community.
TOTAL		**672.94**	**879.73**		

Plant community type	Threatened ecological community	Area within changed 10% AEP flood extent (ha)	Area within FMZ discharge (ha)	Impact risk	Justification
Dry sclerophyll and grassy communities					
PCT 866: Grey Gum - Smooth-barked Apple open forest of the dry hinterland of the Central Coast Sydney Basin Bioregion	Not listed	-	0.34	**Low**	Only small portions of PCT 866 occurrences will be impacted by more frequent flooding (FMZ discharge). Additionally, a reduction in flooding frequency is unlikely to impact this PCT. Any impacts are unlikely to lead to the complete degradation of the remaining stands.
PCT 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion	Not listed	138.67	89.35	**Low**	While a reasonable area of this community is within the predicted changed 10% AEP and FMZ discharge area, it is unlikely to be dependent on flood waters or substantially altered by longer inundation events.
PCT 1183: Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion	*Sydney Turpentine Ironbark Forest CEEC* under the BC Act *Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC* under the EPBC Act	-	1.44	**High**	Listed as critically endangered under the BC Act.
PCT 1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion	*Sydney Turpentine Ironbark Forest CEEC* under the BC Act *Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC* under the EPBC Act	3.23	3.67	**High**	Listed as critically endangered under the BC Act.
PCT 1327: Yellow Bloodwood - ironbark shrubby woodland of the dry hinterland of the Central Coast Sydney Basin Bioregion	Not listed	0.04	0	**Low**	PCT 1327 will not be impacted by the discharge of the FMZ (increased flooding frequency). PCT1327 is not reliant on flooding to maintain its species composition and ecological function. This terrestrial community is therefore unlikely to be substantially impacted by the change in hydrological regimes in the 10% AEP and the FMZ discharge area.
PCT 1328: Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of	Not listed	0.06	0.04	**Low**	Only 0.04 ha of PCT 1328 may be impacted by the discharge of the FMZ (increased flooding frequency). PCT1328 is not reliant on flooding to

Plant community type	Threatened ecological community	Area within changed 10% AEP flood extent (ha)	Area within FMZ discharge (ha)	Impact risk	Justification
the Central Coast Sydney Basin Bioregion					maintain its species composition and ecological function. This terrestrial community is therefore unlikely to be substantially impacted by the change in hydrological regimes in the 10% AEP and the FMZ discharge area.
PCT 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC* under the BC and EPBC Acts	91.20	73.76	**High**	Listed as critically endangered under the BC Act.
TOTAL		**233.20**	**168.60**		
Wet sclerophyll and rainforest communities					
PCT 877: Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	*Western Sydney Dry Rainforest in the Sydney Basin Bioregion EEC* under the BC Act *Western Sydney Dry Rainforest and Moist Woodland on Shale CEEC* under the EPBC Act	3.80	1.83	**Low**	This terrestrial community is unlikely to be substantially impacted by the change in hydrological regimes in the 10% AEP and the FMZ discharge area.
PCT 1385: Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast Sydney Basin Bioregion	Not listed	0.63	2.02	**Low**	PCT 1385 is not reliant on periodic flooding to maintain ecological function. A decrease in flooding is therefore unlikely to have an impact. Increased flooding caused by the FMZ is unlikely to alter ecological function such that the community is lost or modified.
PCT 1557: Rough-barked Apple - Forest Oak - Grey Gum grassy woodland on sandstone ranges of the Sydney Basin	Not listed	0.25	0.07	**Low**	PCT 1557 is not reliant on periodic flooding to maintain ecological function. A decrease in flooding is therefore unlikely to have an impact. Increased flooding of 0.07 ha caused by the FMZ is unlikely to alter ecological function to large stands of this PCT such that it is lost or modified.
TOTAL		**4.68**	**3.92**		

6.4.2 Threatened flora species

As outlined in Table 6-3, the following impacts were identified as 'Medium' or greater risk to biodiversity:

- reduction of flooding extent in wetland and floodplain vegetation communities and habitats
- increased duration of inundation in terrestrial woodland and forest communities and habitat
- bank erosion and slumping resulting in vegetation community and habitat degradation.

'Low' risk impacts for threatened flora species include:

- increased duration of inundation in wetland and floodplain vegetation communities and habitats
- increased fine sediment deposits reducing water quality
- spread of exotic species resulting in increased competition and predation on native species
- spread of disease and pathogens.

Threatened flora species that are considered to have a 'Moderate' or 'High' likelihood of occurrence or species that have been previously recorded in the survey area are identified in Table 6-5 and have been assumed to be present. Where species are listed as critically endangered under the BC Act, the impact risk is automatically allocated to 'High'.

Species in Table 6-5 with an impact risk of 'Medium' or greater have been further assessed through an Assessment of Significance in Appendix F to this report.

Table 6-5. Habitat for threated flora species and populations assessed as having a moderate or higher likelihood of occurring

Threatened flora species	BC Act	EPBC Act	Likelihood of occurrence in 10% AEP	Impact risk	Justification
Acacia bynoeana	E	V	Moderate	**Low**	Species is located within the downstream study area in areas not likely to be subject to regular inundation. This species is known to occur in heath or dry sclerophyll forest on sandy soils (OEH website). This species is unlikely to occur in the area subject to flooding regime changes.
Acacia pubescens	V	V	Recorded	**Medium**	Located in areas where flooding regime is likely to change. This species is unlikely to be negatively impacted by longer dry periods based on the location of most records, however it may be sensitive to periods of inundation.
Allocasuarina glareicola	E	E	Moderate	**Low**	Located near edge of the downstream study area and habitat includes dry sclerophyll woodland (OEH website). This species is unlikely to occur in the area subject to flooding regime changes.
Callistemon linearifolius	V	-	Moderate	**Medium**	Species has not been recorded within the downstream study area. However, it was recorded within the upstream assessment area within the riparian and creek line habitat, which is a significance range extension and change in known habitat preferences. May occur in the area subject to flooding regime changes.
Cynanchum elegans	E	E	Moderate	**Low**	Species has not been recorded within the downstream study area, however the species recorded growing in the ecotones between dry subtropical rainforest and sclerophyll forests and woodlands and is associated with five PCTs within the study area. Species is not likely to be impacted by longer dry periods. It may be sensitive to longer wet periods but unlikely to be significantly impacted.

Threatened flora species	BC Act	EPBC Act	Likelihood of occurrence in 10% AEP	Impact risk	Justification
Darwinia biflora	V	V	Moderate	**Low**	Located near the edge of the downstream study area, occurring on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Species is not likely to be impacted by longer dry periods. It may be sensitive to longer wet periods but unlikely to be significantly impacted.
Dillwynia tenuifolia	V	-	Recorded	**Medium**	Most records located in the downstream study area. Some records located in areas where flooding regime is likely to change. Based on current distribution this species is unlikely to require regular inundation. This species may be sensitive to periods of inundation.
Dillwynia tenuifolia- in the Baulkham Hills local government area	E	-	High	**Low**	Not recorded within the the downstream study area. If present, it is likely to occur in on sandstone habitat towards the PMF. This population is unlikely to be affected by a reduction in flood extent.
Epacris purpurascens var. *purpurascens*	V	-	Recorded	**Medium**	Known records located near the edge of area likely to be affected by changes to flooding regime. Species is not likely to be impacted by longer dry periods. It may be sensitive to longer wet periods but unlikely to be significantly impacted.
Epacris sparsa	V	V	Moderate	**Low**	Not recorded within the downstream study area. If present, it is likely to occur in the riparian zone. Unlikely to be negatively impacted by increased periods of inundation.
Eucalyptus benthamii	V	V	Recorded	**Medium**	Requires deep alluvial soils and a flooding regime that permits seedling establishment (OEH website). Based on current known records and habitat requirements, this species may be sensitive to changes to the downstream flooding regime. The likelihood of significant changes to the downstream flooding regime due to the Project is considered low, and noting the contributions from other downstream catchments.
Eucalyptus camfieldii	V	V	Moderate	**Low**	Records of this species occur closer to the coast than the Project area (OEH website). Not recorded in proximity to the downstream study area. Not likely to be impacted.
Eucalyptus sp. Cattai	CE	CE	Moderate	**High**	Listed as critically endangered under the BC Act.
Grammitis stenophylla	E	-	Moderate	**Low**	No records of this species occur in proximity to the existing PMF. This species grows on rocks in rainforest and wet sclerophyll forest (PlantNet). As this species has not been recorded and limited habitat is available, this species is not likely to be significantly impacted by changes to flooding regime.
Grevillea juniperina subsp. *juniperina*	V	-	Recorded	**Medium**	The majority of known records of this species occur within the downstream study area but outside of the area of material flooding regime change. Most records are unlikely to be affected by changes to flooding regimes. It is not likely to impacted by longer dry periods. Few records may be impacted where the period of flooding is extended as this species may be sensitive to prolonged inundation.

Threatened flora species	BC Act	EPBC Act	Likelihood of occurrence in 10% AEP	Impact risk	Justification
Grevillea parviflora subsp. *parviflora*	V	V	Moderate	**Low**	Not recorded in proximity to the Project study area. This species can occur in a range of habitats, including low lying areas and upper slopes (OEH website). Based on the lack of records within the Project area and the range of habitats that this species can inhabit, it is unlikely that this species will be significantly impacted by flooding regime changes as a result of the Project.
Grevillea shiressii	V	V	Moderate	**Low**	Not recorded in proximity to the Project study area. This species is known to occur along creek banks in wet sclerophyll forest in two populations north of Sydney (OEH website). Based on the lack of records within the Project area and the known distribution of this species, it is unlikely that this species will be significantly impacted by flooding regime changes as a result of the Project.
Gyrostemon thesioides	E	-	Moderate	**Low**	This species is only known from three locations. This most recent sighting is from near the Colo River in Wollemi National Park. The records from the Nepean and Georges Rivers are from 90 and 30 years ago respectively. Consequently, this species is unlikely to occur in the Project study area and is unlikely to be significantly impacted by the Project.
Hibbertia puberula	E	-	Moderate	**Low**	Located near the edge of the downstream study area within Shanes Park. The species is associated with Castlereagh woodlands communities within Western Sydney and Holsworthy areas. The species is known to occur within the moist woodland communities subject to flooding regime changes and may be sensitive to flooding regime changes as a result of the Project.
Kunzea rupestris	V	V	Recorded	**Low**	Habitat for this species includes shallow depressions on large, flat sandstone rock outcrops (OEH website). One record of this species is present in the Project study area, however this record was made with 200-metre accuracy and it is situated in the middle of the Colo River which is unlikely to be the actual location of this species based on the description being 'low heath'. This species is unlikely to occur in the area subject to flooding regime changes.
Lasiopetalum joyceae	V	V	Moderate	**Low**	One record of this species is located near the downstream study area `boundary. This species is known to occur ridgetops on the Hornsby Plateau (OEH website). This species is unlikely to occur in the area subject to flooding regime changes.
Leucopogon exolasius	V	V	Moderate	**Low**	There are no records of this species in proximity to the Project area, however it has been recorded from Stokes Creek (PlantNet) to the west. The species is known to occur in woodland on sandstone. If present within the Project area, the species is unlikely to occur in areas subject to flooding regime changes.
Leucopogon fletcheri subsp. *fletcheri*	E	-	Moderate	**Low**	There are no records of this species in proximity to the Project study area. This species is known to occur in dry eucalypt woodland or shrubland, generally on flat to gently sloping terrain along ridges and spurs (OEH website). This species is unlikely to occur in the area subject to flooding regime changes.

Threatened flora species	BC Act	EPBC Act	Likelihood of occurrence in 10% AEP	Impact risk	Justification
Marsdenia viridiflora R. Br. subsp. *viridiflora population*	EP	-	High	**Medium**	One record of this population has been recorded in proximity to the Project study area. It is known to occur within the moist woodland communities, subject to flooding regime changes, and may be sensitive to flooding regime changes as a result of the Project.
Melaleuca deanei	V	V	Moderate	**Low**	There are no records of this species within the Project study area, but some recorded are located within close proximity to the boundary within the Maroota area. The species typically occurs on sandstone, often in areas which shale influences. Species is not likely to be impacted by longer dry periods. It may be sensitive to longer wet periods, but unlikely to be significantly impacted.
Micromyrtus minutiflora	E	V	High	**Medium**	This species has been recorded within the downstream study area but is not known to occur in the area subject to flooding regime changes. This species is unlikely to be impacted by an increase in dry conditions but may be impacted by increased periods of inundation. This species is associated with the dry and moist woodland communities which are subject to flooding regime changes.
Persoonia hirsuta	E	E	Moderate	**Low**	One record of this population has been recorded in proximity to the Project study area. This species is usually found in sandy soils in dry sclerophyll open forest, woodland, and heath on sandstone (OEH website). It is not known to occur in areas subject to flooding regime changes and is unlikely to occur there.
Persoonia nutans	E	E	Recorded	**Medium**	Most records of this species occur within the downstream study area outside of the area subject to flooding regime changes. Based on known records, this species is unlikely to be reliant on inundation for its survival. Two overlapping records of this species, with 1,000-metre accuracy, are situated at the confluence of the Grose and Nepean Rivers. If present within the area subject to flooding regime changes, individuals of this species may be impacted by increased water retention, however the species is unlikely to be significantly impacted.
Pilularia novae-hollandiae	E	-	Moderate	**Medium**	This species has not been recorded in proximity to the Project study area. The Sydney region is the northern extent of the known range of this species (OEH website). This species appears to exhibit ephemerality based on water availability, and in the Albury-Urana area, most records are from table drains on the sides of roads (DPIE website). This species is likely to be reliant on periods of water inundation and therefore has potential to be impacted by changes to flooding regimes, if present.
Pimelea curviflora var. *curviflora*	V	V	Recorded	**Medium**	Records of the species mostly occur within the the downstream study area however one record is located in an area predicted to experience longer periods of water inundation. This species may be impacted by increased by long periods of inundation but is unlikely to be impacted by longer dry periods based on its known distribution.

Threatened flora species	BC Act	EPBC Act	Likelihood of occurrence in 10% AEP	Impact risk	Justification
Pimelea spicata	E	E	High	**Medium**	This species has been recorded within the downstream study area in proximity to the area subject to flooding regime changes. This species occurs in dry and moist woodland communities (OEH website) and may be sensitive to flooding regime changes as a result of the Project.
Pomaderris brunnea	E	V	Recorded	**Medium**	A single record of this species occurs adjacent to the Colo River. It is known to occur in moist woodland or forest on floodplains and creek lines. This species may be sensitive to flooding regime changes as a result of the Project.
Pterostylis saxicola	E	E	Moderate	**Low**	Two records of this population have been recorded in proximity to the Project study area. The expert report prepared by Dr Weston for this species has determined that the species does not rely on period inundation, and the Project would be unlikely to impact populations of the species occurring within the downstream study area.
Pultenaea parviflora	E	V	Recorded	**Medium**	This species has been recorded within the downstream study area with one record located within the area where longer dry periods may occur. The species is known to occur within the moist woodland communities subject to flooding regime changes and may be sensitive to flooding regime changes as a result of the Project.
Rhodamnia rubescens	CE	-	Recorded	**High**	Listed as critically endangered under the BC Act.
Senna acclinis	E	-	Recorded	**Medium**	This species has been recorded in the area subject to flooding regime changes as a result of the Project. There is potential for this species to be sensitive to increased periods of water inundation.
Seringia denticulata (syn. Keraudrenia corollata var. *denticulata) population*	EP	-	High	**Medium**	One record of this species occurs in the Project study area, adjacent to the Colo River. This species is known to occur on the edge of floodplains on well-drained soil (OEH website). This species may be sensitive to flooding regime changes as a result of the Project.
Syzygium paniculatum	E	V	Moderate	**Low**	There is one record of the species occurring within the Project study area. Species is not likely to be impacted by longer dry periods. It may be sensitive to longer wet periods but unlikely to be significantly impacted.
Tetratheca glandulosa	V	-	Recorded	**Low**	This species has been recorded in the downstream study area. One record is located in an area subject to increased water inundation, however this record is subject to 10-kilometre accuracy. This species is known to predominantly occupy ridgetops and upper slopes and to a lesser extent mid-slope sandstone benches (OEH website). This species is unlikely to be sensitive to flooding regime changes as a result of the Project.
Zieria involucrata	E	V	Recorded	**Medium**	This species has been recorded in the area subject to flooding regime changes as a result of the Project. There is potential for this species to be sensitive to increased periods of water inundation.

6.4.3 Threatened fauna species

As outlined in Table 6-3, the following impacts were identified as 'Medium' or greater risk to biodiversity:

- reduction of flooding extent in wetland and floodplain vegetation communities and habitats
- increased duration of inundation in terrestrial woodland and forest communities and habitat
- bank erosion and slumping resulting in vegetation community and habitat degradation.

'Low' risk impacts for threatened fauna species include:

- increased duration of inundation in wetland and floodplain vegetation communities and habitats
- increased fine sediment deposits reducing water quality
- displacement of fauna habitat resources
- spread of exotic species resulting in increased competition and predation on native species
- spread of disease and pathogens.

Threatened fauna species listed under the BC Act that are considered to have a 'Moderate' or 'High' likelihood of occurrence or species that have been previously recorded in the survey area are outlined in Table 6-6. Species listed as 'migratory' under the EPBC Act with a moderate or high likelihood of occurrence are not included within Table 6-6 as they are not subject to the assessment provisions of the BC Act. Where species are listed as critically endangered under the BC Act, the impact risk is automatically allocated to 'High'.

Species in Table 6-6 with an impact risk of 'Medium' or greater have been further assessed through an Assessment of Significance in Appendix F of this report.

Table 6-6. Habitat for threated fauna species and populations assessed as having a moderate or higher likelihood of occurring

Species	BC Act	EPBC Act	Likelihood of occurrence	Impact risk	Justification
Australasian Bittern (*Botaurus poiciloptilus*)	E	E	Recorded	**Low**	Species known to inhabit fringing vegetation in wetland habitats.
Australian Painted Snipe (*Rostratula australis*)	E	E	Recorded	**Low**	Species known to inhabit fringing vegetation in wetland habitats.
Barking Owl (*Ninox strenua*)	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Black Bittern (*Ixobrychus flavicollis*)	V	-	Recorded	**Low**	Species known to inhabit fringing vegetation in wetland habitats.
Black Falcon (*Falco subniger*)	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Black-necked Stork (*Ephippiorhynchus asiaticus*)	E	-	Recorded	**Low**	Species known to inhabit fringing vegetation in wetland habitats.
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E	-	Recorded	**Medium**	Species known to utilise terrestrial ground cover habitat and woody and leaf litter that may be subject to inundation or reduced flooding extent.
Curlew Sandpiper (*Calidris ferruginea*)	E	CE	Recorded	**Low**	Species known to inhabit fringing vegetation in wetland habitats.
Dural Land Snail (*Pommerhelix duralensis*)	E	E	Recorded	**Medium**	Species known to utilise terrestrial ground cover habitat and woody and leaf litter that may be subject to inundation or reduced flooding extent.

Species	BC Act	EPBC Act	Likelihood of occurrence	Impact risk	Justification
Dusky Woodswallow (*Artamus cyanopterus cyanopterus)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Eastern Cave Bat (*Vespadelus troughtoni)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Eastern Coastal Free-tail Bat (*Micronomus norfolkensis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Eastern False Pipistrelle (*Falsistrellus tasmaniensis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Flame Robin (*Petroica phoenicea)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Freckled Duck (*Stictonetta naevosa)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Gang-gang Cockatoo (*Callocephalon fimbriatum)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Giant Burrowing Frog (*Heleioporus australiacus)*	V	V	Recorded	**Low**	Species is known to occur high in the catchment which will not be subject to substantial changes in flooding or inundation events.
Glossy Black-Cockatoo (*Calyptorhynchus lathami)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Greater Broad-nosed Bat (*Scoteanax rueppellii)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Green and Golden Bell Frog (*Litoria aurea)*	E	V	Recorded	**Medium**	Species historically recorded in wetland habitats that will be subject to longer inundation and potential dry periods, potentially exacerbating the spread of *Gambusia holbrooki* and chytrid.
Grey-headed Flying-fox (*Pteropus poliocephalus)*	V	V	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Koala (*Phascolarctos cinereus)*	V	V	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Large-eared Pied Bat (*Chalinolobus dwyeri)*	V	V	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Little Bentwing-bat (*Miniopterus australis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Little Eagle (*Hieraaetus morphnoides)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.

Species	BC Act	EPBC Act	Likelihood of occurrence	Impact risk	Justification
Little Lorikeet (*Glossopsitta pusilla)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Masked Owl (*Tyto novaehollandiae)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Painted Honeyeater (*Grantiella picta)*	V	V	Moderate	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Powerful Owl (*Ninox strenua)*	V	V	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Red-crowned Toadlet (*Pseudophryne australis)*	V	-	Recorded	**Low**	Species is known to occur high in the catchment which will not be subject to substantial changes in flooding or inundation events.
Regent Honeyeater (*Anthochaera phrygia)*	CE	CE	Recorded	**High**	Species listed as critically endangered under the BC Act.
Sooty Owl (*Tyto tenebricosa)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Southern Myotis (*Myotis Macropus)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation. The anticipated loss or modification of habitat is negligible given the several thousand hectares of commensurate foraging and/or roosting habitat present within the locality.
Speckled Warbler (*Chthonicola sagittata)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Spotted Harrier (*Circus assimilis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Spotted-tailed Quoll (*Dasyurus maculatus)*	V	E	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Square-tailed Kite (*Lophoictinia isura)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Squirrel Glider (*Petaurus norfolcensis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Swift Parrot (*Lathamus discolor)*	E	CE	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Turquoise Parrot (*Neophema pulchella)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.

Species	BC Act	EPBC Act	Likelihood of occurrence	Impact risk	Justification
Varied Sittella (*Daphoenositta chrysoptera)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Yellow-bellied Glider (*Petaurus australis)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.
White-bellied Sea-Eagle (*Haliaeetus leucogaster)*	V	-	Recorded	**Low**	Highly mobile species that is unlikely to be impacted by changes in flooding extents and wetland inundation.

6.5 Assessments of significance

Assessments of significance for threatened species, population and communities listed under the BC Act that would be potentially impacted by the Project are provided in Appendix F of this report. A summary of the results of these assessments is provided in Table 6-7.

For threatened species and communities listed under the BC Act, the assessment addresses the heads of consideration under section 5A of the EP&A Act.

For species and communities listed under the EPBC Act, Assessments of Significance pursuant to the EPBC Act have been prepared as part of Appendix F5 of the EIS (Matters of national environmental significance - biodiversity).

Table 6-7. Summary of findings of Assessment of Significance under the EP&A Act

Threatened species, populations, or communities	Assessment question							Significant impact?
	a	b	c	d	e	f	g	
Vegetation communities								
Castlereagh Swamp Woodland Community	X	X	N	N	N	Y	Y	Unlikely
Cumberland Plain Woodland in the Sydney Basin Bioregion	X	X	Y	Y	N	Y	Y	Potential
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	X	X	N	N	N	Y	Y	Unlikely
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	X	X	Y	Y	N	Y	Y	Potential
Shale Gravel Transition Forest in the Sydney Basin Bioregion	X	X	N	N	N	Y	Y	Unlikely
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	X	X	Y	Y	N	Y	Y	Unlikely
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	X	X	Y	Y	N	Y	Y	Potential
Sydney Turpentine Ironbark Forest in the Sydney Basin Bioregion	X	X	N	N	N	Y	Y	Unlikely
Western Sydney Dry Rainforest	X	X	Y	Y	N	Y	Y	Potential
Flora								
Acacia pubescens	Y	X	X	Y	N	Y	Y	Potential
Callistemon linearifolius	Y	X	X	Y	N	Y	Y	Potential
Dillwynia tenuifolia	Y	X	X	Y	N	Y	Y	Potential
Epacris purpurascens var. *purpurascens*	N	X	X	N	N	Y	Y	Unlikely
Eucalyptus benthamii	Y	X	X	Y	N	Y	Y	Potential
Eucalyptus sp. *Cattai*	N	X	X	N	N	Y	Y	Unlikely

Threatened species, populations, or communities	Assessment question							Significant impact?
	a	b	c	d	e	f	g	
Grevillea juniperina subsp. *Juniperina*	Y	X	X	Y	N	Y	Y	Potential
Hibbertia puberula	N	X	X	N	N	Y	Y	Unlikely
Marsdenia viridiflora R.Br subsp. *viridiflora* - Endangered population	N	X	X	N	N	Y	Y	Unlikely
Micromyrtus minutiflora	Y	X	X	Y	N	Y	Y	Potential
Persoonia nutans	Y	X	X	Y	N	Y	Y	Potential
Pilularia novae-hollandiae	N	X	X	N	N	Y	Y	Unlikely
Pimelea curviflora var. *curviflora*	N	X	X	N	N	Y	Y	Unlikely
Pimelea spicata	Y	X	X	Y	N	Y	Y	Potential
Pomaderris brunnea	Y	X	X	Y	N	Y	Y	Potential
Pultenaea parviflora	Y	X	X	Y	N	Y	Y	Potential
Rhodamnia rubescens	Y	X	X	Y	N	Y	Y	Potential
Senna acclinis	N	X	X	N	N	Y	Y	Unlikely
Seringia denticulata (syn. *Keraudrenia corollata* var. *denticulata*) *population*	N	X	X	N	N	Y	Y	Unlikely
Zieria involucrate	Y	X	X	Y	N	Y	Y	Potential
Fauna								
Australasian Bittern (*Botaurus poiciloptilus*)	Y	X	X	Y	N	Y	Y	Potential
Australian Painted Snipe (*Rostratula australis*)	Y	X	X	Y	N	Y	Y	Potential
Black Bittern (*Ixobrychus flavicollis*)	Y	X	X	Y	N	Y	Y	Potential
Black-necked Stork (*Ephippiorhynchus asiaticus*)	N	X	X	N	N	Y	Y	Unlikely
Cumberland Plain Land Snail (*Meridolum corneovirens*)	Y	X	X	Y	N	Y	Y	Potential
Curlew Sandpiper (*Calidris ferruginea*)	N	X	X	N	N	Y	Y	Unlikely
Dural Woodland Snail (*Pommerhelix duralensis*)	N	X	X	N	N	Y	Y	Unlikely
Green and Golden Bell Frog (*Litoria aurea*)	Y	X	X	Y	N	Y	Y	Potential
Regent Honeyeater (*Anthochaera phrygia*)	Y	X	X	Y	N	Y	Y	Potential

Notes: Y= Yes (negative impact), N= No (no impact), X= not applicable.

6.6 Assessment of potential impacts with regard to the PMF

As previously noted, the PMF is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. It represents a notional upper limit of flood magnitude and no attempt is made to assign a probability of exceedance to such an event (Ball *et al*. 2019). The PMF is highly unlikely to occur in nature given the size of the Warragamba Dam catchment.

The Project would result in only a minor reduction in the flooding extents and durations compared to the existing dam. This would, however have other benefits which are not relevant to biodiversity, such as increasing the time available for evacuations of affected residents and workers.

As previously noted, flood-adapted or flood-dependent vegetation at the extent of the larger flood events would not rely on flooding from these infrequent events (such as the <1% AEP and the PMF) and would rely on local catchment or upstream flooding.

Vegetation at the terrestrial (that is, not riparian) extents of the PMF is generally not flood-adapted or flood-dependent as the likelihood of the PMF is extremely rare. Table 5-3 demonstrates this with large areas of terrestrial woodland potentially impacted in the PMF and small areas within the survey area. This notwithstanding, there would be no material impacts or benefits due to the reduction in the extent of the PMF with the Project.

For threatened flora and fauna species there would be no material impacts or benefits due to the reduction in the extent of the PMF with the Project.

6.7 Impacts on groundwater dependent ecosystems

Groundwater resources at the fringe of flooding extents for larger events are unlikely to rely on flooding for replenishment. Local catchment sources and rainfall would be the predominant sources of water for these groundwater resources. Exceptions include perched water table landforms associated with the Agnes Banks and northern Castlereagh areas. In the Agnes Banks area, the catchment is relatively isolated and small, and currently overbank flood events are important in replenishing aquifers and providing flushing flows to wetlands.

Other groundwater resources that are near the waterways and within the lower flood extents may rely on overbank flooding for replenishment. Areas with reduced transmissivity associated with aquitards, while limited to particular areas, would be associated with particular ecological values, and hence would see particular impacts relating to these changes in hydrology.

While the frequency of overbank flooding would be reduced in some areas, during the discharge of the FMZ there would be higher levels and an increased flow within the main river channel, and low-lying areas would experience increased temporary inundation for up to six days. Where there are linked alluvial aquifers to the main river channel and inundated low-lying areas, there would be a greater opportunity for the groundwater to infiltrate, move and replenish aquifers in overbank areas. This would mitigate any impacts on some aquifers from the reduction in overbank flooding.

The four high priority GDEs identified in the *Greater Metropolitan Region Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (NSW Office of Water 2011), these being Pitt Town Lagoon, Long Swamp, Longneck Lagoon, and O'Hares Creek would not be affected by the Project. The location of each GDE relative to selected flood events was reviewed using GIS; all would continue to be inundated by the 20% AEP event and larger events with the Project.

Appendix G to this report lists the GDEs in the study area.

6.8 Impacts on biodiversity links and corridors

Impacts of direct habitat loss can be exacerbated by fragmentation of nearby vegetation that would not be directly impacted. In many cases, fragmentation and diminishing patch sizes can have similar impacts to that caused by direct habitat removal. Fragmentation is the process by which habitats that were once continuous become divided into separate fragments isolated from each other.

Fragmentation can also put stress on native flora and fauna by increasing competition for species and resources in areas of remaining habitat. Plants and other sessile organisms are usually directly destroyed, while mobile animals retreat to remnant patches of habitat that can lead to increased competition between individuals and species.

The size and shape of a remnant patch determines its susceptibility to further degradation as fragmentation increases the ratio of disturbed 'edge' habitat to more intact 'interior' habitat. Edges are typically warmer, drier, and more exposed than interior areas of remnant patches. Edges area more vulnerable to invasion by exotic and invasive flora and fauna, fire, erosion, loss of structural diversity, increased nutrient loading and pollution. Also, several small, isolated forest or woodland patches may be unable to maintain a larger number of species than a single intact forest or woodland of the same total area.

The Project could potentially impact upon priority conservation lands (PCL) as identified within the *Cumberland Plain Recovery Plan* (DECCW 2011), as well as small remnants and corridors linking these PCLs, notably South Creek and Ropes Creek through changes in flooding.

The Project is unlikely to result in loss of vegetation cover but may change the structure and composition of vegetation communities over the long term. Potential fragmentation and patch size impacts are unlikely but structural changes in adjacent vegetation due to the project may exacerbate the current disturbance regimes and stressors, namely weed invasion, and lead to a subsequent loss of value within these biodiversity links and corridors.

6.9 Impacts to national park estate

Thirteen national parks occur within the study area. In accordance with Section 4, Attachment B of the SEARs, impacts to these estates are discussed in Table 6-8. For most national parks in the study area, the change in flooding extents is very minor. Scheyville National Park and Cattai National Park would experience the greatest reductions in flooding extents but would experience a longer duration of low-level flooding due to the discharge of water from the FMZ. The actual areas affected relative to the overall areas of these parks would be very small.

The reduction in flood extent, depth and duration that would occur due to the Project has been determined through the risk assessment process described in Section 6.3 and is unlikely to result in long-term adverse impacts on ecological processes in the study area. As a result, impacts to national park estates are not expected to result in adverse impacts such that significant biodiversity impacts would eventuate.

Table 6-8. Potential impacts to national park estate

National park estate	Impacts
Blue Mountains National Park	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. Increase in flood duration and longer periods of above average water velocities within the FMZ discharge area.
Mulgoa Nature Reserve	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. Potential impacts to Cumberland Plain Woodland EEC.
Yellomundee Regional Park	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. Increase in flood duration and longer periods of above average water velocities within the FMZ discharge area. Coastal Freshwater Wetlands EEC and Sydney Turpentine Ironbark Forest CEEC are known to occur in the study area
Windsor Downs Nature Reserve	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. Shale Sandstone Transition Forest CEEC and Castlereagh Ironbark Woodland EEC and Cumberland Plain Woodland EEC known to occur in the assessment area.
Scheyville National Park	Reduction to flood extent, depth, and duration between existing and with Project flood scenarios. Increase in flood duration within FMZ discharge area. Coastal Freshwater Wetlands on Coastal Floodplains EEC, Shale Sandstone Transition Forest CEEC, Castlereagh Scribbly Gum Woodland VEC, and Cumberland Plain Woodland CEEC known to occur within the national park.
Agnes Banks Nature Reserve	Reduction to flood extent, depth, and duration between existing and with Project flood scenarios. Coastal Freshwater Wetlands EEC and Castlereagh Scribbly Gum Woodland VEC known to occur in the assessment area.
Pitt Town Nature Reserve	Increase in flood duration within FMZ discharge area. the extent of Coastal Freshwater Wetlands on Coastal Floodplains occurring in the reserve occurs within the FMZ discharge area
Cattai National Park	Reduction to flood extent, depth, and duration between existing and with Project flood scenarios. Increase in flood duration and velocity within FMZ discharge area. Coastal Freshwater Wetlands EEC, River Flat Eucalypt Forest EEC, and Castlereagh Swamp Woodland known to occur within the national park.
Maroota Ridge Stage Conservation Area	Minor reduction in flood extent, depth and duration between existing and with Project flood scenarios. Increase in flood duration within FMZ discharge area. River Flat Eucalypt Forest EEC and Coastal Freshwater Wetlands EEC known to occur within the conservation area.
Wollemi National Park	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. River Flat Eucalypt Forest EEC, Coastal Freshwater Wetlands EEC and Sydney Turpentine Ironbark Forest known to occur within the national park.

National park estate	Impacts
Parr State Conservation Area	Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios. River Flat Eucalypt Forest EEC, Coastal Freshwater Wetlands, Sydney Turpentine Ironbark Forest CEEC and Swamp Sclerophyll Forest EEC known to occur in the conservation area.
Wianamatta Regional Park	Reduction to flood extent, depth, and duration between existing and with Project flood scenarios. Shale Gravel Transition Forest CEEC, Riverflat Eucalypt Forest, Cooks River Castlereagh Ironbark Forest and Cumberland Plain Woodland CEEC known to occur within the national park.

6.10 Key threatening processes

In accordance with Section 6.4 of the SEARs, this assessment must identify whether the Project as a whole, or any component of the Project, would be classified as a key threatening process (KTP) in accordance with the listings in the TSC Act, FM Act and EPBC Act. Impacts to biodiversity values associated with the FM Act are provided in Appendix F4 of the EIS (Aquatic ecology assessment report).

Under Part 2 of the TSC Act, KTPs are described as those threatening processes that are most likely to jeopardise the survival of those species, populations and ecological communities listed under that Act. Under section 4.32 of the BC Act, a threatening process is eligible to be listed as a key threatening process if, in the opinion of the Scientific Committee:

- it adversely affects threatened species or ecological communities, or
- it could cause species or ecological communities that are not threatened to become threatened.

All KTPs listed under the EPBC Act that are associated with the Project have adequately equivalent KTPs listed under the BC Act, however not all KTPs listed under the BC Act have equivalent KTPs listed on the EPBC Act. Consideration of KTPs listed under the EPBC Act is provided in Appendix F5 of the EIS (Matters of national environmental significance - biodiversity).

The Project would potentially result in downstream impacts that constitute, or are part of, or may result in the operation of or increase the impact of 16 KTPs. These are discussed in Table 6-9. A distinction has been made between those that are likely to be associated with the Project, and those that may occur depending on how and if the former KTPs are manifested.

Table 6-9. Key threatening processes relevant to the Project

Key threatening process	EPBC Act equivalent	Details
Likely to occur		
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.	–	The change in the pattern of discharges from Warragamba Dam associated with operation of the FMZ could constitute an ‘alteration to the natural flow regimes of rivers, streams, floodplains and wetlands’ as defined within the Scientific Determination of the KTP. It should be noted, however, that the Hawkesbury-Nepean River system is regulated which has already modified the natural flow regime of the system, including the area downstream of Warragamba Dam. Potential impacts on affected TECs, threatened species and other vegetation in the changed 10% AEP flood extent and the FMZ discharge area would be influenced by the response of individual species to increased temporary inundation (in the FMZ discharge area) and less frequent inundation (in the changed 10% AEP flood extent). Riparian vegetation, which has relatively greater exposure to flooding and elevated within bank flows, would be expected to be more tolerant to these conditions than other vegetation types.
Clearing of native vegetation	Land clearance	The change in water discharge from Warragamba Dam via operation of the FMZ may result in erosion points and bank slumping within the Penrith, Windsor, and Cattai areas of the

Key threatening process	EPBC Act equivalent	Details
		Hawkesbury-Nepean River which could result in the loss of vegetation within these areas. Riparian vegetation has a relatively greater exposure to flooding and elevated within bank flows and would be expected to be more resilient than other vegetation to these conditions which could result in the loss (clearing) of vegetation.
May occur		
Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners	–	Changes to vegetation community structure and composition as a result changes to hydrological flows may result in the operation of this KTP. Specifically, this KTP is associated with landscape-level disturbance with interactions between disturbance types. The PCTs within the study area contain at least five species highly susceptible to Bell Miner associated dieback.
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	Not listed (Fire regimes that cause biodiversity decline currently on the finalised priority assessment list)	Changes to vegetation community structure and composition as a result of changes to hydrological flows may result in the operation of this KTP. Specifically, the expected change in vegetation composition and structure would see shift towards vegetation less mesic in nature, with a higher potential to burn.
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Ecological or environmental changes to temperature, drying and wetting cycles, salinity, water pH, light, nutrition, and dissolved oxygen may exacerbate the operation of, or increase the impact of the KTP. Specifically, ecological changes relating to hydrological or ecological processes in wetland or floodplain environments.
Infection of native plants by *Phytophthora cinnamomi*	Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Changes to vegetation community structure and composition as a result changes to hydrological flows may result in the operation of this KTP and increase the impacts of this KTP. Specifically, this KTP is associated with landscape-level disturbance with interactions between disturbance types. The PCTs within the study area contain a variety of species susceptible to *P. cinnamomi*.
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result of changes to hydrological flows may result in the operation of this KTP and increase the impacts of this KTP. Specifically, this KTP is associated with landscape-level disturbance with interactions between disturbance types. The PCTs within the study area contain a variety of species in the Myrtaceae family, and therefore susceptible to this KTP.
Invasion and establishment of exotic vines and scramblers	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result changes to hydrological flows may result in the operation of this KTP. Specifically, disturbances to riparian areas as a result of changes to flow regimes promote the establishment of invasive vine and scramblers.
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result changes to hydrological flows may result in the operation of this KTP. Particularly, disturbances to riparian areas and grassy woodlands as a result of changes to flow regimes promote the establishment of Scotch Broom. It is recorded upstream of the study area.

Key threatening process	EPBC Act equivalent	Details
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result changes to hydrological flows may result in the operation of this KTP. Specifically, disturbances to riparian areas as a result of changes to flow regimes may promote the establishment of African Olive.
Invasion of native plant communities by *Chrysanthemoides monilifera*	Novel biota and their impact on biodiversity	Changes to vegetation community structure, composition, or ecological processes as a result changes to hydrological flows may result in the operation of this KTP. Specifically, disturbances to ecological inputs into floodplains as a result of changes to flow regimes may promote the establishment and spread of *Chrysanthemoides monilifera*.
Invasion of native plant communities by exotic perennial grasses	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result of changes to hydrological flows may result in the operation of this KTP. Specifically, disturbances to riparian areas as a result of changes to flow regimes may promote the establishment and spread of exotic perennial grasses.
Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)	Novel biota and their impact on biodiversity	Changes to vegetation community structure and composition as a result of changes to hydrological flows may result in the operation of this KTP. Specifically, disturbances to riparian areas as a result of changes to flow regimes may promote the establishment of Lantana, and changes to fire regime and shelter.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants-	Changes to vegetation community structure and composition as a result of changes to hydrological flows may result in the operation of this KTP. Broad changes to floristic and edaphic associations would likely promote the establishment of new species, extents, and densities of escaped garden plants. Changes to riparian processes such as flushing, flood areas and durations may promote changes in extent and densities of escaped aquatic plants.
Predation by *Gambusia holbrooki* Girard, 1859 (Plague Minnow or Mosquito Fish)	Novel biota and their impact on biodiversity	Changes to flows, including less flushing of wetland habitats, and other indirect ecological changes in wetland and riparian areas would likely exacerbate this KTP and increase its impacts.
Removal of dead wood and dead trees	–	The change in water discharge from Warragamba Dam via the FMZ would result in erosion points and bank slumping within the Penrith, Windsor and Cattai areas of the Hawkesbury-Nepean River which may result in the disturbance of soil and loss of dead wood and dead trees as they are swept away by floodwaters, buried by siltation processes and their supporting substrates eroded. This process is exacerbated by the failure of regeneration of these plant communities, changes in species composition with different response decay and resilience qualities, and the resulting reduction in natural accumulation of dead wood.

6.11 Cumulative impacts

Cumulative impacts on biodiversity values from the Project across the construction area, upstream operational area, and downstream area, as well as other projects within the same IBRA subregions have been considered. Table 6-10 provides a summary of these projects and their determined/proposed impact. For the purposes of the cumulative impact assessment, the impacted area provided in Table 6-10 encompass all types of impacts, including the impacts associated with temporary inundation and alterations to hydrological flows discussed in detail within Appendix F1 of the EIS (Biodiversity assessment report - upstream) and this report, as well as vegetation clearing related impacts from construction activities.

The projects included within the cumulative impact assessment are listed below. It should be noted that only key infrastructure projects have been included within the assessment. Therefore, this assessment is not a comprehensive assessment of all other proposed or determined projects within the IBRA subregions associated with the Project. Furthermore, for some projects, there is no publicly available information about the extent of the construction and operational impacts of the project, or those impacts are yet to be determined. Lastly, only impacts to threatened biota across multiple projects, or areas of the Project (upstream area vs. downstream area) are included within the cumulative impact assessment tables.

Table 6-10. Potential cumulative impacts from past, present, and future projects

Project	Construction impact	Operational Impact
Warragamba Dam Raising – Upstream ▪ Upstream operational impacts associated within the Project.	▪ Appendix F1(Upstream BAR)	▪ Appendix F1 (Upstream BAR)
Warragamba Dam Raising – Construction ▪ Construction impacts associated within the Project.	▪ Appendix F3 (Biodiversity assessment report - construction area)	▪ N/A
Warragamba Dam Raising – Downstream ▪ Downstream operational impacts associated within the Project.	▪ Appendix F2 (Downstream ecological assessment)	▪ Appendix F2 (Downstream ecological assessment)
Western Sydney Airport ▪ Located approximately 8.5 km east of Warragamba Dam. ▪ Construction commenced.	▪ Removal of 318.5 ha of native vegetation. ▪ Removal of 141.8 ha of fauna habitat. ▪ Direct and indirect impacts to threatened biota.	▪ Bird and bat strike. ▪ Terrestrial fauna strike. ▪ Noise and vibration. ▪ Light. ▪ Alterations to hydrology and GDEs.
M12 Motorway ▪ 16 km motorway between M7 at Cecil Hills and Northern Road, Luddenham. ▪ Located approximately 10 km east of Warragamba Dam. ▪ Proposal under assessment.	▪ Removal of 118.0 ha of native vegetation. ▪ Removal of 334 threatened plants. ▪ Removal of 1.6 ha of threatened fauna habitat.	▪ Changes to hydrology. ▪ Habitat fragmentation. ▪ Edge effects. ▪ Fauna mortality. ▪ Risk of establishment of weeds and pathogens.
Northern Road Upgrade ▪ Upgrade of Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park. ▪ Located approximately 10 km east of Warragamba Dam. ▪ Construction commenced.	▪ Removal of 39.6 ha of native vegetation. ▪ Removal of threatened flora and fauna habitat. ▪ Removal of 39 threatened plants.	▪ Changes to hydrology. ▪ Habitat fragmentation. ▪ Edge effects. ▪ Fauna mortality. ▪ Establishment of weeds and pathogens.

Project	Construction impact	Operational Impact
Hume Coal Project ▪ Development of an underground mine to extract metallurgical and industrial coal. ▪ Located approximately 70 km south-west of Warragamba Dam. ▪ Proposal under assessment.	▪ Removal of 64 paddock trees. ▪ Removal of 8.3 ha of threatened fauna habitat.	▪ Potential changes to surface and subterranean hydrology. ▪ Habitat fragmentation. ▪ Edge effects. ▪ Fauna mortality. ▪ Establishment of weeds and pathogens.
Gunlake Quarry Extension ▪ Extension of operations at Gunlake Quarry. ▪ Located approximately 170 km south-west of Warragamba Dam. ▪ Proposal determined.	▪ Removal of 54.1 ha of native vegetation. ▪ Removal of threatened flora and fauna habitat.	▪ Erosion and sedimentation. ▪ Habitat fragmentation. ▪ Edge effects. ▪ Fauna mortality. ▪ Establishment of weeds and pathogens.

7 Avoidance and management measures

7.1 Measures to avoid impacts

Chapter 4 of the EIS discusses the proposed options and alternatives that were considered for flood mitigation in the Hawkesbury-Nepean Valley, including:

- Non-structural strategies: these do not alter flood levels but reduce the effects of flooding
- Floodplain works: localised physical works in the floodplain could be used to divert floodwaters from properties
- Drainage strategies: these lower flood levels by assisting floodwaters to escape from the floodplain
- Flood detention strategies: these temporarily store floodwaters on contributing rivers and thereby lower peak levels downstream
- Combined strategies: these combine some of the above approaches.

7.2 Adaptive management and offsetting

Downstream of the Project there are numerous land uses and activities that have an existing impact on the environment. For example, with regard to hydrology and water quality in the downstream catchment these would include inflows from downstream catchments (for example, the Nepean River, Grose River, Macdonald River, and Colo River), runoff from rural and urban land uses, and the discharges from sewage treatment plants. These would, to greater or lesser degrees, be occurring concurrent with the Project impacts and present practicable constraints to accurately apportioning impacts to the Project and to other sources. This uncertainty is likely to increase with increasing distance downstream, and this in turn presents challenges to identifying and mitigating impacts associated with the Project.

Requirement to offset

Attachment B to the SEARs detail the specific assessment requirements for the assessment of impacts within the downstream operational area. As outlined in Section 2(h) of Attachment B, where the Project cannot adequately avoid or mitigate impacts on downstream biodiversity, such that there are no residual impacts from the Project, then a biodiversity offset package should be considered. For the purposes of this assessment, residual impacts are those which will likely have a 'significant impact' on threatened biota as determined by an Assessment of Significance as per section 5A of the EP&A Act.

Section 3 of Attachment B details the requirements of the biodiversity offset package. The biodiversity offset package must:

- meet OEH's (now DPIE) principles for the use of biodiversity offsets in NSW
- identify the conservation mechanisms to be used to ensure the long-term protection and management of the offset sites
- include an appropriate management plan to ensure that any proposed compensatory offsets, retained habitat enhancement features, and/or mitigation measures (such as rehabilitation or monitoring programs) are appropriately managed and funded.

The proposed offset approach for the Project is detailed in Appendix F6 of the EIS (Biodiversity offset strategy). Generally, biodiversity offsets provide benefits to biodiversity to compensate for adverse impacts of an action. The Project acknowledges that there is a high level of uncertainty with regard to quantifying and qualifying the nature and scale of the impacts, especially when the potential impact occurs at a landscape scale and any impact would be gradual over the long term. Because of the extent of the catchment and the variability in catchment processes it is unlikely that monitoring would be able to differentiate between potential impacts resulting from the Project and from other downstream factors. In view of this, it is not proposed to provide offsets for potential downstream impacts.

7.3 Measures to manage impacts

The matters described in Table 7-1 are proposed to minimise direct impacts on downstream biodiversity values during the operational phase of the Project.

Table 7-1. Measures to minimise indirect impacts of the proposed development within the downstream operational area

Impact	Mitigation measure	Outcome	Timing	Responsibility
Inundation of native vegetation	Development of the operational protocol for the FMZ would seek to minimise potential impacts on downstream vegetation from temporary inundation subject to meeting operational priorities for protection of life and property.	Balancing impacts of operations within the upstream and downstream areas	Operation	WaterNSW

8 Summary

Assessment of the potential impacts of the Project has included consideration of potential downstream impacts on biodiversity values. These impacts would be associated principally with operation of the FMZ, and related to the extended period of inundation.

Potential impacts on biodiversity values would also be related to the reduced extent of flooding associated with the Project for all flood events considered. The effect of these impacts is considered negligible.

The assessment has been conducted in accordance with the relevant provisions of the TSC Act through the effect of the transitional provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017, which apply to the Project as the SEARs for the Project were issued prior to the commencement of the BC Act.

A risk-based approach was used to assess the potential impacts of the Project on biodiversity values. This considered threatened ecological communities, and threatened flora and fauna species. Where the risk assessment assigned a rating of 'Medium' or higher, the TEC or threatened species was subject to an Assessment of Significance in accordance with the matters formerly listed in section 5A of the EP&A Act.

This identified the Project would potentially impact:

- five TECs
- 12 threatened flora species
- Six threatened fauna species.

The assessment also considered potential impacts of the Project on GDEs, particularly the four high priority GDEs identified in the *Greater Metropolitan Region Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (NSW Office of Water 2011), these being Pitt Town Lagoon, Long Swamp, Longneck Lagoon, and O'Hares Creek. It was concluded that it was unlikely that these GDEs would be affected by the Project.

Accurately assigning the possible effects of the Project on downstream biodiversity values is complicated due to the numerous land uses and activities that have an existing impact on the environment such as inflows from downstream catchments, runoff from rural and urban land uses, and discharges from sewage treatment plants. These would, to greater or lesser degrees, be occurring concurrent with the Project impacts. This uncertainty is likely to increase with increasing distance downstream, and in turn presents challenges to practical management and identifying impacts associated with the Project.

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Appendix A Likelihood of occurrence

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
Recorded	Species/TEC was observed during the recent surveys or has been previously recorded in the survey area.	Moderate	Potential habitat for species/TEC occurs within the survey area.	None	The species/TEC has not been recorded within the survey area and no suitable habitat occurs survey area.
High	It is likely that a species/TEC inhabits or utilises habitat within the survey area.	Low	It is unlikely that the species/TEC inhabits the survey area.		

Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
FAUNA										
Aves										
Actitis hypoleucos	Common Sandpiper	-	M	-	✓	-	Utilises a wide range of coastal wetlands and some inland wetlands, mostly found around muddy margins or rocky shores. Forages in shallow water and on soft mud, roosts on rocks or vegetation such as mangroves. Northern hemisphere breeding.	N	N	Low
Anseranas semipalmata	Magpie Goose	V	-	✓	-	-	Still relatively common in the northern tropics but had disappeared from south-east Australia by 1920 due to drainage and overgrazing of reed swamps used for breeding. Vagrants can follow food sources to south-eastern NSW. Mainly found in shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges. Often seen walking and grazing on land. Feeds on grasses, bulbs and rhizomes.	Y	N	Low
Anthochaera phrygia	Regent Honeyeater	CE	CE	✓	✓	✓	Mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal wetlands and forests.	Y	Y	Recorded
Apus pacificus	Fork-tailed Swift	-	M	-	✓	-	Almost exclusively aerial, flying from less than one metre to at least 300 m above ground and probably much higher.	N	N	Recorded
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	✓	-	-	Often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including	Y	Y	Recorded

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
Recorded	Species/TEC was observed during the recent surveys or has been previously recorded in the survey area.	Moderate	Potential habitat for species/TEC occurs within the survey area.	None	The species/TEC has not been recorded within the survey area and no suitable habitat occurs survey area.
High	It is likely that a species/TEC inhabits or utilises habitat within the survey area.	Low	It is unlikely that the species/TEC inhabits the survey area.		

Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
							regenerating forests; very occasionally in moist forests or rainforests.			
Botaurus poiciloptilus	Australasian Bittern	E	E	✓	✓	✓	Widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bulrushes and spikerushes.	Y	Y	Recorded
Burhinus grallarius	Bush Stone-curlew	E	-	✓	-	-	Found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common, however, and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	N	N	Low
Calidris acuminata	Sharp-tailed Sandpiper	-	M	-	✓	-	Prefers muddy edges of shallow or brackish wetlands, with inundated or emergent sedges, saltmarsh or other low vegetation. Also found foraging in sewage ponds and flooded paddocks. Northern hemisphere breeding.	N	N	Low
Calidris ferruginea	Curlew Sandpiper	E	CE; M	✓	✓	-	It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in NSW is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland. Northern hemisphere breeding.	Y	Y	Recorded
Calidris melanotos	Pectoral Sandpiper	-	M	-	✓	-	Prefers shallow fresh to saline wetlands, found at coastal lagoons, estuaries, bays, swamps, inundated grasslands, saltmarshes and artificial wetlands. Northern hemisphere breeding.	N	N	Low
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	✓	-	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occurs in subalpine snow gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt	Y	Y	Recorded

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
Recorded	Species/TEC was observed during the recent surveys or has been previously recorded in the survey area.	Moderate	Potential habitat for species/TEC occurs within the survey area.	None	The species/TEC has not been recorded within the survey area and no suitable habitat occurs survey area.
High	It is likely that a species/TEC inhabits or utilises habitat within the survey area.	Low	It is unlikely that the species/TEC inhabits the survey area.		

Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
							forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.			
Callocephalon fimbriatum	Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas	EP	-	✓	-	-	The population is believed to be largely confined to an area bounded by Thornleigh and Wahroonga in the north, Epping and North Epping in the south, Beecroft and Cheltenham in the west and Turramurra/South Turramurra to the east. Usually frequents forested areas with old growth attributes required for nesting and roosting purposes.	N	N	None
Calyptorhynchus lathami	Glossy Black-cockatoo	V	-	✓	-	-	Inhabits forest with low nutrients, characteristically with key *Allocasuarina* spp. Tends to prefer drier forest types with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies. Breed in hollows, stumps or limbs, either living or dead.	Y	Y	Recorded
Chthonicola sagittata	Speckled Warbler	V	-	✓	-	-	Lives in a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.	Y	Y	Recorded
Circus assimilis	Spotted Harrier	V	-	✓	-	-	Occurs throughout the Australian mainland, expect in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.	Y	Y	Recorded
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	✓	-	-	Found in eucalypt woodlands (including box-gum woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey,	Y	N	Moderate

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
Recorded	Species/TEC was observed during the recent surveys or has been previously recorded in the survey area.	Moderate	Potential habitat for species/TEC occurs within the survey area.	None	The species/TEC has not been recorded within the survey area and no suitable habitat occurs survey area.
High	It is likely that a species/TEC inhabits or utilises habitat within the survey area.	Low	It is unlikely that the species/TEC inhabits the survey area.		

Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
							sometimes with one or more shrub species; also found in mallee and river red gum forest bordering wetlands with an open understorey or acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.			
Cuculus optatus	Oriental Cuckoo/ Horsfield's Cuckoo	-	M	-	✓	-	Mainly inhabits coniferous, deciduous and mixed forests. Breeds in northern hemisphere. Brood parasite, laying eggs in nests of other birds.	N	N	Low
Daphoenositta chrysoptera	Varied Sittella	V	-	✓	-	-	Inhabits a wide variety of dry eucalypt forests and woodlands, usually with either shrubby understorey or grassy ground cover or both, in all climatic zones of Australia. Usually in areas with rough-barked trees, such as stringybarks or ironbarks, but also in paperbarks or mature eucalypts with hollows.	Y	Y	Recorded
Dasyornis brachypterus	Eastern Bristlebird	E	E	✓	✓	✓	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands.	N	N	Low
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	✓	-	-	Mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sand flats, and mangrove vegetation.	Y	Y	Recorded
Epthianura albifrons	White-fronted Chat	V	-	✓	-	✓	Low vegetation in salty coastal and inland areas and crops. Runs along ground and is found in local flocks in winter.	Y	N	Low
Epthianura albifrons	White-fronted Chat population in the Sydney Metropolitan Catchment	EP	-	-	-	-	Two isolated sub-populations of White-fronted Chats are currently known from the Sydney Metropolitan CMA area: one at Newington Nature Reserve on the Parramatta River and one at Towra Point Nature Reserve in Botany Bay. These sub-populations are separated from each other by	N	N	None

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
Recorded	Species/TEC was observed during the recent surveys or has been previously recorded in the survey area.	Moderate	Potential habitat for species/TEC occurs within the survey area.	None	The species/TEC has not been recorded within the survey area and no suitable habitat occurs survey area.
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Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
	Management Authority (CMA) area						25 km of urbanised land, across which White-fronted Chats are unlikely to fly.			
Falco subniger	Black Falcon	V	-	✓	-	-	Widely, but sparsely, distributed in NSW, mostly occurring in inland regions. In NSW there is assumed to be a single population that is continuous with a broader continental population, given that falcons are highly mobile, commonly travelling hundreds of kilometres. Inhabits woodland, shrubland and grassland in the arid and semi-arid zones, especially wooded watercourses and agricultural land with scattered remnant trees.	Y	Y	Recorded
Gallinago hardwickii	Latham's Snipe/ Japanese Snipe	-	M	-	✓	-	Non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. Breeds in Asia. Seen in small groups or singly freshwater wetlands on or near the coast, generally among dense cover. Found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration.	N	N	High
Glossopsitta pusilla	Little Lorikeet	V	-	✓	-	-	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occurs in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in tree canopy. Nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts. Most breeding records come from the western slopes.	Y	Y	Recorded
Grantiella picta	Painted Honeyeater	V	V	✓	✓	✓	Nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits boree, brigalow and box-gum woodlands and box-ironbark forests.	Y	N	Moderate

LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA	LIKELIHOOD RATING	RATING CRITERIA
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Scientific name	Common name	BC Act	EPBC Act	Source			Habitat and distribution	Records within study area	Records within 1 in 10	Likelihood of occurrence in 1 in 10
				NSW ATLAS	PMST	SEARs				
Haliaeetus leucogaster	White-bellied Sea-eagle	V	-	✓	-	-	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	Y	Y	Recorded
Hieraaetus morphnoides	Little Eagle	V	-	✓	-	-	Most abundant in lightly timbered areas with open areas nearby. Often recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. May nest in farmland, woodland and forest in tall trees.	Y	Y	Recorded
Hirundapus caudacutus	White-throated Needletail	-	M	-	✓	-	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges.	N	N	High
Irediparra gallinacea	Comb-crested Jacana	V	-	✓	-	-	Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Y	Y	Low
Ixobrychus flavicollis	Black Bittern	V	-	✓	-	-	Usually found on coastal plains below 200 m. Often found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterized by dense waterside vegetation.	Y	Y	Recorded
Lathamus discolor	Swift Parrot	E	CE	✓	✓	✓	Occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.	Y	Y	Recorded
Limosa lapponica baueri	Bar-tailed Godwit/ Western Alaskan Bar-tailed Godwit	-	V	-	✓	-	Widespread in the Torres Strait and along the east and south-east coasts of Queensland, NSW and Victoria. Usually forages near the edge of water or in shallow water, mainly in tidal estuaries and harbours. They prefer exposed sandy or soft mud substrates on intertidal flats, banks and beaches. Breeds in the northern hemisphere.	N	N	Low
Limosa lapponica menzbieri	Bar-tailed Godwit/ Northern Siberian Bar-tailed Godwit	-	CE	-	✓	-	Mainly found in coastal habitats such as intertidal sand flats, mudflats, estuaries, inlets, coastal lagoons and bays. Often found around beds of seagrass and saltmarsh. Northern hemisphere breeding.	N	N	Low
Limosa limosa	Black-tailed Godwit	V	M	✓	-	-	Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats	Y	Y	Low

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							and/or sand flats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps. Northern hemisphere breeding.			
Lophochroa leadbeateri	Major Mitchell's Cockatoo	V	-	✓	-	-	Inhabits a wide range of treed and treeless inland habitats, always within easy reach of water. Feeds mostly on the ground, especially on the seeds of native and exotic melons and on the seeds of species of saltbush, wattles and cypress pines.	Y	Y	None
Lophoictinia isura	Square-tailed Kite	V	-	✓	-	-	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by Woollybutt, Spotted Gum, River Peppermint or Gully Gum. Individuals appear to occupy large hunting ranges of more than 100 km². They require large living trees for breeding, particularly near water with surrounding woodland-forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.	Y	Y	Recorded
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-	✓	-	-	Occupy a wide range of eucalypt woodlands, Acacia shrublands and open forests.	N	N	Low
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	✓	-	-	Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks, river sheoaks (nesting habitat) and tea-trees.	Y	N	High
Monarcha melanopsis	Black-faced Monarch	-	M	-	✓	-	Found along the coast of eastern Australia, becoming less common further south. Inhabits rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating.	N	N	Moderate
Monarcha trivirgatus	Spectacled Monarch	-	M	-	✓	-	Coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. Prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves.	N	N	Low

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Motacilla flava	Yellow Wagtail	-	M	-	✓	-	Breeds in temperate Europe and Asia. Regular wet season visitor to northern Australia. The species is considered a vagrant to Victoria, South Australia and southern Western Australia. Habitat requirements for the Yellow Wagtail are highly variable, but typically include open grassy flats near water. Habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves.	N	N	Low
Myiagra cyanoleuca	Satin Flycatcher	-	M	-	✓	-	Found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	N	N	Recorded
Neochmia ruficauda	Star Finch	PE	E	✓	-	-	Occurs mainly in grasslands and grassy woodlands that are located close to bodies of fresh water. It also occurs in cleared or suburban areas such as along roadsides and in towns. Presumed extinct in NSW.	Y	Y	None
Neophema pulchella	Turquoise Parrot	V	-	✓	-	-	Range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Nests in tree hollows, logs or posts, from August to December.	Y	Y	Recorded
Ninox connivens	Barking Owl	V	-	✓	-	-	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country.	Y	Y	Recorded
Ninox strenua	Powerful Owl	V	-	✓	-	-	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within turpentine tall open forests and black she-oak within open forests. Large mature trees with hollows at	Y	Y	Recorded

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							least 0.5 m deep are required for nesting. Tree hollows are particularly important because a large proportion of the diet is made up of hollow-dependent arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.			
Numenius madagascariensis	Eastern Curlew	-	CE; M	-	✓	-	A primarily coastal distribution. Found in all states, particularly the north, east, and south-east regions including Tasmania. Rarely recorded inland. Mainly forages on soft sheltered intertidal sand flats or mudflats, open and without vegetation or cover. Breeds in the northern hemisphere.	N	N	Low
Oxyura australis	Blue-billed Duck	V	-	✓	-	-	Widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. It is generally only during summer or in drier years that they are seen in coastal areas. Prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation.	N	N	Low
Petroica boodang	Scarlet Robin	V	-	✓	-	-	Found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.	Y	N	High
Petroica phoenicea	Flame Robin	V	-	✓	-	-	Found in a broad coastal band from southern Queensland to just west of the South Australian border. The species is also found in Tasmania. The preferred habitat in summer includes eucalypt forest and woodland, whilst in winter prefers open woodlands and farmlands. It is considered migratory. The Flame Robin breeds from about August to January.	Y	Y	Recorded
Petroica rodinogaster	Pink Robin	V	-	✓	-	-	Found in Tasmania and the uplands of eastern Victoria and far south-eastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as	Y	Y	None

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							the central coast of NSW. Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies.			
Polytelis swainsonii	Superb Parrot	V	V	✓	-	-	Found throughout eastern inland NSW. On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. Inhabits box-gum, box-cypress-pine and boree woodlands and river red gum forest.	Y	Y	Low
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	✓	-	-	This subspecies occurs from Cape York south through Queensland, NSW and Victoria and formerly to the south east of South Australia. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains. Also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. Inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains, as well as woodlands on fertile soils in coastal regions.	N	N	Low
Rhipidura rufifrons	Rufous Fantail	-	M	-	✓	-	Found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. Inhabits tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	N	N	High
Rostratula australis, Rostratula benghalensis	Australian Painted Snipe	E	E	✓	✓	✓	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	Y	Y	Recorded
Stagonopleura guttata	Diamond Firetail	V	-	✓	-	-	Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season). Found in grassy eucalypt woodlands, including box-gum woodlands and	Y	N	Low

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							snow gum woodlands. Also occurs in open forest, mallee, natural temperate grassland, and in secondary grassland derived from other communities.			
Sternula albifrons	Little Tern	E	M	✓	-	-	Migrating from eastern Asia, found on the north, east and south-east Australian coasts. In NSW, it occurs mainly north of Sydney, with smaller numbers found south to Victoria. Breeds along the entire east coast from Tasmania to northern Queensland. Almost exclusively coastal, preferring sheltered environments, however may occur several kilometres from the sea in harbours, inlets and rivers (with occasional offshore islands or coral cay records).	N	N	Low
Stictonetta naevosa	Freckled Duck	V	-	✓	-	-	Breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits.	Y	Y	Recorded
Tringa nebularia	Common Greenshank	-	M	-	✓	-	Variety of inland wetlands and sheltered coastal habitats of varying salinity. Found on mudflats, saltmarsh, mangroves in embayments, harbours, deltas and lagoons. Breeds in northern hemisphere.	N	N	Moderate
Tyto longimembris	Eastern Grass Owl	V	-	✓	-	✓	Ground-dwelling bird, found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains.	N	N	Moderate
Tyto novaehollandiae	Masked Owl	V	-	✓	-	-	Inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting. Mostly recorded in open forest and woodlands adjacent to cleared lands. Nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead. Nest hollows are usually located within dense forests or woodlands. Prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet.	Y	Y	Recorded
Tyto tenebricosa	Sooty Owl	V	-	✓	-	-	Often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW mostly found on escarpments with a mean altitude less than 500 mm. Nests	Y	Y	Recorded

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							and roosts in hollows of tall emergent trees, mainly eucalypts often located in gullies. Nests have been located in trees 125 to 161 cm in diameter.			
Xenus cinereus	Terek Sandpiper	V	M	✓	-	-	Rare migrant to the eastern and southern Australian coasts, being most common in northern Australia, and extending its distribution south to the NSW coast in the east. Main sites in NSW are the Richmond River estuary and the Hunter River estuary. Has been recorded on coastal mudflats, lagoons, creeks and estuaries. Favours mudbanks and sandbanks located near mangroves but may also be observed on rocky pools and reefs, and occasionally up to 10 km inland around brackish pools.	N	N	Low
Fish										
Maccullochella peelii	Murray Cod	-	V	-	✓	-	Historically distributed throughout the Murray-Darling Basin. In NSW, introduced populations persist in Cataract Dam and the Nepean River system. Utilises a diverse range of habitats from clear rocky streams to slow-flowing, turbid lowland rivers and billabongs. Found in the main channels of rivers and larger tributaries and tend to occur in floodplain channels and anabranches when they are inundated, but the species' use of these floodplain habitats appears limited.	N	N	Low
Macquaria australasica	Macquarie Perch	-	E	-	✓	✓	Found in the Murray-Darling Basin of the Lachlan, Murrumbidgee and Murray rivers, and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven. Found in both river and lake habitats, especially the upper reaches of rivers and their tributaries	N	N	Low
Prototroctes maraena	Australian Grayling	-	V	-	✓	✓	Historically, this species occurred in coastal streams from the Grose River Valley, southwards through NSW, Vic. and Tas. Also occasionally occurred high upstream in the Snowy R. Spends only part of its lifecycle in freshwater. The Tambo River population inhabits a clear, gravel-bottomed stream with alternating pools and riffles, and granite outcrops. It has also been associated with clear,	N	N	Low

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							gravel-bottomed habitats in the Mitchell & Wonnangatta Rivers but was present in a muddy-bottomed, heavily silted habitat in the Tarwin R.			
Amphibians										
Heleioporus australiacus	Giant Burrowing Frog	V	V	✓	✓	✓	Has been recorded breeding in a range of water bodies associated with sandy environments of the coast and adjacent ranges from the Sydney Basin south to eastern Victoria. It breeds in hanging swamps, perennial non-flooding creeks and occasionally permanent pools, but permanent water must be present to allow its large tadpoles time to reach metamorphosis.	Y	Y	High
Litoria aurea	Green and Golden Bell Frog	E	V	✓	✓	✓	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bullrushes or spikerushes. It also inhabits numerous types of man-made water bodies including quarries and sand extraction sites. Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow, have a grassy area nearby and diurnal sheltering sites available.	Y	Y	Recorded
Litoria booroolongensis	Booroolong Frog	E	E	-	✓	-	Found along permanent western flowing streams of the Great Dividing Range through most of NSW and down into northern Victoria. Streams range from small slow-flowing creeks to large rivers and the adults are found on or near cobble banks and other rock structures within stream margins and shelter under rocks or amongst vegetation near the ground on the stream edge. The species occurs along streams in both forested areas and open pasture but has been affected by the presence of the introduced willow tree. Sometimes basks in the sun on exposed rocks near flowing water during summer.	N	N	Nil
Litoria brevipalmata	Green-thighed Frog	V	-	✓	-	-	Isolated localities along the coast and ranges from just north of Wollongong to south-east Queensland. Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath,	N	N	Low

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							typically in areas where surface water gathers after rain. Prefer wetter forests in the south of their range but extend into drier forests in northern NSW and southern Queensland.			
Litoria littlejohni	Littlejohn's Tree Frog/Heath Frog	V	V	-	✓	✓	Occurs in wet and dry sclerophyll forests and heathland associated with sandstone outcrops between 280 and 1000 m on the eastern slopes of the Great Dividing Range from the Central Coast down into Victoria. Individuals have been collected from a wide range of water bodies that includes semi-permanent dams, permanent ponds, temporary pools and permanent streams, with calling occurring from fringing vegetation or on the banks. Individuals have been observed sheltering under rocks on high exposed ridges during summer and within deep leaf litter adjacent to the breeding site. Calling occurs in all months of the year, often in association with heavy rains. The tadpoles are distinctive, being large and very dark in colouration.	N	N	Low
Litoria raniformis	Growling Grass Frog/Southern Bell Frog/Green and Golden Frog/Warty Swamp Frog	E	V	-	✓	-	Currently, the species is known to exist only in isolated populations in the Coleambally Irrigation Area, the Lowbidgee floodplain and around Lake Victoria. The species is also found in Victoria, Tasmania and South Australia, where it has also become endangered. It is usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. Also found in irrigated rice crops, particularly where there is no available natural habitat.	N	N	None
Mixophyes balbus	Stuttering Frog	E	V	✓	✓	✓	Associated with streams in dry sclerophyll and wet sclerophyll forests and rainforests of more upland areas of the Great Dividing Range of NSW and down into Victoria. Breeding occurs along forest streams with permanent water where eggs are deposited within nests excavated in riffle zones by the females and the tadpoles swim free into	N	N	Low

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							the stream when large enough to do so. Outside of breeding, individuals range widely across the forest floor and can be found hundreds of metres from water.			
Mixophyes iteratus	Giant Barred Frog	E	E	✓	-	-	This species is found along larger streams of the coast and adjacent ranges of NSW and SE QLD. It inhabits rainforest and wet sclerophyll forest but is also found within cleared farmland where fringing vegetation is retained, including lantana beds. Many sites where the Giant Barred Frog is known to occur are the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters.	N	N	Nil
Pseudophryne australis	Red-crowned Toadlet	V	-	✓	-	-	Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. After raining these creeks are characterised by a series of shallow pools lined by dense grasses, ferns and low shrubs and usually contain leaf litter for shelter. Eggs are terrestrial and laid under litter, vegetation or rocks where the tadpoles inside will reach a relatively late stage of development before waiting for flooding waters before hatching will occur.	Y	Y	Recorded
Invertebrates										
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	✓	-	-	Primarily inhabits Cumberland Plain woodland (a CEEC). This community is a grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	Y	Y	Recorded
Petalura gigantea	Giant Dragonfly	E	-	✓	-	-	Found along the east coast of NSW from the Victorian border to northern NSW. It is not found west of the Great Dividing Range. There are known occurrences in the Blue Mountains and Southern Highlands, in the Clarence River catchment, and on a few coastal swamps from north of	N	N	Low

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							Coffs Harbour to Nadgee in the south. Live in permanent swamps and bogs with some free water and open vegetation. Adults emerge from late October and are short-lived, surviving for one summer after emergence.			
Pommerhelix duralensis	Dural Land Snail	E	E	✓	✓	✓	The species is a shale-influenced habitat specialist, which occurs in low densities along the northwest fringes of the Cumberland Plain on shale-sandstone transitional landscapes.	Y	Y	Recorded
Mammals										
Cercartetus nanus	Eastern Pygmy-possum	V	-	✓	-	-	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows but can also construct its own nest. Because of its small size it is able to utilise a range of hollow sizes including very small hollows. Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5 ha area over a 5-month period.	N	N	Moderate
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	✓	✓	✓	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. Can also be found on the edges of rainforests and in wet sclerophyll forests. This species roosts in caves and mines in groups of between 3 and 37 individuals.	Y	Y	Recorded
Dasyurus maculatus maculatus	Spotted-tailed Quoll	V	E	✓	✓	✓	Found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	Y	Y	Recorded
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	✓	-	-	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high. Two observations have been made of roosts in stem holes of living eucalypts. There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain	Y	Y	Recorded

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							sedentary but enter torpor. This species also appears to be highly mobile, with records showing movements of up to 12 km between roosting and foraging sites.			
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E	✓	✓	✓	Has a patchy distribution in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River, southern coastal Victoria and the Grampian Ranges, south-eastern South Australia, south-west Western Australia and the northern tip of Queensland. They are generally only found in heath or open forest with a heathy understorey on sandy or friable soils.	N	N	Moderate
Kerivoula papuensis	Golden-tipped Bat	V	-	✓	-	-	Distributed along the east coast of Australia in scattered locations from Cape York Peninsula in Queensland to south of Eden in southern NSW. Found in rainforest and adjacent wet and dry sclerophyll forest up to 1000 m. It has also been recorded in tall open forest, *Casuarina*-dominated riparian forest and coastal *Melaleuca* forests.	N	N	Low
Macropus parma	Parma Wallaby	V	-	✓	-	-	Once occurred from north-eastern NSW to the Bega area in the southeast. Their range is now confined to the coast and ranges of central and northern NSW from the Gosford district to the Queensland border. Preferred habitat is moist eucalypt forest with thick, shrubby understorey, often with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest.	N	N	Low
Miniopterus australis	Little Bentwing-bat	V	-	✓	-	-	Occurs in coastal north-eastern NSW and eastern Queensland. An insectivorous bat that roost in caves, in old mines, in tunnels, under bridges, or in similar structures. They breed in large aggregations in a small number of known caves and may travel hundreds of kilometres from feeding home ranges to breeding sites. They have a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.	Y	Y	Recorded
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	-	✓	-	-	Occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other	Y	Y	Recorded

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							man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.			
Mormopterus norfolkensis	Eastern Freetail-bat	V	-	✓	-	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits.	Y	Y	Recorded
Myotis macropus	Southern Myotis	V	-	✓	-	-	Found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Generally, roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage.	Y	Y	Recorded
Petauroides volans	Greater Glider	-	V	-	✓	✓	Restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows.	Y	N	Moderate
Petaurus australis	Yellow-bellied Glider	V	-	✓	-	-	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.	Y	Y	Recorded
Petaurus norfolcensis	Squirrel Glider	V	-	✓	-	-	Generally, occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range. Requires abundant hollow bearing trees and a mix of eucalypts, banksias and acacias. There is only limited information available on den tree use by Squirrel Gliders, but it has been observed using both living and dead trees as well as hollow stumps. Within a suitable vegetation community at least one species should flower heavily in winter and one species of eucalypt should be smooth-barked. Endangered population in the Wagga Wagga LGA.	Y	Y	Recorded

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Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	✓	✓	✓	Found in rocky areas in a wide variety of habitats including rainforest gullies, wet and dry sclerophyll forest, open woodland and rocky outcrops in semi-arid country. Commonly, sites have a northerly aspect with numerous ledges, caves and crevices.	N	N	Low
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	✓	-	-	Has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are occasional records west of the divide. Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabit heath, swamps, rainforest and wet sclerophyll forest.	N	N	Low
Phascolarctos cinereus	Koala	V	V	✓	✓	✓	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall.	Y	Y	Recorded
Phascolarctos cinereus	Koala in the Pittwater local government area	EP	-	✓	-	-	This endangered population occurs within the Pittwater Local Government Area, with most recent records occurring on the Barrenjoey Peninsula.	N	N	None
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V	✓	-	-	Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy.	N	N	Low
Pseudomys gracilicaudatus	Eastern Chestnut Mouse	V	-	✓	-	-	Mainly occurs north from the Hawkesbury River area as scattered records along to the coast and eastern fall of the Great Dividing Range extending north into Queensland. In NSW mostly found in heathland and is most common in dense, wet heath and swamps. In the tropics it is more an animal of grassy woodlands. Optimal habitat appears to be in vigorously regenerating heathland burnt from 18 months to four years previously. By the time the heath is mature, the larger Swamp Rat becomes dominant, and Eastern Chestnut Mouse numbers drop again.	N	N	Low
Pseudomys novaehollandiae	New Holland Mouse/Pookila	-	V	-	✓	-	Currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is	N	N	Low

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							known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.			
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	✓	✓	✓	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.	Y	Y	Recorded
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	✓	-	-	Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	Y	Y	Recorded
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	✓	-	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m. In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat. This species roosts in hollow tree trunks and branches.	Y	Y	Recorded
Vespadelus troughtoni	Eastern Cave Bat	V	-	✓	-	-	Found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW. A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals.	Y	Y	Recorded
Reptiles										
Eulamprus leuraensis	Blue Mountains Water Skink	E	E	✓	-	-	Restricted to the middle and upper Blue Mountains west of Sydney, the Blue Mountains Water Skink is known from approximately 70 threatened highland peat swamps extending from the Newnes Plateau in the north-west to	Y	N	Low

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							just south of Hazelbrook in the south-east. Occurs at high elevations between 560 m and 1140 m. Restricted to an isolated and naturally fragmented habitat of sedge and shrub swamps that have boggy soils and appear to be permanently wet.			
Hoplocephalus bungaroides	Broad-headed Snake	E	V	✓	✓	✓	Occurs almost exclusively in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they spend most of the year sheltering in and under rock crevices and exfoliating rock. However, some individuals will migrate to tree hollows to find shelter during hotter parts of summer.	N	N	Low
Varanus rosenbergi	Rosenberg's Goanna	V	-	✓	-	-	Occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. Found in heath, open forest and woodland, associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component. Individuals require large areas of habitat and feeds on carrion, birds, eggs, reptiles and small mammals. They shelter in hollow logs, rock crevices and in burrows, which they may dig for themselves, or they may use other species' burrows, such as rabbit warrens.	N	N	Moderate
FLORA										
Acacia bynoeana	Bynoe's Wattle	E	V	✓	✓	✓	Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park.	Y	N	Moderate
Acacia gordonii		E	E	✓	✓	✓	Restricted to the north-west of Sydney, with a disjunct distribution occurring in the lower Blue Mountains in the west, and in the Maroota-Glenorie area in the east. Grows	N	N	Low

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							in dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops.			
Acacia pubescens	Downy Wattle	V	V	✓	✓	✓	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone. Grows in open woodland and forest, in a variety of plant communities, including Cooks River-Castlereagh Ironbark forest, Shale-Gravel Transition forest and Cumberland Plain Woodland.	Y	Y	Recorded
Acrophyllum australe		V	V	-	✓	✓	Restricted distribution, occurring from Faulconbridge to Lawson, south of Bilpin and near Kings Tableland, in the Blue Mountains area. Grows in sheltered gullies beneath waterfalls and drip zones of rock overhangs and cliff faces, usually with a south-east to south-west aspect. Typically found in areas where there is a more or less constant supply of water. Usually grows in shale interbeds at the base of small cliffs, in crevices on the sandstone rock face or on talus slopes. The rock overhangs are of Hawkesbury of Narrabeen Sandstone. Found adjacent to open forest of *Eucalyptus piperita* and *Angophora costata* and closed forest of *Doryphora sassafras* and *Ceratopetalum apetalum*. Frequently growing on very thick layers of moss.	N	N	Low
Allocasuarina diminuta subsp. *mimica* population in the Sutherland and Liverpool local government areas		E	-	-		-	The endangered population occurs along sandstone ridges and upper hillsides in the region northwest from Heathcote, towards Menai and Holsworthy, in heathy and low open woodland communities. It is restricted to the local government areas listed in this instance (Sutherland and Liverpool).	N	N	None
Allocasuarina glareicola		E	E	✓	✓	✓	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil. Found in open woodland with Parramatta	Y	N	Moderate

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							Red Gum, Broad-leaved Ironbark, Narrow-leaved Apple, Scribbly Gum and Paperbarks.			
Amperea xiphoclada subsp. *pedicellata*		PE	Ex	✓		-	*Amperea xiphoclada* var. *pedicellata* is known only from the type specimen collected in 1892 from Sydney, NSW. The species has not been observed since and is presumed to be extinct. Previously widespread in heath, woodland and forest in low-fertility, sandy soils.	N	N	Low
Ancistrachne maidenii		V	-	✓		✓	Restricted to northern Sydney, around St Albans – Mt White – Maroota – Berowra areas and to the Shannon Creek area south-west of Grafton. Habitat requirements appear to be specific, with populations occurring in distinct bands in areas associated with a transitional geology between Hawkesbury and Watagan soil landscapes. Grows in dry sclerophyll forest on sandstone-derived soils.	Y	N	Low
Asterolasia elegans		E	E	✓	✓	✓	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also, likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a conservation reserve. Occurs on Hawkesbury sandstone in sheltered forests on mid- to lower slopes and valleys, e.g. in or adjacent to gullies which support sheltered forest.	N	N	Low
Astrotricha crassifolia	Thick-leaf Star-hair	V	V	✓		-	Occurs near Patonga (Gosford LGA), and in Royal NP and on the Woronora Plateau (Sutherland and Campbelltown LGAs). There is also a record from near Glen Davis (Lithgow LGA). Occurs in dry sclerophyll woodland on sandstone.	N	N	Low
Baloskion longipes	Dense Cord-rush	V	V	✓		-	Has been recorded from the Kanangra-Boyd area to the Southern Tablelands but all populations are small. Populations have been recorded in Blue Mountains National Park, Kanangra-Boyd National Park, Penrose State Forest (in Hanging Rock Swamp), Morton National Park (The Vines), the Clyde Mountain area and Ballalaba (south of Braidwood). Commonly found in swamps or depressions in sandy alluvium, sometimes growing with sphagnum	N	N	Low

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							moss. Also occurs in swales within tall forest, and in Black Gum (*Eucalyptus aggregate*) Woodland.			
Boronia umbellata	Orara Boronia	V	V	✓		-	Found at only a few locations between Glenreagh and Lower Bucca, north of Coffs Harbour, but it is locally common in the restricted area where it occurs. This Boronia grows as an understorey shrub in and around gullies in wet open forest. It appears to regenerate well after disturbance, but it is not known whether prolonged or repeated disturbance affects long-term persistence.	N	N	Low
Bossiaea oligosperma	Few-seeded Bossiaea	V	V	-		✓	Known from two disjunct areas – the lower Blue Mountains in the Warragamba area (Wollondilly, Allum, Tonalli River catchments) and the Windellama area in Goulburn Mulwaree Shire, where it is locally abundant. A 1960s record for the Araluen Valley south of Braidwood is credible but has not been relocated.	N	N	Low
Caesia parviflora var. *minor*	Small Pale Grass-lily	E	-	✓		-	Found in damp places in open forest on sandstone.	N	N	Low
Caladenia tessellata	Thick Lip Spider Orchid/ Daddy Long-legs	E	V	✓		-	The Thick Lip Spider Orchid is known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct. It was also recorded in the Huskisson area in the 1930s. The species occurs on the coast in Victoria from east of Melbourne to almost the NSW border. It is generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil.	N	N	Low
Callistemon linearifolius	Netted Bottle Brush	V	-	✓		-	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Recorded in 2000 at Coalcliff in the northern Illawarra. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges. Identified during upstream surveys.	N	N	Moderate
Chamaesyce psammogeton	Sand Spurge	E	-	✓		-	Sand Spurge is found sparsely along the coast from south of Jervis Bay (at Currarong, Culburra and Seven Mile Beach	N	N	Low

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							National Park) to Queensland (and Lord Howe Island). Populations have been recorded in Wamberal Lagoon Nature Reserve, Myall Lakes National Park, Moonee Beach Nature Reserve and Bundjalung National Park. It grows on fore-dunes, pebbly strandlines and exposed headlands, often with Spinifex (*Spinifex sericeus*) and Prickly Couch (*Zoysia macrantha*).			
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	✓	✓	-	Does not appear to have well-defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum, Silvertop Ash, Red Bloodwood and Black She-oak and appears to prefer open areas in the understorey of this community.	N	N	Low
Cynanchum elegans	White-flowered Wax Plant	E	E	✓	✓	✓	Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	N	N	Moderate
Darwinia biflora		V	V	✓	✓	✓	Recorded in Ku-ring-gai, Hornsby, Baulkham Hills and Ryde local government areas. The northern, southern, eastern and western limits of the range are at Maroota, North Ryde, Cowan and Kellyville, respectively. Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. The vegetation structure is usually woodland, open forest or scrub-heath.	N	N	Moderate
Darwinia fascicularis subsp. *oligantha*	*Darwinia fascicularis* subsp. *oligantha* population in the Baulkham Hills and Hornsby local government areas	EP	-	✓		-	Occurs around rock platforms and in rocky heath associated with friable sandstone shallow soils.	N	N	Low
Darwinia glaucophylla		V	-	✓		-	Occurs between Gosford and the Hawkesbury River around Calga, Kariong and Mt Kuring-Gai. Known from approximately 15 sites, several within or near to Brisbane Waters NP and one within Popran NP. Occurs entirely	N	N	Low

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							within the Gosford LGA of the Sydney Basin Bioregion. It occurs in sandy heath, scrub and woodlands often associated with sandstone rock platforms or near hanging swamps and friable sandstone shallow soils. Associated species in scrub include: *Banksia ericifolia, Acacia terminalis, Acacia oxycedrus, Angophora hispida, Hakea teretifolia, Bauera rubioides, and in woodland: Corymbia gummifera, Corymbia eximia, Eucalyptus haemastoma and Eucalyptus punctata.*			
Darwinia peduncularis		V	-	✓		-	Occurs as local disjunct populations in coastal NSW with a couple of isolated populations in the Blue Mountains. It has been recorded from Brooklyn, Berowra, Galston Gorge, Hornsby, Bargo River, Glen Davis, Mount Boonbourwa and Kings Tableland. Usually grows on or near rocky outcrops on sandy, well-drained, low nutrient soil over sandstone.	N	N	Low
Dendrobium melaleucaphilum	Spider Orchid	E	-	✓		-	Occurs in coastal districts and nearby ranges, extending from Queensland to its southern distributional limit in the lower Blue Mountains. In NSW, it is currently known from seven recent collections. There has been no subsequent confirmation from the locations of three earlier (pre-1922) collections and it is possible that these are now extinct. It grows frequently on *Melaleuca styphelioides*, less commonly on rainforest trees or on rocks in coastal districts.	N	N	Low
Deyeuxia appressa		E	E	✓		-	A highly-restricted NSW endemic known only from two pre-1942 records in the Sydney area (Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown, and Killara, near Hornsby). Almost nothing is known about the species' habitat and ecology. Flowers spring to summer and is mesophilic (grows in moist conditions).	N	N	Low
Dillwynia tenuifolia		V	-	✓		✓	The core distribution is the Cumberland Plain from Windsor to Penrith east to Deans Park. In western Sydney, may be locally abundant particularly within scrubby-dry heath areas within Castlereagh Ironbark forest and Shale	Y	Y	Recorded

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							Gravel Transition forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum woodland. At Yengo, is reported to occur is disturbed escarpment woodland on Narrabeen sandstone.			
Dillwynia tenuifolia - Kemps Creek Population	Dillwynia tenuifolia - Kemps Creek Population	EP	-	✓		-	In western Sydney, may be locally abundant particularly within scrubby-dry heath areas within Castlereagh Ironbark forest and Shale Gravel Transition forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum woodland. At Yengo, is reported to occur in disturbed escarpment woodland on Narrabeen sandstone.	N	N	None
Dillwynia tenuifolia - in the Baulkham Hills local government area	Dillwynia tenuifolia Sieber ex D.C. in the Baulkham Hills local government area	EP	-	✓		-	The core distribution is the Cumberland Plain from Windsor to Penrith east to Deans Park. Other populations in western Sydney are recorded from Voyager Point and Kemps Creek in the Liverpool LGA, Luddenham in the Penrith LGA and South Maroota in the Baulkham Hills Shire. Disjunct localities include: the Bulga Mountains at Yengo in the north; Kurrajong Heights and Woodford in the Lower Blue Mountains. In western Sydney, may be locally abundant particularly within scrubby-dry heath areas within Castlereagh Ironbark forest and Shale Gravel Transition forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum woodland. At Yengo, is reported to occur in disturbed escarpment woodland on Narrabeen sandstone.	N	N	Moderate
Diuris bracteata		E	Ex	✓		-	For over 100 years *Diuris bracteata* was known only from the original collection made near Gladesville in northern Sydney. The complete absence of records for most of the 20th Century resulted in this species being listed as 'presumed extinct' on Part 4 of Schedule 1 of the Threatened Species Conservation Act. In recent years, however, extant populations from north-west of Gosford	N	N	Low

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							have been recorded and this area is now the only known area of occurrence of the species. All known plants fall within the Gosford and Wyong LGAs. It is found in dry sclerophyll woodland and forest with a predominantly grassy understorey.			
Diuris aequalis	Buttercup Doubletail	E	V	-		-	Recorded in Kanangra-Boyd National park, Gurnang State forest, towards Wombeyan Caves, the Taralga-Goulburn area, and the ranges between Braidwood, Tarago and Bungendore. Grows in forest, low open woodland with grassy understorey and secondary grassland on the higher parts of the Southern and Central tablelands.	N	N	Low
Epacris purpurascens var. *purpurascens*		V	-	✓		✓	Recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Found in a range of habitat types, most of which have a strong shale soil influence.	Y	Y	High
Epacris sparsa	Sparse Heath	V	V	✓	✓	✓	Restricted to the lower Grose River, within the Hawkesbury and Blue Mountains LGAs. Grows in Riparian Sandstone Scrub, where it is found on the base of cliffs or rock faces, on rock ledges or among rocks in the riparian flood zone. Grows in small pockets of damp clay soil, chiefly on south-west facing slopes.	N	N	Moderate
Eucalyptus aggregata	Black Gum	V	V	-	✓	-	Found in the NSW Central and Southern tablelands, with small isolated populations in Victoria and the ACT. Has a moderately narrow distribution, occurring mainly in the wetter, cooler and higher parts of the tablelands in the lowest parts of the landscape, on alluvial soils, on cold, poorly-drained flats and hollows adjacent to creeks and small rivers. Also occurs as isolated paddock trees in modified native or exotic pastures.	N	N	Low
Eucalyptus benthamii	Camden White Gum	V	V	✓	✓	✓	Occurs on the alluvial flats of the Nepean River and its tributaries. There are two major subpopulations: the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. Several trees are scattered along the Nepean River around Camden and Cobbitty. At least five trees occur on the Nattai River in	Y	Y	Recorded

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							Nattai National Park. Requires a combination of deep alluvial soils and a flooding regime that permits seedling establishment. Occurs in open forest.			
Eucalyptus camfieldii	Heart-leaved Stringybark	V	V	✓		-	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas.	N	N	Moderate
Eucalyptus glaucina	Slaty Red Gum	V	V	✓		-	Found only on the north coast of NSW and in separate districts: near Casino where it can be locally common, and farther south, from Taree to Broke, west of Maitland. It grows in grassy woodland and dry eucalypt forest, and on deep, moderately fertile and well-watered soils.	N	N	Low
Eucalyptus nicholii	Narrow-leaved Black Peppermint	V	V	✓		-	Typically grows in dry grassy woodland, on shallow soils of slopes and ridges. Found primarily on infertile soils derived from granite or metasedimentary rock. Seedling recruitment is common, even in disturbed soils, if protected from grazing and fire.	N	N	Low
Eucalyptus scoparia	Wallangarra White Gum	E	V	-		-	In NSW it is known from only three locations near Tenterfield. Found in open eucalypt forest and woodland on well-drained granite hilltops, slopes and rocky outcrops, typically at high altitudes. At lower elevations can occur in less rocky soils in damp situations.	N	N	Low
Eucalyptus sp. *Cattai*		CE	CE	✓	✓	-	Occurs as a rare emergent tree in scrub, heath and low woodland on sandy soils, usually as isolated individuals or occasionally in small clustered groups. The sites at which it occurs are generally flat and on ridge tops. Associated soils are laterised clays overlying sandstone. There are no known populations occurring in conservations reserves.	N	N	Moderate
Euphrasia arguta		CE	CE	-		-	Euphrasia arguta was rediscovered in the Nundle area of the NSW north western slopes and tablelands in 2008. Prior to this, it had not been collected for 100 years. Historically, *Euphrasia arguta* has only been recorded from	N	N	Low

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							relatively few places within an area extending from Sydney to Bathurst and north to Walcha. The Royal Botanic Gardens Specimen Register records an additional location reported and vouchered in 2002 from near the Hastings River, and *Euphrasia arguta* was also recorded from the Barrington Tops in 2012.			
Galium australe	Tangled Bedstraw	E	-	✓		-	Tangled Bedstraw is widespread in Victoria and Tasmania and is also found in South Australia) and ACT Territory in Jervis Bay). Following a taxonomic revision, many recent records in NSW have been re-determined as other species. Tangled Bedstraw has been recorded historically in the Nowra (Colymea) and Narooma areas and is extant in Nadgee Nature Reserve, south of Eden. Records in the Sydney area are yet to be confirmed. In NSW (and ACT Territory in Jervis Bay), Tangled Bedstraw has been recorded in Turpentine forest and coastal Acacia shrubland. In other states the species is found in a range of near-coastal habitats, including sand dunes, sand spits, shrubland and woodland.	N	N	Low
Genoplesium baueri	Bauer's Midge Orchid/Yellow Gnat-orchid	E	E	✓	✓	✓	Grows in dry sclerophyll forest and moss gardens over sandstone. Flowers February to March. Has been recorded between Ulladulla and Port Stephens. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded in Berowra Valley Regional Park, Royal National Park and Lane Cove National Park and may also occur in the Woronora, O'Hares, Metropolitan and Warragamba catchments.	N	N	Low
Gentiana wingecarribiensis	Wingecarribee Gentian	CE	E	-		✓	Wingecarribee Gentian is known only from Hanging Rock Swamp and Wingecarribee Swamp on the Southern Highlands. Wingecarribee Gentian grows in bogs, in Sphagnum Moss humps and in sedge communities. This species is specifically excluded from matters for further consideration in the SEARs.	N	N	Low
Grammitis stenophylla	Narrow-leaf Finger Fern	E	-	✓		-	Moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest.	N	N	Moderate

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Grevillea caleyi	Caley's Grevillea	CE	CE	✓		-	Restricted to an 8 km square area around Terrey Hills, approximately 20 km north of Sydney. Occurs in three major areas of suitable habitat, namely Belrose, Ingleside and Terrey Hills/Duffys Forest within the Ku-ring-gai, Pittwater and Warringah LGAs. All sites occur on the ridgetop between elevations of 170 to 240 m asl, in association with laterite soils and a vegetation community of open forest, generally dominated by *Eucalyptus sieberi* and *Eucalyptus gummifera*. Commonly found in the endangered Duffys Forest ecological community.	N	N	Low
Grevillea juniperina subsp. *juniperina*	Juniper-Leaved Grevillea	V	-	✓		-	Endemic to western Sydney, centred on an area bounded by Blacktown, Erskine Park, Londonderry and Windsor with outlier populations at Kemps Creek and Pitt Town. Recorded from Cumberland Plain woodland, Castlereagh Ironbark woodland, Castlereagh Scribbly Gum woodland and Shale-Gravel Transition forest. Grows on reddish clay to sandy soils derived from Wianamatta Shale and tertiary alluvium (often with shale influence), typically containing lateritic gravels.	Y	Y	Recorded
Grevillea parviflora subsp. *parviflora*	Small-flowered Grevillea	V	V	✓	✓	-	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	N	N	Moderate
Grevillea parviflora subsp. *supplicans*		E	-	✓		-	Occurs in heathy woodland associations on skeletal sandy soils over massive sandstones. This taxon is strongly associated with clay-capped ridges of the Lucas Heights and Faulconbridge soil landscapes, but it is quite restricted within these areas, suggesting it has a preference for yellow clays with periodically impeded drainage. May be associated with the margins of the Sydney Turpentine Ironbark Forest endangered ecological community and, to a greater extent, with Shale/Sandstone Transition Forest endangered ecological community.	N	N	Low

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Grevillea shiressii		V	V	✓		-	Grows along creek banks in wet sclerophyll forest with a moist understorey in alluvial sandy or loamy soils.	N	N	Moderate
Gyrostemon thesioides		E	-	✓		✓	Grows on hillsides and riverbanks and may be restricted to fine sandy soils. Within NSW it has only ever been recorded at three sites: to the west of Sydney, near the Colo, Georges and Nepean rivers. The most recent sighting was of a single male plant near the Colo River within Wollemi National Park. The species has not been recorded from the Nepean and Georges rivers for 90 and 30 years respectively, despite searches. Also occurs in Western Australia, South Australia, Victoria and Tasmania.	N	N	Moderate
Hakea dohertyi	Kowmung Hakea	E	E	-		✓	It is found in the Kowmung Wilderness Complex and Burragorang Ironbark Woodland formations in the Burragorang area of NSW (Fisher et al. 1995) and occurs on sandstone outcrops in eucalypt open forest (Barker et al. 1999; Harden 1991; Barker et al. 2000).	N	N	Low
Haloragis exalata subsp. *exalata*	Square Raspwort/	V	V	✓	✓	✓	Occurs in 4 widely scattered localities in eastern NSW. It is disjunctly distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW. The species appears to require protected and shaded damp situations in riparian habitats.	N	N	Low
Haloragodendron lucasii	Hal	E	E	✓	✓	✓	Occurs on Hawkesbury Sandstone in moist sandy loam soil. The species prefers sheltered aspects and inhabits gentle slopes below cliff lines near creeks in low open woodland or open forest. Its distribution is correlated with high soil moisture and phosphorous levels.	N	N	Low
Hibbertia fumana		CE	-	-		-	Although originally collected by R. Brown, Caley and Sieber from sites as diverse as 'near South Head' and 'western Sydney', the only known extant population is in the Moorebank area (which could be the 'in occidental Sydney' or 'near Sydney' of either author). Currently only known from a single population at Moorebank but potentially elsewhere in greater Sydney.	N	N	Low

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Hibbertia procumbens	Spreading Guinea Flower	E	-	✓		-	Within NSW, known from several locations only on the Central Coast in the Gosford and Wyong local government areas. These populations are at Bumble Hill near Yarramalong in Wyong LGA; Kulnura, Strickland State Forest, Mangrove Mountain, Somersby, Calga/Mt White and Peats Ridge in the Gosford LGA; and near Mogo Creek to the west of Mangrove Creek Dam. It has been recorded in four conservation reserves: Yengo, Popran and Brisbane Water National Parks and the non-production Strickland State Forest. Also occurs in Victoria and Tasmania, although investigation is required to verify that the disjunct NSW populations are the same species. Majority of known populations occur within *Banksia ericifolia–Angophora hispida–Allocasuarina distyla* scrub/heath on skeletal sandy soils. May also be found associated with 'hanging swamp' vegetation communities on sandy deposits.	N	N	Low
Hibbertia puberula		E	-	✓		✓	Occurs on sandy soil often associated with sandstone. Flowering time is October to November.	N	N	Moderate
Hibbertia sp. Bankstown R.T. Miller & C.P. Gibson s.n. 18/10/06 (BC Act). *syn. Hibbertia puberula subsp. glabrescens* Toelken and Miller (EPBC Act)		CE	CE	-		-	This species is endemic to NSW and is currently known to occur in only one population at Bankstown Airport in Sydney's southern suburbs, in the Bankstown LGA.	N	N	Low
Hibbertia spanantha	Julian's Hibbertia	CE	CE	✓		-	Endemic to NSW where it is restricted to three locations. Grows in forest with canopy species including *Eucalyptus pilularis*, *Eucalyptus resinifera*, *Corymbia gummifera* and *Angophora costata*. The understorey is open with species of Poaceae, Orchidaceae, Fabaceae and Liliaceae.	N	N	Low

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Hibbertia stricta subsp. *furcatula*		E	-	-		-	Habitat of the southern Sydney population is broadly dry eucalypt forest and woodland. This population appears to occur mainly on upper slopes and above the Woronora River gorge escarpment, at or near the interface between the Lucas Heights soil landscape and Hawkesbury sandstone. Habitat of the South Coast population is poorly recorded but appears to be dry sclerophyll forest or woodland associations in sandy soils over sandstone.	N	N	Low
Hibbertia superans		E	-	✓		✓	Flowering time is July to December. The species occurs on sandstone ridgetops often near the shale-sandstone boundary. Occurs in both open woodland and heathland, and appears to prefer open distributed areas, such as tracksides.	N	N	Low
Homoranthus darwinioides		V	V	-	✓	-	Grows in various woodland habitats with shrubby understoreys, usually in gravely sandy soils. Landforms the species has been recorded growing on include flat sunny ridge tops with scrubby woodland, sloping ridges, gentle south-facing slopes, and a slight depression on a roadside with loamy sand.	N	N	Low
Kennedia retrorsa		V	V	✓		-	Found in a variety of habitats from mountainsides to riparian zones, from sheltered forest to steep, exposed rocky ridgelines.	N	N	Low
Keraudrenia corollata var. denticulata in the Hawkesbury local government area		EP	-	✓		✓	Occurs in tall open forest with *Eucalyptus deanei*, *Tristaniopsis laurina*, *Backhousia myrtifolia*, *Commersonia fraseri*, *Rulingia dasyphylla* and *Hibiscus heterophyllus*. Occurs on sandy soil on sandstone banks, edge of floodplains or on road verges. Soils are low in nutrients and well-drained.	N	N	High
Kunzea rupestris		V	V	✓	✓	✓	Grows in shallow depressions on large flat sandstone rock outcrops. Characteristically found in short to tall shrubland or heathland.	Y	Y	Moderate
Lasiopetalum joyceae		V	V	✓	✓	-	Has a restricted range occurring on lateritic to shaley ridgetops on the Hornsby Plateau south of the Hawkesbury River. It is currently known from 34 sites	Y	N	Moderate

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							between Berrilee and Duffys Forest. Seventeen of these are reserved. Grows in heath on sandstone.			
Leptospermum deanei	Deane's Tea-tree	V	V	✓	✓	-	Woodland on lower hill slopes or near creeks. Sandy alluvial soil or sand over sandstone. Occurs in riparian shrub, woodland and open forest.	N	N	Low
Leucopogon exolasius	Woronora Beard-heath	V	V	✓		-	Grows in woodland on sandstone. Restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park.	N	N	Moderate
Leucopogon fletcheri subsp. *fletcheri*		E	-	✓		-	Occurs in dry eucalypt woodland or in shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs.	N	N	Moderate
Lindsaea fraseri	Fraser's Screw Fern	E	-	✓		-	In NSW it is known only from two areas - near Hastings Point on the Tweed coast and in the Pillar Valley east of Grafton. Also occurs in far north and south-east Queensland. Poorly drained, infertile soils in swamp forest or open eucalypt forest, usually as part of a ferny understorey.	N	N	Low
Marsdenia viridiflora subsp. Viridiflora in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas		EP	-	✓		✓	Grows in vine thickets and open shale woodland.	Y	N	High
Maundia triglochinoides		V	-	✓		-	Restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now extinct. Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients.	N	N	Low

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Melaleuca biconvexa	Biconvex Paperbark	V	V	✓		✓	Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north.	N	N	Low
Melaleuca deanei	Deane's Melaleuca/	V	V	✓	✓	✓	Grows in wet heath on sandstone in coastal districts from Berowra to Nowra.	N	N	Moderate
Melaleuca groveana	Grove's Paperbark	V	-	✓		-	Widespread, scattered populations in coastal districts north of Yengo National Park to southeast Queensland. Also found as a disjunct population near Torrington on the northern tablelands. Grove's Paperbark grows in heath and shrubland, often in exposed sites, in low coastal hills, escarpment ranges and tablelands on outcropping granite, rhyolite and sandstone on rocky outcrops and cliffs. It also occurs in dry scrubby open forest and woodlands.	N	N	Low
Micromyrtus blakelyi		V	V	✓	✓	✓	Typically occurs within heathlands in shallow sandy soil in cracks and depressions of sandstone rock platforms.	N	N	Low
Micromyrtus minutiflora		E	V	✓	✓	✓	Grows in Castlereagh Scribbly Gum woodland, Ironbark forest, Shale-Gravel Transition forest, open forest on tertiary alluvium and consolidated river sediments.	Y	N	High
Microtis angusii	Angus's Onion Orchid	E	E	✓		-	Currently known from only one site at Ingleside, north of Sydney. A collection previously thought to be this species was made from Sunny Corner 100 km west of Sydney but has since been confirmed as being genetically distinct and may possibly be a subspecies. It is not easy to define the preferred natural habitat of this orchid as the Ingleside location is highly disturbed. The dominant species occurring on the site are introduced weeds *Hyparrhenia hirta* (Coolatai grass) and *Acacia saligna*. The Ingleside population occurs on soils that have been modified but were originally those of the restricted ridgetop lateritic soils in the Duffys Forest - Terrey Hills - Ingleside and Belrose areas. These soils support a specific and distinct vegetation type, the Duffys Forest Vegetation Community which is listed as an endangered ecological community	N	N	Low

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				NSW ATLAS	PMST	SEARs				
							under the TSC Act and ranges from open forest to low open forest and rarely woodland.			
Olearia cordata		V	V	✓	✓	✓	Grows in dry open sclerophyll forest and open shrubland, on sandstone ridge.	N	N	Low
Pelargonium sp. *Striatellum*	Omeo's Stork's-bill/Omeo Storksbill	E	E	-		✓	Flowering occurs from October to March. Occurs 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. The species is known to form clonal colonies by rhizomatous propagation.	N	N	Low
Persoonia acerosa	Needle Geebung	V	V	✓	✓	✓	Occurs in dry sclerophyll forest, scrubby low-woodland and heath on low fertility soils. Recorded only on the central coast and in the Blue Mountains, from Mt Tomah in the north to as far south as Hill Top where it is now believed to be extinct. Mainly in the Katoomba, Wentworth Falls, Springwood area.	N	N	Low
Persoonia bargoensis	Bargo Geebung	E	V	-		-	The Bargo Geebung occurs in woodland or dry sclerophyll forest on sandstone and on heavier, well-drained, loamy, gravely soils.	N	N	Low
Persoonia glaucescens	Mittagong Geebung	E	V	-		-	The Mittagong Geebung grows in woodland to dry sclerophyll forest on clayey and gravely laterite. The preferred topography is ridge-tops, plateaux and upper slopes. Aspect does not appear to be a significant factor.	N	N	Low
Persoonia hirsuta	Hairy Geebung	E	E	✓	✓	✓	Distributed from Singleton in the north, along the east coast to Bargo in the south and the Blue Mountains to the west. A large area of occurrence, but occurs in small populations, increasing the species' fragmentation in the landscape. Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. Usually present as isolated individuals or very small populations. Probably killed by fire (as other *Persoonia* spp. Are) but will regenerate from seed.	Y	N	Moderate
Persoonia marginata	Clandulla Geebung	V	V	-		-	Grows in dry sclerophyll forest and woodland communities on sandstone. Appears to respond well to disturbance,	N	N	Low

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							with greater densities found along the edges of tracks and in areas disturbed by forestry activities.			
Persoonia mollis subsp. *maxima*		E	E	✓	✓	-	Occurs in sheltered aspects of deep gullies or on the steep upper hillsides of narrow gullies on Hawkesbury Sandstone. These habitats support relatively moist, tall forest vegetation communities, often with warm temperate rainforest influences. Flowers are likely to be pollinated predominantly by native bees. Self-pollination is usually unsuccessful.	N	N	Low
Persoonia nutans	Nodding Geebung	E	E	✓	✓	✓	Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks woodland or Castlereagh Scribbly Gum woodland. Restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south.	Y	Y	Recorded
Pilularia novae-hollandiae	Austral Pillwort	E	-	✓		✓	Grows in shallow swamps and waterways, often among grasses and sedges. It is most often recorded in drying mud as this is when it is most conspicuous.	N	N	Moderate
Pimelea curviflora var. *curviflora*		V	V	✓	✓	✓	Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta River and Port Jackson region including Five Sock, Bellevue Hill and Manly. Occurs on shale-lateritic soils over sandstone and shale-sandstone transition soils on ridgetops and upper slopes amongst woodlands.	Y	Y	Recorded
Pimelea spicata	Spiked Rice-flower	E	E	✓	✓	✓	Once widespread on the Cumberland Plain, the Spiked Rice-flower occurs in two disjunct areas: the Cumberland Plain (Narellan, Marayong, Prospect Reservoir areas) and the Illawarra (Landsdowne to Shellharbour to northern Kiama). In both the Cumberland Plain and Illawarra environments this species is found on well-structured clay soils. On the inland Cumberland Plain sites, it is associated with grey box and Ironbark. In the coastal Illawarra it	Y	N	High

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							occurs commonly in Coast Banksia open woodland with a better developed shrub and grass understorey.			
Pomaderris brunnea	Brown Pomaderris/ Rufous Pomaderris	E	V	✓	✓	✓	The species is expected to live for 10-20 years, while the minimum time to produce seed is estimated to be 4-6 years. Found in a very limited area around the Colo, Nepean and Hawkesbury rivers, including the Bargo area. It also occurs at Walcha on the New England Tableland and in far eastern Gippsland in Victoria.	Y	Y	Recorded
Pomaderris prunifolia	*Pomaderris prunifolia* in the Parramatta, Auburn, Strathfield and Bankstown Local Government Areas	EP	-	✓		-	Known from only three sites within the listed LGAs: at Rydalmere, within Rockwood Cemetery and at The Crest of Bankstown. At Rydalmere it occurs along a road reserve near a creek, among grass species on sandstone. At Rookwood Cemetery it occurs in a small gully of degraded Cooks River-Castlereagh Ironbark forest on shale soils.	N	N	Nil
Prostanthera askania	Tranquillity Mintbush	E	E	✓		-	Occurs over a very restricted geographic range (of less than 12 km) in the upper reaches of creeks that flow into Tuggerah Lake or Brisbane Water within the Wyong and Gosford local government areas. Eight populations are known from the catchments of Ourimbah Creek, Narara Creek, Dog Trap Gully, Chittaway Creek and Berkeley Creek. A further two populations are known from the Erina Creek–Fires Creek catchment. The species may also have occurred in West Gosford. Occurs adjacent to, but not immediately in, drainage lines on flat to moderately steep slopes formed on Narrabeen sandstone and alluvial soils derived from it. Occurs in moist sclerophyll forest and warm temperate rainforest communities, and the ecotone between them. These communities are generally tall forests with a mesic understorey; Sydney Blue Gum Eucalyptus saligna and Turpentine Syncarpia glomulifera are usually present, though canopy species present can be highly variable.	N	N	Low

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Prostanthera cineolifera	Singleton Mint Bush	V	V	✓		-	Restricted to only a few localities near Scone, Cessnock and St Albans. Grows in open woodlands on exposed sandstone ridges. Usually found in association with shallow or skeletal sands.	N	N	Low
Prostanthera densa	Villous Mint-bush	V	V	✓		-	This species has been recorded from the Currarong area in Jervis Bay, Royal National Park (Marley), Cronulla, Helensburgh and Port Stephens (Nelson Bay). The Sydney and Royal National Park populations were thought possibly extinct, but the species is now known to occur at Bass and Flinders Point in Cronulla. Prostanthera densa generally grows in sclerophyll forest and shrubland on coastal headlands and near coastal ranges, chiefly on sandstone, and rocky slopes near the sea.	N	N	Low
Prostanthera junonis	Somersby Mintbush	E	E	✓		-	The species is restricted to the Somersby Plateau. It occurs on both the Somersby and Sydney Town soil landscapes on gently undulating country over weathered Hawkesbury sandstone within open forest-low woodland-open scrub. It occurs in both disturbed and undisturbed sites.	N	N	Low
Prostanthera marifolia	Seaforth Mintbush	CE	CE	✓		-	*Prostanthera marifolia* is currently only known from the northern Sydney suburb of Seaforth and has a very highly restricted distribution within the Sydney Basin Bioregion. The single population is fragmented by urbanisation into three small sites. All known sites are within an area of 2 x 2 km. The sites are within the local government area of Northern Beaches Council. Occurs in localised patches in or in close proximity to the endangered Duffys Forest ecological community. Located on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses, a soil type which only occurs on ridge tops and has been extensively urbanised.	N	N	Low
Prostanthera saxicola	Prostanthera Saxicola population in Sutherland and	EP	-	-		-	Primarily in Eucalypt forest, heath and low shrubland, often in damp or moist sites. This population is restricted to the named LGAs (Liverpool and Sutherland) in the southern to south-western parts of Sydney. Recorded occurrences are mainly between Holsworthy station and	N	N	None

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	Liverpool local government areas						Sutherland station, north from Lucas Heights and south of the Georges River.			
Pterostylis chaetophora		V	-	✓		-	Recorded from Queensland and NSW. In NSW it is currently known from 18 scattered locations in a relatively small area between Taree and Kurri Kurri, extending to the south-east towards Tea Gardens and west into the Upper Hunter, with additional records near Denman and Wingen. There are also isolated records from the Sydney region. The species occurs in two conservation reserves, Columbey National Park and Wingen Maid Nature Reserve.	N	N	Low
Pterostylis gibbosa	Illawarra Greenhood	E	E	-	✓	-	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage.	N	N	Low
Pterostylis nigricans	Dark Greenhood	V	-	✓		-	The Dark Greenhood occurs in north-east NSW north from Evans Head, and in Queensland. Coastal heathland with heath banksia, and lower-growing heath with lichen-encrusted and relatively undisturbed soil surfaces, on sandy soils.	N	N	Low
Pterostylis pulchella	Waterfall Greenhood/ Pretty Greenhood	V	V	-		-	The Waterfall Greenhood is found only at Fitzroy Falls, Belmore Falls, upper Bundanoon Creek (Meryla) and Minnamurra Falls. It is found on cliff faces close to waterfalls and creek banks and mossy rocks alongside running water.	N	N	Low
Pterostylis saxicola	Sydney Plains Greenhood	E	E	✓	✓	✓	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. 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 Sydney Plains Greenhood occurs are sclerophyll forest or woodland on shale-sandstone transition soils or shale soils.	Y	N	Moderate

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Pultenaea aristata	Prickly Bush-pea	V	V	-		-	Grows in moist, dry sclerophyll woodland to heath on sandstone, specifically the drier areas of Upland Swamps. Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong.	N	N	Low
Pultenaea elusa	Elusive Bush-pea	CE	E	-		✓	The Elusive Bush-pea has only been recorded twice, in 1938 at Penrose and Wingello on the Southern Tablelands. Both collections of the Elusive Bush-pea record the habitat only as swamp. *This species is specifically excluded from matters for further consideration in the SEARs.	N	N	Low
Pultenaea glabra	Smooth Bush-pea/Swamp Bush-pea	V	V	-	✓	✓	Grows in swamp margins, hillslopes, gullies and creekbanks and occurs within dry sclerophyll forest and tall damp heath on sandstone. Restricted to the higher Blue Mountains.	N	N	Low
Pultenaea parviflora		E	V	✓	✓	✓	Endemic to the Cumberland Plain. May be locally abundant, particularly within scrubby-dry heath areas within Castlereagh Ironbark forest and Shale Gravel Transition forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum woodland.	Y	Y	Recorded
Pultenaea pedunculata	Matted Bush-pea	E	-	✓		-	*Pultenaea pedunculata* occurs in a range of habitats. NSW populations are generally among woodland vegetation but plants have also been found on road batters and coastal cliffs. It is largely confined to loamy soils in dry gullies in populations in the Windellama area.	N	N	Low
Pultenaea villifera population in the Blue Mountains local government area	*Pultenaea villifera Sieber* ex DC. population in the Blue Mountains local government area	EP	-	✓		-	Grows in dry sclerophyll forest and woodlands on sandy soil and appears to favour sheltered spots.	N	N	Nil
Rhizanthella slateri	Eastern Australian Underground Orchid	V	E	✓	✓	✓	Habitat requirements are poorly understood and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest.	N	N	Low

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Rhodamnia rubescens	Scrub Turpentine	CE	-	✓		-	Occurs in coastal districts north from Batemans Bay in NSW, approximately 280 km south of Sydney, to areas inland of Bundaberg in Queensland. Populations of *R. rubescens* typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 m asl. in areas with rainfall of 1,000-1,600 mm. Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils.	Y	Y	Recorded
Rhodomyrtus psidioides	Native Guava	CE	-	✓		-	Occurs from Broken Bay, approximately 90 km north of Sydney, New South Wales, to Maryborough in Queensland. Populations are typically restricted to coastal and sub-coastal areas of low elevation however the species does occur up to c. 120 km inland in the Hunter and Clarence River catchments and along the Border Ranges in NSW. Pioneer species found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest often near creeks and drainage lines.	N	N	Low
Rutidosis heterogama	Heath Wrinklewort	V	V	-		-	Grows in heath on sandy soils and moist areas in open forest and has been recorded along disturbed roadsides.	N	N	Low
Senna acclinis	Rainforest Cassia	E	-	✓		-	Occurs in coastal districts and adjacent tablelands of NSW from the Illawarra in NSW to Queensland. Grows on the margins of subtropical, littoral and dry rainforests.	Y	Y	Recorded
Syzygium paniculatum	Magenta Lilly Pilly/ Magenta Cherry/Daguba/ Scrub Cherry/ Creek Lilly Pilly/ Brush Cherry	E	V	✓	✓	-	Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State forest. On the south coast the species occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast it occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	N	N	Moderate
Tetratheca glandulosa	Glandular Pink-bell	V	-	✓		✓	Associated with shale-sandstone transition habitat where shale-cappings occur over sandstone, with associated soil landscapes such as Lucas Heights, Gymea, Lambert and Faulconbridge. Topographically, the plant occupies ridgetops, upper-slopes and to a lesser extend mid-slope	Y	Y	Recorded

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							sandstone benches. Soils are generally shallow, consisting of a yellow, clayey-sandy loam. Stony lateritic fragments are also common in the soil profile on many of these ridgetops. Vegetation structure varies from heaths and scrub to woodlands-open woodlands, and open forest.			
Tetratheca juncea	Black-eyed Susan	V	V	✓	✓	✓	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. It is usually found in low open forest-woodland with a mixed shrub understorey and grassy groundcover. The	N	N	Low
Thelymitra kangaloonica	Kangaloon Sun Orchid	CE	CE	-	✓	-	Thelymitra sp. Kangaloon is only known to occur on the southern tablelands of NSW in the Moss Vale - Kangaloon - Fitzroy Falls area at 550-700 m above sea level. It is known to occur at three swamps that are above the Kangaloon Aquifer. It is found in swamps in sedgelands over grey silty grey loam soils.	N	N	Low
Thesium australe	Austral Toadflax	V	V	-	✓	✓	Grows in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Occurs in grassland or grassy woodland. Grows on Kangaroo Grass tussocks but has also been recorded within the exotic Coolatai Grass.	N	N	Low
Triplarina imbricata	Creek Triplarina	E	E	-		-	Found only in a few locations in the ranges south-west of Glenreagh and near Tabulam in north-east NSW. Along watercourses in low open forest with water gum.	N	N	Low
Velleia perfoliata		V	V	✓	✓	-	The species is only known from the Hawkesbury District and Upper Hunter Valley in the Central Coast botanical subdivision of NSW. *Velleia perfoliate* grows in heath on shallow sandy soil over Sandstone. It is currently known to exist in 9 populations. Five of these populations are reserved whilst a further population is partly reserved. Four of the reserved sites are situated adjacent to fire trails.	N	N	Low

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Wahlenbergia multicaulis Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield LGAs	Tadgell's Bluebell in the local government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield	EP	-	-		-	Found in disturbed sites and grows in a variety of habitats including forest, woodland, scrub, grassland and the edges of watercourses and wetlands. Typically occurs in damp, disturbed sites (with natural or human disturbance of various forms), typically amongst other herbs rather than in the open.	N	N	None
Wilsonia backhousei	Narrow-leafed Wilsonia	V	-	-		-	In NSW, Narrow-leafed Wilsonia is found on the coast between Mimosa Rocks National Park and Wamberal, north of Sydney. This is a species of the margins of salt marshes and lakes.	N	N	Low
Wollemia nobilis	Wollemi Pine	CE	CE	-	✓	-	The Wollemi Pine occurs in the warm temperate rainforest and rainforest margins in a eucalypt forest-woodland complex within the Sydney Sandstone Biome of the eastern coast of NSW. Topography controls vegetation association where Wollemi Pine occurs. Within the canyons rainforest occurs and the surrounding ridges have dry sclerophyll woodland.	N	N	Low
Zieria involucrata		E	V	✓	✓	✓	Has a disjunct distribution in the Baulkham Hills, Hawkesbury, Hornsby and Blue Mountains LGAs. Recent records for the species come from 22 populations in the catchments of the Macdonald, Colo and Hawkesbury Rivers. Occurs on Hawkesbury sandstone, Narrabeen Group sandstone and on Quaternary alluvium. Found in sheltered forests on mid- to lower slopes and valleys, in or adjacent to gullies which support sheltered forest, although some populations extend up-slope into drier vegetation.	Y	Y	Recorded
Zieria murphyi	Velvet Zieria	V	V	✓		-	Velvet Zieria is found in the Blue Mountains at Mt Tomah and in the southern highlands where it has been recorded in Morton National Park in the Bundanoon area, and at	N	N	Low

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							Penrose. It is found in sheltered positions in moist gullies in moist eucalypt forest with sandy soil.			

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TECs				
Agnes Banks Woodland in the Sydney Basin Bioregion CEEC	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion EEC*	N	N	Low
Blue Mountains Shale Cap Forest in the Sydney Basin Bioregion EEC	*Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC*	Y	Y	High
Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion VEC	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion EEC*	N	N	Low
Castlereagh Swamp Woodland Community EEC	*Not listed*	N	N	Low
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion EEC	*Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion CEEC*	Y	N	Moderate
Cumberland Plain Woodland in the Sydney Basin Bioregion	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	Y	Y	Recorded
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC	*Not listed*	Y	Y	Recorded
Moist Shale Woodland in the Sydney Basin Bioregion EEC	*Western Sydney Dry Rainforest and Moist Woodland on Shale CEEC*	N	N	Low
Shale Gravel Transition Forest in the Sydney Basin Bioregion EEC	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC*	Y	Y	Recorded
Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC*	Y	Y	Recorded
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC	*Not Listed*	Y	Y	Recorded
Sydney Turpentine Ironbark Forest CEEC	*Turpentine-Ironbark Forest of the Sydney Basin Bioregion CEEC*	Y	Y	Recorded
Western Sydney Dry Rainforest in the Sydney Basin Bioregion EEC	*Western Sydney Dry Rainforest and Moist Woodland on Shale CEEC*	Y	Y	Recorded

Appendix B PCT Descriptions

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List of Photographs

PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion

Distribution within the study area: Recorded towards Windsor Downs Nature Reserve and Scheyville National Park. The PCT is known to occur on clay soils with a high concentration of iron-indurated gravel derived from Tertiary alluvium (NPWS 2015).

Structure/characteristics: Woodland to open forest community with an open layer of sclerophyll shrubs and a grassy groundcover. Dominant canopy includes *Eucalyptus fibrosa, Eucalyptus moluccana* and *Melaleuca decora*. Common lower stratum species include: *Daviesia ulicifolia, Lissanthe strigosa, Bursaria spinosa* subsp. *spinosa, Microlaena stipoides* var. *stipoides and Cheilanthes sieberi* subsp. *sieberi* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Three condition classes were recorded in this PCT:

- Moderate/good_good: consisting of an intact canopy and midstorey with a moderate diversity of native species within the ground cover. Some weeds occur scattered throughout the native vegetation
- Moderate/good_medium: A native canopy exists however the midstorey and groundcovers are a mix of locally native and non-native species (weeds). Common non-native species include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and midstorey plants are present. This condition class is characterised by low native species richness and low native species abundance. Mainly dominated by non-local species (weeds).

Conservation status: *Shale Gravel Transition Forest in the Sydney Basin Bioregion* (BC Act) and *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* (EPBC Act).

Table 1. Common native species recorded within PCT 724

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Eucalyptus fibrosa, Eucalyptus moluccana, Melaleuca decora*
Midstorey	7 - 12 m	30	*Acacia parramattensis*
Shrub layer	1.0 - 2 m	25 - 30	*Daviesia ulicifolia, Lissanthe strigosa, Bursaria spinosa* subsp. *spinosa*
Groundcover	To 1 m	20 - 50	*Microlaena stipoides var. stipoides, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans, Pratia purpurascens, Themeda triandra, Lomandra filiformis, Dichondra repens, Brunonia australis, Oxalis perennans.*

Photograph 1. PCT 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora *grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_good.*

Photograph 2. PCT 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora *grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_low.*

PCT 781 (HN520) Coastal Freshwater Lagoons of the Sydney Basin Bioregion and South East Corner Bioregion

Distribution in the study area: Scattered throughout the floodplains of the study area. The most significant Coastal Freshwater Lagoons within the study area include: Pitt Town Lagoon, Longneck Lagoon, Broadwater Swamp, Halls Swamp, and Gees Lagoon.

Structure/characteristics: Freshwater or slightly brackish coastal lagoons with a patchy to dense cover of reeds and sedges and an occasional shrub canopy. Dominant species include *Phragmites australis, Typha orientalis, Eleocharis sphacelata, Juncus spp., Carex spp., Isolepis spp., Melaleuca ericifolia / Casuarina glauca, Melaleuca ericifolia* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Three condition classes have been assigned to this PCT:

- Moderate/good: Dominated by native sedges, rushes, shrubs and ground cover species. Very few non-local species.
- Moderate/good_low: Very few native species. Dominated by introduced grasses such as *Chloris gayana, Paspalum dilatatum*, and *Cenchrus clandestinus*.
- Moderate/good_derived: A derived condition class. Some structural and floristic modification due to surrounding land uses such as grazing.

Conservation status: *Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* (BC Act).

Table 2. Common native species recorded within PCT 781.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	5	Occasional - *Casuarina glauca, Melaleuca ericifolia, Melaleuca decora, Melaleuca linearifolia.*
Groundcover	To 1 m	20 - 100	*Eleocharis sphacelata, Phragmites australis, Typha orientalis, Baumea rubiginosa, Paspalum distichum, Ranunculus inundatus, Carex* spp.*, Juncus* spp.*, Cycnogeton procerum*

Photograph 3. PCT 781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion – moderate/good.

Photograph 4. PCT 781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion – moderate/good_low. Note the introduced grass cover in the ground layer.

PCT 835 (HN526) Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion

Distribution within the study area: Occurs mainly throughout the Western Sydney region of the study area along stream banks and alluvial flats.

Structure/characteristics: Woodland to open forest community with an open layer of shrubs and a grassy groundcover. Dominant canopy includes *Eucalyptus tereticornis, Casuarina glauca,* and *Angophora floribunda.* Common midstorey and groundcover species include *Acacia parramattensis, Bursaria spinosa* subsp. *spinosa, Sigesbeckia orientalis, Microlaena stipoides var. stipoides, Oplismenus aemulus, Dichondra repens and Entolasia marginata* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Four condition classes have been assigned to this PCT:

- Moderate/good_good: Consisting of an intact canopy and midstorey, with a moderate diversity of native species within the ground layer. Some weeds occur scattered throughout stands of this community
- Moderate/good_medium: A native canopy occurs with a mix of native and non-native mid-storey and groundcover species. Common non-native species include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), *Araujia sericifera* (Moth vine) and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and native midstorey species. Generally, a low native species richness and low native species abundance
- Moderate/good_derived: An open vegetation structure with a high percentage of regenerating native species characteristic of this community is evident of this condition class.

Conservation status: *River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* (BC Act).

Table 3. Common native species recorded within PCT 835

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Eucalyptus tereticornis, Casuarina glauca, Angophora floribunda*
Midstorey	7 - 12 m	40	*Acacia parramattensis*
Shrub layer	1.5 - 2 m	25 - 30	*Daviesia ulicifolia, Lissanthe strigosa, Bursaria spinosa* subsp. *spinosa*
Groundcover	To 1 m	20 - 50	*Microlaena stipoides var. stipoides, Oplismenus aemulus; Dichondra repens, Entolasia marginata, Lobelia purpurascens, Commelina cyanea*

Photograph 5. PCT 835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_medium.

Photograph 6. PCT: 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_low.

PCT 849 (HN528) Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion

Distribution within the study area: Occurs mainly in the Cumberland Plain region of the study area on clay loam soils. Mainly occurs set back from creek banks and waterways.

Structure/characteristics: Woodland to open forest community with an open layer of sclerophyll shrubs and a grassy groundcover. Dominant canopy species include *Eucalyptus moluccana* and *Eucalyptus tereticornis.* The dominant understorey species include *Bursaria spinosa* subsp. *spinosa, Dichondra repens, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans* and *Microlaena stipoides* var. *stipoides* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Three condition classes have been assigned to this PCT:

- Moderate/good_good: Consisting of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout the community
- Moderate/good_medium: A native canopy exists with a mix of native and locally non-native mid-storey and groundcover species. Common locally non-native species include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), *Sida rhombifolia, Solanum nigrum* (Blackberry nightshade), *Bidens pilosa* (Cobblers Pegs) and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees, and native understorey species persist. Low native species richness and low native species abundance. This community is predominantly dominated by locally non-native species.

Conservation status: *Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC* (BC Act) and *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC* (EPBC Act).

Table 4. Common native species recorded within PCT: 849.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	25-30	*Eucalyptus moluccana, Eucalyptus tereticornis*
Midstorey	7 - 12 m	15	*Acacia parramattensis*
Shrub layer	1.5 - 2 m	25	*Lissanthe strigosa, Bursaria spinosa* subsp. *spinosa*
Groundcover	To 1 m	20 - 30	*Microlaena stipoides* var. *stipoides, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans, Lobelia purpurascens, Themeda triandra, Lomandra filiformis, Dichondra repens, Brunonia australis, Oxalis perennans.*

Photograph 7. PCT 849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – moderate/good.

Photograph 8. PCT 849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_medium.

Photograph 9. PCT 849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_low.

PCT 866 (HN554): Grey Gum - Smooth-barked Apple open forest of the dry hinterland of the Central Coast, Sydney Basin Bioregion

Distribution within the study area: Mapped by Ryan, Fisher and Schaeper (1996) as occurring to the north of the Colo River just south of Comleroy State Forest. This PCT has not been ground-truthed as part of the vegetation surveys.

Structure/characteristics: Based on the PCT descriptions, the community is likely to be an open forest community dominated by the following species; *Angophora costata, Eucalyptus crebra, Syncarpia glomulifera, Allocasuarina torulosa, Exocarpos strictus, Myrsine variabilis, Persoonia linearis, Entolasia stricta, Goodenia heterophylla, Hardenbergia violacea and Pomax umbellata* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good_good. The extent of this community within the study area is likely to consist of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species are likely to be present.

Conservation status: This PCT does not align to any TEC under either the BC Act or EPBC Act.

Table 5. Common native species likely to occur within PCT 866.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Eucalyptus punctata, Angophora costata, Syncarpia glomulifera, Eucalyptus crebra*
Midstorey	7 - 12 m	30	*Exocarpos strictus, Allocasuarina torulosa*
Shrub layer	1.5 - 2 m	25 - 30	*Myrsine variabilis; Persoonia linearis, Podolobium ilicifolium*
Groundcover	To 1 m	20 - 50	*Goodenia heterophylla; Hardenbergia violacea, Pomax umbellata, Themeda triandra, Entolasia stricta*

PCT 877 (HN538): Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion

Distribution within the study area: Occurs mainly as small scattered patches within the deeper sheltered gullies of the Cumberland Plain region. No validation of this PCT was completed during the current vegetation surveys.

Structure/characteristics: Based on PCT descriptions this is a closed forest to rainforest community with a dense canopy and midstorey. The dominant canopy species includes *Backhousia myrtifolia.* Common midstorey and groundcover species include *Notelaea longifolia, Breynia oblongifolia, Hymenanthera dentata, Sigesbeckia orientalis, Adiantum aethiopicum, Asplenium flabellifolium, Pellaea falcata and Dichondra repens* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good_good. The extent of the community within the study area is likely to consist of an intact canopy and midstorey, with a high proportion of native species within the groundcover. Some locally non-native species are likely to be present.

Conservation status: *Western Sydney Dry Rainforest in the Sydney Basin Bioregion* (BC Act) and *Western Sydney Dry Rainforest and Moist Woodland on Shale* (EPBC Act).

Table 6. Common native species likely to occur within PCT 877.

Stratum	Height (m)	% cover*	Dominant native species
Midstorey	7 - 12 m	60	*Backhousia myrtifolia*
Shrub layer	1.5 - 2 m	25 - 30	*Notelaea longifolia, Breynia oblongifolia, Sigesbeckia orientalis*
Groundcover	To 1 m	20	*Adiantum aethiopicum, Pellaea falcata, Dichondra repens, Microlaena stipoides* var. *stipoides, Oplismenus imbecillis*

PCT 924 (HN552): Melaleuca linariifolia alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion

Distribution within the study area: Occurs mainly to the north of the study area coinciding with the occurrence of PCT 781 Coastal Freshwater Lagoons. Large occurrences of the PCT are located at Gees Lagoon, Turnbulls Swamp, and Teatree Swamp.

Structure/characteristics: This vegetation is ground water dependant, usually consisting of a very dense stand of *Melaleuca linariifolia.* Other common species include *, Cynodon dactylon, Paspalum distichum* and *Phragmites australis* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good_good. The extent of the community within the study area consists of an intact canopy and midstorey, with a high proportion of native species occurring within the groundcover. Some locally non-native species were present.

Conservation status: *Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* (BC Act).

Table 7. Common native species recorded within across PCT 924

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	40-60	*Melaleuca linariifolia, M. decora*
Groundcover	To 1 m	20 - 50	*Paspalum distichum, Phragmites australis, Typha orientalis, Cynodon dactylon, Cyperus spp.*

Photograph 10. PCT 924: Melaleuca linariifolia *alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion – moderate/good_good.*

PCT 1328 (HN613): Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast, Sydney Basin Bioregion

Distribution within study area: This PCT was not ground-truthed during the vegetation surveys. It has been mapped as occurring on exposed slopes toward middle Colo and along the gullies and slopes of Wheeny Creek.

Structure/characteristics: This PCT has been described as a woodland with a canopy dominated by *Corymbia eximia, Angophora bakeri, Eucalyptus punctata, Eucalyptus sparsifolia.* Common midstorey and groundcover species include *Acacia suaveolens, Acacia ulicifolia, Hovea linearis, Lambertia formosa, Entolasia stricta, Lomandra obliqua, Pomax umbellata and Pteridium esculentum* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good_good. The extent of the community within the study area likely consists of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species are likely to occur scattered throughout the community.

Conservation status: Not listed.

Table 8. Common native species likely to occur within across PCT 1328.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Corymbia eximia, Angophora bakeri, Eucalyptus punctata, Eucalyptus sparsifolia*
Shrub layer	1.5 - 2 m	30	*Acacia suaveolens, Acacia ulicifolia, Hovea linearis, Lambertia formosa*
Groundcover	To 0.5 m	25	*Entolasia stricta, Lomandra obliqua, Pomax umbellata* and *Pteridium esculentum*

PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

Distribution within the study area: Occurs mainly within the Cumberland Plain region of the study area on shale and sandstone transitional soil types. The largest patches include Cattai National Park and private properties across Maraylya and Ebenezer.

Structure/characteristics: A woodland to open forest community with an open layer of shrubs and a grassy groundcover. Dominant canopy includes *Eucalyptus crebra, Eucalyptus fibrosa,* and *E. punctata.* Dominant understorey species include *Allocasuarina littoralis, Bursaria spinosa* subsp. *spinosa, Ozothamnus diosmifolius, Hibbertia aspera, Lepidosperma laterale, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans* and *Lobelia purpurascens* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Four condition classes have been assigned to this PCT:

- Moderate/good_good: Consisting of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout the vegetation
- Moderate/good_medium: A native canopy occurs with a mix of locally native and introduced species occurring in the midstorey and groundcover. Common locally non-native species include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees, and understorey species occur. A low native species richness and low native species abundance occurs within observed stands of this community in this condition class. Mainly dominated by locally non-native species
- Moderate/good_derived: An open vegetation structure occurs with a high proportion of regenerating species native to this community.

Conservation status: *Shale Sandstone Transition Forest in the Sydney Basin Bioregion* (BC Act) and *Shale Sandstone Transition Forest of the Sydney Basin Bioregion* (EPBC Act).

Table 9. Common native species recorded within PCT 1395.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata*
Midstorey	7 - 12 m	30	*Acacia parramattensis, Allocasuarina littoralis*
Shrub layer	1.5 - 2 m	30	*Persoonia linearis, Bursaria spinosa* subsp. *spinosa, Ozothamnus diosmifolius, Hibbertia aspera*
Groundcover	To 0.5 m	25	*Lepidosperma laterale, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans*, *Lobelia purpurascens, Microlaena stipoides* var. *stipoides, Entolasia stricta, Lomandra multiflora, Themeda triandra, Panicum simile, Echinopogon caespitosus.*

Photograph 11. PCT 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_good.

Photograph 12. PCT 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_medium.

Photograph 13. PCT 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_low.

Photograph 14. PCT 1395: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion – moderate/good_derived.

PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion

Distribution within the study area: This community has been mapped on a private property at Windsor Downs likely along a drainage depression. This PCT was not ground-truthed during the vegetation surveys.

Structure/characteristics: The PCT has been described as a woodland community with a canopy assemblage including *Melaleuca decora*, *Eucalyptus parramattensis* subsp. *parramattensis and Melaleuca linariifolia.* Common lower storey species are likely to include *Melaleuca decora, Melaleuca nodosa, Pultenaea villosa, Acacia longifolia, Goodenia paniculata, Schoenus apogon, Centella asiatica and Cheilanthes sieberi* subsp. *sieberi* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good_good. Vegetation in this condition class is likely to consist of an intact canopy and midstorey, with a relatively moderate to native diversity within the ground layer. Some weeds are likely to occur scattered throughout.

Conservation status: *Castlereagh Swamp Woodland Community* (BC Act).

Table 10. Common native species recorded within PCT 1067.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 20 m	30	*Eucalyptus parramattensis* subsp. *parramattensis*
Midstorey	5 - 10 m	30	*Melaleuca decora, Melaleuca linariifolia*
Shrub layer	1.5 - 2 m	25 - 30	*Melaleuca decora, Melaleuca nodosa, Pultenaea villosa, Acacia longifolia, Melaleuca linariifolia*
Groundcover	To 1 m	20 - 50	*Goodenia paniculata, Centella asiatica, Juncus usitatus, Lobelia purpurascens, Themeda triandra, Paspalidium distans, Eragrostis brownii, Fimbristylis dichotoma*

PCT 1106 (NR223): River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion

Distribution within the study area: Occurs mainly to the north of the study area along the banks of the upper Colo River, but also in the south and west of the study area.

Structure/characteristics: A woodland to open forest community with a canopy dominated by *Casuarina cunninghamiana* subsp. *cunninghamiana*. Common understorey species include: *Waterhousea floribunda, Angophora floribunda, Angophora subvelutina* and *Callistemon viminalis.* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

Four condition classes have been assigned to this PCT:

- Moderate/good_good: Consisting of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout
- Moderate/good_medium: A native canopy exists with a midstorey and groundcover comprised of both native and locally non-native species. Common non-native species include *Ligustrum sinense* (Small-leaved Privet), *Cardiospermum grandiflorum* (Balloon vine) and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees, and native understorey species still occur. A low native species richness and low native species abundance. This condition class is characterised by a dominance of locally non-native species
- Moderate/good_derived: An open vegetation structure occurs with a high proportion of regenerating species native to this community.

Conservation status: None listed.

Table 11. Common native species recorded within across PCT 1106

Stratum	Height (m)	% cover*	Dominant native species
Tree	30 m	30	*Casuarina cunninghamiana, Angophora floribunda*
Midstorey	5 m	30	*Waterhousea floribunda, Backhousia myrtifolia*
Shrub layer	1.5 m	10	*Breynia oblongifolia, Tristaniopsis laurina*
Ground layer	To 1 m	20	*Microlaena stipoides* var. *stipoides, Cheilanthes sieberi* subsp. *sieberi, Lobelia purpurascens, Centella asiatica, Oxalis perennans.*

Photograph 15. PCT 1106: River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion – moderate/good_derived condition.

PCT 1385 (HN577): Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast, Sydney Basin Bioregion

Distribution within the study area: Occurs to the north of the study area. Patches of this PCT occur to along Putty Road on the northern side of the Colo River.

Structure/characteristics: An open forest community with a canopy consisting of *Angophora floribunda*, *Eucalyptus punctata* and *Eucalyptus eugenioides*. Common understorey species include *Allocasuarina torulosa, Breynia oblongifolia, Jacksonia scoparia, Persoonia linearis, Billardiera scandens, Dianella caerulea, Entolasia stricta,* and *Lobelia purpurascens* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

Three condition classes have been assigned to this PCT:

- Moderate/good_good: Consists of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout
- Moderate/good_medium: A native canopy exists with a midstorey and groundcover consisting of a mix of native and introduced species. Common weeds include *Cardiospermum grandifolium* (Balloon vine), *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and native understorey species occur. Low native species richness and low native species abundances were recorded. Mainly dominated by locally non-native species.

Conservation status: Not listed.

Table 12. Common native species recorded within PCT 1385.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Angophora floribunda, Eucalyptus piperita, Eucalyptus amplifolia,*
Midstorey	7 - 12 m	10	*Acacia implexa, Allocasuarina torulosa*
Shrub layer	1.5 - 2 m	25 - 30	*Breynia oblongifolia, Persoonia linearis*
Groundcover	To 1 m	20 - 30	*Lobelia purpurascens, Dianella revoluta, Entolasia stricta.*

Photograph 16. PCT 1385: Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast, Sydney Basin Bioregion – moderate/good_medium.

PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion

Distribution within the study area: This PCT has been mapped as occurring along the sandstone gullies of the edge of the Cumberland Plain.

Structure/characteristics: A forest community with a canopy dominated by *Angophora costata*, *Corymbia gummifera*, and *Eucalyptus piperita*. Common lower storey species include *Banksia serrata, Persoonia linearis, Persoonia levis, Phyllanthus hirtellus, Leptospermum trinervium, Entolasia stricta, Pteridium esculentum, Dianella caerulea and Smilax glyciphylla* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

Three condition classes have been assigned to this PCT:

- Moderate/good_good: Consists of an intact canopy and midstorey with a moderately native groundcover. Some locally non-native species occur scattered throughout
- Moderate/good_medium: A native canopy exists with a mix of native and locally non-native mid-storey and groundcover species. Common non-native species include *Sida rhombifolia, Bidens pilosa* (Cobbler's Pegs), *Plantago lanceolata, Hypochaeris radicata* (cats ear), *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet) and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and native understorey species occur. Low native species richness and low native species abundances were recorded. Mainly dominated by locally non-native species.

Conservation status: Not listed.

Table 13. Common native species recorded within across PCT 1181.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Angophora costata, Corymbia gummifera, Eucalyptus piperita, Syncarpia glomulifera*
Midstorey	7 - 12 m	30	*Banksia serrata, Allocasuarina littoralis*
Shrub layer	1.5 - 2 m	25 - 30	*Persoonia linearis, Persoonia levis, Leptospermum trinervium, Banksia spinulosa, Acacia ulicifolia, Xylomelum pyriforme, Grevillea mucronulata; Eriostemon australasius.*
Groundcover	To 1 m	20 - 50	*Entolasia stricta, Pteridium esculentum, Xanthosia pilosa, Lepidosperma laterale, Lomandra obliqua, Phyllanthus hirtellus, Gonocarpus teucrioides*

Photograph 17. PCT 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion – moderate/good_good.

Photograph 18. PCT 1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion – moderate/good_low.

PCT 1183 (HN587): Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion

Distribution within the study area: Occurs mainly to the north of the study area within sheltered gullies or on slopes. The community has been predominantly mapped as occurring near Halls Swamp and Greens Swamp.

Structure/characteristics: open forest community with an open layer of sclerophyll shrubs and grassy groundcover. Dominant species include: *Angophora costata, Eucalyptus piperita, Syncarpia glomulifera, Acacia elata, Acacia linifolia, Allocasuarina torulosa, Backhousia myrtifolia, Adiantum aethiopicum, Blechnum cartilagineum, Calochlaena dubia, Caustis flexuosa* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

Two condition classes have been assigned to this PCT:

- Moderate/good_good: Consists of an intact canopy and midstorey, with a moderately native groundcover. Some weeds occur scattered throughout. Overall this condition class has a high resilience.
- Moderate/good_medium: A native canopy occurs with a mid-storey and ground cover supporting both locally native and non-native species. Common weeds include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet) and *Lantana camara* (Lantana).

Conservation status: Not listed.

Table 14. Common native species recorded within PCT 1183.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Angophora costata, Eucalyptus piperita, Syncarpia glomulifera, Corymbia gummifera, Eucalyptus deanei, Eucalyptus punctata*
Midstorey	10 m	30	*Pittosporum undulatum, Acacia elata, Allocasuarina torulosa*
Shrub layer	1.5 - 2 m	25 - 30	*Persoonia levis, Persoonia linearis, Backhousia myrtifolia, Breynia oblongifolia, Dodonaea triquetra*
Groundcover	To 1 m	20 - 50	*Gonocarpus teucrioides, Lepidosperma laterale, Lomatia silaifolia, Pteridium esculentum, Calochlaena dubia, Entolasia stricta.*

Photograph 19. PCT 1183: Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion – moderate/good. The vegetation shown in this photograph is dominated by Backhousia myrtifolia.

PCT 1504 (HN1504): Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion

Distribution within the study area: occurs mainly to the north of the study area around Colo. The community occurs on the alluvial flats of the Colo River.

Structure/characteristics: A forest community with a canopy dominated by *Eucalyptus saligna* and *E. deanei*, with *E. elata* less common. *Angophora floribunda* was also common in this PCT. The understorey consisted of a moderate to dense layer of *Backhousia myrtifolia, Acmena smithii, Ficus coronata*, and *Glochidion ferdinandi. Tristaniopsis laurina* was common in the shrub layer. The groundcover was typically sparse consisting of *Lomandra longifolia, Microlaena stipoides, Calochlaena dubia* and *Doodia aspera* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

Four condition classes have been assigned to this PCT:

- Moderate/good_good: Consists of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout
- Moderate/good_medium: A native canopy occurs along with a midstorey and groundcover comprised of a mix of locally native and non-native species. Common weeds include: *Cardiospermum grandifolium* (Balloon vine), *Araujia sericifera* (moth vine), *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet) and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and native understorey species remain. A low native species richness and low native species abundance was recorded. Mainly dominated by locally non-native species
- Moderate/good_derived: An open vegetation structure with high proportion of regenerating species native to this community.

Conservation status: *River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act.

Table 15. Common native species recorded within PCT 1504.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	30 m	30	*Eucalyptus saligna, E. deanei, E. elata, Angophora floribunda*
Midstorey	15 m	30	*Acmena smithii, Backhousia myrtifolia, Glochidion ferdinandi*
Shrub layer	1.5 - 2 m	25 - 30	*Tristaniopsis laurina, Pandorea pandorana, Trema tomentosa, Cissus hypoglauca, Clematis aristata*
Groundcover	To 1 m	20 - 50	*Lomandra longifolia, Microlaena stipoides* var. *stipoides, Calochlaena dubia, Doodia aspera*

Photograph 20. PCT 1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion – moderate/good_good.

Photograph 21. PCT 1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion – moderate/good_medium

Photograph 22. PCT 1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion – moderate/good_low

Photograph 23. PCT 1504: Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion – moderate/good_derived.

PCT 1284 (HN606): Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion

Distribution within the study area: Occurs mainly the south of the Colo River within sheltered sandstone slopes and the gullies of Greens Swamp.

Structure/characteristics: A forest community with a canopy dominated by *Syncarpia glomulifera* and *Eucalyptus deanei*. Common understorey and groundcover species include *Cissus hypoglauca*, *Clematis aristata, Elaeocarpus reticulatus, Leucopogon lanceolatus, Billardiera scandens, Blechnum cartilagineum, Calochlaena dubia* and *Dianella caerulea* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

Three condition classes have been assigned to this PCT:

- Moderate/good_good: Consisting of an intact canopy and midstorey along with a moderately native groundcover. Some weeds occur scattered throughout. Overall this condition class has a high resilience.
- Moderate/good_medium: A native canopy exists along with a midstorey and groundcover consisting of a mixture of locally native and non-native species. Common non-native species include *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana)
- Moderate/good_low: Very few remnant trees and native understorey species remain. Low diversity of native species and low abundance. Mainly dominated by introduced species.

Conservation status: This PCT can conform to the Endangered Ecological Community, Sydney Turpentine Ironbark Forest however it has not been assessed as doing so within the study area.

Table 16. Common native species recorded within PCT 1284.

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Syncarpia glomulifera* subsp. *glomulifera, Eucalyptus deanei, Eucalyptus piperita*
Midstorey	7 - 12 m	30	*Allocasuarina torulosa, Elaeocarpus reticulatus*
Shrub layer	1.5 - 2 m	25 - 30	*Leucopogon lanceolatus, Pandorea pandorana, Persoonia linearis, Cissus hypoglauca, Clematis aristata*
Groundcover	To 1 m	20 - 50	*Eustrephus latifolius, Geitonoplesium cymosum, Lepidosperma laterale, Lomandra longifolia, Pteridium esculentum, Tylophora barbata, Calochlaena dubia, Dianella caerulea.*

Photograph 24. PCT 1284: Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion – moderate/good_good.

PCT 1292 (HN607): Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion

Distribution within the study area: Recorded as thin patches occurring along the sandy banks and sandstone beds of streams. Only small patches of this community were recorded within the study area. The most significant occurrence was recorded along the Nepean River near Bents Basin State Conservation Area.

Structure/characteristics: A low forest community dominated by a dense layer of shrubs. Common species include: *Tristaniopsis laurina, Ceratopetalum apetalum, Lomatia myricoides, Lomandra longifolia, Entolasia stricta, Schoenus melanostachys* and *Lomandra fluviatilis* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds

One condition class has been assigned to this PCT - Moderate/good_good. Consists of an intact canopy and midstorey with a moderately native groundcover. Some locally non-native species occur scattered throughout.

Conservation status: Not listed.

Table 17. Common native species recorded within PCT 1292.

Stratum	Height (m)	% cover*	Dominant native species
Midstorey	10 m	60	*Ceratopetalum apetalum, Backhousia myrtifolia*
Shrub layer	1.5 - 2 m	25 - 30	*Lomatia myricoides, Tristaniopsis laurina*
Groundcover	To 1 m	20 - 50	*Lomandra longifolia, Entolasia stricta, Schoenus melanostachys, Sticherus flabellatus*

Photograph 25. PCT 1292: Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion– moderate/good_good.

PCT 1327 (HN6012): Yellow Bloodwood - ironbark shrubby woodland of the dry hinterland of the Central Coast, Sydney Basin Bioregion

Distribution within study area: This PCT has been mapped as occurring towards middle Colo, along the gullies and slopes of Wheeny Creek.

Structure/characteristics: this PCT has been described as a woodland community with an open canopy, an open layer of sclerophyllous shrubs and grassy groundcover. Dominant canopy includes *Angophora costata, Corymbia eximia, Eucalyptus punctata* and *Eucalyptus beyeriana.* The shrub layer includes *Acacia parvipinnula, Persoonia linearis, Pultenaea scabra* and *Oxylobium ilicifolium.* Frequently occurring ground cover species include *Dianella revoluta* var. *revoluta, Entolasia marginata, Entolasia stricta* and *Hardenbergia violacea* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds: One condition class has been assigned to this PCT - Moderate/good_good. Vegetation in this condition class is likely to consist of an intact canopy and midstorey with a relatively native ground layer. Some weeds are likely to occur scattered throughout.

Conservation status: Not listed.

Table 18. Common native species likely to occur within PCT 1327

Stratum	Height (m)	% cover*	Dominant native species
Tree	15 - 25 m	30	*Corymbia eximia, Eucalyptus fibrosa, Eucalyptus crebra, Angophora costata, Eucalyptus punctata*
Midstorey	7 - 12 m	30	*Allocasuarina torulosa, Elaeocarpus reticulatus*
Shrub layer	1.5 - 2 m	25 - 30	*Persoonia linearis, Oxylobium ilicifolium*
Ground layer	To 1 m	20 - 50	*Hardenbergia violacea, Pomax umbellata, Themeda triandra, Dianella revoluta* var. *revoluta, Entolasia stricta*

PCT 1557 (HN665): Rough-barked Apple – Forest Oak – Grey Gum grassy woodland on sandstone ranges of the Sydney Basin

Distribution within study area: This PCT was recorded along the sandstone ridges and slopes around Cattai National Park.

Structure/characteristics: the PCT has been described as a woodland community with an open layer of sclerophyll shrubs with a groundcover consisting of grasses and forbs. Dominant canopy species recorded includes *Angophora floribunda* and *Eucalyptus punctata.* The shrub layer and sub-canopy includes species such as *Allocasuarina torulosa, Bursaria spinosa* , *Persoonia linearis* and *Breynia oblongifolia.* The groundcover assemblage includes *Themeda australis* , *Imperata cylindrica* , *Microlaena stipoides* , *Lepidosperma laterale* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/Good_good. This condition class consists of an intact canopy and midstorey, with a moderately diverse native groundcover. Some non-local exotic species were recorded in the groundcover.

Conservation status: Not listed.

Table 19. Common native species likely to occur within PCT 1557

Stratum	Height (m)	% cover*	Dominant native species
Tree	15 - 25 m	30	*Corymbia eximia, Angophora bakeri, Eucalyptus punctata*
Midstorey	7 - 12 m	30	*Allocasuarina littoralis, Leptospermum trinervium*
Shrub layer	1.5 - 2 m	25 - 30	*Persoonia linearis, Exocarpos strictus*
Groundcover	To 1 m	20 - 50	*Lomandra longifolia, Lomandra obliqua, Lomandra filiformis, Lepidosperma laterale, Dianella caerulea*

PCT 1718 (HN932): Swamp Mahogany – Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast

Distribution within study area: This PCT was recorded in the valleys of Maroota Ridge State Conservation Area. The occurrence of this PCT was confirmed in the field. Further extents of this PCT likely occur elsewhere in the study area but have not been identified due to access to private property issues.

Structure/characteristics: This PCT has an open or dense canopy with some trees exceeding 25 meters in height. The most common canopy species include *Eucalyptus robusta* (Swamp Mahogany) and *Melaleuca linariifolia* (Flax-leaved Paperbark). The open condition of some extents is a result of past clearing practices. It can include areas dominated by ferns, reeds or sedges. A shrub or small-tree layer can occur including species such as *Glochidion ferdinandi* var. *ferdinandi*, *Acmena smithii*, *Acacia longifolia* and *Ficus coronata* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds: One condition class has been assigned to this PCT - Moderate/good. Vegetation consists of an intact canopy and midstorey, with a diverse native groundcover. Non-local exotic species occur scattered throughout the ground-truthed vegetation.

Conservation status: Equivalent to *Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act.

Table 20. Common native species likely to occur within PCT 1718

Stratum	Height (m)	% cover*	Dominant native species
Tree	15 - 25 m	30	*Eucalyptus robusta, Melaleuca linariifolia, Angophora floribunda*
Midstorey	7 - 12 m	30	*Elaeocarpus reticulatus, Callistemon salignus, Glochidion ferdinandi*
Shrub layer	1.5 - 2 m	25 - 30	*Pittosporum revolutum, Pittosporum undulatum, Leptospermum polygalifolium*
Ground layer	To 1 m	20 - 50	*Dianella revoluta, Dianella caerulea, Dichondra repens*

PCT 725 (HN513): Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion

Distribution within the study area: A small area of this PCT was recorded (desktop analysis) within the Cumberland Plain occurring within the 10% AEP.

Structure/characteristics: Woodland to open forest community with an open layer of sclerophyll shrubs Dominant canopy includes *Eucalyptus fibrosa* and *Melaleuca decora* (BioNet Vegetation Classification, 2019).

Condition and presence of weeds:

One condition class has been assigned to this PCT - Moderate/good. Native vegetation that was unable to be stratified in the field or from desktop analysis. This does not conform to 'low condition' as per the BAM.

Conservation status: *Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion* (endangered under the BC Act) and *Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion* (critically endangered under the EPBC Act).

Table 21. Common native species likely to occur within PCT 725

Stratum	Height (m)	% cover*	Dominant native species
Canopy	15 - 25 m	30	*Eucalyptus fibrosa*
Midstorey	7 - 12 m	30	*Melaleuca decora, Acacia falcata*
Shrub layer	1.0 - 2 m	25 - 30	*Lissanthe strigosa, Melaleuca nodosa, Daviesia ulicifolia, Bursaria spinosa*
Groundcover	To 1 m	20 - 50	*Microlaena stipoides, Entolasia stricta, Cheilanthes sieberi, Aristida vagans, Lepidosperma laterale*

Appendix C Plot and transect data

Zone	Plot	Date	Recorders	MU	No. Native species	Native overstorey cover %	Native midstorey cover %	Native ground cover (grasses) %	Native ground cover (shrubs) %	Native ground cover (other) %	Exotic plant cover %	No. trees with hollows	Regener-ation	Total length of fallen logs (m)	Bearing (º)	Eastings	Northings	Zone
7	DS136	-	-	HN538_Moderate/good_high	29	0	67	6	0	6	0	1	1	30	-	304702	6285368	56
	DS137	-	-		22	30	50	5	0	5	2	0	1	10	-	282901	6273048	56
18	DS117	-	-	HN607_Moderate/good	28	27	9	0	0	3	3	1	1	0	-	280948	6242807	56
	DS118	-	-		32	29	0	12	10	20	5	0	1	15	-	280848	6242698	56
19	DS22	-	-	HN606_Moderate/good	28	13.5	29	10	26	28	0	0	1	21	-	295273	6299285	56
	DS27	-	-		22	18	30	8	8	16	2	1	1	31	-	295431	6299597	56
	DS49	-	-		37	32	35	10	4	22	0	0	1	18	-	299434	6296507	56
	DS64	-	-		21	24	24	36	0	72	0	3	1	55	-	292170	6295200	56
	DS72	-	-		15	36	50.5	0	0	42	10	2	1	32	-	300761	6297658	56
22	DS101	-	-	HN512_Moderate/good	30	10	16	54	0	18	0	0	1	2	-	297058	6275164	56
	DS102	-	-		29	0	17.5	6	0	10	0	0	1	60	-	297250	6275204	56
	DS103	-	-		32	6.5	13.5	66	10	24	0	0	1	15	-	297217	6274912	56
	DS104	-	-		39	13.5	17.5	70	0	16	0	0	1	12	-	297505	6274685	56
23	DS12	14/11/18	AN & RC	HN512_Moderate/good_good	24	50	0	22	0	22	14	0	1	12	180	304039	6282372	56
	DS19	15/01/19	JC & RC		17	46	0	26	18	8	0	0	0	8	5	289187	6275857	56
	DS20	21/01/19	JC & RC		20	56.5	0	16	10	8	2	0	1	8	168	288586	6278106	56
24	DS105	-	-	HN512_Moderate/good_ low	27	0	6.6	0	2	38	92	0	0.3	0	-	303962	6282587	56
26	DS23	-	-	HN520_Moderate/good	12	0	0	40	0	96	0	0	1	0	-	295192	6298997	56
	DS25	-	-		13	0	0	16	0	98	0	0	0	0	-	295090	6298904	56
	DS56	-	-		9	0.5	6	22	0	90	6	0	1	0	-	300837	6297006	56
	DS57	-	-		11	7.5	0	0	0	80	10	0	0	0	-	300820	6297138	56
	DS59	-	-		10	0	0	10	0	100	0	0	1	0	-	292320	6295088	56
	DS60	-	-		9	0	0	70	0	76	0	0	1	0	-	292367	6295064	56
	DS61	-	-		14	0	0	98	0	78	0	0	1	0	-	292249	6295099	56
	DS63	-	-		7	0	0	0	0	100	0	0	1	0	-	292110	6295030	56
	DS86	-	-		23	0	5	10	0	100	0	0	1	0	-	304214	6282503	56
	DS87	-	-		6	0	0	0	0	94	12	0	1	0	-	300973	6281508	56
	DS90	-	-		16	0	0	0	0	40	13	0	0	0	-	307171	6284437	56
27	DS2	18/10/18	LL & AN	HN520_Moderate/good_good	15	0	0	66	0	84	0	0	1	0	38	308237	6289624	56
28	DS26	-	-	HN520_Moderate/good_low	7	0	0	66	0	48	30	0	0	0	-	295613	6299838	56
	DS52	-	-		6	0	0	12	0	30	64	0	0	0	-	299891	6297035	56
	DS54	-	-		29	3	40	50	60	82	3	0	1	0	-	300937	6292930	56
	DS71	-	-		8	0	0	80	0	58	2	0	0	0	-	300881	6297621	56
29	DS88	-	-	HN520_Moderate/good_medium	19	0	0	10	0	50	5	0	0	0	-	305766	6285029	56
	DS89	-	-		22	0	0	0	0	50	4	0	0	0	-	304315	6286834	56
30	DS50	-	-	HN520_Moderate/good_other	9	0	8	82	0	94	0	0	0	0	-	299537	6296670	56
31	DS7	31/10/18	AN & JC	HN526_Moderate/good	33	10	17	6	14	26	10.6	0	1	4	187	283042	6272583	56
	DS15	15/11/18	AN & RC		13	27.5	0	20	0	18	44	0	1	0	235	304621	6283118	56
	DS74	-	-		26	9.5	10.5	62	4	16	0	0	1	14	-	303858	6282062	56

Zone	Plot	Date	Recorders	MU	No. Native species	Native overstorey cover %	Native midstorey cover %	Native ground cover (grasses) %	Native ground cover (shrubs) %	Native ground cover (other) %	Exotic plant cover %	No. trees with hollows	Regener-ation	Total length of fallen logs (m)	Bearing (º)	Eastings	Northings	Zone
33	DS11	13/11/18	JC & RC	HN526_Moderate/good_good	13	0	14	0	0	2	74	0	0	21	145	281253	6243028	56
	DS95	-	-		21	4	24	4	0	0	45	0	1	40	-	281264	6243049	56
34	DS76	-	-	HN526_Moderate/good_low	45	1	12	70	0	12	143	0	1	0	-	292784	6266128	56
	DS78	-	-		18	43.5	0.2	0	0	2	5	0	1	49	-	304461	6285238	56
35	DS13	14/11/18	AN & RC	HN526_Moderate/good_medium	5	21	0	0	0	0	28	0	1	8	65	304210	6282715	56
	DS21	03/01/19	JC & RC		8	81	0	36	0	0	6	0	0	7	20	300882	6281539	56
	DS77	-	-		26	29	0	40	0	16	20.5	0	1	0	-	304329	6285300	56
	DS79	-	-		18	0	0	86	0	4	51	0	1	20	-	304320	6285012	56
	DS80	-	-		27	0	27.5	38	0	8	93.5	0	1	0	-	304395	6284625	56
	DS84	-	-		21	8.5	13.5	2	0	2	10	0	1	0	-	304126	6286819	56
	DS85	-	-		23	2	30	50	0	0	20	0	1	23	-	283027	6269049	56
	DS97	-	-		28	9.1	3.1	4	0	6	44	0	1	6	-	304123	6283025	56
	DS98	-	-		22	8.4	11.4	2	0	8	63	0	1	6	-	304225	6283041	56
38	DS14	14/11/18	AN & RC	HN528_Moderate/good_low	21	12	5	46	8	42	74	0	1	0	270	304541	6283288	56
	DS113	-	-		31	2.6	6	60	6	6	87	0	1	1	-	304355	6282317	56
40	DS24	-	-	HN552_Moderate/good	8	0	22	18	0	92	0	0	1	0	-	294930	6298780	56
	DS46	-	-		26	15	4.5	56	10	80	0	0	0	0	-	287637	6299051	56
	DS47	-	-		24	5	50	82	0	60	0	0	1	0	-	287562	6299174	56
	DS48	-	-		16	35	0.5	70	10	62	22	0	1	0	-	287532	6299089	56
	DS62	-	-		18	44	0	42	44	0	0	0	1	0	-	292264	6295127	56
41	DS123	-	-	HN556_Moderate/good	26	11	2.5	25	2	14	32	0	1	5	-	305785	6285129	56
	DS124	-	-		29	11.5	7.5	25	0	9	0	0	1	22	-	307274	6284422	56
	DS125	-	-		33	16	2.5	29	0	16	5	0	1	35	-	307000	6284470	56
42	DS122	-	-	HN556_Moderate/good_derived	14	0	0	24	0	1	35	0	1	0	-	304243	6286596	56
44	DS132	-	-	HN556_Moderate/good_medium	19	15	0	5	0	0	32	0	1	0	-	304472	6286574	56
48	DS53	-	-	HN577_Moderate/good_medium	12	0	17	22	0	8	56	0	0	0	-	300937	6296929	56
	DS55	-	-		27	47	24	38	4	64	2	0	1	0	-	300860	6297002	56
	DS58	-	-		29	30	13	0	0	66	0	6	1	15	-	300850	6297119	56
49	DS65	-	-	HN586_Moderate/good	31	3.4	40.5	6	10	42	0	0	1	20	-	298321	6294631	56
	DS66	-	-		25	0	5	80	2	40	10	0	1	8	-	298489	6294485	56
	DS67	-	-		12	11.5	0	100	4	36	0	0	1	71	-	298496	6294506	56
	DS68	-	-		28	10.5	7.5	14	22	18	20	0	1	0	-	298665	6294402	56
	DS69	-	-		20	44	0	86	0	70	4	0	1	10	-	298662	6294376	56
50	DS10	12/11/18	JC & RC	HN586_Moderate/good_good	19	13.5	8	12	22	42	0	1	1	34	255	308025	6284507	56
52	DS1	29/06/2018	LL & JC	HN586_Moderate/good_medium	13	27	0	4	0	20	90	0	1	26	90	279074	6250958	56
53	DS51	-	-	HN587_Moderate/good	17	5	37	14	0	56	14	0	0	0	-	299864	6297107	56
56	DS70	-	-	HN606_Moderate/good_medium	27	3	38.5	40	4	30	14	0	1	22	-	301004	6297678	56
	DS73	-	-		14	2.3	12.4	34	0	8	38	1	1	20	-	300970	6297636	56

Zone	Plot	Date	Recorders	MU	No. Native species	Native overstorey cover %	Native midstorey cover %	Native ground cover (grasses) %	Native ground cover (shrubs) %	Native ground cover (other) %	Exotic plant cover %	No. trees with hollows	Regener-ation	Total length of fallen logs (m)	Bearing (º)	Eastings	Northings	Zone
59	DS4	24/10/18	AN & IS	HN613_Moderate/good_good	26	28	0.5	72	2	0	0	1	1	32.5	0	308135	6289558	56
	DS18	18/11/18	RM & MA		41	23	1	44	0	18	0	4	1	0	260	294770	6296436	56
60	DS33	-	-	HN647_Moderate/good	19	18	50	0	0	12	0	0	1	18	-	294840	6299798	56
	DS34	-	-		23	0	15.5	2	6	8	22	0	0	0	-	294828	6299590	56
	DS41	-	-		23	15	27	70	0	4	0	1	1	29	-	287023	6301798	56
	DS42	-	-		9	13	30	0	60	2	15.5	0	1	57	-	287108	6301946	56
	DS45	-	-		17	13	38	50	0	8	10	0	1	35	-	286979	6302123	56
61	DS32	-	-	HN647_Moderate/good_derived	10	15	0	0	0	0	100	0	0	0	-	294953	6300125	56
	DS36	-	-		11	35	0	64	0	0	15	0	0	0	-	294482	6299015	56
62	DS3	23/10/18	AN & IS	HN647_Moderate/good_good	37	44.5	0	32	0	6	0	0	1	21	54	299929	6299780	56
63	DS28	-	-	HN647_Moderate/good_low	10	5	5	18	0	6	80	0	1	29	-	295637	6300058	56
	DS29	-	-		9	2	9	2	0	6	85	1	1	12	-	295392	6300188	56
	DS30	-	-		13	12.5	10	2	0	4	43	0	1	17	-	295241	6300270	56
	DS31	-	-		11	2	6	4	0	14	100	0	0	8	-	294900	6300034	56
	DS37	-	-		21	21.5	0	20	0	2	40	0	1	11	-	294285	6299179	56
	DS38	-	-		16	15	19	22	0	4	42	0	1	20.5	-	294144	6299549	56
	DS39	-	-		6	9.5	0	0	0	2	47	2	0	41	-	294059	6300238	56
	DS40	-	-		21	16	6	24	0	6	46	0	0	0	-	294102	6299541	56
	DS43	-	-		13	6.5	1	44	0	6	40	0	1	0.5	-	287313	6302070	56
	DS44	-	-		17	1	23	44	4	24	32	0	1	17	-	287481	6302208	56
64	DS35	-	-	HN647_Moderate/good_medium	16	10	31	0	8	6	34	1	1	29	-	294832	6299394	56
67	DS17	18/11/18	RM & MA	HU932_Moderate/good_good	42	40	48	40	2	46	0	2	1	0	100	308291	6289537	56
71	DS5	25/10/18	AN & IS	NR223_Moderate/good_medium	20	6	10	0	0	0	28	0	0	41	260	307342	6284641	56
	DS6	31/10/18	AN & JC		12	34	0	0	2	4	30.6	0	0	1	95	283434	6272912	56
	DS8	01/11/18	AN & JC		32	47.5	0	0	24	8	14	0	1	7	47	286272	6278817	56

Appendix D Floristic data

Legend

Status – lin	Locally indigenous
Status – HTW	High threat weed
Status - *	Neither locally indigenous nor high threat weed
C (cover)	A measure or estimate of the appropriate measures for each recorded species; recorded from 1-5% and then to the nearest 5%. If the cover of a species is less than 1% and considered important, then the estimated cover has been recorded.
A (abundance)	A relative measure of the number of individuals or shoots of a species within a survey plot.

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				DS101	DS101	DS102	DS102	DS103	DS103	DS12	DS12	DS19	DS19	DS20	DS20	DS104	DS104	DS105	DS105	DS109	DS109
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
lin	Acanthaceae	*Brunoniella australis*	Blue Trumpet			0.1	4	0.5	30	1.5	5000					1	40				
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower			0.1	4	0.5	20												
lin	Anthericaceae	*Arthropodium milleflorum*	Pale Vanilla-lily											0.01	3						
lin	Anthericaceae	*Caesia parviflora*	Pale Grass-lily			4	5	0.1	1	0.01	1									0.1	8
lin	Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily																	0.2	10
lin	Anthericaceae	*Tricoryne elatior*	Yellow Autumn-lily															0.1	5		
lin	Apiaceae	*Centella asiatica*	Gotu Cola	0.1	5	0.5	5	2	50							0.2	12	60	150	0.3	50
*	Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush															0.1	25		
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod	0.1	1			0.1	2	0.3	7							2	5		
HTW	Asparagaceae	*Asparagus aethiopicus*	Asparagus Fern	0.5	10																
HTW	Asparagaceae	*Asparagus asparagoides*	Bridal Creeper							0.2	20					0.2	2	0.2	20	0.1	5
	Asteraceae	Asteraceae 1												0.1	20						
lin	Asteraceae	*Calotis lappulacea*	Yellow Burr-daisy			0.1	1														
lin	Asteraceae	*Cassinia uncata*	Sticky Cassinia	0.2	4																
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane			1	40											0.1	30		
HTW	Asteraceae	*Delairea odorata*	Cape Ivy													0.5	3				
lin	Asteraceae	*Euchiton sphaericus*	Star Cudweed																	0.1	7
*	Asteraceae	*Hypochaeris radicata*	Catsear	0.1	15																
lin	Asteraceae	*Lagenifera stipitata*	Blue Bottle-daisy			0.1	4														
*	Asteraceae	*Senecio madagascariensis*	Fireweed			2	50											0.2	30	0.1	5
*	Asteraceae	*Sonchus oleraceus*	Common Sowthistle	3	20																
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot	2	190			3	100	0.05	5			0.2	50	0.2	5	0.1	50	0.5	60
lin	Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell													0.1	1				
lin	Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak													5	3				
lin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush			2	6			0.01	1					1	3				
lin	Chenopodiaceae	*Einadia nutans*	Climbing Saltbush															0.1	5	0.2	5
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew	2	10									0.01	4	1	3			0.1	4
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew											0.01	6						
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed	4	175	1	20	5	500	0.4	1000			0.1	7	3	5	1	200	1	50
lin	Cyperaceae	*Carex appressa*	Tall Sedge	0.1	1											3	5	0.1	10		
lin	Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge																	1	4
lin	Cyperaceae	*Cyperus polystachyos*														3	12				
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge					0.2	5			10	50								
lin	Dilleniaceae	*Hibbertia aspera*	Rough Guinea Flower									0.1	5								
lin	Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath									5	50								
lin	Ericaceae	*Lissanthe strigosa*	Peach Heath	1	5	2	7														
lin	Fabaceae (Faboideae)	*Desmodium brachypodum*	Large Tick-trefoil							0.1	5										
lin	Fabaceae (Faboideae)	*Desmodium rhytidophyllum*												2	27						
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine			0.2	15			0.2	100										
lin	Fabaceae (Faboideae)	*Glycine microphylla*	Small-leaf Glycine					0.1	2							0.2	10				
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	0.1	15	0.6	16	0.5	10	0.5	500			0.5	50	1	50			0.1	20
lin	Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle							0.1	1										

lin	Fabaceae (Mimosoideae)	*Acacia falcata*		0.1	1	0.5	2			0.2	2										
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle			0.2	1	3	2							0.1	2				
lin	Geraniaceae	*Geranium solanderi*	Native Geranium	0.5	6													1	100		
lin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia									0.1	3								
*	Haloragaceae	*Myriophyllum aquaticum*	Parrots Feather													2	30				
lin	Juncaceae	*Juncus* spp.	A Rush															0.1	20		
lin	Juncaceae	*Juncus subsecundus*	Finger Rush													2	6				
lin	Lamiaceae	*Plectranthus parviflorus*				0.2	5	3	14												
lin	Lauraceae	*Cassytha glabella*				0.5	7	1	9							3	8			0.1	4
lin	Lomandraceae	*Lomandra cylindrica*										10	200								
lin	Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush			1	40			0.5	1000	0.1	2			0.1	1			1	20
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush																	4	28
lin	Lomandraceae	*Lomandra micrantha*	Small-flowered Mat-rush											35	500						
lin	Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush									10	50								
lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry					0.1	2												
*	Malvaceae	*Pavonia hastata*								0.5	500										
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	2	100			1	5							0.2	12			0.1	2
lin	Myoporaceae	*Eremophila debilis*	Amulla							0.3	2									0.1	2
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple													5	1				
lin	Myrtaceae	*Callistemon linearis*	Narrow-leaved Bottlebrush									0.5	35								
lin	Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum					50	4							50	3				
lin	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark									5	1								
lin	Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark									50	18								
lin	Myrtaceae	*Eucalyptus moluccana*	Grey Box							15	12									35	2
lin	Myrtaceae	*Eucalyptus sideroxylon*	Mugga Ironbark													3	1				
lin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	5	1									0.1	2						
lin	Myrtaceae	*Melaleuca decora*		70	55	75	24	60	20	45	38	20	12	75	28	5	2	35	5	5	5
lin	Myrtaceae	*Melaleuca nodosa*				3	12	60	30			5	6			70	18				
HTW	Oleaceae	*Ligustrum lucidum*	Large-leaved Privet													0.1	1	5	100		
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	15	x			0.1	4	0.3	1										
lin	Oxalidaceae	*Oxalis perennans*		0.1	20	0.1	5	1	50					0.2	48					0.1	20
lin	Passifloraceae	*Passiflora* spp.														1	3				
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily											0.02	6						
lin	Phormiaceae	*Dianella revoluta*	Blueberry Lily							0.3	20	0.2	8			0.2	1			0.2	4
lin	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry					0.1	2												
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	5	15	3	3	10	25	1	20			20	39					3	13
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues															0.2	50		
lin	Plantaginaceae	*Veronica plebeia*	Trailing Speedwell	0.1	1	0.1	4									0.1	2				
HTW	Poaceae	*Andropogon virginicus*	Whisky Grass															0.1	15		
lin	Poaceae	*Aristida ramosa*	Purple Wiregrass			5	100	5	100									5	100	30	150
lin	Poaceae	*aristida vagans*	Threeawn Speargrass							0.3	5										
lin	Poaceae	*Austrodanthonia racemosa*	Wallaby Grass																	3	30
HTW	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass															80	500		
lin	Poaceae	*Cymbopogon refractus*	Barbed Wire Grass							0.25	5									5	50

lin	Poaceae	*Cynodon dactylon*	Common Couch	1	30																
lin	Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass																	3	100
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	5	40	5	100	5	50	1	50					10	60			5	55
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass															0.3	55		
lin	Poaceae	*Entolasia marginata*	Bordered Panic	12	40			5	100			0.1	1			10	x				
lin	Poaceae	*Entolasia stricta*	Wiry Panic			0.1	3					5	200	0.5	50	10	60			0.3	16
lin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass															0.3	40		
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass			1	60														
lin	Poaceae	*Imperata cylindrica*	Blady Grass																	1	10
	Poaceae	*Lolium* sp.												0.01	1						
lin	Poaceae	*Microlaena stipoides*	Weeping Grass			5	100	50	500	25	1000					65	300			20	50
lin	Poaceae	*Oplismenus aemulus*		3	80			3	15	0.2	50					4	30				
lin	Poaceae	*Oplismenus imbecillis*						1	25												
lin	Poaceae	*Panicum effusum*	Hairy Panic			0.2	10														
lin	Poaceae	*Panicum simile*	Two-colour Panic							0.3	10										
	Poaceae	*Panicum* sp.												0.3	30						
lin	Poaceae	*Paspalidium distans*								5	1000	0.1	2								
*	Poaceae	*Pennisetum clandestinum*	Kikuyu Grass															0.3	55		
*	Poaceae	*Setaria parviflora*	Setaria gracilis															5	100	0.5	30
lin	Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass					3	50												
lin	Polygonaceae	*Persicaria decipiens*	Slender Knotweed													0.1	3				
*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel															0.1	50		
lin	Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair	4	30											2	30				
lin	Pteridaceae	*Cheilanthes distans*	Bristly Cloak Fern							0.3	500										
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern	0.1	10	0.2	40	0.1	3					1	50					0.2	30
lin	Pteridaceae	*Pellaea falcata*	Sickle Fern					2	14												
lin	Ranunculaceae	*Clematis aristata*	Old Man's Beard													0.1	1				
*	Rosaceae	*Rubus fruticosus* sp. agg.	Blackberry complex															0.2	5		
lin	Rubiaceae	*Opercularia diphylla*	Stinkweed			0.1	5														
lin	Rubiaceae	*Pomax umbellata*	Pomax																	0.1	18
*	Rubiaceae	*Richardia stellaris*												0.1	11						
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade			0.1	8									1	2				
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade			0.1	2	0.1	1	0.01	1					0.1	1				
	Solanaceae	*Solanum* sp.												0.1	6						
HTW	Verbenaceae	*Lantana camara*	Lantana																	0.1	2
*	Verbenaceae	*Verbena bonariensis*	Purpletop															0.2	40		

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				DS2	DS 2	DS 23	DS 23	DS 25	DS 25	DS 26	DS 26	DS 50	DS 50	DS 52	DS 52	DS 54	DS 54	DS 56	DS 56	DS 57	DS 57	DS 59	DS 59	DS 60	DS 60	DS 61	DS 61	DS 63	DS 63	DS 71	DS 71	DS 86	DS 86	DS 87	DS 87	DS 88	DS 88	DS 89	DS 89	DS 90	DS 90
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
*	Alliaceae	*Nothoscordum gracile*	Onion Weed (Nothoscordum borbonicum*misidentified)																																					2	30
lin	Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed																																			0.1	1		
lin	Apiaceae	*Centella asiatica*	Gotu Cola					0.3	30	0.5	50			1	200	0.1	65	0.2	100	0.1	15	0.1	10	0.1	10	0.1	20											0.2	150		
lin	Apiaceae	*Daucus glochidiatus*	Native Carrot																																	0.1	1				
	Apiaceae	*Daucus sp.*																																						0.1	5
*	Araliaceae	*Hydrocotyle bonariensis*	Largeleaf Pennywort																											1	2					1	25				
in	Araliaceae	*Hydrocotyle pedicellosa*	Pennywort													0.1	150																								
lin	Araliaceae	*Hydrocotyle sibthorpioides*	Hydrocotyle peduncularis															0.1	25	0.1	10	0.1	5																		
	Araliaceae	*Hydrocotyle sp*		5	800																																				
HTW	Asteraceae	*Ageratina riparia*	Mistflower																																					10	0
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs																																	0.1	1				
lin	Asteraceae	*Centipeda cunninghamii*	Common Sneezeweed																	0.1	30							0.1	5												
lin	Asteraceae	*Centipeda minima*	spreading sneezeweed																																					0.1	1
lin	Asteraceae	*Centipeda spp.*																																				25	0		
*	Asteraceae	*Cirsium vulgare*	Spear Thistle																									0.1	1							1	15	0.1	3		
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane							0.5	50					0.1	15																					0.1	5		
*	Asteraceae	*Conyza spp.*	A Fleabane											0.1	11																										
*	Asteraceae	*Hypochaeris radicata*	Catsear											0.1	2																										
*	Asteraceae	*Senecio madagascariensis*	Fireweed																																	2	55	0.5	15		
lin	Asteraceae	*Sigesbeckia orientalis*	Indian Weed																							0.1	3									0.1	5				
HTW	Asteraceae	*Xanthium occidentale*	Noogoora Burr																																			5	100		
*	Brassicaceae	*Rorippa palustris*	Marsh Watercress																																					0.5	25
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot																																			0.1	25		
	Commelinaceae	*Commelina spp.*	*Commelina diffusa. misidentification									5	0																												
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed							0.1	2																											3	150		
lin	Cunoniaceae	*Callicoma serratifolia*	Black Wattle													0.2	1																								
lin	Cyperaceae	*Carex appressa*	Tall Sedge									0.5	10					0.2	15	0.2	20	0.1	15			30	0	80	0	2	2	0.5	10			85	0	5	100	65	0
lin	Cyperaceae	*Carex inversa*	Knob Sedge																																			0.1	25		
*	Cyperaceae	*Cyperus brevifolius*	Mullumbimby Couch																													3	30								
HTW	Cyperaceae	*Cyperus eragrostis*	Umbrella Sedge																																					0.2	15
lin	Cyperaceae	*Cyperus polystachyos*																														3	40	5	100						
lin	Cyperaceae	*Cyperus sp.*	A Sedge					0.1	4																													0.1	15		

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				DS2	DS 2	DS 23	DS 23	DS 25	DS 25	DS 26	DS 26	DS 50	DS 50	DS 52	DS 52	DS 54	DS 54	DS 56	DS 56	DS 57	DS 57	DS 59	DS 59	DS 60	DS 60	DS 61	DS 61	DS 63	DS 63	DS 71	DS 71	DS 86	DS 86	DS 87	DS 87	DS 88	DS 88	DS 89	DS 89	DS 90	DS 90
lin	Cyperaceae	*Eleocharis sphacelata*	Tall Spike Rush			40	0	65	0									75	0			30	0	20	0																
*	Cyperaceae	*Isolepis prolifera*																				0.1	10	0.1	10	0.1	15														
lin	Cyperaceae	*Lepidosperma longitudinale*	Pithy Sword-sedge			20	0																																		
lin	Cyperaceae	*Lepironia articulata*	Grey Rush			30	0																																		
lin	Cyperaceae	*Machaerina rubiginosa*	Baumea rubiginosa					0.1	10																																
lin	Cyperaceae	*Machaerina spp.*	Baumea spp.					0.5	20																																
lin	Cyperaceae	*Schoenoplectus mucronatus*																								0.1	5														
lin	Cyperaceae	*Schoenus melanostachys*	Black Bog-rush													0.1	2																								
	Cyperaceae	*Schoenus spp.*						1	10																																
lin	Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern	30	100											0.5	85																								
lin	Dennstaedtiaceae	*Pteridium esculentum*	Common Bracken	1	400											0.1	25	0.1	10																					0.1	5
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine							0.1	1																														
lin	Geraniaceae	*Geranium homeanum*																																		0.1	2				
*	Juncaceae	*Juncus cognatus*												0.5	100																										
lin	Juncaceae	*Juncus continuus*				0.1	1			35	0	0.1	3			0.1	5																								
lin	Juncaceae	*Juncus planifolius*												50	0					0.1						0.1	5			0.1	1										
lin	Juncaceae	*Juncus prismatocarpus*				5	0	5	0																																
	Juncaceae	*Juncus spp.*	A Rush					0.1	1									0.1	1	0.1	2																				
lin	Juncaceae	*Juncus usitatus*		0.001	1									0.2	20	0.1	25	0.5	25	40	0					30	0	5	0	25	0	1	70	3	30	1	5	10	0	0.5	5
lin	Juncaginaceae	*Cycnogeton microtuberosum*	Triglochin microtuberosa																															1	9						
lin	Juncaginaceae	*Cycnogeton spp.*	*PlantNet inconsistent (Triglochin procera)			1	6																																		
lin	Lamiaceae	*Lycopus australis*	Australian Gipsywort																													1	30								
*	Lamiaceae	*Scutellaria racemosa*																																		0.1	5	5	60	0.5	50
lin	Lauraceae	*Cassytha glabella*																								0.1	5	0.1	5	0.1	1									0.1	1
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush																							0.2	1														
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily													0.1	1																								
*	Malvaceae	*Pavonia hastata*																																		0.1	5				
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne																																			0.1	1		
lin	Marsileaceae	*Marsilea mutica*	Nardoo																			1	80	1	200																
lin	Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum													5	0																								
lin	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint													5	0																								
lin	Myrtaceae	*Eucalyptus spp.*														1	2																								
lin	Myrtaceae	*Kunzea sp.*														0.1	1																								
lin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon													30	0																								

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				DS2	DS 2	DS 23	DS 23	DS 25	DS 25	DS 26	DS 26	DS 50	DS 50	DS 52	DS 52	DS 54	DS 54	DS 56	DS 56	DS 57	DS 57	DS 59	DS 59	DS 60	DS 60	DS 61	DS 61	DS 63	DS 63	DS 71	DS 71	DS 86	DS 86	DS 87	DS 87	DS 88	DS 88	DS 89	DS 89	DS 90	DS 90
lin	Myrtaceae	*Melaleuca decora*																														0.2	1								
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark			5	0					25	0			8	0			8	0			1	6																
lin	Myrtaceae	*Melaleuca thymifolia*	Thyme Honey-myrtle																			0.1	1																		
lin	Myrtaceae	*Syncarpia glomulifera*	Turpentine													5	0																								
HTW	Ochnaceae	*Ochna serrulata*	Mickey Mouse Plant													0.1	1																								
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet													0.1	3																								
lin	Onagraceae	*Ludwigia peploides*	Water Primrose																																			0.1	5		
lin	Oxalidaceae	*Oxalis perennans*	Oxalis																																			0.1	25		
lin	Philydraceae	*Philydrum lanuginosum*	Frogsmouth					0.2	20			0.1	3									0.1	5	2	15	0.1	5														
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily													0.1	1																								
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree													0.5	1																								
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn													0.1	1																								
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues																																	0.1	1				
HTW	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass							60	0			35	0																										
	Poaceae	*Bromus sp.*																																		0.1	2				
lin	Poaceae	*Cynodon dactylon*	Common Couch					5	0	30	0			10	0	5	0	0.5	50	30	0					0.2	100			10	0					10	0				
	Poaceae	*Cynodon spp.*	Giant Star Grass					10	0																							5	100								
*	Poaceae	*Digitaria sanguinalis*	Crab Grass																											0.1	5										
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass									0.1	10																												
lin	Poaceae	*Ehrharta erecta*	Panic Veldtgrass																											2	10										
*	Poaceae	*Ehrharta longiflora*	Annual Veldtgrass													0.1	65																								
lin	Poaceae	*Entolasia marginata*	Bordered Panic													0.2	75																								
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass							5	0																														
lin	Poaceae	*Hemarthria uncinata*	Matgrass																											5	0										
*	Poaceae	*Megathyrsus maximus*	Panicum maximum									0.3	2																												
lin	Poaceae	*Microlaena stipoides*	Weeping Grass													0.1	55																								
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass			5	0																																		
lin	Poaceae	*Oplismenus imbecillis*	Creeping Beard Grass													0.2	100																								
lin	Poaceae	*Panicum simile*	Two-colour Panic					5	0			90	0																												
	Poaceae	*Panicum spp.*	Panicum																			30	0	50	0	5	0	5	0												
	Poaceae	*Paspalidium spp.*				5	0																																		
HTW	Poaceae	*Paspalum dilatatum*	Paspalum							50	0	0.1	10	65	0	0.1	15	0.1	15	0.2	25							0.5	40												
lin	Poaceae	*Paspalum distichum*	Water Couch	80	400																					50	0			70	0										
*	Poaceae	*Phalaris aquatica*	Phalaris																																					0.1	25

				DS2	DS 2	DS 23	DS 23	DS 25	DS 25	DS 26	DS 26	DS 50	DS 50	DS 52	DS 52	DS 54	DS 54	DS 56	DS 56	DS 57	DS 57	DS 59	DS 59	DS 60	DS 60	DS 61	DS 61	DS 63	DS 63	DS 71	DS 71	DS 86	DS 86	DS 87	DS 87	DS 88	DS 88	DS 89	DS 89	DS 90	DS 90
lin	Poaceae	*Phragmites australis*	Common Reed																													70	300	90	550						
	Poaceae	*Poacea 'Tass grass sample'*		0.25	10																																				
*	Poaceae	*Setaria parviflora*	Setaria gracilis																	0.2	22																				
*	Poaceae	*Setaria pumila*	Pale Pigeon Grass																											2	1										
HTW	Poaceae	*Stenotaphrum secundatum*	Buffalo Grass											10	0																										
lin	Polygonaceae	*Persicaria decipiens*	Slender Knotweed					4	100					1	150					10	0			3	20							2	50	5	50	5	100	3	150	1	55
lin	Polygonaceae	*Persicaria hydropiper*	Water Pepper									30	0	2	50											20	0	10	0												
lin	Polygonaceae	*Persicaria praetermissa*														0.1	60	20	0	0.2	55	15	0	25	0	1	50	5	0											0.1	10
	Polygonaceae	*Persicaria sp.*		25	400																																				
lin	Polygonaceae	*Persicaria strigosa*	Spotted Knotweed			1	50			5	0	80	0																	10	0										
lin	Polygonaceae	*Persicaria subsessilis*	Hairy Knotweed			5	0			8	0																														
*	Polygonaceae	*Rumex crispis*	Curled Dock																																					0.2	10
*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel																																	0.3	55	0.1	25		
lin	Primulaceae	*Myrsine howittiana*	Brush muttonwood													0.1	3																								
lin	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung													0.1	1																								
lin	Ranunculaceae	*Ranunculus inundatus*	River Buttercup													0.1	10					0.1	15	0.1	5													0.2	25		
lin	Ranunculaceae	*Ranunculus lappaceus*	Common Buttercup													0.1	5																								
lin	Ranunculaceae	*Ranunculus plebeius*	Forest Buttercup																																	1	55	1	25	1	55
HTW	Ranunculaceae	*Ranunculus repens**	Creeping Buttercup															0.1	20	0.1	10																				
	Ranunculaceae	*Ranunculus spp.*				1	100	0.5	50																																
*	Rubiaceae	*Galium divaricatum*	Slender Bedstraw																																	0.1	15				
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda													0.1	2																								
*	Sapindaceae	*Acer negundo*	Box Elder																																	0.1	1				
lin	Typhaceae	*Typha orientalis*	Broad-leaved Cumbungi																													20	50	5	50						
*	Verbenaceae	*Verbena bonariensis*	Purpletop							5	0			0.1	5																										
lin	Violaceae	*Viola sp*	Violet	10	1600																																				

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				DS11	DS11	DS13	DS13	DS15	DS15	DS21	DS21	DS7	DS7	DS74	DS74	DS76	DS76	DS77	DS77	DS78	DS78	DS79	DS79	DS80	DS80	DS84	DS84	DS85	DS85	DS95	DS95	DS97	DS97	DS98	DS98
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
lin	Acanthaceae	*Brunoniella australis*	Blue Trumpet			0.05	5					0.1	50																						
lin	Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed															1	35																
lin	Anthericaceae	*Caesia parviflora*	Pale Grass-lily											0.3	3																				
lin	Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily											0.4	13																				
lin	Anthericaceae	*Tricoryne elatior*	Yellow Autumn-lily											0.1	3																				
lin	Apiaceae	*Centella asiatica*	Gotu Cola					0.1	20																							0.1	8	0.1	8
*	Apiaceae	*Conium maculatum*	Hemlock	30	500																														
lin	Apiaceae	*Daucus glochidiatus*	Native Carrot															0.1	10																
HTW	Apocynaceae	*Araujia sericifera*	Moth Vine																	0.1	1	0.1	4	0.1	8										
lin	Apocynaceae	*Marsdenia suaveolens*	Scented Marsdenia																									0.1	1						
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod					0.3	2																										
HTW	Asparagaceae	*Asparagus asparagoides*	Bridal Creeper			0.01	1	0.5	20																							0.1	14	0.1	4
HTW	Asphodelaceae	*Asphodelus fistulosus*	Wild Onion					0.1	10																										
HTW	Asteraceae	*Ageratina riparia*	Mistflower																									0.1	5						
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs																	1	55	0.1	15			1	25	0.1	1	1	55				
lin	Asteraceae	*Calotis dentex*																												0.2	10				
*	Asteraceae	*Cirsium vulgare*	Spear Thistle															0.1	4	0.1	2	0.5	25	0.5	10										
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane													0.1	10			1	25					0.1	1	1	25	0.5	15				
*	Asteraceae	*Conyza spp.*	A Fleabane															0.2	25			3	35	0.5	15										
*	Asteraceae	*Gamochaeta celviceps*	Cudweed															0.1	15																
*	Asteraceae	*Hypochaeris radicata*	Catsear																							0.1	1								
	Asteraceae	*Hypochaeris sp.*								0.01	2																								
lin	Asteraceae	*Ozothamnus diosmifolius*	Rice Flower											0.1	1																				
*	Asteraceae	*Senecio madagascariensis*	Fireweed	4	0.05											0.1	20			0.1	1	0.1	3			1	5			0.2	10				
	Asteraceae	*Senecio sp.*																								0.2	5								
lin	Asteraceae	*Sigesbeckia orientalis*	Indian Weed													0.2	14			0.1	1														
*	Asteraceae	*Taraxacum officinale*	Dandelion															0.1	8																
lin	Blechnaceae	*Blechnum ambiguum*																												0.2	15				
*	Cactaceae	*Opuntia stricta*	Common Prickly Pear	0.5	5																									5	40				
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot									0.25	1000	0.1	18	0.2	20															0.1	10	0.1	14
lin	Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell											0.1	2																				
*	Caryophyllaceae	*Paronychia brasiliana*	Chilean Whitlow Wort, Brazilian Whitlow															0.2	25																
lin	Casuarinaceae	*Allocasuarina torulosa*	Forest Oak									0.01	1																						
lin	Casuarinaceae	*Casuarina cunninghamiana*	River Oak															30	x							10	x	5	40						
lin	Casuarinaceae	*Casuarina glauca*				35	50	25	100							5	5															80	49	45	22
lin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush	10	200													1	15							0.5	20	1	5	0.1	2				
lin	Chenopodiaceae	*Einadia nutans*	Climbing Saltbush																													0.1	8		
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew	3	40	1	1									0.2	30															0.1	4		

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	Commelinaceae	*Commelina sp.*																0.1	5																
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew	10	150																														
HTW	Commelinaceae	*Tradescantia fluminensis*	Trad													0.1	20					0.1	5	0.1	5	2	55			10	x				
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed					1	5000			0.1	500	1.6	210	0.3	100	3	150					2	150							0.1	10	0.1	12
lin	Cyperaceae	*Carex appressa*	Tall Sedge																													0.1	6		
lin	Cyperaceae	*Carex inversa*	Knob Sedge																					0.1	5										
lin	Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge											0.3	3																				
lin	Cyperaceae	*Cyperus polystachyos*														3	10							0.1	1										
lin	Cyperaceae	*Cyperus sp.*	A Sedge															0.2	30					0.1	15										
lin	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge									5	50																						
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge											0.2	3																				
lin	Dennstaedtiaceae	*Pteridium esculentum*	Common Bracken	50	5																							5	40	0.1	3				
lin	Ericaceae	*Lissanthe strigosa*	Peach Heath									0.2	7	0.5	1																				
*	Fabaceae (Caesalpinioideae)	*Delonix regia *out of know region*	Royal Poinciana																	0.1	10														
*	Fabaceae (Caesalpinioideae)	*Gladitsia triacanthos*	Honey Locust							0.01	3											45	x	10	x			1	1						
lin	Fabaceae (Caesalpinioideae)	*Senna spp.*														1	10																	0.1	1
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine					0.05	2			0.05	1																						
lin	Fabaceae (Faboideae)	*Glycine microphylla*	Small-leaf Glycine											0.1	5																				
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine					0.05	1			0.05	3			0.1	20															0.2	11	0.1	2
lin	Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla					0.02	1					0.2	3																				
lin	Fabaceae (Faboideae)	*Jacksonia scoparia*	Dogwood									0.01	1																						
*	Fabaceae (Faboideae)	*Trifolium sp*																0.1	1																
lin	Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	25	8							10	20																	35	x				
lin	Fabaceae (Mimosoideae)	*Acacia falcata*												1	3																				
lin	Fabaceae (Mimosoideae)	*Acacia mearnsii*	Black Wattle																					20	x										
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle											5	4	5	9									3	1								
lin	Geraniaceae	*Geranium homeanum*																0.1	5					0.1	4										
lin	Geraniaceae	*Geranium solanderi*	Native Geranium																													0.1	4	0.1	8
in	Goodeniaceae	*Brunonia australis *might be typo-out of known distrubution*	Blue Pincushion											0.1	4																				
lin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia									0.1	50																						
lin	Haloragaceae	*Gonocarpus teucrioides*	Germander Raspwort									0.1	5																						
lin	Juncaceae	*Juncus continuus*														5	37							0.1	3										
lin	Juncaceae	*Juncus usitatus*						0.2	6															2	15										
lin	Juncaginaceae	*Cycnogeton microtuberosum*	Triglochin microtuberosa													10	50																		
lin	Lamiaceae	*Ajuga australis*	Austral Bugle																													0.1	6		
lin	Lamiaceae	*Lycopus australis*	Australian Gipsywort													0.5	20																		
*	Lamiaceae	*Scutellaria racemosa*																0.1	5			0.1	35												
lin	Lauraceae	*Cassytha glabella*												0.1	8															2	15				

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lin	Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush											2	70																				
lin	Lomandraceae	*Lomandra glauca*	Pale Mat-rush									0.2	20																						
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	7	2									1	5	5	12													0.2	3				
lin	Lomandraceae	*Lomandra multiflora*	Many-flowered Mat-rush											1	3																				
lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry	0.01	1																														
*	Malvaceae	*Modiola caroliniana*	Red-flowered Mallow															4	55			0.1	1	0.1	5										
*	Malvaceae	*Pavonia hastata*						0.1	100					1	25	10	20																	1	50
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	0.02	3											2	10	4	55	1	25	5	55	1	25			0.1	1			0.1	5	0.2	20
lin	Meliaceae	*Melia azedarach*	White Cedar							0.01	2																	10	x						
lin	Menispermaceae	*Stephania japonica*	Snake vine																	0.1	1														
lin	Menyanthaceae	*Liparophyllum exaltatum*	Villarsia exaltata													0.5	10																		
lin	Myoporaceae	*Eremophila debilis*	Amulla											0.6	4																				
lin	Myrtaceae	*Callistemon salignus*	Willow Bottlebrush																			1	1			10	x								
lin	Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum																	35	x														
lin	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark									7	9																						
lin	Myrtaceae	*Eucalyptus elata*	River Peppermint	0.5	1																														
lin	Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark							3	1																								
lin	Myrtaceae	*Eucalyptus moluccana*	Grey Box											30	2	1	1																		
lin	Myrtaceae	*Eucalyptus robusta*	Swamp Mahogany							15	6																								
lin	Myrtaceae	*Eucalyptus saligna*	Sydney blue gum																							25	x								
lin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum							20	5	1	3			5	1													5	1			2	1
lin	Myrtaceae	*Kunzea ambigua*	Tick Bush									10	20																						
lin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon									10	20													5	40								
lin	Myrtaceae	*Melaleuca decora*												10	7																	1	1		
lin	Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree							40	8															0.5	2								
HTW	Oleaceae	*Ligustrum lucidum*	Large-leaved Privet													5	5							0.1	1							0.1	3	5	30
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	1	1	0.2	1	0.1	10							70	300					0.1	1	35	x	1	2	0.1	1			1	13	35	60
*	Oleaceae	*Olea europaea*	Common Olive													2	2													0.2	1				
*	Oxalidaceae	*Oxalis corniculata*														0.1	20																		
lin	Oxalidaceae	*Oxalis perennans*	Oxalis					0.05	5							0.1	20	0.1	25			0.1	15												
	Oxalidaceae	*Oxalis Spp.*										0.01	1																						
lin	Passifloraceae	*Passiflora herbertiana*	Native Passionfruit																	0.1	1														
lin	Phormiaceae	*Dianella revoluta*	Blueberry Lily									0.25	20	0.3	5																				
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush									0.2	4																					0.2	2
lin	Phyllanthaceae	*Phyllanthus gunnii*	Scrubby Spurge	0.01	1																														
*	Phytolaccaceae	*Phytolacca octandra*	Inkweed													0.2	5																		
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn			0.1	1					0.5	7	5	13	20	10															0.5	5	2	2
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	0.5	20			0.4	11			0.05	3																			0.1	10		
lin	Plantaginaceae	*Veronica plebeia*	Trailing Speedwell									0.05	5					0.1	1																

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lin	Poaceae	*Aristida ramosa*	Purple Wiregrass											15	70																				
lin	Poaceae	*Aristida vagans*	Threeawn Speargrass	5	100							10	500																						
lin	Poaceae	*Aristida warburgii*												5	30																				
lin	Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass																									5	100						
	Poaceae	*Avena spp.*						0.1	1																										
*	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass													3	80															2	50		
*	Poaceae	*Bromus catharticus*	Prairie Grass							2	100					3	40																		
lin	Poaceae	*Cymbopogon refractus*	Barbed Wire Grass									1	20	5	30																				
lin	Poaceae	*Cynodon dactylon*	Common Couch					10	1000							2	30													10	x	0.3	20		
lin	Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass											5	50													1	25						
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass													3	100																		
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass			2.5	100																	0.1	1			5	60	5	150	3	100	3	80
lin	Poaceae	*Entolasia stricta*	Wiry Panic	5	100							2.5	50	3	40															5	80				
lin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass											3	4																				
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass	50	1000																					2	5	5	150	65	x				
	Poaceae	*Eragrostis spp.*										5	50																						
lin	Poaceae	*Microlaena stipoides*	Weeping Grass					2	100					45	150	5	150	10	x	0.1	1	85	x	10	x			40	x	10	x	3	100	2	100
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass			0.1	10	0.5	50					0.1	10	1	5	35	x					1	80			3	250			0.1	8	0.1	10
lin	Poaceae	*Panicum effusum*	Hairy Panic											4	60																				
HTW	Poaceae	*Paspalum dilatatum*	Paspalum					0.3	10							3	25																		
*	Poaceae	*Pennisetum clandestinum*	Kikuyu Grass																			0.1	1												
lin	Poaceae	*Phragmites australis*	Common Reed							30	200																								
	Poaceae	*Poaceae spp.*								50	1000																								
*	Poaceae	*Setaria parviflora*	Setaria gracilis																											0.5	10				
lin	Poaceae	*Themeda triandra*	Kangaroo Grass									1	20																						
lin	Polygonaceae	*Persicaria decipiens*	Slender Knotweed													3	40							5	100										
*	Polygonaceae	*Rumex crispis*	Curled Dock															0.1	1			0.1	2												
	Polygonaceae	*Rumex sp.*														0.1	2									0.1	3								
*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel													0.1	20					0.1	45											0.1	6
*	Primulaceae	*Lysimachia arvensis*	Scarlet Pimpernel					0.1	100																										
lin	Proteaceae	*Grevillea robusta*																																0.1	1
lin	Pteridaceae	*Cheilanthes distans*	Bristly Cloak Fern											0.2	20																				
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern	5	100							0.25	500																						
lin	Pteridaceae	*Pellaea falcata*	Sickle Fern	5	50																														
lin	Ranunculaceae	*Clematis aristata*	Old Man's Beard																					0.1	1										
lin	Ranunculaceae	*Ranunculus plebeius*	Forest Buttercup													0.1	10							1	25										
*	Rosaceae	*Rubus fruticosus sp. agg.*	Blackberry complex																													0.1	1		
lin	Rosaceae	*Rubus rosifolius*	Native Raspberry																											0.1	2				
*	Rosaceae	*Rubus ulmifolius*	Blackberry	1	50																														

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lin	Rubiaceae	*Opercularia diphylla*	Stinkweed									0.25	1000																						
lin	Rubiaceae	*Pomax umbellata*	Pomax									0.05	5																						
*	Salicaceae	*Salix sp.*	Willow													1	1																		
*	Sapindaceae	*Acer negundo*	Box Elder																					10	x										
HTW	Sapindaceae	*Cardiospermum grandiflorum*	Balloon Vine													5	3	0.1	1	85	x							3	25			0.1	1	0.1	2
HTW	Solanaceae	*Cestrum parqui*	Green Cestrum													2	5							0.5	10	3	35	3	55						
HTW	Solanaceae	*Lycium ferocissimum*	African Boxthorn	1	8																														
*	Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush					0.1	3											2	10	2	1			1	1								
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade					0.2	20							0.1	2			0.1	1							0.5	25			1	50		
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade					0.1	5			0.1	10							0.1	1														
*	Solanaceae	*Solanum pseudocapsicum*	Madeira Winter or Jerusalem Cherry																	0.1	2			0.1	1										
	Solanaceae	*Solanum sp.*																								0.1	2								
lin	Stackhousiaceae	*Stackhousia muricata*	Western Stackhousia									0.01	1																						
HTW	Verbenaceae	*Lantana camara*	Lantana									0.2	4					0.1	20	2	5					4	45	5	10					1	5
*	Verbenaceae	*Verbena bonariensis*	Purpletop													0.1	3											0.2	5						
*	Verbenaceae	*Verbena rigida*	Veined Verbena															0.1	1					0.1	10	0.1	5								
lin	Vitaceae	*Cayratia clematidea*	Native Grape	0.01	1																							1	5						

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STATUS	FAMILY	GENUS SPECIES	COMMON NAME	DS113 C	DS113 A	DS14 C	DS14 A	DS16 C	DS16 A
Iin	Acanthaceae	*Brunoniella australis*	Blue Trumpet			0.2	500	0.5	100
Iin	Anthericaceae	*Arthropodium spp.*						0.05	10
Iin	Anthericaceae	*Tricoryne elatior*	Yellow Autumn-lily					0.1	50
Iin	Apiaceae	*Centella asiatica*	Gotu Cola	0.1	10	0.05	5		
HTW	Asparagaceae	*Asparagus asparagoides*	Bridal Creeper			0.3	100	0.1	10
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	0.1	6				
Iin	Asteraceae	*Cotula australis*	Carrot Weed	0.1	10				
*	Asteraceae	*Hypochaeris radicata*	Catsear	0.1	4				
Iin	Asteraceae	*Lagenophora stipitata*	Blue Bottle-daisy			0.1	20	0.1	50
*	Asteraceae	*Senecio madagascariensis*	Fireweed	0.2	10	0.01	1	0.01	1
Iin	Campanulaceae	*Lobelia purpurascens*	Whiteroot			1	5000	0.2	100
Iin	Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell					0.02	5
Iin	Casuarinaceae	*Casuarina glauca*		10	20				
Iin	Commelinaceae	*Commelina cyanea*		0.1	12	0.05	5		
Iin	Convolvulaceae	*Dichondra repens*	Kidney Weed	0.1	12	0.5	1000	0.2	100
Iin	Cyperaceae	*Carex inversa*	Knob Sedge			0.1	5000		
Iin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine			0.1	20	0.1	50
Iin	Fabaceae (Faboideae)	*Glycine microphylla*	Small-leaf Glycine	0.1	10				
Iin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine			0.5	1000	0.1	100
Iin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	5	5				
*	Gentianaceae	*Centaurium spp.*		0.1	5				
Iin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia			0.05	3	0.2	50
	Juncaceae	*Juncus spp.*	A Rush	0.1	2				
Iin	Juncaceae	*Juncus usitatus*				0.1	3		
Iin	Lamiaceae	*Ajuga australis*	Austral Bugle	0.1	1				
Iin	Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush					1.5	1000
*	Malvaceae	*Pavonia hastata*				25	5000	0.1	5
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	0.5	16				
Iin	Myoporaceae	*Eremophila debilis*	Amulla					0.5	20
Iin	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark			30	50	15	17
Iin	Myrtaceae	*Eucalyptus moluccana*	Grey Box					5	6
Iin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum			1	2		
Iin	Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree			1	1		
HTW	Oleaceae	*Ligustrum lucidum*	Large-leaved Privet	2	3				
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	10	9	30	20		
Iin	Oxalidaceae	*Oxalis perennans*	Oxalis	0.1	20			0.1	20
Iin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	5	30	0.3	20		
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	3	25				
HTW	Poaceae	*Andropogon virginicus*	Whisky Grass	13	185				
Iin	Poaceae	*Aristida vagans*	Threeawn Speargrass			15	500	40	1000
HTW	Poaceae	*Axonopus fissifolius*		70	200				
Iin	Poaceae	*Bothriochloa macra*	Red Grass					0.1	10

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lin	Poaceae	*Cymbopogon refractus*	Barbed Wire Grass					0.2	20
lin	Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass	30	100				
	Poaceae	*Dichelachne spp.*	Plumegrass					0.1	2
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass					0.2	50
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass			0.5	10		
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	50	100	45	1000	35	1000
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass	0.2	20	1	50		
lin	Poaceae	*Paspalidium distans*				2	1000	5	500
HTW	Poaceae	*Paspalum dilatatum*	Paspalum	15	70				
*	Poaceae	*Setaria pumila*	Pale Pigeon Grass					0.1	3
lin	Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass					1	100
lin	Poaceae	*Themeda triandra*		0.2	6	0.1	2	0.5	20
lin	Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair			0.05	10		
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern			0.1	100	0.1	100
*	Rosaceae	*Rubus fruticosus sp. agg.*	Blackberry complex	1	5				
lin	Rubiaceae	*Opercularia diphylla*	Stinkweed					0.2	50
*	Rubiaceae	*Richardia stellaris*				0.1	20		
HTW	Solanaceae	*Lycium ferocissimum*	African Boxthorn	0.1	1				
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade					0.1	5
*	Solanaceae	*Solanum pseudocapsicum*		0.1	2				
HTW	Verbenaceae	*Lantana camara*	Lantana			0.6	4		
*	Verbenaceae	*Verbena bonariensis*	Purpletop	1	20				

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				DS136	DS136	DS137	DS137
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A
HTW	Asteraceae	*Ageratina adenophora*	Crofton Weed			0.1	5
lin	Sapindaceae	*Alectryon subcinereus*	Wild Quince	1	1		
	Poaceae	*Austrostipa sp.*				5	100
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle			15	x
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			0.1	1
lin	Acanthaceae	*Brunoniella australis*	Blue Trumpet	0.1	1		
lin	Cunoniaceae	*Callicoma serratifolia*	Black Wattle			5	20
lin	Myrtaceae	*Callistemon salignus*	Willow Bottlebrush	1	1		
lin	Lauraceae	*Cassytha glabella*				1	15
lin	Vitaceae	*Cayratia clematidea*	Native Grape			0.2	15
lin	Cunoniaceae	*Ceratopetalum apetalum*	Coachwood			25	x
HTW	Solanaceae	*Cestrum parqui*	Green Cestrum	0.1	3		
*	Asteraceae	*Cirsium vulgare*	Spear Thistle	0.1	2		
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	0.1	5		
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed	1	35		
lin	Myrtaceae	*Eucalyptus punctata*	Grey Gum	5	2		
lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry	0.1	2	0.1	1
lin	Goodeniaceae	*Goodenia ovata*	Hop Goodenia			1	5
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda			2	15
lin	Araliaceae	*Hydrocotyle peduncularis*				0.1	15
lin	Violaceae	*Melicytus dentatus*	Tree Violet	5	60		
HTW	Verbenaceae	*Lantana camara*	Lantana	5	20		
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	1	4	0.1	3
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush			1	10
lin	Moraceae	*Maclura cochinchinensis*	Cockspur Thorn	1	1		
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark			10	x
lin	Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree	25	x		
lin	Poaceae	*Oplismenus aemulus*		5	150	5	150
lin	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine	2	5		
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod	5	20		
*	Malvaceae	*Pavonia hastata*		0.1	3		
lin	Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	0.1	1		
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower	3	45	0.1	1
	Not Found	*Ranunculus sp.*	Not Found	0.1	5		
lin	Rosaceae	*Rubus moluccanus*	Molucca Bramble			0.1	1
*	Lamiaceae	*Scutellaria racemosa*		0.1	5		
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	3	55		
lin	Asteraceae	*Sigesbeckia orientalis*	Indian Weed			0.1	2
*	Solanaceae	*Solanum pseudocapsicum*	Madeira Winter Cherry	0.1	4		
lin	Gleicheniaceae	*Sticherus flabellatus*	Umbrella Fern			1	15
lin	Moraceae	*Streblus brunonianus*	Whalebone Tree	15	x		
lin	Aizoaceae	*Tetragonia tetragonioides*	New Zealand Spinach	1	15		

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lin	Osmundaceae	*Todea barbara*	King Fern			5	5
*	Commelinaceae	*Tradescantia albiflora*	Wandering Jew	5	100		
lin	Myrtaceae	*Tristaniopsis laurina*	Kanooka			2	5
*	Verbenaceae	*Verbena bonariensis*	Purpletop	0.1	3		
lin	Monimiaceae	*Wilkiea spp.*		1	3		

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				DS24	DS24	DS46	DS46	DS47	DS47	DS48	DS48	DS62	DS62
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A
lin	Apiaceae	*Centella asiatica*	Indian Pennywort			1	100	10	x	1	100	1	150
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod			0.1	1	2	20				
lin	Araliaceae	*Hydrocotyle pedicellosa*	Pennywort			5	x						
lin	Araliaceae	*Hydrocotyle peduncularis*								0.2	60	0.1	20
*	Asteraceae	*Conyza spp.*	A Fleabane							0.2	60		
lin	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine			0.2	10	3	40				
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot			0.1	5						
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew					0.1	20	0.2	60		
lin	Cyperaceae	*Carex appressa*	Tall Sedge					0.1	5	0.1	5		
lin	Cyperaceae	*Carex inversa*	Knob Sedge									0.2	15
lin	Cyperaceae	*Carex spp.*										10	x
lin	Cyperaceae	*Cyperus polystachyos*								0.1	1		
lin	Cyperaceae	*Cyperus spp.*		0.1	4	15	x	0.1	10				
lin	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge			0.1	1						
lin	Cyperaceae	*Gahnia clarkei*	Tall Saw-sedge			5	x	0.1	2				
lin	Cyperaceae	*Isolepis producta*										5	x
lin	Cyperaceae	*Schoenoplectus mucronatus*				0.1	1						
lin	Cyperaceae	*Schoenus melanostachys*						0.1	1			0.1	2
lin	Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern									10	x
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken			5	x	1	30	0.1	5		
lin	Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern			20	x	10	x				
*	Fabaceae (Faboideae)	*Trifolium repens*	White Clover							0.1	30		
lin	Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern					5	x				
lin	Juncaceae	*Juncus continuus*		1	20								
lin	Juncaceae	*Juncus planifolius*										0.1	5
lin	Juncaceae	*Juncus prismatocarpus*		20	x								
lin	Juncaceae	*Juncus usitatus*						0.1	1	2	60	10	x
lin	Lauraceae	*Cassytha glabella*										0.1	2
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush									5	x
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily							0.1	1		
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne			0.1	2			10	x		
lin	Menispermaceae	*Stephania japonica*	Snake vine			0.1	5	1	10				
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle					5	x				
lin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon			0.2	2	30	x	0.1	2		
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	70	x	45	x	10	x	20	x	40	x
HTW	Oleaceae	*Ligustrum lucidum*	Large-leaved Privet							1	1		
lin	Philydraceae	*Philydrum lanuginosum*	Frogsmouth	1	10								
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily			0.1	2						
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			0.1	10						
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree			10	x	1	1	5	x		
lin	Plantaginaceae	*Veronica plebeia*	Trailing Speedwell					0.1	1				
lin	Poaceae	*Cynodon dactylon*	Common Couch			1	50			15	x	0.2	100

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lin	Poaceae	*Digitaria spp.*	A Finger Grass	5	x								
lin	Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass					0.1	10				
lin	Poaceae	*Entolasia marginata*	Bordered Panic			15	x	20	x	0.5	40	2	100
lin	Poaceae	*Microlaena stipoides*	Weeping Grass					5	x			0.2	80
lin	Poaceae	*Oplismenus aemulus*								5	x		
lin	Poaceae	*Oplismenus imbecillis*				10	x	35	x				
lin	Poaceae	*Panicum simile*	Two-colour Panic	5	x								
HTW	Poaceae	*Paspalum dilatatum*	Paspalum					0.1	5				
*	Poaceae	*Setaria gracilis*								0.5	40		
lin	Polygonaceae	*Persicaria hydropiper*	Water Pepper									20	x
lin	Polygonaceae	*Persicaria praetermissa*				0.1	1	0.1	5	5	x	0.5	100
lin	Polygonaceae	*Persicaria strigosa*		50	x								
lin	Polygonaceae	*Persicaria subsessilis*	Hairy Knotweed	70	x								
*	Primulaceae	*Lysimachia arvensis*	Scarlet Pimpernel							0.1	15		
lin	Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair			0.1	15						
lin	Ranunculaceae	*Clematis aristata*	Old Man's Beard			0.1	1						
lin	Rosaceae	*Rubus parvifolius*	Native Raspberry			0.1	1						
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda			1	55			0.1	2		
lin	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla					0.1	1				
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade							0.1	2		
lin	Violaceae	*Viola hederacea*	Ivy-leaved Violet			5	x	0.5	20	0.2	100	0.1	100

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				DS122	DS122	DS123	DS123	DS124	DS124	DS125	DS125	DS132	DS132
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A
lin	Apiaceae	*Centella asiatica*	Gotu Cola					0.1	25			1	55
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod					5	20	0.5	5		
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs					0.2	15				
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane							0.1	1		
*	Asteraceae	*Dimorphotheca sp.*	Cape Daisy					5	100				
	Asteraceae	*Gnaphalium sp.*	A Cudweed	0.1	1								
*	Asteraceae	*Hypochaeris radicata*	Catsear			0.1	2						
lin	Asteraceae	*Ozothamnus diosmifolius*	Rice Flower			1	5						
*	Asteraceae	*Senecio madagascariensis*	Fireweed	2	65	0.5	25					0.1	10
	Asteraceae	*Senecio sp.*		3	75								
*	Asteraceae	*Taraxacum officinale*	Dandelion					0.1	2				
lin	Blechnaceae	*Blechnum spp.*						0.1	5				
*	Cactaceae	*Opuntia stricta*	Common Prickly Pear									2	5
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot			0.1	1	0.1	1	0.1	1		
lin	Cannabaceae	*Trema tomentosa*	Native Peach							0.1	1		
lin	Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak							10	0		
lin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush					0.1	2	0.2	2		
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew			0.1	5	1	55	0.1	5	0.1	1
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed			1	45	5	150	3	150	2	150
HTW	Crassulaceae	*Bryophyllum delagoense*	Mother-of-millions					5	20				
lin	Cyperaceae	*Carex appressa*	Tall Sedge							0.1	1		
lin	Cyperaceae	*Carex inversa*	Knob Sedge					0.1	1				
lin	Cyperaceae	*Cyperus sp.*	A Sedge	0.1	1								
lin	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge							0.1	1		
lin	Dilleniaceae	*Hibbertia diffusa*	Wedge Guinea Flower			1	5						
lin	Ericaceae	*Leucopogon juniperinus*	Prickly Beard-heath			2	10						
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine			0.1	1	0.5	25			0.11	1
lin	Fabaceae (Mimosoideae)	*Acacia floribunda*	White Sally							0.2	1		
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle			5	8			1	1		
*	Gentianaceae	*Centaurium spicatum*		0.6	36								
*	Gentianaceae	*Centaurium tenuiflorum*	Branched Centaury, Slender centaury	1	35								
lin	Geraniaceae	*Geranium homeanum*										0.1	1
lin	Juncaceae	*Juncus usitatus*								0.5	5	1	5
lin	Lamiaceae	*Plectranthus parviflorus*				1	25						
*	Lamiaceae	*Scutellaria racemosa*								0.2	55		
lin	Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush					0.2	5				
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily					0.1	1				
*	Malvaceae	*Pavonia hastata*				5	100						
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne					0.1	6	0.1	5	0.1	5
lin	Menispermaceae	*Stephania japonica*	Snake vine							1	35		
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple									10	0
lin	Myrtaceae	*Callistemon salignus*	Willow Bottlebrush			2	1	5	20				
lin	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark			10	0					10	0

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Iin	Myrtaceae	*Eucalyptus punctata*	Grey Gum			2	1						
Iin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum					15	0	25	0	5	100
Iin	Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree									5	20
HTW	Ochnaceae	*Ochna serrulata*	Mickey Mouse Plant							0.1	1		
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet			1	1						
Iin	Oxalidaceae	*Oxalis perennans*	Oxalis									1	15
Iin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush							1	5		
Iin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn			10	0			0.2	1		
Iin	Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum			0.5	3						
Iin	Poaceae	*Austrodanthonia racemosa*	Wallaby Grass	0.1	5								
Iin	Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass			5	15						
Iin	Poaceae	*Cymbopogon refractus*	Barbed Wire Grass			5	20					2	5
Iin	Poaceae	*Cynodon dactylon*	Common Couch			2	65	10	0	10	0		
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass							5	150		
Iin	Poaceae	*Entolasia marginata*	Bordered Panic							5	150		
Iin	Poaceae	*Entolasia stricta*	Wiry Panic					10	0	10	0		
Iin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass					0.1	5				
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass	65	0			10	0			1	5
	Poaceae	*Eragrostis spp.*				10	0						
Iin	Poaceae	*Microlaena stipoides*	Weeping Grass			5	150	10	0	15	0	5	150
Iin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass			0.5	55			0.1	25	5	150
HTW	Poaceae	*Paspalum dilatatum*	Paspalum							1	35		
*	Polygonaceae	*Rumex crispis*	Curled Dock	0.1	1					0.1	1		
*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel	1	65								
Iin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern	1	35	0.2	55	0.1	5				
Iin	Ranunculaceae	*Clematis aristata*	Old Man's Beard					0.1	1				
*	Rubiaceae	*Richardia stellaris*		0.5	50								
Iin	Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart					0.1	1	0.5	1		
*	Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush							0.2	5		
Iin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade					0.1	1	0.1	5		
	Solanaceae	*Solanum sp.*						0.2	1				
HTW	Verbenaceae	*Lantana camara*	Lantana			5	10			0.5	5	35	0
*	Verbenaceae	*Verbena rigida*	Veined Verbena	1	35					0.1	1		
Iin	Vitaceae	*Cayratia clematidea*	Native Grape					0.1	1				

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				DS53	DS53	DS55	DS55	DS58	DS58
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A
Iin	Anthericaceae	*Tricoryne spp.*						0.1	1
Iin	Apiaceae	*Centella asiatica*	Gotu Cola	0.1	15	0.1	12		
Iin	Apiaceae	*Platysace lanceolata*	Shrubby Platysace					0.1	15
HTW	Apocynaceae	*Araujia sericifera*	Moth Vine					0.1	1
Iin	Araliaceae	*Hydrocotyle peduncularis*				0.1	15		
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	0.1	6	0.1	1		
*	Asteraceae	*Hypochaeris radicata*	Catsear	0.1	13				
Iin	Campanulaceae	*Lobelia purpurascens*	Whiteroot			0.1	2		
Iin	Casuarinaceae	*Allocasuarina torulosa*	Forest Oak			0.2	1		
Iin	Cyatheaceae	*Cyathea leichhardtiana*	Prickly Tree Fern			0.2	1		
HTW	Cyperaceae	*Cyperus eragrostis*	Umbrella Sedge	0.1	5				
	Cyperaceae	*Cyperus sp.*	A Sedge	5	0				
Iin	Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern			10	0		
Iin	Dennstaedtiaceae	*Pteridium esculentum*	Common Bracken			0.1	5	5	0
Iin	Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	0.1	1				
Iin	Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash			0.5	1		
	Fabaceae (Caesalpinioideae)	*Senna acclinis*		0.1	1				
Iin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine					0.1	1
Iin	Fabaceae (Faboideae)	*Pultenaea tuberculata*	Wreath Bush-pea					0.1	5
Iin	Fabaceae (Mimosoideae)	*Acacia falcata*						0.1	5
Iin	Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle					5	0
Iin	Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses					0.1	3
Iin	Hypericaceae	*Hypericum gramineum*	Small St John's Wort	0.1	3				
Iin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	0.1	1	0.1	2		
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne			0.1	1	0.1	2
Iin	Menispermaceae	*Stephania japonica*	Snake vine			0.1	1		
Iin	Moraceae	*Ficus coronata*	Sandpaper Fig			0.2	1		
Iin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple			3	1		
Iin	Myrtaceae	*Corymbia eximia*	Yellow Bloodwood					1	2
Iin	Myrtaceae	*Eucalyptus amplifolia*	Cabbage Gum					5	0
Iin	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint					8	0
Iin	Myrtaceae	*Kunzea ambigua*	Tick Bush					0.1	5
Iin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon			0.2	10		
Iin	Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree					0.5	3
Iin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	25	0	40	0	0.1	1
Iin	Phormiaceae	*Dianella revoluta*	Blueberry Lily					0.1	2
Iin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush					0.1	1
Iin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree			5	0	0.5	3
Iin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn			1	8	0.5	15
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues					0.1	1
Iin	Poaceae	*Aristida vagans*	Threeawn Speargrass					1	1
HTW	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass	60	0				

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*	Poaceae	*Bromus catharticus*	Prairie Grass					0.1	10
lin	Poaceae	*Cynodon dactylon*	Common Couch	0.4	50	0.5	75	0.5	50
lin	Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass	20	0				
lin	Poaceae	*Echinopogon ovatus*	Forest Hedgehog Grass			0.1	5		
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass					5	0
lin	Poaceae	*Entolasia marginata*	Bordered Panic			0.2	60	0.2	100
lin	Poaceae	*Entolasia stricta*	Wiry Panic					0.2	100
lin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass	5	0	0.1	1	0.1	1
lin	Poaceae	*Imperata cylindrica*	Blady Grass					0.2	60
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	0.2	20	0.5	75	0.1	50
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass			1	60		
lin	Poaceae	*Panicum simile*	Two-colour Panic	0.4	40				
HTW	Poaceae	*Paspalum dilatatum*	Paspalum	5	0				
*	Poaceae	*Setaria parviflora*		5	0	0.1	2		
lin	Polygonaceae	*Persicaria praetermissa*				2	60		
lin	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung			0.1	1	0.5	10
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern			0.1	2		
lin	Ranunculaceae	*Ranunculus lappaceus*	Common Buttercup					0.1	15
lin	Rhamnaceae	*Pomaderris sp.*						0.1	1
*	Rosaceae	*Rubus fruticosus sp. agg.*	Blackberry complex	0.1	2				
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda			0.1	2		
lin	Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush					0.1	2
lin	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla			0.1	1		
HTW	Verbenaceae	*Lantana camara*	Lantana			0.1	1		

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				DS1	DS1	DS10	DS10	DS65	DS65	DS66	DS66	DS67	DS67	DS68	DS68	DS69	DS69
STATUS	**FAMILY**	**GENUS SPECIES**	**COMMON NAME**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**
Iin	Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall	50	400	10	11										
Iin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle					15		30		10	6	5	10	2	2
Iin	Myrtaceae	*Acmena smithii*	Lilly Pilly					7	5								
Iin	Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair					1	3								
Iin	Casuarinaceae	*Allocasuarina torulosa*	Forest Oak					3	1								
HTW	Poaceae	*Andropogon virginicus**	Whisky Grass							0.1	10						
Iin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple					10						1	1		
HTW	Basellaceae	*Anredera cordifolia*	Madeira Vine	2	800												
Iin	Poaceae	*Aristida vagans*	Threeawn Speargrass											1	2	0.1	100
Iin	Araliaceae	*Astrotricha floccosa*						0.1	1								
Iin	Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass	2	100												
*	Poaceae	*Axonopus affinis**	Narrow-leafed Carpet Grass											0.1	5		
Iin	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry											0.1	1	0.1	3
Iin	Malvaceae	*Brachychiton acerifolius*	Illawarra Flame Tree					0.1	1								
Iin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			0.1	1										
Iin	Pittosporaceae	*Bursaria longisepala*				4	0.5										
Iin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn					1	1	1	3			25			
Iin	Cunoniaceae	*Callicoma serratifolia*	Black Wattle					25		0.1	1						
Iin	Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern							5	10						
HTW	Sapindaceae	*Cardiospermum grandiflorum*	Balloon Vine	1	5												
Iin	Cyperaceae	*Carex spp.*								3	2						
Iin	Lauraceae	*Cassytha glabella*												1	20		
Iin	Vitaceae	*Cayratia clematidea*	Native Grape	10	1000												
Iin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern	0.1	200	50	1							0.5	20	1	25
Iin	Ranunculaceae	*Clematis aristata*	Old Man's Beard					3	5	1	2	1	2	0.1	1	0.1	2
*	Asteraceae	*Conyza albida**	Tall fleabane					0.1	1	5	10						
Iin	Cyperaceae	*Cyathochaeta diandra*						3	3								
Iin	Poaceae	*Cynodon dactylon*	Common Couch											10	100	15	
Iin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily			0.01	2										
Iin	Phormiaceae	*Dianella revoluta*	Blueberry Lily							0.1	1						
Iin	Convolvulaceae	*Dichondra repens*	Kidney Weed							0.1	1						
Iin	Dicksoniaceae	*Dicksonia antarctica*	Soft Treefern					10									
Iin	Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush			0.1	1							1	5	1	5
Iin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass					0.1	3					0.1	10		
Iin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush	0.1	200					0.1	1						
Iin	Poaceae	*Entolasia marginata*	Bordered Panic	0.1	400			0.1	2	25		0.1	10				
Iin	Poaceae	*Entolasia stricta*	Wiry Panic			0.1	100							25		35	
Iin	Myrtaceae	*Eucalyptus acmenioides*	White Mahogany											30			
Iin	Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark			5	3										
Iin	Myrtaceae	*Eucalyptus fibrosa*	Red Ironbark			30	6										
Iin	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint					2	1								
Iin	Myrtaceae	*Eucalyptus punctata*	Grey Gum			2	1										

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lin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum											5			
lin	Santalaceae	*Exocarpos cupressiformis*	Cherry Ballart			0.2	1										
lin	Cyperaceae	*Gahnia sieberi*	Red-fruit Saw-sedge					1	5								
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	0.5	200												
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree					30		0.1	2						
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine			0.1	10							0.1	1	0.1	4
lin	Haloragaceae	*Gonocarpus teucrioides*	Germander Raspwort											0.1	1	0.1	1
lin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia							0.1	5						
lin	Dilleniaceae	*Hibbertia riparia*												0.1	1	0.1	1
*	Asteraceae	*Hypochaeris radicata*	Catsear											0.1	5	0.1	5
lin	Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern					15		2	10						
lin	Poaceae	*Imperata cylindrica*	Blady Grass							1	10			1	10	5	
lin	Fabaceae (Faboideae)	*Jacksonia scoparia*	Dogwood			1	2										
lin	Juncaceae	*Juncus usitatus*								0.1	1						
lin	Fabaceae (Faboideae)	*Kennedia rubicunda*	Dusky Coral Pea					0.1	1								
HTW	Verbenaceae	*Lantana camara*	Lantana	40	50	0.5	1										
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge			10	100	1	5					2	5	10	
lin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon							20							
lin	Ericaceae	*Leucopogon muticus*	Blunt Beard-heath			2	2										
lin	Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush											0.1	1		
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	0.5	9	5	50							3	10	0.5	4
lin	Lomandraceae	*Lomandra obliqua*												0.1	1		
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark					10		2	2	40	4				
lin	Myrtaceae	*Melaleuca thymifolia*	Thyme Honey-myrtle													6	
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	0.1	2000			0.1	10	40		80	1000	10		15	
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda					2	5	0.1	1	1	2				
lin	Primulaceae	*Myrsine variabilis*						0.1	1								
lin	Poaceae	*Oplismenus aemulus*		0.5	4000			0.1	1	0.5	5	0.1	10				
lin	Poaceae	*Oplismenus imbecillis*				0.1	100										
lin	Oxalidaceae	*Oxalis perennans*		0.1	200												
lin	Asteraceae	*Ozothamnus diosmifolius*	White Dogwood									0.1	1				
lin	Poaceae	*Panicum simile*	Two-colour Panic							1	10			1	10	10	
lin	Passifloraceae	*Passiflora herbertiana*		0.01	20												
*	Malvaceae	*Pavonia hastata*		0.001	2												
lin	Adiantaceae	*Pellaea falcata*	Sickle Fern	0.1	40												
lin	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung			2	0.05			2	3			20		60	
lin	Poaceae	*Poa labillardierei*	Tussock					0.1	6					1	10	0.5	5
lin	Rubiaceae	*Pomax umbellata*	Pomax			0.5	50										
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot							0.1	1						
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken					1	5			10	100	15		25	
HTW	Rosaceae	*Rubus fruticosus*	Blackberry complex							2	1			10		10	
lin	Rosaceae	*Rubus parvifolius*	Native Raspberry					1	10	1	3	0.1	2				
lin	Cyperaceae	*Schoenus melanostachys*						2	2								
lin	Asteraceae	*Senecio diaschides*								0.1	3						

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*	Poaceae	*Setaria pumila*	Pale Pigeon Grass							0.1	1						
lin	Menispermaceae	*Stephania japonica*	Snake vine					2	5			1	2				
lin	Cannabaceae	*Trema tomentosa*	Native Peach					1	3			1	1				
lin	Anthericaceae	*Tricoryne elatior*	Yellow Autumn-lily											0.1	1		

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				DS51	DS51
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A
lin	Myrtaceae	*Acmena smithii*	Lilly Pilly	5	x
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	80	x
lin	Blechnaceae	*Blechnum spp.*		20	x
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	0.1	2
lin	Vitaceae	*Cayratia clematidea*	Native Grape	0.1	20
lin	Vitaceae	*Cissus hypoglauca*	Giant Water Vine	5	x
lin	Myrtaceae	*Corymbia gummifera*	Red Bloodwood	5	x
lin	Ebenaceae	*Diospyros australis*	Black Plum	0.1	1
lin	Blechnaceae	*Doodia aspera*		70	x
lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry	0.1	5
lin	Moraceae	*Ficus coronata*	Creek Sandpaper Fig	5	x
lin	Luzuriagaceae	*Geitonoplesium spp.*		0.1	5
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda	5	x
lin	Poaceae	*Panicum simile*	Two-colour Panic	2	30
lin	Apocynaceae	*Parsonsia spp.*		0.2	20
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower	0.1	5
lin	Fabaceae (Caesalpinioideae)	*Senna spp.**		0.1	5
lin	Smilacaceae	*Smilax australis*	Lawyer Vine	0.5	10
HTW	Commelinaceae	*Tradescantia fluminensis**	Wandering Jew	30	x

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				DS22	DS22	DS27	DS27	DS49	DS49	DS64	DS64	DS70	DS70	DS72	DS72	DS73	DS73
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A	C	A	C	A
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower					0.1	20								
lin	Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair			0.5	20	1									
lin	Adiantaceae	*Adiantum formosum*	Giant Maidenhair	5													
lin	Apiaceae	*Centella asiatica*	Indian Pennywort	1	100			0.3	200			0.1	10				
HTW	Apocynaceae	*Araujia sericifera*	Moth Vine			0.2	4										
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod									1	1				
lin	Araliaceae	*Polyscias murrayi*	Pencil Cedar					0.3	1								
HTW	Asparagaceae	*Asparagus asparagoides*	Bridal Creeper			0.1	20										
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs			0.1	3										
*	Asteraceae	*Conyza albida*	Tall fleabane									0.1	10				
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane			0.1	10										
lin	Asteraceae	*Ozothamnus diosmifolius*	White Dogwood													1	3
lin	Asteraceae	*Sigesbeckia orientalis*	Indian Weed					0.1	5	0.1	25						
lin	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine			4	18										
lin	Blechnaceae	*Doodia aspera*						0.1	5								
lin	Blechnaceae	*Doodia caudata*	Small Rasp Fern	20													
lin	Casuarinaceae	*Allocasuarina torulosa*	Forest Oak	1	3												
lin	Casuarinaceae	*Casuarina cunninghamiana*	River Oak			8											
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew													1	1
lin	Commelinaceae	*Commelina diffusa*						0.1	1								
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew			3	50							10			
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed					0.1	20			0.1	20				
lin	Convolvulaceae	*Polymeria calycina*		0.1	5												
*	Crassulaceae	*Kalanchoe spp.*														1	1
lin	Cyperaceae	*Carex appressa*	Tall Sedge	5				0.1	5	0.1	1						
lin	Cyperaceae	*Carex inversa*	Knob Sedge									3	7				
lin	Cyperaceae	*Carex spp.*								0.1	1						
lin	Cyperaceae	*Cyperus spp.*						0.2	10								
lin	Cyperaceae	*Gahnia clarkei*	Tall Saw-sedge	5													
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge											1	1		
lin	Cyperaceae	*Lepironia articulata*		1	3												
lin	Cyperaceae	*Schoenus melanostachys*										5					
lin	Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern							1	100						
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	5		1	30	2		15				1	10		
lin	Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	5				30						2	3		
lin	Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash	0.2	2												
lin	Fabaceae (Caesalpinioideae)	*Senna acclinis*	Rainforest Cassia			0.1	1										
lin	Fabaceae (Caesalpinioideae)	*Senna spp.*						0.3	45								
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine					0.1	10								
lin	Fabaceae (Faboideae)	*Indigofera australis*	Australian Indigo			0.5	5										
lin	Fabaceae (Faboideae)	*Podolobium ilicifolium*	Prickly Shaggy Pea	0.1	1												
lin	Fabaceae (Mimosoideae)	*Acacia dealbata*	Silver Wattle	0.1	1												

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lin	Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle									10					
lin	Fabaceae (Mimosoideae)	*Acacia implexa*	Hickory Wattle									1	2			5	
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle									10				5	
lin	Fabaceae (Mimosoideae)	*Acacia spp.*	Wattle					0.1	5								
lin	Juncaceae	*Juncus subsecundus*	Finger Rush	0.1	10												
lin	Juncaceae	*Juncus usitatus*										5					
lin	Lamiaceae	*Plectranthus parviflorus*										0.1	1				
lin	Lobeliaceae	*Pratia purpurascens*	Whiteroot					0.1	30	0.1	5						
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	0.1	1			0.5	20	1		20				1	5
lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry			2	6							2	2		
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily			2	20	0.1	3	0.1	5	1	1	0.1	1	1	3
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne									1	2				
lin	Menispermaceae	*Stephania japonica*	Snake vine			0.2	10	5		5							
lin	Moraceae	*Ficus coronata*	Creek Sandpaper Fig			10											
lin	Moraceae	*Ficus macrophylla*												2	2		
lin	Myrtaceae	*Acmena smithii*	Lilly Pilly			10		30									
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple	15				20				5					
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	5				1	6	5		1	2	40			
lin	Myrtaceae	*Corymbia gummifera*	Red Bloodwood	10													
lin	Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum							5							
lin	Myrtaceae	*Eucalyptus elata*	River Peppermint			30											
lin	Myrtaceae	*Eucalyptus punctata*	Grey Gum											25			
lin	Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum			15		10		20							
lin	Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum									20				5	
lin	Myrtaceae	*Kunzea ambigua*	Tick Bush									1	2			2	5
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	25				50		5		20					
lin	Myrtaceae	*Melaleuca sieberi*								0.1	2						
lin	Myrtaceae	*Syncarpia glomulifera*	Turpentine	15													
lin	Myrtaceae	*Tristaniopsis laurina*	Kanooka			10						1	1				
HTW	Ochnaceae	*Ochna serrulata*	Mickey Mouse Plant					0.3	50					1	5		
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet			10						0.1	1				
lin	Oleaceae	*Notelaea longifolia*	Large Mock-olive											1	5		
lin	Oxalidaceae	*Oxalis perennans*						0.1	50								
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily	5													
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush			0.1	3	0.2	1			1	2			2	10
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree					5				5					
lin	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	0.1	5												
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn											3	8	5	10
lin	Plantaginaceae	*Veronica spp.*						0.1	2								
lin	Poaceae	*Austrodanthonia racemosa*	Wallaby Grass							5							
lin	Poaceae	*Cynodon dactylon*	Common Couch									50					
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass					0.1	5								
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass					0.1	2								
lin	Poaceae	*Entolasia marginata*	Bordered Panic									3	50				

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lin	Poaceae	*Entolasia stricta*	Wiry Panic		1						5				1	10		
lin	Poaceae	*Hemarthria uncinata*	Matgrass										10					
lin	Poaceae	*Imperata cylindrica*	Blady Grass				0.5	10										
lin	Poaceae	*Microlaena stipoides*	Weeping Grass						10		1	100			0.1	1	10	
lin	Poaceae	*Oplismenus aemulus*			1	50			50		0.5	100	0.1	5				
lin	Poaceae	*Panicum simile*	Two-colour Panic						70									
HTW	Poaceae	*Paspalum dilatatum*	Paspalum						0.1	20								
lin	Poaceae	*Poa affinis*			0.2	100			0.1	5								
lin	Polygonaceae	*Persicaria strigosa*											0.1	10				
lin	Polygonaceae	*Persicaria subsessilis*	Hairy Knotweed		0.5	60												
lin	Primulaceae	*Myrsine variabilis*													0.1	1	1	2
lin	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung		0.1	1												
lin	Ranunculaceae	*Clematis aristata*	Old Man's Beard						0.1	5	0.1	1						
lin	Rhamnaceae	*Alphitonia excelsa*	Red Ash										1	2			10	
lin	Rosaceae	*Rubus molluccanus var. trilobus*	Molucca Bramble						0.1	60								
lin	Rubiaceae	*Galium spp.*							1	3								
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda						25		0.2	10	2	3	20			
lin	Rubiaceae	*Opercularia diphylla*	Stinkweed				0.1	2										
lin	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla		0.1	1	5								0.1	1		
lin	Solanaceae	*Duboisia myoporoides*	Corkwood								1	10					1	3
*	Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush						0.1	3								
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade				0.1	3										
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade				1	2										
lin	Ulmaceae	*Trema tomentosa*	Native Peach				1	8										
HTW	Verbenaceae	*Lantana camara*	Lantana										5	5			10	
lin	Vitaceae	*Cayratia clematidea*	Native Grape				0.1	3	0.1	5								
lin	Vitaceae	*Cissus hypoglauca*	Giant Water Vine				15		5									

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				DS117	DS117	DS118	DS118
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower	0.1	2		
lin	Apiaceae	*Daucus glochidiatus*	Native Carrot			0.1	5
lin	Araliaceae	*Astrotricha spp.*		0.1	1		
HTW	Asteraceae	*Ageratina adenophora*	Crofton Weed			0.1	1
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs			0.1	5
lin	Asteraceae	*Centipeda cunninghamii*	Common Sneezeweed			0.1	5
*	Asteraceae	*Cirsium vulgare*	Spear Thistle			0.1	1
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	0.1	2	0.1	5
lin	Asteraceae	*Euchiton sp.*				0.5	35
lin	Blechnaceae	*Doodia aspera*	Prickly rasp fern	0.1	10		
*	Brassicaceae	*Brassica sp.*	A Mustard			0.1	2
*	Brassicaceae	*Rorippa palustris*	Marsh Watercress			0.1	2
lin	Casuarinaceae	*Casuarina cunninghamiana*	River Oak	2	1	10	0
*	Commelinaceae	*Tradescantia albiflora*	Wandering Jew			5	100
HTW	Cyperaceae	*Cyperus eragrostis*	Umbrella Sedge			0.1	5
*	Fabaceae (Caesalpinioideae)	*Gladitsia triacanthos*	Honey Locust	0.5	5	5	5
lin	Fabaceae (Mimosoideae)	*Acacia binervia*	Coast Myall			1	1
lin	Fabaceae (Mimosoideae)	*Acacia floribunda*	White Sally	0.5	1		
lin	Fabaceae (Mimosoideae)	*Acacia longifolia*		0.5	2		
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1	2		
lin	Juncaceae	*Juncus usitatus*				0.1	1
lin	Lauraceae	*Cassytha glabella*		0.1	1		
lin	Lindsaeaceae	*Lindsaea linearis*	Screw Fern	0.1	5		
lin	Lomandraceae	*Lomandra fluviatilis*		3	25		
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	3	4	1	15
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	0.1	2		
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple	2	2		
lin	Myrtaceae	*Austromyrtus tenuifolia*		5	15		
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle	5	8		
lin	Myrtaceae	*Tristaniopsis laurina*	Kanooka	25	0	10	0
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	2	25	10	0
lin	Oxalidaceae	*Oxalis perennans*	Oxalis			0.1	1
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily	0.1	2		
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree	10	0	5	5
lin	Poaceae	*Aristida sp.*				5	150
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass			5	150
lin	Poaceae	*Entolasia stricta*	Wiry Panic	2	55	0.5	25
lin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass	0.1	5		
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass	0.1	2		
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass			0.5	5
lin	Polygonaceae	*Persicaria decipiens*	Slender Knotweed			1	45
lin	Polygonaceae	*Persicaria praetermissa*				0.1	4
lin	Potamogetonaceae	*Potamogeton ochreatus*	Blunt Pondweed			0.1	1

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lin	Proteaceae	*Lomatia myricoides*		0.1	1		
lin	Pteridaceae	*Adiantum aethiopicum*	Common Maidenhair	0.2	15	1	55
lin	Rubiaceae	*Gynochthodes jasminoides*	Sweet Morinda	0.1	2	1	5
*	Sapindaceae	*Acer negundo*	Box Elder			0.1	1
lin	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla	0.2	1		
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade			0.1	1
lin	Violaceae	*Viola hederacea*				2	250

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				DS4	DS4	DS18	DS18
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A
*	Apocynaceae	*Gonocarpus sp.*				1	100
lin	Araliaceae	*Hydrocotyle laxiflora*	Stinking Pennywort	0.1	20		
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs	0.3	500		
lin	Campanulaceae	*Lobelia purpurascens*	Whiteroot	0.25	100	1	1200
lin	Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak			1	10
lin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush	0.1	5		
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew	0.01	2		
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed	0.2	100		
lin	Convolvulaceae	*Polymeria calycina*		0.1	20		
lin	Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge	0.01	1		
lin	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge			2	20
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge			1	30
lin	Dennstaedtiaceae	*Pteridium esculentum*	Common Bracken	2	20	4	50
lin	Ericaceae (Epacridoideae)	*Epacris pulchella*	Wallum Heath			1	1
lin	Fabaceae (Faboideae)	*Daviesia squarrosa*				1	150
lin	Fabaceae (Faboideae)	*Desmodium rhytidophyllum*				1	1
lin	Fabaceae (Faboideae)	*Dillwynia floribunda*				1	1
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining glycine	0.05	5		
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine	0.2	1000		
lin	Fabaceae (Faboideae)	*Hardenbergia violacea*	False Sarsaparilla			1	1
lin	Fabaceae (Faboideae)	*Pultanea sp (s)*	Bush-pea			1	1
lin	Fabaceae (Faboideae)	*Viminaria juncea*	Native Broom			1	20
lin	Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle	3	8		
lin	Fabaceae (Mimosoideae)	*Acacia floribunda*	White Sally	5	5		
lin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia			1	25
lin	Lomandraceae	*Lomandra filiformis subsp. coriacea*	Wattle Matt-rush			1	500
lin	Lomandraceae	*Lomandra gracilis*				1	200
lin	Lomandraceae	*Lomandra obliqua*				2	3000
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	0.2	50		
lin	Malvaceae	*Lasiopetalum ferrugineum*				1	50
lin	Moraceae	*Ficus spp.*		0.1	1		
lin	Myrtaceae	*Angophora bakeri*	Narrow-leaved Apple	3.5	5	1	50
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple	5	4		
lin	Myrtaceae	*Corymbia eximia*	Yellow Bloodwood	10	10	35	12
lin	Myrtaceae	*Eucalyptus punctata*	Grey Gum			10	1
lin	Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree			3	25
lin	Oxalidaceae	*Oxalis perennans*	Oxalis	0.1	1		
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily			1	10
lin	Phormiaceae	*Dianella longifolia*	Blue Flax-Lily			1	50
lin	Phormiaceae	*Dianella revoluta*	Blueberry Lily			1	30
lin	Phyllanthaceae	*Glochidion ferdinandi var. ferdinandi*				1	1
lin	Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge			1	400

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lin	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry			1	25
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	0.25	4	1	1
lin	Poaceae	*Aristida vagans*	Threeawn Speargrass			1	300
	Poaceae	*Entolasia spp.*		2.5	500		
lin	Poaceae	*Entolasia stricta*	Wiry Panic			20	600
lin	Poaceae	*Imperata cylindrica*	Blady Grass	0.1	50	10	100
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	45	500	10	1200
lin	Poaceae	*Oplismenus aemulus*	Australian Basket Grass	2.5	500		
lin	Poaceae	*Themeda triandra*				20	600
lin	Polygonaceae	*Rumex brownii*	Swamp Dock	0.05	5		
lin	Proteaceae	*Grevillea mucronulata*				1	25
lin	Proteaceae	*Persoonia ?linifolia*	Geebung			1	3
lin	Rosaceae	*Rubus parvifolius*	Native Raspberry	0.1	5		
lin	Rubiaceae	*Pomax umbellata*	Pomax			1	150
lin	Rutaceae	*Phebalium squamulosum*	Scaly Phebalium			1	5
lin	Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush			1	2
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade	0.1	4		

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				DS 28	DS 28	DS 29	DS 29	DS 3	DS 3	DS 30	DS 30	DS 31	DS 31	DS 32	DS 32	DS 33	DS 33	DS 34	DS 34	DS 35	DS 35	DS 36	DS 36	DS 37	DS 37	DS 38	DS 38	DS 39	DS 39	DS 40	DS 40	DS 41	DS 41	DS 42	DS 42	DS 43	DS 43	DS 44	DS 44	DS 45	DS 45
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
lin		*Shrub white flowers*						10	5																																
lin	Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower													0.1	1	0.3	30	0.1	2																	0.1	5		
lin	Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair							0.5	30					0.3	60			0.2	20					0.1	10														
lin	Adiantaceae	*Adiantum hispidulum*	Rough Maidenhair							0.1	3																														
lin	Apiaceae	*Centella asiatica*	Indian Pennywort																			0.1	15							5											
*	Apiaceae	*Hydrocotyle bonariensis*																				0.5	15																		
lin	Apiaceae	*Hydrocotyle peduncularis*																																		0.5	100	5			
lin	Apiaceae	*Hydrocotyle spp.*						0.1	1																																
HTW	Apocynaceae	*Araujia sericifera*	Moth Vine	0.1	2																			25								0.3	60							0.3	4
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod					0.1	10																																
HTW	Asparagaceae	*Asparagus aethiopicus*	Asparagus Vine	0.1	10					0.2	20																														
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs	0.5	100									0.1	2																			0.1	3						
lin	Asteraceae	*Cassinia spp. A*						2.5	5																																
lin	Asteraceae	*Cassinia spp. B*						1	1																																
*	Asteraceae	*Cirsium vulgare*	Spear Thistle																											0.1	10										
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane											0.5	10							0.2	5			0.1	1			0.5	50			1	300	5		0.5	100	0.2	100
*	Asteraceae	*Conyza spp.*										0.1	3																	0.1	1										
HTW	Asteraceae	*Delairea odorata*	Cape Ivy																					1	20																
lin	Asteraceae	*Euchiton spp.*	A Cudweed																											0.1	3										
*	Asteraceae	*Hypochaeris radicata*	Catsear									0.1	15	0.6	20							0.5	25							0.2	40										
lin	Asteraceae	*Sigesbeckia orientalis*	Indian Weed																											0.1	3										
*	Asteraceae	*Sonchus asper*	Prickly Sowthistle																															0.1	1	0.1	5				
*	Asteraceae	*Sonchus oleraceus*	Common Sowthistle					0.1	100																																
lin	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine													0.2	30							0.1	3							0.3	150								
lin	Blechnaceae	*Doodia aspera*																		0.2	30																				
lin	Campanulaceae	*Pratia purpurascens*	Whiteroot																																			0.1	5		
lin	Campanulaceae	*Pratia spp.*						0.1	100																																
lin	Campanulaceae	*Wahlenbergia gracilenta*	Annual Bluebell																											0.1	1										
*	Caryophyllaceae	*Stellaria media*	Common Chickweed					0.5	100																																

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lin	Casuarinaceae	*Casuarina cunninghamiana*	River Oak	10		10				2	1			10				0.5				60		20		10						20				30		10		10	
lin	Casuarinaceae	*Casuarina cunninghamiana subsp. cunninghamiana*	River Oak					3	1																																
lin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush									2	60																	0.1	6			0.1	1						
lin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew																	0.1	2																				
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew	2	50	40								5		0.2	50	0.3		5	10			80				5				20		10						5	
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed					0.5	1															0.2	20																
HTW	Convolvulaceae	*Ipomoea indica*	Morning Glory															0.1	1	0.1	1																				
lin	Cunoniaceae	*Callicoma serratifolia*	Black Wattle																																			0.1	5		
lin	Cyperaceae	*Carex spp.*																				0.1	1							0.1	1										
lin	Cyperaceae	*Gahnia aspera*	Rough Saw-sedge																											0.1	1							0.2	6		
lin	Dawsoniaceae	*Dawsonia polytrichoides*						0.1	100																																
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	0.1		0.1	10	0.1	50															5								1	100	5				10		1	50
lin	Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern																							0.1	3									0.2	20	15			
lin	Dryopteridaceae	*Lastreopsis microsora*	Creeping Shield Fern																									0.1	10												
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining Glycine					0.01	5																																
lin	Fabaceae (Faboideae)	*Glycine microphylla*	Small-leaf Glycine																					0.1	1									0.1	1						
lin	Fabaceae (Faboideae)	*Glycine tabacina*	Variable Glycine			0.1	1			0.1	1			0.1	20	0.1	1	0.1	1	0.1	2	0.1	5	0.1	1					0.1	1			0.1	2	0.1	1				
*	Fabaceae (Faboideae)	*Trifolium repens*	White Clover											0.5	10							0.5	10																		
lin	Fabaceae (Mimosoideae)	*Acacia binervata*	Two-veined Hickory																									10				20									
lin	Fabaceae (Mimosoideae)	*Acacia filicifolia*	Fern-leaved Wattle	0.5	1																																				
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle																																			10		10	
lin	Fabaceae (Mimosoideae)	*Acacia spp.*		0.1	5																									0.1	10										
lin	Geraniaceae	*Geranium solanderi*	Native Geranium																											1	50	0.1	50							0.3	50
lin	Juncaceae	*Juncus continuus*																																				0.1	5		
lin	Juncaceae	*Juncus spp.*																				0.1	1																		
lin	Juncaceae	*Juncus usitatus*																												0.1	3					0.1	5				
lin	Lamiaceae	*Clerodendrum tomentosum*	Hairy Clerodendrum					1	3																																
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush					0.1	1							0.2	20	0.1	1					0.2	1							0.3	20			0.2	10	0.2	5		

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lin	Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry															0.1	2	0.1	1																				
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	0.2	25			0.05	5	0.2	6					1	30	0.2	33	0.1	2					0.1	3														
*	Malvaceae	*Modiola caroliniana*	Red-flowered Mallow																											0.1	1										
*	Malvaceae	*Sida rhombifolia*	Paddy's Lucerne											0.2	20							0.5	14	5						0.5	100	0.2	100	0.2	50	0.2	50			0.1	10
lin	Meliaceae	*Melia azedarach*	White Cedar																													0.1	1								
lin	Menispermaceae	*Sarcopetalum harveyanum*	Pearl Vine													0.2	30	1	3									0.1	1												
lin	Menispermaceae	*Stephania japonica*	Snake Vine					0.1	10							0.2	20	0.5	5					2	50	0.1	10			2	20	0.3	40					2	50	0.2	30
lin	Moraceae	*Ficus coronata*	Creek Sandpaper Fig			25		3	1							0.1	1	0.5	2	1	20			0.5	2	15		1	1	10		8									
lin	Myrtaceae	*Acmena smithii*	Lilly Pilly							0.1	1					70		70		20				5								5									
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple					6	3					5																											
lin	Myrtaceae	*Backhousia myrtifolia*	Grey Myrtle															5														5									
lin	Myrtaceae	*Callistemon spp.*						5	3																																
lin	Myrtaceae	*Corymbia gummifera*	Red Bloodwood																							5															
lin	Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum					2	1					50						20																					
lin	Myrtaceae	*Eucalyptus elata*	River Peppermint	20		15		3	4	25		15		30		15						30		0.1	1	20		25		20		40		30						35	
lin	Myrtaceae	*Kunzea ambigua*	Tick Bush																																	60		20			
lin	Myrtaceae	*Leptospermum polygalifolium*	Tantoon																																	2	25	60			
lin	Myrtaceae	*Leptospermum spp.*	Tea-tree					2.5	7																																
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark													1	1	0.5	2	5				5		0.5	1			0.4	2	30								40	
lin	Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree																							5															
lin	Myrtaceae	*Syncarpia glomulifera*	Turpentine																	5																					
lin	Myrtaceae	*Tristaniopsis laurina*	Kanooka					5	5																															20	
HTW	Ochnaceae	*Ochna serrulata*	Mickey Mouse Plant	0.2	20					10																														0.1	1
HTW	Oleaceae	*Ligustrum lucidum*	Large-leaved Privet	5						15								1	100					1	3			10													
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	5						70				20		0.5				5				60		50		75		2	60										
HTW	Oleaceae	*Olea europaea*	Common Olive	10		2	3																																		
lin	Oxalidaceae	*Oxalis perennans*				0.1	1			0.1	1			0.1	4	0.1	3					0.5	50	0.1	1					0.3				0.1	2	0.1	5			0.5	100
lin	Oxalidaceae	*Oxalis spp.*						0.25	1000																							0.1	100								

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lin	Passifloraceae	*Passiflora spp.*																										0.1	1												
lin	Phormiaceae	*Dianella longifolia*	Blueberry Lily															0.1	1																						
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush													0.2	50	0.2	50					0.5	2							0.2	10							0.3	20
lin	Phyllanthaceae	*Glochidion ferdinandi*	Cheese Tree							10								0.5	5	1	4																				
lin	Phyllanthaceae	*Poranthera microphylla*	Small Poranthera					0.1	50																																
lin	Pittosporaceae	*Bursaria spinosa*	Native Blackthorn					0.1	5																																
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues									0.1	1																	0.2	40							0.1	100		
HTW	Poaceae	*Andropogon virginicus*	Whisky Grass																											0.5	2										
lin	Poaceae	*Austrodanthonia racemosa*	Wallaby Grass											15																											
lin	Poaceae	*Austrodanthonia spp.*																																1	10						
lin	Poaceae	*Austrostipa ramosissima*	Stout Bamboo Grass	0.1	20							0.1	1											5		0.1	5			5		0.2	50							0.5	80
HTW	Poaceae	*Axonopus fissifolius*	Narrow-leafed Carpet Grass					0.1	10					50		0.1	10					15								85											
*	Poaceae	*Briza minor*	Shivery Grass					0.1	10																																
lin	Poaceae	*Cynodon dactylon*	Common Couch									60		5								10										30		80		30		20		30	
lin	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass																											0.1	5										
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass			0.5	50																							5								25			
lin	Poaceae	*Entolasia marginata*	Bordered Panic																																					5	
lin	Poaceae	*Eragrostis brownii*	Brown's Lovegrass									0.1	15	0.5	8																										
HTW	Poaceae	*Eragrostis curvula*	African Lovegrass									0.5	15	5																											
lin	Poaceae	*Imperata cylindrica*	Blady Grass																					3	14																
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	2	40			60	1000	5		5		5				0.1	4			70		5		5						30		5		5				10	
lin	Poaceae	*Oplismenus aemulus*		10				10	500	0.1	10					1	100	0.5	10	0.2	12			0.5	10	0.5	20	0.1	5	0.1	5	20				5				10	
lin	Poaceae	*Oplismenus imbecillis*						2	200																																
HTW	Poaceae	*Paspalum dilatatum*	Paspalum											5								30		5						25				5		20		1	100		
*	Poaceae	*Pennisetum clandestinum*	Kikuyu Grass											10																10						5					
*	Poaceae	*Setaria gracilis*																				3	100							3	30										
lin	Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass																			5																			
lin	Polygonaceae	*Persicaria decipiens*	Slender Knotweed																																	10					
lin	Polygonaceae	*Rumex brownii*	Swamp Dock																			0.1	16																		
*	Polygonaceae	*Rumex crispus*	Curled Dock									0.1	2																												

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*	Primulaceae	*Anagallis arvensis*	Scarlet Pimpernel																			0.4	30																		
lin	Primulaceae	*Rapanea variabilis*																0.1	3																						
lin	Proteaceae	*Lomatia myricoides*	River Lomatia															0.1	3																						
lin	Proteaceae	*Stenocarpus salignus*	Scrub Beefwood																													10									
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern					0.05	20																																
lin	Ranunculaceae	*Clematis aristata*	Old Man's Beard					0.25	10																																
HTW	Rosaceae	*Rubus fruticosus*	Blackberry Complex																																			2	3	0.3	4
lin	Rosaceae	*Rubus moluccanus*	Molucca Bramble																					0.2	1																
lin	Rosaceae	*Rubus parvifolius*	Native Raspberry					0.01	5																													2	50		
lin	Rosaceae	*Rubus rosifolius*	Rose-leaf Bramble	0.2	30																											0.4	50								
lin	Rubiaceae	*Morinda jasminoides*	Sweet Morinda			30				0.2	2					5	100	5	80	5						0.2	10											0.1	1	0.5	5
lin	Rubiaceae	*Opercularia diphylla*	Stinkweed															0.1	2																						
HTW	Simaroubaceae	*Ailanthus altissima*	Tree of Heaven					8	5																																
lin	Smilacaceae	*Smilax glyciphylla*	Sweet Sarsaparilla			0.1	1									0.2	20	8								5															
*	Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush	2	7	0.1	2																	0.1	3					0.1	1	0.2	10	40		0.2	2			1	20
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade																											0.2	25			5						0.5	10
lin	Solanaceae	*Solanum prinophyllum*	Forest Nightshade																											0.1	1	0.1	1								
*	Solanaceae	*Solanum pseudocapsicum*	Madeira Winer Cherry																																	0.2	20				
lin	Ulmaceae	*Trema tomentosa*	Native Peach																					5						0.1	4										
HTW	Verbenaceae	*Lantana camara*	Lantana	75		65		15	20	35		0.1	2			4	3	0.1	1	0.2	3			0.2	3					1		0.3		20						1	10
*	Verbenaceae	*Verbena bonariensis*	Purpletop																			0.5	30															0.1	10	0.1	20
*	Verbenaceae	*Verbena rigida*	Veined Verbena									0.2	35																												
lin	Vitaceae	*Cayratia clematidea*	Native Grape									0.1	1			0.1	100							0.3	3							0.4	5								
lin	Vitaceae	*Cayratia spp.*																																						0.2	30
lin	Vitaceae	*Cissus antarctica*	Water Vine																							5															
lin	Vitaceae	*Cissus hypoglauca*	Giant Water Vine			2	6	2.5	5	5						0.2	3	1	20	5																					

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				DS9	DS9
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A
lin	Apiaceae	*Actinotus helianthi*	Flannel Flower	0.1	12
lin	Apiaceae	*Trachymene incisa*	Trachmene	0.1	30
lin	Campanulaceae	*Pratia purpurascens*	Whiteroot	10	200
lin	Casuarinaceae	*Allocasuarina littoralis*	Black She-oak	5	18
lin	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	2	20
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	5	50
lin	Ericaceae	*Leucopogon muticus*	Blunt Beard-heath	0.1	4
lin	Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses	0.1	3
lin	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia	10	200
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	1	50
lin	Lomandraceae	*Lomandra obliqua*		0.1	50
lin	Lomandraceae	*Lomandra filiformis*	Wattle matt-rush	50	1000
lin	Myrtaceae	*Eucalyptus punctata*	Grey Gum	15	2
lin	Myrtaceae	*Corymbia eximia*	Yellow Bloodwood	5	5
lin	Myrtaceae	*Angophora bakeri*	Narrow-leaved Apple	5	4
lin	Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree	25	40
lin	Phormiaceae	*Dianella caerulea*	Blue Flax-lily	0.1	3
lin	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	0.1	8
lin	Poaceae	*Eragrostis marginata*		5	200
lin	Poaceae	*Aristida vagans*	Threeawn Speargrass	2	100
lin	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung	0.1	5
lin	Pteridaceae	*Cheilanthes sieberi*	Rock Fern	0.1	50
lin	Rubiaceae	*Pomax umbellata*	Pomax	0.1	7
lin	Santalaceae	*Exocarpos strictus*	Dwarf Cherry	0.2	9

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				DS17	DS17
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A
lin	Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	1	15
lin	Apiaceae	*Centella asiatica*	Indian Pennywort	1	500
lin	Apiaceae	*Hydrocotyle sibthorpioides*		1	50
lin	Apocynaceae	*Parsonsia straminea*	Common Silkpod	1	10
lin	Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine	1	3
lin	Campanulaceae	*Pratia purpurascens*	Whiteroot	10	200
lin	Convolvulaceae	*Dichondra repens*	Kidney Weed	2	1500
lin	Cyperaceae	*Carex sieberii*		1	20
lin	Cyperaceae	*Schoenus melanostachys*		25	150
lin	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	3	200
lin	Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash	1	1
lin	Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil	1	200
lin	Fabaceae (Faboideae)	*Glycine clandestina*	Twining Glycine	2	800
lin	Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	1	5
lin	Haloragaceae	*Gonocarpus teucrioides*		1	50
lin	Lamiaceae	*Ajuga australis*	Austral Bugle	1	10
lin	Lauraceae	*Endiandra discolor*	Rose Walnut	1	1
lin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	1	25
lin	Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	1	100
lin	Menispermaceae	*Stephania japonica*	Snake Vine	1	10
lin	Myrtaceae	*Angophora floribunda*	Rough-barked Apple	15	5
lin	Myrtaceae	*Callistemon salignus*	Willow Bottlebrush	10	5
lin	Myrtaceae	*Eucalyptus robusta*	Swamp Mahogany	10	3
lin	Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark	20	10
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet	<1	2
lin	Oleaceae	*Notelaea longifolia*	Large Mock-olive	1	1
lin	Phormiaceae	*Dianella longifolia*	Blueberry Lily	1	25

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lin	Phormiaceae	*Dianella revoluta*	Blueberry Lily	2	100
lin	Phormiaceae	*Dianella caerulea var. producta*		2	100
lin	Phyllanthaceae	*Glochidion ferdinandi var. pubens*	Hairy Cheese Tree	10	10
lin	Pittosporaceae	*Pittosporum revolutum*	Rough Fruit Pittosporum	1	1
lin	Poaceae	*Entolasia marginata*	Bordered Panic	20	4000
lin	Poaceae	*Imperata cylindrica*	Blady Grass	1	150
lin	Poaceae	*Microlaena stipoides*	Weeping Grass	50	4000
lin	Poaceae	*Oplismenus aemulus*		10	1200
lin	Poaceae	*Oplismenus imbecillis*		10	1200
lin	Rosaceae	*Rubus parvifolius*	Native Raspberry	1	50
lin	Rubiaceae	*Morinda jasminoides*	Sweet Morinda	25	250
lin	Rutaceae	*Melicope sp.*		1	1
HTW	Verbenaceae	*Lantana camara*	Lantana	1	1
lin	Vitaceae	*Cayratia clematidea*	Native Grape	1	2
lin		Sample hairy stipule		1	1

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				DS5	DS5	DS6	DS6	DS8	DS8
STATUS	FAMILY	GENUS SPECIES	COMMON NAME	C	A	C	A	C	A
HTW	Amaranthaceae	*Alternanthera philoxeroides*	Alligator Weed			20	1000	0.01	1
Iin	Apiaceae	*Centella asiatica*	Indian Pennywort	0.1	10				
*	Apiaceae	*Ciclospermum leptophyllum*	Slender Celery			0.1	10		
HTW	Apocynaceae	*Araujia sericifera*	Moth Vine					0.1	5
Iin	Apocynaceae	*Parsonsia straminea*	Common Silkpod	5	10			0.5	5
*	Asteraceae	*Bidens pilosa*	Cobbler's Pegs	0.2	20	0.1	20	0.5	100
*	Asteraceae	*Cirsium vulgare*	Spear Thistle			0.01	1		
*	Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane			0.2	5		
*	Asteraceae	*Conyza canadensis*	Canadian Fleabane			0.1	3		
*	Asteraceae	*Conyza spp.*	A Fleabane					0.05	4
*	Asteraceae	*Senecio madagascariensis*	Fireweed					0.01	1
*	Asteraceae	*Sonchus asper*	Prickly Sowthistle	0.05	1				
*	Asteraceae	*Sonchus oleraceus*	Common Sowthistle			0.1	10		
*	Brassicaceae	*Hirschfeldia incana*	Buchan Weed			0.2	20		
*	Caryophyllaceae	*Cerastium glomeratum*	Mouse-ear Chickweed			2.5	50		
*	Caryophyllaceae	*Stellaria media*	Common Chickweed	0.1	20				
Iin	Casuarinaceae	*Casuarina cunninghamiana subsp. cunninghamiana*	River Oak	30	20	20	11	15	20
*	Chenopodiaceae	*Chenopodium ambrosioides*	Mexican Tea			0.1	5		
Iin	Chenopodiaceae	*Einadia hastata*	Berry Saltbush			0.1	1		
Iin	Commelinaceae	*Commelina cyanea*	Native Wandering Jew			0.1	5	0.1	10
HTW	Commelinaceae	*Tradescantia fluminensis*	Wandering Jew	30	1000	0.5	50	1	50
Iin	Cyperaceae	*Carex appressa*	Tall Sedge	1	10				
*	Euphorbiaceae	*Euphorbia peplus*	Petty Spurge					0.05	3
*	Fabaceae (Faboideae)	*Vicia spp.*	Vetch			0.1	5		
Iin	Fabaceae (Mimosoideae)	*Acacia decurrens*	Black Wattle			0.5	2		
Iin	Fabaceae (Mimosoideae)	*Acacia elata*	Mountain Cedar Wattle					0.2	2
Iin	Goodeniaceae	*Goodenia ovata*	Hop Goodenia					0.5	3
Iin	Juncaceae	*Juncus spp.*	A Rush	0.5	5			0.01	1
Iin	Juncaceae	*Juncus usitatus*				0.25	5		
Iin	Lamiaceae	*Plectranthus parviflorus*						0.5	50
Iin	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush			1	4	0.5	4
Iin	Menispermaceae	*Stephania japonica*	Snake vine	2.5	10				
Iin	Moraceae	*Ficus coronata*	Creek Sandpaper Fig					5	10
Iin	Myrtaceae	*Callistemon salignus*	Willow Bottlebrush	7	5				
Iin	Myrtaceae	*Callistemon spp.*						3	5
Iin	Myrtaceae	*Eucalyptus deanei*	Mountain Blue Gum					6	4
Iin	Myrtaceae	*Tristaniopsis laurina*	Kanooka	2.5	1				
		Acacia implexa maybe binervia						0.2	2
		Asp asparag		0.01	1				
		Cydosperma lept		0.1	20				
		gol? Ap?		0.2	20				
		Grass 1		20	500				

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		Grass 2		10	500				
		Pink		0.1	10				
		weed		0.1	10				
		Yellow		0.01	1				
HTW	Oleaceae	*Ligustrum sinense*	Small-leaved Privet					0.1	2
lin	Oxalidaceae	*Oxalis perennans*				0.1	10		
lin	Oxalidaceae	*Oxalis spp.*		0.05	1				
lin	Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush					0.2	2
lin	Pittosporaceae	*Pittosporum undulatum*	Sweet Pittosporum					1	2
*	Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues			0.1	10		
lin	Plantaginaceae	*Veronica plebeia*	Trailing Speedwell					0.01	1
*	Poaceae	*Bromus catharticus*	Praire Grass			5	20	0.05	1
lin	Poaceae	*Cynodon dactylon*	Common Couch			20	1000		
HTW	Poaceae	*Ehrharta erecta*	Panic Veldtgrass			0.25	20	20	1000
*	Poaceae	*Lolium spp.*	A Ryegrass			10	50	0.5	100
lin	Poaceae	*Oplismenus aemulus*						5	1000
*	Poaceae	*Setaria parviflora*				0.25	20	0.2	20
HTW	Polygonaceae	*Acetosa sagittata*	Rambling Dock					0.04	3
*	Polygonaceae	*Rumex crispus*	Curled Dock			0.3	3		
lin	Polygonaceae	*Rumex spp.*	Dock	0.1	20				
*	Primulaceae	*Lysimachia arvensis*	Scarlet Pimpernel			0.2	3		
lin	Ranunculaceae	*Clematis glycinoides*	Headache Vine					0.1	3
*	Rubiaceae	*Galium aparine*	Goosegrass			0.1	1		
lin	Rubiaceae	*Opercularia aspera*	Coarse Stinkweed					5	10
HTW	Sapindaceae	*Acer negundo*	Box Elder			0.1	1		
HTW	Sapindaceae	*Cardiospermum grandiflorum*	Balloon Vine					0.2	5
*	Sapindaceae	*Cardiospermum halicacabum*	Small Balloon Vine			0.1	1		
*	Solanaceae	*Solanum nigrum*	Black-berry Nightshade	0.2	20			0.05	1
lin	Ulmaceae	*Trema tomentosa*	Native Peach					10	20
*	Verbenaceae	*Verbena bonariensis*	Purpletop			0.5	3	0.02	2
lin	Vitaceae	*Cayratia spp.*		0.2	5				

Appendix E Fauna species list

Fauna species list

Common Name	Scientific Name	NSW Status	Comm Status	Confidence (bats only)
Birds (103)				
Striated Thornbill	*Acanthiza lineata*			
Yellow Thornbill	*Acanthiza nana*			
Brown Thornbill	*Acanthiza pusilla*			
Eastern Spinebill	*Acanthorhynchus tenuirostris*			
Common Myna	*Acridotheres tristis**			
Azure Kingfisher	*Alcedo azurea*			
Australian King Parrot	*Alisterus scapularis*			
Chestnut Teal	*Anas castanea*			
Grey Teal	*Anas gracilis*			
Australasian Shoveler	*Anas rhynchotis*			
Pacific Black Duck	*Anas superciliosa*			
Australasian Darter	*Anhinga novaehollandiae*			
Domestic goose	*Anser* sp.*			
Red Wattlebird	*Anthochaera carunculata*			
Little Wattlebird	*Anthochaera chrysoptera*			
Fork-tailed Swift	*Apus pacificus*		M	
Wedge-tailed Eagle	*Aquila audax*			
Great Egret	*Ardea alba*			
Intermediate Egret	*Ardea intermedia*			
White-necked Heron	*Ardea pacifica*			
Hardhead	*Aythya australis*			
Cattle Egret	*Bubulcus ibis*			
Sulphur-crested Cockatoo	*Cacatua galerita*			
Little Corella	*Cacatua sanguinea*			
Fan-tailed Cuckoo	*Cacomantis flabelliformis*			
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*			
Australian Wood Duck	*Chenonetta jubata*			
Golden-headed Cisticola	*Cisticola exilis*			
Grey Shrike-thrush	*Colluricincla harmonica*			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*			
White-throated Treecreeper	*Cormobates leucophaea*			
Australian Raven	*Corvus coronoides*			
Pied Butcherbird	*Cracticus nigrogularis*			

Common Name	Scientific Name	NSW Status	Comm Status	Confidence (bats only)
Australian Magpie	*Cracticus tibicen*			
Grey Butcherbird	*Cracticus torquatus*			
Black Swan	*Cygnus atratus*			
Laughing Kookaburra	*Dacelo novaeguineae*			
Varied Sittella	*Daphoenositta chrysoptera*	V		
White-faced Heron	*Egretta novaehollandiae*			
Black-shouldered Kite	*Elanus axillaris*			
Black-fronted Dotteral	*Elseyornis melanops*			
Galah	*Eolophus roseicapilla*			
Eastern Yellow Robin	*Eopsaltria australis*			
Dollarbird	*Eurystomus orientalis*			
Eurasian Coot	*Fulica atra*			
Dusky Moorhen	*Gallinula tenebrosa*			
Bar-shouldered Dove	*Geopelia humeralis*			
Peaceful Dove	*Geopelia placida*			
Brown Gerygone	*Gerygone mouki*			
White-throated Gerygone	*Gerygone olivacea*			
Magpie-lark	*Grallina cyanoleuca*			
White-bellied Sea-eagle	*Haliaeetus leucogaster*	V		
Black-winged Stilt	*Himantopus himantopus*			
Welcome Swallow	*Hirundo neoxena*			
Wonga Pigeon	*Leucosarcia melanoleuca*			
Yellow-faced Honeyeater	*Lichenostomus chrysops*			
Brown Cuckoo-dove	*Macropygia phasianella*			
Superb Fairy-wren	*Malurus cyaneus*			
Noisy Miner	*Manorina melanocephala*			
Bell Miner	*Manorina melanophrys*			
Little Grassbird	*Megalurus gramineus*			
Lewins Honeyeater	*Meliphaga lewinii*			
White-naped Honeyeater	*Melithreptus lunatus*			
Superb Lyrebird	*Menura novaehollandiae*			
Little Pied Cormorant	*Microcarbo melanoleucos*			
Satin Flycatcher	*Myiagra cyanoleuca*		M	
Red-browed Finch	*Neochmia temporalis*			
White-eared Honeyeater	*Nesoptilotis leucotis*			

Common Name	Scientific Name	NSW Status	Comm Status	Confidence (bats only)
Southern Boobook	*Ninox boobook*			
Olive-backed Oriole	*Oriolus sagittatus*			
Rufous Whistler	*Pachycephala rufiventris*			
Spotted Pardalote	*Pardalotus punctatus*			
Striated Pardalote	*Pardalotus striatus*			
House Sparrow	*Passer domesticus**			
Australian Pelican	*Pelecanus conspicillatus*			
Fairy Martin	*Petrochelidon ariel*			
Great Cormorant	*Phalacrocorax carbo*			
Little Black Cormorant	*Phalacrocorax sulcirostris*			
Pied Cormorant	*Phalacrocorax varius*			
Common Bronzewing	*Phaps chalcoptera*			
Noisy Friarbird	*Philemon corniculatus*			
White-cheeked Honeyeater	*Phylidonyris niger*			
Yellow-billed Spoonbill	*Platalea flavipes*			
Royal Spoonbill	*Platalea regia*			
Eastern Rosella	*Platycercus eximius*			
Purple Swamphen	*Porphyrio porphyrio*			
Eastern Whipbird	*Psophodes olivaceus*			
Satin Bowerbird	*Ptilonorhynchus violaceus*			
Red-whiskered Bul-bul	*Pycnonotus jocosus**			
Red-necked Avocet	*Recurvirostra novaehollandiae*			
Grey Fantail	*Rhipidura albiscapa*			
Willie Wagtail	*Rhipidura leucophrys*			
White-browed Scrub-wren	*Sericornis frontalis*			
Pied Currawong	*Strepera graculina*			
Australasian Grebe	*Tachybaptus novaehollandiae*			
Australian White Ibis	*Threskiornis moluccus*			
Straw-necked Ibis	*Threskiornis spinicollis*			
Sacred Kingfisher	*Todiramphus sanctus*			
Rainbow Lorikeet	*Trichoglossus moluccanus*			
Common Blackbird	*Turdus merula**			
Masked Lapwing	*Vanellus miles*			
Bassian Thrush	*Zoothera lunulata*			
Silvereye	*Zosterops lateralis*			

Common Name	Scientific Name	NSW Status	Comm Status	Confidence (bats only)
Mammals (31)				
Unidentified antechinus	*Antechinus* sp.			
White-striped Freetail-bat	*Austronomus australis*			C
Cow	*Bos taurus**			
Dog	*Canis lupus familiaris**			
Red Deer	*Cervus elaphus**			
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	C/Pr
Gould's Wattled Bat	*Chalinolobus gouldii*			C
Chocolate Wattled Bat	*Chalinolobus morio*			C
Horse	*Equus caballus**			
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		C/Pr/Po
Common Wallaroo	*Macropus robustus*			
Little Bentwing-bat	*Miniopterus australis*	V		C
Eastern Bentwing Bat	*Miniopterus schreibersii oceanensis*	V		C/Pr
Eastern Freetail-bat	*Mormopterus norfolkensis*	V		C/Pr
Eastern Free-tailed Bat	*Mormopterus ridei*			C
Southern Myotis	*Myotis macropus*	V		C/Pr/Po
Unidentified long-eared bat	*Nyctophilus* spp.			C/Pr
Sugar Glider	*Petaurus breviceps*			
Koala	*Phascolarctos cinereus*	V	V	
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	
Black Rat	*Rattus rattus**			
Eastern Horseshoe-bat	*Rhinolophus megaphyllus*			C
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		C/Pr/Po
Eastern Broad-nosed Bat	*Scotorepens orion*			C/Pr
Common Brushtail Possum	*Trichosurus vulpecula*			
Large Forest Bat	*Vespadelus darlingtoni*			C
Eastern Cave Bat	*Vespadelus troughtoni*	V		Pr
Little Forest Bat	*Vespadelus vulturnus*			C
Common Wombat	*Vombatus ursinus*			
Red Fox	*Vulpes vulpes**			
Swamp Wallaby	*Wallabia bicolor*			
Reptiles (3)				
Eastern Water Dragon	*Intellagama lesueurii*			
Red-bellied Black Snake	*Pseudechis porphyriacus*			

Common Name	Scientific Name	NSW Status	Comm Status	Confidence (bats only)
Unidentified long-necked turtle				
Amphibians (3)				
Common Eastern Froglet	*Crinia signifera*			
Striped Marsh Frog	*Limnodynastes peronii*			
Bibrons Toadlet	*Pseudophryne bibronii*			

Notes: E = Endangered; V = Vulnerable; * = Exotic; C = Confident; Pr = Probable; Po: Possible

Appendix F Assessments of significance (EP&A Act)

Contents

Assessments of significance

Threatened species and threatened ecological communities (TECs) assessed as having a reasonable likelihood to occur within the 10% AEP event and/or FMZ area, and with a 'Medium' or greater impact risk as a result of the Project are addressed in the following Seven Part Tests of Significance. These assessments have been conducted in accordance with section 5A of the EP&A Act. Refer to Section 6 for the full impact risk assessment. Comment with regard to the 10% AEP event and/or FMZ area is by way of exception with both having been considered for all matters as relevant.

The following threatened communities and species have been assessed as per the matters in the 'Seven Part Test':

Threatened ecological communities

- Castlereagh Swamp Woodland Community endangered ecological community (EEC)
- Cumberland Plain Woodland in the Sydney Basin Bioregion critically endangered ecological community (CEEC)
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC
- Shale Gravel Transition Forest in the Sydney Basin Bioregion EEC
- Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC
- Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC
- Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion CEEC
- Western Sydney Dry Rainforest CEEC

Threatened flora species

- Acacia pubescens (Downy Wattle)
- Callistemon linearifolius
- Dillwynia tenuifolia
- Epacris purpurascens var. purpurascens
- Eucalyptus benthamii (Camden White Gum)
- Eucalyptus sp. Cattai
- Grevillea juniperina subsp. juniperina (Juniper-leaved Grevillea)
- Hibbertia puberula
- Marsdenia viridiflora R. Br. subsp. viridiflora in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool, and Penrith LGAs
- Keraudrenia corollata var. denticulata endangered population in the Hawkesbury LGA
- Persoonia nutans (Nodding Geebung)
- Pilularia novae-hollandiae (Austral Pillwort)
- Pimelea curviflora var. curviflora
- Pimelea spicata (Spiked Rice-flower)
- Pomaderris brunnea (Brown Pomaderris)
- Pultenaea parviflora
- Rhodamnia rubescens (Scrub Turpentine)
- Senna acclinis (Rainforest Cassia)
- Zieria involucrata

Threatened fauna species

- Cumberland Plain Land Snail (*Meridolum corneovirens*)
- Dural Woodland Snail (*Pommerhelix duralensis*)
- Green and Golden Bell Frog (*Litoria aurea*)
- Regent Honeyeater (*Anthochaera phrygia*)

Where relevant, objectives or actions of a recovery plan or threat abatement plan have been identified. Comment on consistency with relevant objectives or actions of a recovery plan or threat abatement plan has been made by way of exception.

Definitions for key impact areas in relation to the extent of a TEC or potential threatened species habitat

- **10% AEP event:** the areas subject to reduced inundation events between the existing 10% AEP event and the predicted 10% AEP event scenario following the commencement of the Project.
- **FMZ discharge area:** the downstream area that would be affected by inundation during flood mitigation operations.

Downstream limit of Project influence

As the Hawkesbury River widens as it approaches the lower estuarine areas and tidal influences begin to dominate water levels closer to the ocean, potential downstream impacts decrease with distance downstream until they become negligible. Other influences on hydrology and water quality in the downstream catchment may also be significant, such as inflows from downstream catchments (for example, the Nepean River, Grose River, Macdonald River, and Colo River), runoff from rural and urban land uses, and the discharge of sewage treatment plants.

Identification of a practicable downstream boundary for the aquatic ecology impact assessment considered both changes to downstream hydrology and to water quality as follows.

An analysis of changes in water levels was carried out to identify where water levels were generally similar to pre and post-Project conditions. This was based on an assessment of the hydrographs at various downstream cross-sections. This identified that the change in water levels downstream would range from about 200 millimetres to 400 millimetres at Wisemans Ferry and decrease to less than 100 millimetres immediately downstream of Wisemans Ferry.

A second consideration in establishing the downstream boundary was potential changes in water quality associated with operation of the flood mitigation zone (the Project would not result in any changes in water quality in the dam during normal operations as there would be no change in the full supply level or how the dam is operated currently).

When the flood mitigation zone is capturing inflows from the Lake Burragorang catchment, there would be no change in downstream water quality. However, when captured water is being released from the flood mitigation zone after a flood event there is potential for impacts if the water quality of the captured water is worse than downstream water quality.

A detailed discussion around the downstream water quality impacts of the Project is provided in Chapter 27, Section 27.5.4 of the EIS. The assessment examined changes in Total Nitrogen, Total Phosphorus, chlorophyll-a, and Total Suspended Solids. The assessment identified that water quality in the flood mitigation zone was generally better than the downstream receiving environment and would not have any material impact on downstream quality.

On the basis of consideration of likely downstream hydrological and water quality changes, the principal focus for the assessments of significance is the area upstream of Wisemans Ferry.

Castlereagh Swamp Woodland

Endangered under the BC Act
Not listed under the EPBC Act

The Castlereagh Swamp Woodland TEC is represented by the following plant community types (PCTs) in the 10% AEP event flood area:

- PCT 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion
- PCT 883 - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion in the wider locality is also expected to conform to the TEC as described in Vegetation Information System (VIS) (2019) and mapped in the *Remnant Vegetation of the Western Cumberland subregion VIS_ID 4207* (OEH 2015).

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent for the 10% AEP event and the FMZ discharge areas.

About 1,546 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

<table>
<tr><th rowspan="2">TEC</th><th colspan="2">Extent of TEC (hectares)</th></tr>
<tr><th>10% AEP event</th><th>FMZ discharge area</th></tr>
<tr><td>Castlereagh Swamp Woodland</td><td>2.76</td><td>0.0</td></tr>
<tr><th colspan="2">Relevant impacts</th><th>Impact risk ratings</th></tr>
<tr><td colspan="2">Reduction of flooding extent in wetland and floodplain vegetation communities and habitats</td><td>Medium</td></tr>
<tr><td colspan="2">Bank erosion and slumping resulting in vegetation community and habitat degradation</td><td>Medium</td></tr>
<tr><td colspan="2">Spread of exotic species resulting in increased competition and predation on native species</td><td>Very Low</td></tr>
<tr><td colspan="2">Spread of disease and pathogens</td><td>Very Low</td></tr>
</table>

Assessment of significance

(a)	**in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**
Not applicable to a threatened ecological community.	
(b)	**In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**
Not applicable to a threatened ecological community.	
(c)	**In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:** **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i)	A small area of this community is mapped on a private property at Windsor Downs along a drainage depression within the 10% AEP event area. Based on the predicted extent of the community in the wider locality, up to 1,545 hectares is expected to occur within the Project study area. As the TEC is typically associated with poorly-drained depressions and creeklines on clay soils associated with Tertiary alluvium (NPWS 2004), it is likely that the community is dependent on seasonal waterlogging events, however this community is also mapped as a high-potential Groundwater Dependent Ecosystem (BoM 2019). The key impact for this community as a result of the Project is the predicted reduction of flooding extent in wetland and floodplain vegetation communities and habitats. Increased inundation is not predicted to occur as the community is not mapped within the FMZ discharge area. While the extent of the TEC within the existing 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated by the 10% AEP event are predicted to be inundated by the 20% AEP event with the Project. The area subject to reduced flooding in the 10% AEP event is relatively small (3 hectares), which represents approximately 0.2% of the predicted extent of the community in the Project study area. The reduction in the 10% AEP flood extent and frequency is considered **unlikely** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(ii)	It is expected that wetland and floodplain communities possess some resilience to natural variations in periodic flooding (that is, during drought conditions, etc). While gradual alterations to the structure of the community may occur over these natural extended dry periods, the extent of this change is unlikely to result in complete loss of the TEC. The structural response of the TEC as a result of the Project cannot be predicted with the information available. As noted above, while the 10% AEP event will result in reduced inundation in these TEC areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Any modification to the floristic composition of the local occurrence of the TEC may be minimal, predominantly occurring in the small area within the 10% AEP event (3 hectares), which represents approximately 0.2% of the predicted local occurrence of the community. It should be noted that gradual alterations to the structure of the community may occur outside the 10% AEP event. The reduction in 10%AEP event flood extent and frequency is **unlikely** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

(i) An estimated 3 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. As this community appears to be dependent on seasonal waterlogging, less frequent flooding may result in some modification to the vegetation structure and composition in the long term. However, noting that the community is also associated with poorly-drained sites, moderate to large rainfall events may mitigate this limitation.

(ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The area of the TEC in the 10% AEP event is already isolated and surrounded by agricultural land. It is unlikely that the changed flooding regime will increase this fragmentation.

(iii) The 3 hectares of this TEC within the 10% AEP event represents approximately 0.2% of the predicted extent of the TEC in the Project study area. It is unlikely the extent of the TEC within the 10% AEP event changed flood extent represents important habitat for the long-term survival of the community in the locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this TEC.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The Castlereagh Swamp Woodland TEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) are as follows:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands.
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

The Project will not directly assist or facilitate any of the priority objectives (or their actions). It will likely result in impacts not consistent with the objectives and actions of the Cumberland Plain recovery plan.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, the following key threatening process relevant to this TEC:

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- Clearing of native vegetation
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion and establishment of Scotch Broom (*Cytisus scoparius*)
- Invasion establishment and spread of Lantana (*Lantana camara*)

- Infection of native plants by *Phytophthora cinnamomi* - Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae - Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.	

Conclusion
The Project may result in modifications to up to 3 hectares of this TEC in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 on average with the Project. 3 hectares of the TEC represents approximately 0.2% of the expected extent of the community in the Project study area. The Project is **unlikely to result in a significant impact** on Castlereagh Swamp Woodland TEC within the 10% AEP event changed flood extent. This assessment does not consider impacts to changes in flood extent and frequency outside of the 10% AEP event changed flood extent. It should be noted that a large proportion of the TEC occurs within with the study area. Impacts to the TEC outside the 10% AEP event changed flood extent have the potential to be significant.

Cumberland Plain Woodland in the Sydney Basin Bioregion

Critically Endangered under the BC Act
Critically Endangered under the EPBC Act

The Cumberland Plain Woodland in the Sydney Basin Bioregion TEC is represented by the following PCTs in the 10% AEP event flood area:

- PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion occurring in the wider Project study area also conforms to Cumberland Plain Woodland.

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 2,411 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

The numbers below do not include potential areas of derived native grassland that could conform to Cumberland Plain Woodland. This was not recorded within the 10% AEP event area, but may occur in the wider Project study area.

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Cumberland Plain Woodland in the Sydney Basin Bioregion	157.69	24.95

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	Medium
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in wetland vegetation communities and habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened ecological community.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened ecological community.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i) The Cumberland Plain Woodland in the Sydney Basin Bioregion TEC occurs on soils derived from Wianamatta Shale, and throughout the driest part of the Sydney Basin. Tozer (2003) estimated the total extent of woody vegetation referred to as Cumberland Plain Woodland in the Sydney Basin Bioregion TEC was 11,054 hectares. Based on the predicted extent of PCTs 849 and 850 in the wider locality, about 2,411 hectares of the this TEC is expected to occur within the wider Project study area. Approximately 21 percent of the TEC occurs within the downstream Project study area. The mean annual rainfall for areas containing the TEC is typically in the range of 700-900 millimetres and is generally lower than that received on more elevated terrain that partially surrounds the Plain. Due to its distribution within the Hawkesbury-Nepean floodplain, the community may be dependent on flooding events within a certain frequency range. The predicted reduction of flooding extent within the 10% AEP event may result in adverse impacts or modifications to the TEC. The area subject to a reduction in flood extent and frequency within the 10% AEP event changed flood extent is 158 hectares or approximately 7 percent of the TEC within the local occurrence. Increased inundation is expected to occur across 25 hectares in FMZ discharge area, which may result in temporary damage to fringing vegetation. The area subject to increased inundation is relatively small and represents about 1 percent of the predicted extent of the community in the downstream Project study area and 0.2 percent of its estimated remaining intact extent. As a result, the reduction in flooding extent and frequency in the 10% AEP event, and increase in flood frequency within the FMZ discharge area has the **potential** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction. ii) While gradual alterations to the structure of the community may occur over an extended dry period, the extent of this change is unlikely to result in complete loss of the TEC. The longer period of time for inundation in the FMZ discharge area may result in damage to fringing vegetation, however this is not expected to have a permanent adverse effect on this community. The reduction in flooding extent and frequency in the 10% AEP event, and increase in flood frequency within the FMZ discharge area is **unlikely** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 158 hectares of this TEC occurs within the 10% AEP event changed flooding extent and would be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. These areas are scattered across the catchment and generally represent small strips of the community on the lower slopes. Less frequent

flooding may result in some modification to the vegetation structure and composition in the long term. This area represents approximately 7 percent of the local occurrence. 25 hectares of the TEC occurs in FMZ discharge area, which may result in temporary damage to fringing vegetation. The area subject to increased inundation is relatively small and represents approximately 1% of the predicted extent of the community in the local occurrence.

(ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The area of the TEC in the 10% AEP event and the FMZ discharge area is already isolated and generally surrounded by agricultural land. It is unlikely that the changed flooding regime will increase this fragmentation.

(iii) The estimated 158 hectares of this TEC that occurs within the 10% AEP event changed flood extent represents approximately 7 percent of the local occurrence. The 25 hectares of this TEC within the FMZ discharge area represents approximately one percent of the predicted extent of the local occurrence. Given the 'critically endangered status' of this TEC, these areas may be considered important habitat for the long-term survival of the community in the locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this TEC.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Cumberland Plain Woodland CEEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water, 2010) are as follows:

- *To build a protected area network, comprising public and private lands, focused on the priority conservation lands.*
- *To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.*
- *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.*
- *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.*

The Project will not directly assist or facilitate any of the priority objectives (or their actions). It will likely result in impacts not consistent with the objectives and actions of the Cumberland Plain recovery plan.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC:

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- Clearing of native vegetation
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*)
- Invasion and establishment of Scotch Broom (*Cytisus scoparius*)
- Invasion establishment and spread of Lantana (*Lantana camara* L. *sens.* Lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata* Wall. Ex G. Don) Cif
- Infection of native plants by *Phytophthora cinnamomi*
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.

Conclusion
The Project may result in modifications to up to 25 hectares of this TEC in the FMZ discharge area where the TEC is expected to experience an increased duration of temporary inundation, however vegetation damage as a result of this is expected to be temporary. Up to 158 hectares would experience fewer flooding events in the 10% AEP event. Potential impacts to these areas represent about 7 percent of the TEC across the local occurrence. Given that the TEC is listed as 'critically endangered', these impacts may occur within areas considered to be important to the long-term survival of the TEC. The Project has the **potential** to result in a significant impact on *Cumberland Plain Woodland CEEC* within the 10% AEP flood event area changed flood extent.

Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Endangered under the BC Act
Not listed under the EPBC Act

The Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is represented by the following PCTs in the 10% AEP flood event area:

- PCT 781 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
- PCT 924 - *Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley Sydney Basin Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 1,402 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	43.36	874.37

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	Medium
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in wetland vegetation communities and habitats	Low
Increased fine sediment deposits reducing water quality	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a)	**in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**
Not applicable to a threatened ecological community.	
(b)	**In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**
Not applicable to a threatened ecological community.	
(c)	**In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:** **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i)	Examples of this community in the 10% AEP event area include areas around Pitt Town Lagoon, Longneck Lagoon, Broadwater Swamp, Halls Swamp, Gees Lagoon, Turnbulls Swamp, and Teatree Swamp. Based on the predicted extent of PCT 781 and 924 in the wider locality, up to 1,402 hectares of the Freshwater Wetlands on Coastal Floodplains TEC is expected to occur within the wider Project study area. This TEC is typically associated with periodic or semi-permanent inundation by freshwater, although there may be minor saline influence in some wetlands. It typically occurs on silts, muds or humic loams in depressions, flats, drainage lines, backswamps, lagoons and lakes associated with coastal floodplains. This TEC is mapped as a high-potential Groundwater Dependant Ecosystem (BoM, 2019). The key impacts for this community as a result of the Project is the predicted reduction of flooding extent in wetland vegetation communities and the increased duration of inundation in the FMZ discharge area. Approximately 43 hectares of the TEC within the 10% AEP event area is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. In addition, a large area of this community (874 hectares) will be subject to increased inundation within the FMZ discharge area. The 43 hectares subject to fewer flooding and inundation events represents about 3 percent of the predicted extent of the community in the Project study area. The longer period of time for inundation in the FMZ discharge area may result in temporary damage to fringing vegetation and water quality reduction due to sedimentation and turbidity. Within the locality, occurrences of the Freshwater Wetlands TEC are concentrated within individual sites such as the seven previously mentioned wetlands and swamps. Potentially, this could have meant that impacts to the TEC in the individual sites was disproportionate to impacts across the entire locality. Analysis of the flood modelling against the TEC mapping found that this was not the case – the vast majority of the Freshwater Wetlands TEC occurred within the 'with project' AEP indicating it would not be impacted by a change in flooding frequency. As a result, the reduction in flooding extent and frequency in the 10% AEP event area, and increase in flood frequency within the FMZ discharge area is **unlikely** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(ii)	It is expected that wetland and floodplain communities possess some resilience to natural variations in periodic flooding (that is, during drought conditions, etc). While gradual alterations to the structure of the community may occur over these natural extended dry periods, the extent of this change is unlikely to result in complete loss of the TEC. The structural response of the TEC as a result of the Project cannot be predicted with the information available. As noted above, this community will still receive flows during rain events and is likely highly dependent on groundwater. Any modification to the floristic composition of the local occurrence of the TEC unknown and is unlikely to result in the loss of the TEC across the local occurrence. Increased water flows into the TEC may potentially be beneficial for some aspects of wetland ecosystem health.

The reduction in flooding extent and frequency in the 10% AEP event area, and increase in flood frequency within the FMZ discharge area is **unlikely** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Approximately 43 hectares of this TEC occurs within the 10% AEP event area changed flooding extent and is expected to be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. These areas are scattered across the catchment and generally represent small strips of the community along drainage lines and tributaries. Less frequent flooding may result in some modification to the vegetation structure and composition in the long term. (ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The area of the TEC in the 10% AEP event area is already isolated and surrounded by agricultural land. It is unlikely that the changed flooding regime will increase this fragmentation. (iii) The 43 hectares of this TEC within the 10% AEP event area represents about 3 percent of the predicted extent of the TEC in the Project study area. It is unlikely this extent of the TEC represents important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC does not currently have an approved recovery plan or threat abatement plan, however recovery strategies are outlined as part of the NSW Saving Our Species program. These include (but are not limited to): ▪ restoring natural processes that promote natural surface water flow ▪ managing grazing pressure ▪ controlling weeds ▪ identifying wetlands which hold water longer and those that are at risk of drying out to target appropriate management actions. The Project will not directly assist or facilitate any of these recovery actions. It will likely result in impacts not consistent with the recovery actions proposed for the community.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*) ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*)

- Invasion establishment and spread of Lantana (*Lantana camara* L. *sens*. Lat) - Infection of native plants by *Phytophthora cinnamomi* - Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Conclusion
The Project may result in modifications to up to 43 hectares of this TEC in the 10% AEP event area which is currently inundated every 10 years on average, and which is predicted to be inundated every 20 years on average with the Project. Water inputs from rain and ground water may assist in mitigating effects associated with changes to flood frequency. About 1,401 hectares of the TEC is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The 43 hectares of the TEC represents about 3 percent of the expected extent of the community in the Project study area. The Project is **unlikely to result in a significant impact** on the Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC within the 10% AEP event area changed flood extent.

River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Endangered under the BC Act
Critically Endangered under the EPBC Act

The River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is represented by the following PCTs in the 10% AEP event area:

- PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 1106 - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
- PCT 1504 - Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River Sydney Basin Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 3,429 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	460.78	852.68

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland and floodplain vegetation communities and habitats	**Medium**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**
Spread of exotic species resulting in increased competition and predation on native species	**Very Low**
Spread of disease and pathogens	**Very Low**

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened ecological community.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened ecological community.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i) Examples of this community occur throughout the in the 10% AEP event particularly associated with the fringing riparian zones around rivers, creeks, lagoons and tributaries. It is the most widespread TEC in the 10% AEP event and Project study areas, with about 461 hectares occurring in the 10% AEP event area and 853 hectares within the FMZ discharge area. Based on the predicted extent of PCTs 835, 1106 and 1504 in the wider locality, about 3,429 hectares of the River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC may occur. This TEC is typically associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. The final determination for this community notes that the composition of the River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil. The key impacts for this community as a result of the Project is the predicted reduction of flooding extent in wetland vegetation communities and the increased duration of inundation in the FMZ discharge area. About 461 hectares of the TEC within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. It is acknowledged that this community is associated with habitats where flooding is periodic and flood mitigation is a key threat for the persistence of this community. In addition, 853 hectares of this community would be subject to increased inundation within the FMZ discharge area. The reduced flooding frequency across 461hectares in the Hawkesbury-Nepean catchment represents about 13 percent of the predicted extent of the community in the Project study area. Long-term changes in relation to species composition and structure could occur during prolonged dry periods. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to fringing vegetation and water quality reduction due to sedimentation and turbidity, this is not expected to have a permanent adverse effect on this community. As a result, the reduction in 10% AEP event flood extent and frequency has the **potential** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction. (ii) Gradual alterations to the structure of the community may occur over an extended dry period, modifying the existing characteristics including important component species. The TEC includes characteristic species adapted to and/or requiring existing regimes of seasonal inundation and/or waterlogging, the spatial extent of component flora and fauna species that make up the local occurrence would be determined by these existing hydrological ecological regimes. The reduction in the 10% AEP flood extent and frequency and increase in flood frequency within the FMZ discharge area has the **potential** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

(i) About 461 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. These areas are widespread across the catchment and generally represent native vegetation along drainage lines and tributaries. Less frequent flooding may result in some modification to the vegetation structure and composition in the long term. About 853 hectares of the TEC occurs in the FMZ discharge area and would be subject to increased inundation in flooding events.

(ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. This TEC is currently well connected by its distribution along waterways and floodplains and it is unlikely that the changed flooding regime will increase any fragmentation of the community.

(iii) The 461 hectares of this TEC within the 10% AEP event area represents about 13 percent of the predicted extent of the TEC in the Project study area. It is likely this extent of the TEC represents important habitat for the long-term survival of the community in the locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this TEC.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) are as follows:

- *To build a protected area network, comprising public and private lands, focused on the priority conservation lands.*
- *To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.*
- *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.*
- *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.*

The Project would not directly assist or facilitate any of the priority objectives (or their actions).

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC:

- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- Clearing of native vegetation
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*)
- Invasion and establishment of Scotch Broom (*Cytisus scoparius*)

- Invasion establishment and spread of Lantana (*Lantana camara* L. *sens*. Lat)
- Infection of native plants by *Phytophthora cinnamomi*
- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants

Conclusion

The Project may impact up to 461hectares of this TEC in the 10% AEP event area and approximately 853 hectares of the TEC is expected to experience longer inundation in the FMZ discharge area. This may result in gradual alterations to the composition and structure of about 13 percent of the community in the locality however the extent of this change is unlikely to result in loss of the TEC. Impacts in relation to increased inundation in the FMZ Discharge area are expected to be temporary.

The Project has the potential to result in a significant impact on the River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC within the 10% AEP event changed flood extent.

Shale Gravel Transition Forest in the Sydney Basin Bioregion

Endangered under the BC Act
Critically Endangered under the EPBC Act

The Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC is represented by the following PCTs in the 10% AEP event area:

- PCT 724 - Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 1,380 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Shale Gravel Transition Forest in the Sydney Basin Bioregion	45.67	1.23

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	Medium
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in wetland vegetation communities and habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened ecological community.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened ecological community.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i) The Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC predominantly occurs in northern extent of the Cumberland Plain but has also been recorded in southern areas of the Sydney Basin such as Liverpool and Holsworthy. As at 2011 only 1,721 hectares of the Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC remained intact representing about 32 percent of its original extent (NPWS 2004; OEH 2011). Based on the predicted extent of PCT 724 in the wider locality, up to 1,380 hectares of the TEC could occur within the Project study area. This TEC occurs primarily in areas where shallow deposits of Tertiary alluvium overlie shale soils but may also occur in association with localised concentrations of iron-indurated gravel. Shale Gravel Transition Forest grades into Cumberland Plain Woodland as alluvial and ironstone influences decline. On thicker deposits of Tertiary alluvium, it grades into Cooks River/Castlereagh Ironbark Forest or Castlereagh Scribbly Gum Woodland. South of the Tertiary alluvial deposits at Holsworthy, this community forms complex mosaics with shale/sandstone transitional communities. The key impact for this community as a result of the Project is the predicted reduction of flooding extent in wetland vegetation communities. Increased inundation is not predicted to occur as the community is only mapped in a very small area (1 hectare) within the FMZ discharge area. The extent of the TEC within the 10% AEP event area is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The area subject to reduced flooding in the 10% AEP event is relatively small (46 hectares), which represents about 3 percent of the predicted extent of the community in the Project study area and about 2.7 percent of its estimated remaining intact extent. As a result, the reduction in 10% AEP event flood extent and frequency is **unlikely** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction. ii) The Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC is a transitional community (occurs as one community changes to another), with an assemblage comprised of species usually associated with clay and poorer gravel/alluvial soils. Gradual alterations to the structure of the community may occur over an extended dry period, which may result in potential long-term modifications to the composition and structure. As noted above, the 10% AEP event will result in reduced inundation in this TEC; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Any modification to the floristic composition of the local occurrence of the TEC that occurs within the small area within the 10% AEP event (46 hectares), represents about 2.7 percent of the predicted remaining occurrence of the community. The reduction in 10% AEP event flood extent and frequency is **unlikely** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) An estimated 46 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. This community is not known to be dependent on seasonal waterlogging or flooding and therefore, less frequent flooding is unlikely to result in substantial modification to the vegetation structure and composition in the long term. (ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and rural development. The area of the TEC in the 10% AEP event is already isolated and surrounded by agricultural land. It is unlikely that the changed flooding regime will increase this fragmentation. (iii) The 46 hectares of this TEC within the 10% AEP event represents approximately 2.7 percent of the predicted remaining extent of the TEC. It is unlikely this extent of the TEC represents important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water, 2010) are as follows: ▪ *To build a protected area network, comprising public and private lands, focused on the priority conservation lands.* ▪ *To deliver best practise management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.* ▪ *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.* ▪ *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.* A targeted management plan has been developed for the Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC under the Saving Our Species program. This plan identifies key management actions of which the following apply to the Project: ▪ *Encourage land managers to participate in conservation agreements.* ▪ *Identify the 'best available' remaining remnants of the TEC in private lands and council reserves.* ▪ *Identify and map green corridors with the aim of restoring TEC connectivity using the OEH (2015) Biodiversity Investment Opportunities Map- Mapping Priority Investment Areas for the Cumberland Sub region.* ▪ *Control invasive grasses and undertake local, manual control of Bridal Creeper, Tiger Pear, and Mother of Millions then stock pile removed weeds under black plastic.* The Project will not directly assist or facilitate any of the priority objectives (or their actions). It will likely result in impacts not consistent with the objectives and actions of the Cumberland Plain recovery plan.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, the following key threatening process relevant to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*) ▪ Invasion establishment and spread of Lantana (*Lantana camara*) ▪ Infection of native plants by *Phytophthora cinnamomi* ▪ Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae ▪ Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
Conclusion
The Project may result in minor modifications to up to 46 hectares of this TEC in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The 46 hectares of the TEC represents about 2.7 percent of the estimated remaining extent of the community. The Project is **unlikely to result in a significant impact** on the Shale Gravel Transition Forest in the Sydney Basin Bioregion TEC within the 10% AEP event changed flood extent. This assessment does not consider impacts to changes in flood extent and frequency outside of the 10% AEP changed flood extent. It should be noted almost all of the remaining known extent of the TEC occurs within the TEC boundary. Therefore, impacts to the TEC outside the 10% AEP changed flood extent have the potential to be significant.

Shale Sandstone Transition Forest in the Sydney Basin Bioregion

Critically Endangered under the BC Act
Critically Endangered under the EPBC Act

The Shale Sandstone Transition Forest in the Sydney Basin Bioregion TEC is represented by the following PCT in the 10% AEP event area:

- PCT 1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 709 hectares of this TEC (as PCT 1395) occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	91.20	73.76

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	Medium
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in wetland vegetation communities and habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a)	**In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**
Not applicable to a threatened ecological community.	
(b)	**In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**
Not applicable to a threatened ecological community.	
(c)	**In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:** **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i)	Before European settlement, the Shale Sandstone Transition Forest in the Sydney Basin Bioregion TEC was extensive around the edges of the Cumberland lowlands throughout western Sydney, most particularly in the southern half. It is estimated that 9,950 hectares remains intact. Examples of the community occur in Blue Mountains National Park, Cattai National Park and Gulguer Nature Reserve. Based on the predicted extent of PCT 1395 in the wider locality, up to 709 hectares of this TEC could occur within the wider Project study area. This TEC occurs primarily on soils derived from a shallow shale or clay material overlying sandstone, or where shale-derived materials has washed down over sandstone-derived substrate. It occurs on plateaux and hillsides and at the margins of shale cappings over sandstone. The key impacts for this community as a result of the Project is the predicted reduction of flooding extent (91 hectares) in the 10% AEP event area and increased inundation within the FMZ discharge area (74 hectares). The extent of the TEC within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. In addition, the area subject to reduced flooding in the 10% AEP event represents about 0.9 percent of the predicted remaining intact extent of the TEC. The larger predicted extent of the TEC in the wider Project study area suggests that the community can persist without frequent (that is, 1 in 10 year) flood events. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to fringing vegetation. As a result, the reduction in flooding extent and frequency in the 10% AEP event area and increase in flood frequency within the FMZ discharge area has the **potential** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(ii)	While gradual alterations to the structure of the community may occur over an extended dry period in the 10% AEP event area, the extent of this change is unlikely to result in complete loss of the TEC, rather a potential long-term modification of the existing floristic and structural characteristics. The TEC is not known to depend on flooding regimes or seasonal inundation and/or waterlogging. Any modification to the floristic composition of the local occurrence of the TEC is expected to be minimal and long-term and is unlikely to result in the loss of the TEC in the locality. The longer inundation period predicted within the FMZ discharge area may result in temporary damage to groundcover vegetation, however this is unlikely to have a permanent adverse effect on this community. The reduction in flooding extent and frequency in the 10% AEP event area, and increase in flood frequency within the FMZ discharge area has the **potential** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community: (i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and (ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and (iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
(i) About 91 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. These areas are widespread across the catchment and generally represent native vegetation along drainage lines and tributaries. Less frequent flooding may result in some modification to the vegetation structure and composition in the long term. Approximately 74 hectares of the TEC occurs in the FMZ discharge area and would be subject to increased inundation in flooding events. (ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. This TEC is currently fairly well connected by its distribution along waterways in the northern areas of the 10% AEP event and it is unlikely that the changed flooding regime will increase any fragmentation of the community. (iii) The 91 hectares of this TEC within the 10% AEP event represents about 0.9 percent of the predicted remaining extent of the TEC. It is unlikely the extent of the TEC in the 10% AEP event represents important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Shale Sandstone Transition Forest in the Sydney Basin Bioregion TEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) are as follows: ▪ *To build a protected area network, comprising public and private lands, focused on the priority conservation lands.* ▪ *To deliver best practise management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.* ▪ *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.* ▪ *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.* A targeted management plan has also been developed for Shale Sandstone Transition Forest CEEC under the Saving Our Species program. This plan identifies key management actions of which the following apply to the Project: ▪ *Encourage water sensitive design.* ▪ *Develop a guide/program for revegetation.* ▪ *Identify key areas to increase linkages throughout the TEC.* ▪ *Encourage land managers to participate in conservation agreements.* The Project will not directly assist or facilitate any of the priority objectives (or their actions). It will likely result in impacts not consistent with the objectives and actions of the Cumberland Plain recovery plan.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*) ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*) ▪ Invasion establishment and spread of Lantana (*Lantana camara* L. *sens*. Lat) ▪ Infection of native plants by *Phytophthora cinnamomi* ▪ Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae ▪ Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
Conclusion
The Project may result in minor modifications to up to 91 hectares of this TEC in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The known distribution of the TEC across the Sydney Basin suggests that the community is not dependent on frequent flood events to persist. 91 hectares of the TEC represents about 0.9 percent of the estimated remaining extent of the community. Impacts in relation to increased inundation in the FMZ Discharge area are expected to be temporary. The Project is **unlikely to result in a significant impact** on the Shale Sandstone Transition Forest in the Sydney Basin Bioregion TEC within the 10% AEP event changed flood extent.

Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Endangered under the BC Act
Not listed under the EPBC Act

The Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is represented by the following PCTs in the 10% AEP event area:

- PCT 1718 - Swamp Mahogany – Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast.

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 5.9 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	1.96	0.43

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	**Medium**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**
Increased duration of inundation in wetland vegetation communities and habitats	**Low**
Increased fine sediment deposits reducing water quality	**Low**
Spread of exotic species resulting in increased competition and predation on native species	**Very Low**
Spread of disease and pathogens	**Very Low**

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened ecological community.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened ecological community.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i) A small area of the Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC is mapped within Maroota Ridge State Conservation Area associated with Swamp Mahogany – Flax-leaved Paperbark forest. Based on the predicted extent of the community in the wider locality, only to 5.90 hectares is expected to occur within the wider Project study area. As the TEC is typically is associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains. While it is likely that the community is dependent on seasonal waterlogging events, this community is also mapped as a high-potential Groundwater Dependant Ecosystem (BoM 2019). The key impact for this community as a result of the Project is the predicted reduction of flooding extent in wetland and floodplain vegetation communities and habitats. Increased inundation is not predicted to substantially occur as only a small area (0.43 hectares) of the community is mapped within the FMZ discharge area. While the extent of the TEC within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. In addition, the area subject to reduced flooding in the 10% AEP event is relatively small (about 2 hectares), which represents about 33 percent of the predicted extent of the community the local occurrence As a result, the reduction in 10% AEP flood extent and frequency and increase in flood frequency within the FMZ discharge area **has the potential** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction. (ii) It is expected that wetland and floodplain communities possess some resilience to changes in natural variations in periodic flooding (that is, during drought conditions, etc). The structural response of the TEC as a result of the Project cannot be predicted with the information available. Gradual alterations to the structure of the community may occur over an extended dry period modifying the existing characteristics including important component species. As noted above, while the 10% AEP event will result in reduced inundation in this TEC; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The TEC includes characteristic species adapted to and/or requiring existing regimes of seasonal inundation and/or waterlogging, the spatial extent of component flora and fauna species that make up the local occurrence would be determined by these existing hydrological ecological regimes. The reduction in 10% AEP event flood extent and frequency and increase in flood frequency within the FMZ discharge area Project is **has the potential** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 2 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. As this community appears to be dependent on seasonal waterlogging, less frequent flooding may result in some modification to the vegetation structure and composition in the long term. However, noting that the community is also associated with poorly-drained sites, moderate to large rainfall events may mitigate this limitation. (ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The area of the TEC in the 10% AEP event is entirely in Maroota State Conservation area in an area relatively well connected to other intact native vegetation. It is unlikely that the changed flooding regime will increase fragmentation for this community. (iii) The 2 hectares of this TEC within the 10% AEP event area represents about 33 percent of the predicted extent of the local occurrence. This may represent important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC does not currently have an approved recovery plan or threat abatement plan, however recovery strategies are outlined as part of the NSW Saving Our Species program. These include (but are not limited to): ▪ Maintaining, improving or reinstating optimal hydrological regimes ▪ Controlling weeds using a 'staged approach' ▪ Undertaking strategic control of pest animals ▪ Implementing appropriate water sensitive design to reduce impacts of runoff ▪ Improving the understanding of optimal hydrological regimes. The Project will not directly assist or facilitate any of these recovery actions. It will likely result in impacts not consistent with the recovery actions proposed for the community.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*) ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*) ▪ Invasion establishment and spread of Lantana (*Lantana camara* L. *sens.* Lat) ▪ Infection of native plants by *Phytophthora cinnamomi*

▪ Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
Conclusion
The Project may result in modifications to up to 2 hectares of this TEC in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The community is unlikely to be dependent on frequent flood events to persist and the community is highly likely to be dependent on groundwater. The estimated 2 hectares of the TEC represents about 33 percent of the expected extent of the community in the local occurrence. The Project **has the potential** to result in a significant impact on the Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC within the 10% AEP event changed flood extent.

Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion

Critically Endangered under the BC Act
Critically Endangered under the EPBC Act

The Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion TEC is represented by the following PCTs in the 10% AEP event area:

- PCT 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
- PCT 1284 - Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

About 139 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion	3.23	5.11
Relevant impacts		**Impact risk ratings**
Reduction of flooding extent in wetland vegetation communities and habitats		**Medium**
Bank erosion and slumping resulting in vegetation community and habitat degradation		**Medium**
Increased duration of inundation in wetland vegetation communities and habitats		**Low**
Spread of exotic species resulting in increased competition and predation on native species		**Very Low**
Spread of disease and pathogens		**Very Low**

Assessment of significance

(a)	**in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**
Not applicable to a threatened ecological community.	
(b)	**In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**
Not applicable to a threatened ecological community.	
(c)	**In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: (i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i)	The Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion TEC occurs in the north of the Project study area in association with the Colo River catchment, the lower parts of the Hawkesbury and its tributaries near and upstream to the confluence of the Colo River, and in Yellomundee Regional Park. The community is known to occur on soils derived either from Wianamatta Shale or from Wianamatta Shale interbedded with Hawkesbury Sandstone. The community occurs on low rolling hills characteristic of the Cumberland Lowlands and the broad, shale-capped ridges of the surrounding plateaux. Based on the predicted extent of the community in the wider locality, up to 139 hectares is expected to occur within the Project study area and a remaining 2,940 hectares is predicted across its range. The TEC is known to rely on moderate rainfall (900-1100 mm) events and moisture available for plant growth is determined by a range of factors including the timing and magnitude of rainfall events, soil depth and texture and topographic factors. The community is unlikely to rely on flooding events, however these regimes may influence plant growth and health. The Project is the predicted to reduce the flooding extent within the 10% AEP event changed flood extent, impacting about 3 hectares of the TEC. Increased inundation in the FMZ discharge area would impact 5 hectares of this community. While the extent of the TEC within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. In addition, the area subject to reduced flooding in the 10% AEP event is relatively small (3 hectares), which represents about 2.3 percent of the predicted extent of the community in the Project study area. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to fringing vegetation, this is not expected to have a permanent adverse effect on this community. As a result, the reduction in 10% AEP event flood extent and frequency and increase in inundation frequency within the FMZ discharge area is **unlikely** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(ii)	While gradual alterations to the structure of the community may occur over an extended dry period, the extent of this change is unlikely to result in complete loss of the TEC. As noted above, while the 10% AEP event will result in reduced inundation in this TEC, areas which are currently inundated every 10 on average years are predicted to be inundated every 20 years on average with the Project. Any modification to the floristic composition of the local occurrence of the TEC is expected to be minimal and isolated to the small area within the 10% AEP event (about 3 hectares), which represents about 2.3 percent of the TEC within the locality. The Project is **unlikely** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) An estimated 3 hectares of this TEC occurs within the 10% AEP event changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. As this community appears to be dependent on sustained moisture for plant growth, less frequent flooding may result in some modification to the vegetation structure and composition in the long term. However, noting that the community is also associated with areas subject to moderate rainfall events, this may mitigate this limitation. (ii) The vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The area of the TEC in the 10% AEP event is near connected habitats around Wollemi National Park and Parr State Conservation Area near the Colo River. It is unlikely that the changed flooding regime will increase fragmentation for this community. (iii) The 3 hectares of this TEC within the 10% AEP event area represents about 2.3 percent of the TEC within the locality. It is unlikely this extent of the TEC represents important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion TEC does not currently have an approved recovery plan or threat abatement plan, however recovery strategies are outlined as part of the NSW Saving Our Species program. These include (but are not limited to): ▪ Identify and map green corridors with the aim of restoring TEC connectivity ▪ Conduct targeted and fine-scale, sensitive weed control ▪ Provide advice to Councils on using water sensitive designs ▪ Liaise with utility companies to provide advice on preventing sewage/storm water overflow into creek lines that flow into the TEC ▪ Ensure creek line stabilisation through bush regeneration and suitable replanting ▪ Minimise the effect of hydrological impacts from adjacent developments by mitigating runoff into the TEC The Project will not directly assist or facilitate any of these recovery actions. It will likely result in impacts not consistent with the recovery actions proposed for the community.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*) ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*) ▪ Invasion establishment and spread of Lantana (*Lantana camara* L. *sens.* Lat)

▪ Infection of native plants by *Phytophthora cinnamomi* ▪ Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Conclusion
The Project may result in modifications to up to 3 hectares of this TEC in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. 5 hectares of the TEC is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The TEC's reliance on moderate rainfall events suggests that the community is not dependent on frequent flood events to persist. 3 hectares of the TEC represents approximately 2.8 percent of the TEC's local occurrence. The Project is **unlikely to result in a significant impact** on the Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion TEC within the 10% AEP event changed flood extent.

Western Sydney Dry Rainforest in the Sydney Basin Bioregion

Endangered under the BC Act
Critically Endangered under the EPBC Act

The Western Sydney Dry Rainforest in the Sydney Basin Bioregion TEC is represented by the following PCT in the 10% AEP flood event area:

- PCT 877 - Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion

The table below outlines the mapped extent of the TEC within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP and the FMZ discharge areas.

About 139 hectares of this TEC occurs across the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this TEC are also listed and impact risk ratings provided as per Chapter 6 of this report.

TEC	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	3.80	1.83

Relevant impacts	Impact risk ratings
Reduction of flooding extent in wetland vegetation communities and habitats	**Medium**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**
Increased duration of inundation in wetland vegetation communities and habitats	**Low**
Spread of exotic species resulting in increased competition and predation on native species	**Very Low**
Spread of disease and pathogens	**Very Low**

Assessment of significance

(a)	**in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction**
Not applicable to a threatened ecological community.	
(b)	**In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**
Not applicable to a threatened ecological community.	
(c)	**In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:** **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
(i)	The Western Sydney Dry Rainforest in the Sydney Basin Bioregion TEC is typically is associated with sheltered lower slopes and in gullies on clay soils derived from Wianamatta shale. It is likely that in areas with less habitat dependence on aspect (south facing slope, narrow or deep gullies), that flooding extent within and/or proximity to low inflammability floodplain mesic vegetation are key driver for this community's extent. These later habitat values would be expected to be driving factors within the FMZ discharge area and the lower flood contours such as the 10% AEP. The key impacts for this community as a result of the Project is the predicted reduction of flooding extent in wetland and floodplain vegetation communities and habitats and increased inundation within the FMZ discharge area. Associated impacts to these would be the impacts of spread & increased impact of disease and pathogens, as well as spread and increased impact of exotic species resulting in competition. Current extents of this community within the FMZ discharge area (about 2 hectares) have the potential to see increased associated spread and weed species such as Lantana, African Olive and Bridal Creeper. Additionally, this localised increase in shade competition, humidity and periods of time with plants underwater would assist the spread and impact of Myrtle Rust on this locally dominated *Backhousia myrtifolia* which is known be susceptible to the disease. Within the 10% AEP changed flood extent, about 4 hectares of the EEC will see a decrease in flood inputs to soil moisture, likely resulting in changes to inflammability of this fire sensitive EEC, both within mesic buffering vegetation and within the existing dry rainforest. This would lead to a likely reduction of lower slope fire refuge values. The lower slope extents of the EEC are likely strongly driven by the obligate input in most lower areas of soil moisture inputs such as proximity to and frequency of riparian and floodplain processes. Disruption of this lower slope fire refuge values could have implications to fire behaviour across the broader study area, particularly with contiguous relevant vegetation to lower slope dry rainforest with increased inflammability. As a result, the Project **has the potential** to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction.
(ii)	The local extents of this EEC are dominated by *Backhousia myrtifolia*. This relatively simple and homogenous floristic dominance across the study area, and the shared impacts of reduced flooding extent over the study area, would see broadly shared albeit spatially variable impacts from the Project. However, the dynamics of these impacts across the study area are likely themselves variable and not linear correlations to flood levels in those locations. The nature of the broad impact pathways identified above mean that changes to flood extents may alter the composition of the EEC across the study area. The reduction in 10% AEP flood extent **has the potential** to have an adverse effect on the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 4 hectares of this TEC occurs within the 10% AEP changed flooding extent and is expected be subject to fewer flooding events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. This community appears to be dependent on complex dynamics of protection from fire, maintenance of adequate environmental moisture relative to other environmental conditions (aspect, wind, temperature), exotic species competition and soil nutrients. The changes in flooding extent may result in some modification to the vegetation structure and composition over the long term that may affect extents of this EEC. (ii) The generally naturally linear distribution of this EEC renders it highly susceptible to fragmentation and isolation of impacts as discussed above. (iii) The 4 hectares of this TEC within the 10% AEP flood event area represents about 3 percent of the predicted extent of the TEC in the Project study area. For the reasons discussed above, it is likely the extent of the TEC within the 10% AEP changed flood extent represents important habitat for the long-term survival of the community in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this TEC.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
The Western Sydney Dry Rainforest in the Sydney Basin Bioregion TEC is included in the approved recovery plan for the Cumberland Plain. The proposed recovery objectives as outlined in the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) are as follows: ▪ To build a protected area network, comprising public and private lands, focused on the priority conservation lands. ▪ To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation. ▪ To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program. ▪ To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner. The Project will not directly assist or facilitate any of the priority objectives (or their actions). It will likely result in impacts not consistent with the objectives and actions of the Cumberland Plain recovery plan.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this TEC: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands ▪ Clearing of native vegetation ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*) ▪ Invasion and establishment of Scotch Broom (*Cytisus scoparius*)

▪ Invasion establishment and spread of Lantana (*Lantana camara* L. *sens*. Lat) ▪ Infection of native plants by *Phytophthora cinnamomi* ▪ Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae ▪ Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Conclusion
The Project may result in modifications to up to 4 hectares of this TEC in the 10% AEP; areas which are currently predicted to be inundated every 10 years are predicted to be inundated every 20 years under a project scenario. The 4 hectares of the TEC represents about 3 percent of the expected extent of the community in the Project study area. The Project **has the potential** to result in a significant impact on Western Sydney Dry Rainforest in the Sydney Basin Bioregion EEC within the 10% AEP changed flood extent.

Acacia pubescens (Downy Wattle)

Vulnerable under the BC Act
Vulnerable under the EPBC Act

1,054 individuals of *Acacia pubescens* (Downy Wattle) were recorded in the survey area (that is, the existing 10% AEP event) during the surveys undertaken for this assessment within and around Scheyville National Park in association with PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion. Furthermore, the species has been previously recorded around Windsor Downs and Pitt Town.

Typically, the species is found in open woodland and forest in a variety of plant communities, however most occurrences are within Cooks River/Castlereagh Ironbark Forest, Shale Gravel Transition Forest or Shale Plains Woodland. For this assessment, suitable habitat for *Acacia pubescens* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within five kilometres of any known records. These are:

- PCT 724 (HN512) - Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 725 (HN513) - Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1181 (HN586) - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- PCT 1395 (HN556) - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
- PCT 835 (HN526)- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528) – Grey Box Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542) – Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 3,840 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Potential impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Extent of TEC (hectares)	
	10% AEP event	FMZ discharge area
Acacia pubescens (Downy Wattle)	473.39	423.92

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Medium
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
1,054 individuals of *Acacia pubescens* (Downy Wattle) were recorded in the survey area (that is, the 10% AEP event area) during the surveys undertaken for this assessment within and around Scheyville National Park (it is noted that since this is a clonal species, a census based on counts of separate clumps may overestimate the number of genetically distinct individuals). The species has been previously recorded around Windsor Downs and Pitt Town. The records of the species in this locality between Scheyville National Park and Windsor Downs Nature Reserve is likely to constitute a viable local population of *Acacia pubescens*. *Acacia pubescens* flowers between August and October and pollination is usually by insects and birds. Recruitment appears to occur more frequently from vegetative suckers rather than seedlings. *Acacia* species are generally known to have high seed dormancy and long-lived persistent soil seedbanks. It is not known if altered hydrological regimes will have an effect on life cycle aspects of *Acacia pubescens*, however the species is known to be responsive to fire. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is unknown whether the species relies on specific hydrological regimes for its life cycle. While the known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species within the Pitt Town and Windsor Downs localities, about 473 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 424 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. Up to 3,839.99 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. This area represents 25 percent of the available habitat for the species within the Project study area. The known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the

Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known recent records of *Acacia pubescens* primarily occur within the conserved habitats associated with Scheyville National Park and Windsor Downs Nature Reserve. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle. It is thought that the suckering mechanism of *Acacia pubescens* allows the species to tolerate some levels of disturbance and the species has high seed dormancy and long-lived persistent soil seedbanks (NPWS 2003b).

The habitat within the 10% AEP event and FMZ discharge areas is expected to be important for the local population of *Acacia pubescens* in the Pitt Town and Windsor Downs locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A recovery plan for *Acacia pubescens* was published in 2003 by the NSW National Parks and Wildlife Services (NPWS). The overall objective of the recovery plan is *'to prevent the status of Acacia pubescens from becoming endangered, by reducing habitat loss and by implementing management regimes aimed at maintaining representative populations across the species' range*' (NPWS 2003b). The plan consists of 13 recovery actions which aim to meet the overall objective (NPWS 2003b).

In addition to this approved recovery plan, the former OEH developed management objectives and plans for various threatened species as part of its Saving Our Species (SoS) program.

The SoS program has identified three key management sites, with part of Site 2 occurring within the Project study area. Site 2: Hawkesbury covers a total area of 6,900 hectares in north-west Sydney on private land surrounding Oakville and The Peninsular, but also includes Scheyville National Park, Windsor Downs Nature Reserve and Pitt Town Nature Reserve. Management objectives and actions listed for Site 2 include:

- Maintain appropriate fire regime for the species/community via trial ecological burns
- Reduce and maintain weed densities at low levels via site-based weed control
- Minimise illegal collection of the species via land manager consultation
- Minimise illegal collection of the species via provide advice to land manager

The Project is likely to be inconsistent with the recovery plan and the SoS program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.

Conclusion
The Project may result in minor modifications to areas of known *Acacia pubescens* habitat in the 10% AEP event; area which is currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project **has the potential** to result in a significant impact on *Acacia pubescens* within the 10% AEP event changed flood extent.

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Callistemon linearifolius

Vulnerable under the BC Act
Not listed under the EPBC Act

Callistemon linearifolius was not recorded during the surveys undertaken for this assessment. This species has not been recorded in the Project study area as the Cumberland Plain is the western – or more accurately, inland - extent of the known range of this species. The closest records occur within 1 kilometre of the Project study area along a tributary of Cattai Creek near Glenorie.

Typically, the species is found in dry sclerophyll forest that surrounds rivers, creeks and other water courses. For this assessment, suitable habitat for *Callistemon linearifolius* includes the PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion.
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 443 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Callistemon linearifolius	126.10	170.14

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Changes to terrestrial woodland and forest communities and habitat	Very low
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Medium
Spread of exotic species resulting in increased competition and predation on native species	Low
Spread of disease and pathogens	Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The following impacts rated with a moderate or higher risk - outlined in the table above - are relevant to the lifecycle of *Callistemon linearifolius*: ▪ Reduction of flooding extent in habitats. ▪ Bank erosion and slumping resulting in vegetation community and habitat degradation. ▪ Increased duration of inundation in habitats. ▪ Spread of exotic species resulting in increased competition and predation on native species. The lifecycle ecology of *Callistemon linearifolius* is poorly understood. Benson and McDougall (1998) write that this species of *Callistemon* has a lifespan of 30 years. They also write that there is no known association between the ecology of *C. linearifolius* and fire. This is contrary to what is listed in OEH's BioNet Atlas, which recommends 'no fire more than once every 7 years' and 'restrict bushfire'. This would imply that frequent fire may have a negative impact on the lifecycle ecology of *C. linearifolius*. A reduction in peak flood extents and durations, along with a reduction in peak flood flows may impact the lifecycle of *C. linearifolius* as its occurrence is dependent on the presence of groundwater or water ways. In the Upstream Study Area *Callistemon linearifolius* was recorded along the edge of Lake Burragorang and along the Little River. *Callistemon linearifolius* is also known from the Georges and Hawkesbury Rivers. It is possible then, that this species – and its lifecycle – is associated with the presence of readily available water. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is unknown whether the species relies on specific hydrological regimes for its life cycle. While the known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 443 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. An estimated 126 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and 170 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. The known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. (ii) The *C. linearifolius* habitat within the study area has been previously fragmented through agricultural and residential development. The habitat occurring in the central areas of the Cumberland Plain and along the Hawkesbury/Nepean Rivers will likely be impacted more than the habitat contiguous with large extents of native vegetation. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The limited understanding on the ecology of *C. linearifolius* makes an assessment of the importance of habitat difficult.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
A targeted strategy for managing *Callistemon linearifolius* has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *C. linearifolius* has been assigned to the 'data-deficient species' management stream. The former OEH provides the following justification for the allocation of *C. linearifolius* to the data-deficient species management stream: 'This species is in the Data Deficient stream as its taxonomy needs to be reviewed and little is known about it ecology'. The former OEH provides the following advice as to how this species will be managed: ▪ Resolve taxonomic uncertainty for all species in the genera. ▪ Develop a habitat profile including information on distribution, population sizes across its range, geological requirements and fire ecology to assist active management. The Project is consistent with management advice given by the former OEH.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
'Threatening process' means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the *Threatened Species Conservation Act 1995*. There are 37 listed key threatening processes under the *Threatened Species Conservation Act 1995*. The Project has the potential to contribute to and increase the impact of seven Key Threatening Processes (KTPs) listed under the TSC Act. The following seven KTPs relate to *Callistemon linearifolius:* ▪ Clearing of native vegetation. ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands. ▪ Invasion and establishment of exotic vines and scramblers. ▪ Invasion of native plant communities by exotic perennial grasses.

- Invasion of native plant communities by African Olive, *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. - Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat). - Ecological consequences of high frequency fires.
Conclusion
The Project may result in minor modifications to areas of known *Callistemon linearifolius* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average, and which are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events. The Project **has the potential** to result in a significant impact on *Callistemon linearifolius* within the 10% AEP event changed flood extent.

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Dillwynia tenuifolia

Vulnerable under the BC Act
Not listed under the EPBC Act

Eleven scattered *Dillwynia tenuifolia* individuals were identified at Scheyville National Park in association with PCTs 1067, 724 and 835 during the surveys undertaken for this assessment. The species has also been previously recorded across the Cumberland Plain, with most concentrated records occurring in intact vegetation around Castlereagh Nature Reserve, Wianamatta Regional Park, Wianamatta Nature Reserve, Agnes Banks Nature Reserve. Records also occur in the north around Scheyville National Park and Cattai.

Within the Western Sydney extent of its distribution, *Dillwynia tenuifolia* occurs in dry/scrubby heath as part of Castlereagh Ironbark Forest and/or Shale Gravel Transition Forest that is supported by tertiary alluviums or laterised clays. Within areas of habitat, *D. tenuifolia* is associated with occurrences of *Eucalyptus fibrosa*, *Eucalyptus globoidea*, *Eucalyptus longifolia*, *Eucalyptus parramattensis*, *Eucalyptus sclerophylla* and *Melaleuca decora*. For this assessment, suitable habitat for *Dillwynia tenuifolia* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 724 (HN512) - Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 725 (HN513) - Broad-leaved Ironbark – *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 849 (HN528) - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 883 (HN542) - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 958 (HN555) – Narrow-leaved Apple – Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion.
- PCT 1395 (HN556) - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 1067 (HN562) - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 1081 (HN564) - Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion.
- PCT 835 (HN526) - Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion.

A local population of a threatened plant species as defined in the Threatened Species Assessment Guidelines, is ‘those individuals occurring in the study area or the cluster of individuals that extend in to habitat adjoining and contiguous with the study area that could reasonably be expected to be cross-pollinating with those in the study area’ (NSW DECC 2007). Numerous D. tenuifolia occur within the Project study area according to previous records. The occurrence of the local population has been precautionarily defined by the known occurrences of the species and the surrounding associated PCTs occurring in the study area.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 8,068 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Dillwynia tenuifolia	620.22	680.73
Relevant impacts	**Impact risk ratings**	
Reduction of flooding extent in habitats	**High**	
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**	
Increased duration of inundation in habitats	**Low**	
Spread of exotic species resulting in increased competition and predation on native species	**Very Low**	
Spread of disease and pathogens	**Very Low**	

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Eleven individuals of *Dillwynia tenuifolia* were recorded in the survey area (that is, the 10% AEP event area) during the surveys undertaken for this assessment within Scheyville National Park. The species has also been previously recorded across the Cumberland Plain, with most concentrated records occurring in intact vegetation around Castlereagh Nature Reserve, Wianamatta Regional Park, Wianamatta Nature Reserve, Agnes Banks Nature Reserve. *Dillwynia tenuifolia* flowers sporadically throughout the year peaking in August to March. Hard-coated seed is produced upon successful pollination (the pollinators of this species are currently unknown) which will persist within a soil-stored seed bank. Ants are the likely vector for seed dispersal, indicating that movement of seed from its parent plant is somewhat limited. It is not known if altered hydrological regimes will have an effect on life cycle aspects of *Dillwynia tenuifolia*, however recruitment occurs with germination of the seed bank after fire. The Project is not expected to have a measurable impact on fire regimes in the catchment. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is not known whether the species relies on specific hydrological regimes for its life cycle. The known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average and are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species and may not affect its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the local population of the species on the Cumberland Plain, about 620 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 681 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 8,068 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. The known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species and may not affect its seed bank.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Dillwynia tenuifolia* primarily occur within the conserved habitats in the Cumberland Plain. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and predicted longer dry periods in the 10% AEP event has the potential to result in the loss of the species in the study area over the long-term. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. It is unknown whether the species relies on specific hydrological regimes for its lifecycle.

The habitat within the 10% AEP event and FMZ discharge areas is expected to be important for the local population of *Dillwynia tenuifolia* on the Cumberland Plain.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Dillwynia tenuifolia is included in the Cumberland Plain Recovery Plan. The actions outlined in the Cumberland Plain Recovery Plan are as follows:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands.
- To deliver best practise management for threatened species, populations and ecological communities across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with conservation.
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened species, populations and ecological communities, and thereby improve capacity to manage these in a strategic and effective manner.

A targeted strategy for managing *Dillwynia tenuifolia* has also been developed under the Saving Our Species Program. *D. tenuifolia* has been assigned to the 'keep watch species' management stream. Justification for the allocation of *D. tenuifolia* to the keep watch species management stream is as follows:

Relatively large populations of this species occur within reserves (for example, between 10,000 and 50,000 individuals recorded in Wianamatta, Windsor Downs and Castlereagh Nature Reserves) where current management is sufficient to ensure their long-term security.

The Project **would likely not be consistent** with the recovery plan and the SoS program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.

Conclusion
The Project may result in minor modifications to areas of known *Dillwynia tenuifolia* habitat in the 10% AEP event area which is currently inundated every 10 years aand predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project **has the potential** to result in a significant impact on *Dillwynia tenuifolia* within the 10% AEP event changed flood extent.

References

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Epacris purpurascens var. purpurascens

Vulnerable under the BC Act
Not listed under the EPBC Act

Epacris purpurascens var. *purpurascens* was not recorded during the surveys undertaken for this assessment, however the species has been previously recorded in relatively intact vegetation around Maraylya and Cattai.

The species is found in a range of habitat types however prefers dry sclerophyll forest, scrubs and swamps or soil with a strong shale influence (OEH 2017). According to the Final Determination (2000) the species is known from about 30 locations where the size of populations, where known, varies from very small (1-5 plants) to greater than 1000 individuals. For this assessment, suitable habitat for *Epacris purpurascens* var. *purpurascens* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 1181 (HN586) - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion
- PCT 1395 (HN556) - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1292 (HN607) - Water Gum - Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion
- PCT 835 (HN526) – Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 371 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Epacris purpurascens var. *purpurascens*	112.33	129.01
Relevant impacts		**Impact risk ratings**
Reduction of flooding extent in habitats		**High**
Bank erosion and slumping resulting in vegetation community and habitat degradation		**Medium**
Increased duration of inundation in habitats		**Low**
Spread of exotic species resulting in increased competition and predation on native species		**Very Low**
Spread of disease and pathogens		**Very Low**

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Epacris purpurascens var. *purpurascens* was not recorded during the surveys undertaken for this assessment, however the species has been previously recorded in relatively intact vegetation around Maraylya and Cattai. The life cycle for *Epacris purpurascens var. purpurascens* including aspects related to the series or stages of plant reproduction, growth, development, ageing and death is not well understood. Pollinators are unknown however it is thought that seed is dispersed via water and wind (NPWS 2002). The lifespan of individuals has been reported to be 5-20 years, requiring at least 2-4 years before seed is produced in the wild (OEH 2017). Plants are killed by fire and re-establish from soil-stored seed (OEH 2017). It is not known if altered hydrological regimes would have an effect on life cycle aspects of *Epacris purpurascens* var. *purpurascens*, however recruitment occurs with germination of the seed bank after fire. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species are known to occur on skeletal soils on ridgetops. While the known and potential habitats for this species within the 10% AEP event area is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. Very few records of the species occur within the 10% AEP event changed flooding extent and FMZ discharge area. As a result, the reduction in 10% AEP event flood extent and frequency is **unlikely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species in the Maraylya and Cattai localities, about 112 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 129 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species. Up to about 371 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. While the known and potential habitats for this species within the 10% AEP event area are likely to experience a reduction in flooding during minor flood events, most of this area is still predicted to receive flows during the 5% AEP and 1% AEP flood eventscenarios. The longer period of time for inundation in the FMZ discharge area may result in temporary damage to individuals of this species, this is not expected to have a permanent adverse effect on this species or its seed bank.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Epacris purpurascens* var. *purpurascens* primarily occur within relatively intact and connected habitats around Cattai National Park. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species extend beyond the extent of the Project study area suggesting that the species does not rely on frequent flooding events to persist. While the habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Epacris purpurascens* var. *purpurascens* in the Cattai locality, the **impacts to this habitat are expected to be minor.**	
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).	
No critical habitat has been declared for this species.	
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.	
No recovery plan or threat abatement plant has been prepared for *Epacris purpurascens var. purpurascens*. However, management objectives for the species are included as part of its Saving Our Species (SoS) programme. The SoS program has identified four priority management sites, namely, Site 1: Ku-ring-gai High School in Ku-Ring-Gai LGA, Site 2: Western Hornsby Plateau in City of Parramatta, Hornsby, The Hills Shire LGA, Site 3: Woronora in Wollongong LGA and Site 4: Upper Nepean SCA in Wingecarribee, Wollondilly, Wollongong LGA. None of these key management sites overlap with the Project study area and therefore the Project **would not be inconsistent** with the objectives or actions of the SoS program.	
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat) ▪ Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.	
Conclusion	
The Project may result in minor modifications to areas of known *Epacris purpurascens var. purpurascens* habitat in the 10% AEP event area. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The species persistence in habitats outside the Project study area suggests that the species is not reliant on regular flooding regimes. The Project is **unlikely to result in a significant impact** on *Epacris purpurascens var. purpurascens* within the 10% AEP event changed flood extent.	

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Eucalyptus benthamii (Camden White Gum)

Vulnerable under the BC Act
Vulnerable under the EPBC Act

Eucalyptus benthamii was recorded along the Nepean River at Bents Basin State Conservation Area and at Wallacia in association with PCT 1106 - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion during the surveys undertaken for this assessment. The species has also been previously recorded in this area in associated with PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion.

This species occurs on the alluvial flats of the Nepean River and its tributaries. The species occurs in open forest, with associated species (at the Bents Basin site) including *Eucalyptus elata*, *Eucalyptus baueriana*, *Eucalyptus amplifolia*, *Eucalyptus deanei* and *Angophora subvelutina*. *Eucalyptus benthamii* requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Recruitment of juveniles appears to be most successful on bare silt deposits in rivers and streams.

The local population of *Eucalyptus benthamii* is confined to the Nepean River around Wallacia and at Bents Basin State Conservation Area. The size of the population subject to this assessment includes the 300 individuals at Bents Basin and the nine trees downstream of Bents Basin near Wallacia (Benson 1985; Butcher *et al.*, 2005; OEH 2019). The local population occurs over an area of 746.57 hectares.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 747 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Eucalyptus benthamii (Camden White Gum)	64.11	167.25

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Eucalyptus benthamii was recorded along the Nepean River at Bents Basin State Conservation Area and at Wallacia in association with PCT 1106 - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion during the surveys undertaken for this assessment. The species has also been previously recorded in this area in associated with PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion. This species is known to occur on the alluvial flats of the Nepean River and its tributaries. It requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Germination and recruitment of new individuals is dependent on flooding and the substrate in which seeds have been stored. For seeds to geminate, periodic flooding of the soils-stores seedbank is required. The key impact for this species as a result of the Project is the predicted reduction of flooding extent in the 10% AEP event changed flooding area. The increased inundation in the FMZ discharge area may assist in recruitment for the species in flooding events, however this may also result in localised erosion impacts. As a result, the Project **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) In the locality, *Eucalyptus benthamii* occurs on the alluvial banks of the Nepean River. The alluvial sands together with a periodic flooding regime allows for germination and seedling establishment. The associated PCTs in the local population area: ▪ PCT 835 - Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion ▪ PCT 1106 - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion Based on the local population of the species on the Cumberland Plain, about 64 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 167 hectares in the FMZ discharge area. Due to the depth of the Nepean River in this area, the difference in the existing and Project 10% AEP event area is very small and not measurable (that is, reduction in flooding extent is minor). Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The longer period of time for inundation in the FMZ discharge area may result in erosion and temporary damage to vegetation, this is expected to have an overall adverse effect on this species and its germination.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Eucalyptus benthamii* occur along the Nepean River near Wallacia surrounded by existing agricultural land uses. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. Flooding regimes may assist in the spread of the species during germination and recruitment. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the species in the locality due to the depth of the Nepean River not resulting in major changes to flooding extents. Longer inundation in the FMZ discharge area may result in some erosion and subsequent vegetation damage and decline; this is expected to be detrimental to the germination process for the species.

The known habitat within the 10% AEP event area and FMZ discharge area is likely to be highly important for the local population of *Eucalyptus benthamii* along the Nepean River.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Three Priority Management Sites have been identified for *Eucalyptus benthamii* in OEH's *Help Save the Camden White Gum* report (OEH 2019); Kedumba, Camden Airport and Bent's Basin. The Bents Basin Priority Management Site falls within the 10% AEP event making it relevant to the Project. The following two threats and their management actions are as follows:

- Rural/residential/industrial development: Provide advice to planning authorities.
- Mixed Weeds: Site-based weed control.

The Project may result in impacts to the Bents Basin Priority Management Site.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.

Conclusion

The Project may result in temporary erosion and vegetation damage impacts to *Eucalyptus benthamii* habitat in the FMZ discharge area, which may be detrimental for the germination and recruitment process for this species that requires flooding events.

The Project **has the potential** to result in a significant impact on *Eucalyptus benthamii* within the 10% AEP event changed flood extent.

Eucalyptus sp. Cattai

Critically Endangered under the BC Act
Critically Endangered under the EPBC Act

Eucalyptus sp. Cattai was not recorded during the surveys undertaken for this assessment. This species has not been recorded within the Project study area as the boundary occurs just to the west of the species recorded distribution. The closest records of *Eucalyptus* sp. Cattai occur within 1 kilometre of the Project study area along Cattai Creek and its tributaries.

The species is found in scrub, heath and low woodland usually in small groups or as solitary individuals. *Eucalyptus* sp. Cattai habitat is supported by sandy soils and laterised clays that overlay sandstone. For this assessment, suitable habitat for *Eucalyptus* sp. Cattai includes the PCT that is associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 1181 (HN586) - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 86 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Eucalyptus sp. Cattai	27.99	25.86

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Very Low
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Medium
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Information on the lifecycle of *Eucalyptus* sp. Cattai is limited. This species is described as a small tree or mallee that occurs on ridgetops. Its elevated position on ridgetops makes it unlikely that the local population would be made extinct by the impacts of the Project.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 28 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 26 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. About 86 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) The *Eucalyptus* sp. Cattai habitat within the study area has been previously fragmented through agricultural and residential development. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The highly restricted distribution of *Eucalyptus* sp. Cattai makes all remaining habitat important to its survival.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
A targeted strategy for managing *Eucalyptus* sp. Cattai has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *Eucalyptus* sp. Cattai has been assigned to the 'site managed species' management stream. The following priority management site has been identified for *Eucalyptus* sp. Cattai: ▪ The Hills Shire in Hornsby, The Hills Shire LGA The Project study area overlaps with the northern extent of the priority management site. The Project may exacerbate the following threats to the priority management site: ▪ Risk of too frequent or too intense fires inhibiting growth or reproduction ▪ Urban and rural residential development, infrastructure maintenance and bushfire hazard control. ▪ Poor recruitment and a restricted population size. The Project is therefore not consistent with management advice given by the former OEH.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
'Threatening process' means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the *Threatened Species Conservation Act 1995*. There are 37 listed key threatening processes under the *Threatened Species Conservation Act 1995*. The proposed development will contribute (either directly or indirectly) to seven key threatening processes (KTPs), namely: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Clearing of native vegetation. ▪ High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition. ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat) Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif. Although each of these processes are already in operation within the study area, the action proposed is likely to exacerbate the aforementioned KTPs.
Conclusion
The local population of *Eucalyptus* sp. Cattai has been assessed as occurring within the study area from the PCT associated with its habitat, however, no records of the species occur within the 10% AEP event changed flood extent or within the Project study area. Records for the species occur immediately outside the Project study area, within the main known distribution of the species occurring on surrounding ridgetops. The Project is **unlikely to result in a significant impact** on *Eucalyptus sp.* Cattai within the 10% AEP event changed flood extent.

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Grevillea juniperina subsp. juniperina (Juniper-leaved Grevillea)

Vulnerable under the BC Act
Not listed under the EPBC Act

Grevillea juniperina subsp. *juniperina* was recorded in Wianamatta Regional Park during the surveys undertaken for this assessment. The species has been previously recorded associated with relatively intact vegetation around Blacktown, Erskine Park, Londonderry and Windsor, with outlier populations at Kemps Creek and Pitt Town. It grows on reddish clay to sandy soils derived from Wianamatta Shale and tertiary alluvium (often with shale influence), typically containing lateritic gravels. It has been recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition forest.

For this assessment, suitable habitat for *Grevillea juniperina* subsp. *juniperina* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 724 (HN512) - Broad-leaved Ironbark – Grey Box – *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 725 (HN513) - Broad-leaved Ironbark – *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 835 (HN526) – Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1067 (HN562) – Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542) - Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528) - Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 850 (529) - Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 7,991 hectares of habitat for this species occurs in the in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

<table>
<tr><th rowspan="2">Species</th><th colspan="2">Potential habitat (hectares)</th></tr>
<tr><th>10% AEP event</th><th>FMZ discharge area</th></tr>
<tr><td>Grevillea juniperina subsp. juniperina</td><td>545.28</td><td>655.03</td></tr>
<tr><th colspan="2">Relevant impacts</th><th>Impact risk ratings</th></tr>
<tr><td colspan="2">Reduction of flooding extent in habitats</td><td>High</td></tr>
<tr><td colspan="2">Bank erosion and slumping resulting in vegetation community and habitat degradation</td><td>Medium</td></tr>
<tr><td colspan="2">Increased duration of inundation in habitats</td><td>Low</td></tr>
<tr><td colspan="2">Spread of exotic species resulting in increased competition and predation on native species</td><td>Very Low</td></tr>
<tr><td colspan="2">Spread of disease and pathogens</td><td>Very Low</td></tr>
</table>

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Grevillea juniperina subsp. *juniperina* was recorded in Wianamatta Regional Park during the surveys undertaken for this assessment *Grevillea juniperina* subsp. *juniperina* is restricted to the Cumberland Plain in western Sydney around Rooty Hill, Plumpton, Castlereagh Nature Reserve and Pitt Town. It grows on reddish clay to sandy soils derived from Wianamatta Shale and tertiary alluvium (often with shale influence), typically containing lateritic gravels. It has been recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition forest. Flowering may occur sporadically throughout the year, but particularly between July and October. Flowers are reported to be bird pollinated, although bees have also been observed visiting flowers. Fire can lead to a sudden increase in the recruitment of seedlings. Germination experiments have shown that germination rates are improved by exposure to both smoke and heat. The frequency of fire is likely to be an important factor in the life cycle of this species. It is not known if altered hydrological regimes will have an effect on life cycle of this species. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle. The known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the local population of the species within the Castlereagh, Windsor Downs and Wianamatta localities, about 545 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 655 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 7,991 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. The known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may

result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Grevillea juniperina* subsp. *juniperina* primarily occur within relatively intact habitats on the floodplain. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life. It is thought that the suckering mechanism of *Grevillea juniperina* subsp. *juniperina* allows the species to tolerate some levels of disturbance and the species has high seed dormancy and long-lived persistent soil seedbanks (NPWS 2003b).

The habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Grevillea juniperina* subsp. *juniperina* in the Pitt Town and Windsor Downs locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Grevillea juniperina subsp. *juniperina* is addressed in the Department of Environment, Climate Change and Water's Cumberland Plain Recovery Plan (DECCW 2010). The overall objective of the Cumberland Plain Recovery Plan is to provide for the long-term survival and protection of the threatened biodiversity of the Cumberland Plain (DECCW 2010). The specific recovery objectives of the plan are as follows:

- *To build a protected area network, comprising public and private lands, focused on the priority conservation lands.*
- *To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.*
- *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program.*
- *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.*

A targeted strategy for managing *Grevillea juniperina* subsp. *juniperina* has been developed under the Saving Our Species Program. This management strategy highlights the following three management sites:

1. Cranebrook in the Penrith LGA: includes the Wianamatta Nature Reserve.
2. Shane's Park in Blacktown, Penrith LGA: includes Wianamatta Regional Park.
3. Colebee in the Blacktown LGA: outside the 10% AEP event area.

The Project is unlikely to be consistent with any of the recovery objectives set out in the Cumberland Plain Recovery Plan or any management actions outlined in the Saving Our Species program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (Lantana camara L. sens. lat)

▪ Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif
Conclusion
The Project may result in minor modifications to areas of known *Grevillea juniperina* subsp. *juniperina* habitat in the 10% AEP event ares which are currently inundated every 10 years on average, and is predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project **has the potential** to result in a significant impact on *Grevillea juniperina* subsp. *juniperina* within the 10% AEP event changed flood extent.

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Hibbertia puberula

Endangered under the BC Act
Not listed under the EPBC Act

Hibbertia puberula was not recorded during the surveys undertaken for this assessment. This species has not been recorded in the Project study area with the species distribution occurring predominantly in the south-east of the Cumberland Plain. The closest records however occurs within one kilometre of the Project study area at Shane's Park.

Hibbertia puberula is typically found in dry sclerophyll woodland communities however outlier records have been made from heathlands and even upland swamps. For this assessment, suitable habitat for *Hibbertia puberula* includes the PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion

The *Hibbertia puberula* at Shane's Park were recorded in following PCTs not listed as associated habitat as per the TBDC:

- PCT 725 (HN513): Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542): Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- PCT 724 (HN512): Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 517 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Hibbertia puberula	6.75	1.60

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Moderate
Bank erosion and slumping resulting in vegetation community and habitat degradation	Moderate
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	High
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The lifecycle ecology of *Hibbertia puberula* is poorly understood. The revision of *Hibbertia* by Toelken and Miller (2012) identifies *Hibbertia puberula* as producing an aril – a fleshy outgrowth subtending or encompassing a seed somewhat like an elaiosome. The presence of an aril may indicate that seed dispersal is facilitated by ants. Additionally, OEH writes that a threat to *Hibbertia puberula* is road maintenance and slashing (OEH 2003). This may suggest that *Hibbertia puberula* is not able to easily re-establish itself after physical damage and disturbances or reproduce asexually via suckering. A reduction in peak flood extents and durations along with a reduction in peak flood flows are unlikely to impact the aforementioned aspects of the *Hibbertia puberula* lifecycle. An increase in dry weather flows and variability due to environmental flow releases is unlikely to affect the lifecycle of *Hibbertia puberula* either. An increase in low-level flooding and flows caused by the discharge of the FMZ is unlikely impact the lifecycle of *Hibbertia puberula*. This is because the waters discharged by the FMZ are unlikely to reach the habitat assessed as occurring within 5 kilometres of the Shane's Park records. As a result, the reduction in 10% AEP event flood extent and frequency is unlikely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 7 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 1.6 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality (Shane's Park). About 517 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) All areas of existing *Hibbertia puberula* habitat within the study area are already fragmented. Areas of *Hibbertia puberula* habitat are however likely to become further fragmented because of the Project. Reductions in flood extents and durations will impact areas of habitat such as PCT 1067 (HN562) that require periodic inundation and access to ground-water. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle.

The habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Hibbertia puberula* in the Shane's Park and Windsor Downs locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
A targeted strategy for managing *Hibbertia puberula* has been developed under the Saving Our Species Program. Under the Saving Our Species program, *Hibbertia puberula* has been assigned to the 'site-managed species' management stream. The following four priority management sites have been identified in NSW: ▪ Wollemi National Park in the Hawkesbury LGA ▪ Yeramba Lagoon in the Canterbury-Bankstown LGA ▪ West Menai in the Sutherland Shire LGA ▪ Jerrawangala National Park in the Shoalhaven LGA None of these priority management sites will be impacted by the Project.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
'Threatening process' means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the *Threatened Species Conservation Act 1995*. There are 37 listed key threatening processes under the *Threatened Species Conservation Act 1995*. The Project has the potential to contribute to and increase the impact of six Key Threatening Processes listed under the TSC Act. The following six KTPs relate to *Hibbertia puberula*: ▪ Clearing of native vegetation. ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands. ▪ Invasion and establishment of exotic vines and scramblers. ▪ Invasion of native plant communities by exotic perennial grasses. ▪ Invasion of native plant communities by African Olive, *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat). The alteration to the flow and extents of the Nepean and Hawkesbury Rivers along with their associated waterways wetlands and swamps will result a reduction of certain communities (including the PCTs listed in the introduction). The reduction in the extent of this vegetation is considered by OEH to be clearing of native vegetation, even if only certain strata levels are impacted. A reduction in the coverage of native flora species may create an opportunity for the further spread and establishment of weeds and exotic species. Such species would include African Olive, Lantana and number of perennial grasses.
Conclusion
The Project may result in minor modifications to areas of known *Hibbertia puberula* habitat in the 10% AEP event area. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project is **unlikely to result in a significant impact** on *Hibbertia puberula* within the 10% AEP event changed flood extent.

References

NSW Office of Environment and Heritage (2003). *Hibbertia puberula*. NSW Scientific Committee – final determination.

Toelken, H. R. and Miller, R. T. (2012). Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales. J. *Adelaide Bot*. Gard. 25: 71-96.

Marsdenia viridiflora R. Br. subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith Local Government Areas

Endangered under the BC Act
Not listed under the EPBC Act

With regard to the Project, Penrith, Blacktown and Liverpool LGAs are within the downstream study area. *Marsdenia viridiflora* R. Br subsp. *viridiflora* was not recorded in the study area during vegetation mapping associated with the Project. Only one individual has previously been recorded (BioNet records) within the study area – near South Creek Wianamatta. Numerous records (also from BioNet) have been within 1 kilometre of the study area, just outside of Wianamatta Nature Reserve.

Marsdenia viridiflora R. Br. subsp*. viridiflora* has been described as occurring in vine thickets and open shale woodlands (OEH 2019). For this assessment however, suitable habitat for *Hibbertia puberula* includes the PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

Liverpool LGA

- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion

Penrith LGA

- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion

Blacktown LGA

- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 832 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Marsdenia viridiflora subsp. *viridiflora*	0	0

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	**Moderate**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Moderate**
Increased duration of inundation in habitats	**Low**
Spread of exotic species resulting in increased competition and predation on native species	**Moderate**
Spread of disease and pathogens	**Low**

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to an endangered population.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
It is suggested that species in the *Marsdenia* genus may be insect pollinated due to the specialised structure of its flowers (RBGS 2019). However, the specific breeding mechanisms (including pollination) of *Marsdenia viridiflora* R. Br subsp. *viridiflora* are largely unknown. No records of *Marsdenia viridiflora* R. Br subsp. *viridiflora* have been recorded within the existing 10% AEP event or within the Project study area. A reduction in peak flood extents and durations along with a reduction in peak flood flows are unlikely to impact the aforementioned aspects of the *Marsdenia viridiflora* R. Br subsp. *viridiflora* lifecycle. An increase in dry weather flows and variability due to environmental flow releases is unlikely to affect the lifecycle of *Marsdenia viridiflora* R. Br subsp. *viridiflora*. An increase in low-level flooding and flows caused by the discharge of the Flood Mitigation Zone is unlikely to impact the lifecycle of *Marsdenia viridiflora* R. Br subsp. *viridiflora*. This is because the waters discharged by the FMZ are unlikely to reach the habitat assessed as occurring within 5 kilometres of the Shane's Park records. As a result, the reduction in 10% AEP event flood extent and frequency is unlikely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) No potentially suitable habitat occurs within the 10% AEP event changed flooding extent and no habitat occurs within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. About 832 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) Through a changed hydrological regime, 831.65 hectares of suitable habitat within the study area is likely to be modified. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species (iii) This question relates to the importance of habitat for the species in the locality, which in this instance is an assessment of the importance of the habitat in the study area. 831.65 hectares of suitable habitat for *Marsdenia viridiflora* R. Br subsp. *viridiflora* endangered population is presumed to be present within the study area. Based on a lack of targeted surveys or detailed understanding of this species all habitat in the study area is assumed to be important.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The *Marsdenia viridiflora* R. Br subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Fairfield, Holroyd, Liverpool and Penrith LGAs Endangered Population is included in the Cumberland Plain Recovery Plan that was published in 2011 by the Department of Environment, Climate Change and Water (DECCW). The Cumberland Plain Recovery Plan identifies actions for implementation by local, State and Australian government authorities which are grouped under the following recovery objectives:

1. To build a protected area network, comprising public and private lands, focused on the priority conservation lands,
2. To deliver best practice management for threatened species, populations and ecological communities across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with conservation,
3. To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program, and
4. To increase knowledge of the threats to the survival of the Cumberland Plain's threatened species, populations and ecological communities, and thereby improve capacity to manage these in a strategic and effective manner.

The Cumberland Plain Recovery Plan seeks to focus recovery efforts on those lands which represent the best opportunities to secure viable, long-term conservation outcomes in the region (DECCW 2011). These lands have been identified as '*Priority Conservation Lands* (PCLs)' (DECCW 2011). According to mapped extents of PCLs, the *Marsdenia viridiflora R. Br subsp. viridiflora* Endangered Population is known to occur within the Castlereagh PCL and the Mulgoa PCL. Both these PCLs may be impacted by the Project (as they are within the study area). Therefore, the Project is inconsistent with the management objectives for this PCL that contains *Marsdenia viridiflora R. Br subsp. viridiflora*.

In addition to this approved recovery plan, the OEH has developed management objectives and plans for various threatened species as part of its Saving Our Species (SoS) program. The stated management objective for *Marsdenia viridiflora R. Br subsp. viridiflora* Endangered Population under the program is '*This action statement aims to secure this population in the long-term*' (OEH 2019). The SoS program does not identify any key management sites for the *Marsdenia viridiflora R. Br subsp. viridiflora* Endangered Population.

Broadly the effects of the Project are inconsistent with the objectives or management actions of the recovery plan and the SoS program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed development will contribute (either directly or indirectly) to eight key threatening processes (KTPs), namely:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Clearing of native vegetation.
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.
- Invasion of native plant communities by exotic perennial grasses
- Infection of native plants by *Phytophthora cinnamomi*
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.

Although each of these processes are already in operation within the study area, the Project could exacerbate the aforementioned KTPs.
Conclusion
The Project may result in minor modifications to areas of known *Marsdenia viridiflora R. Br subsp. viridiflora* habitat in the 10% AEP event area. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project is **unlikely to result in a significant impact** on *Marsdenia viridiflora R. Br subsp. viridiflora* within the 10% AEP event changed flood extent.

References

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Royal Botanic Gardens Sydney (RBGS) (2019) Pollination, State of New South Wales and Office of Environment and Heritage, https://www.rbgsyd.nsw.gov.au/Science/Our-work-discoveries/Natural-Areas-Management/Ecology-of-Cumberland-Plain-Woodland/Woodland-ecology/Processes-affecting-the-life-cycle/Pollination, Accessed 16 August 2019.

Department of Environment and Climate Change (DECC) (2007) Threatened species assessment guidelines: The assessment of significance, Department of Environment and Climate Change NSW, Sydney South.

Department of Environment, Climate Change and Water (DECCW) (2011) Cumberland Plain Recovery Plan, Department of Environment, Climate Change and Water.

Micromyrtus minutiflora

Endangered under the BC Act
Vulnerable under the EPBC Act

Targeted surveys for *Micromyrtus minutiflora* were not undertaken in the downstream study area for the Project. Moreover, *Micromyrtus minutiflora* was not incidentally encountered in the survey area during vegetation mapping associated with the Project. *Micromyrtus minutiflora* has previously been recorded (from BioNet records) in the study area however; at Londonderry, Richmond, Agnes Banks and near Castlereagh.

Hibbertia puberula occurs in a variety of communities; Castlereagh Scribbly Gum Woodland, Ironbark Forest, Shale/Gravel Transition Forest, open forest on tertiary alluvium and on consolidated river sediments (OEH 2019). For this assessment, suitable habitat for *M. minutiflora* includes the PCTs that are associated with the species (as per the TBDC and that have been mapped by SMEC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion

Micromyrtus minutiflora was also recorded (BioNet records) in the following PCTs mapped by SMEC but not listed as associated habitat as per the TBDC:

- PCT 835 (HN526): Forest Reed Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542): Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 4,555 hectares of habitat for this species in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Micromyrtus minutiflora	245.97	269.54

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Low
Changes to terrestrial woodland and forest communities	Moderate
Bank erosion and slumping resulting in vegetation community and habitat degradation	Low
Increased duration of inundation in habitats	High
Spread of exotic species resulting in increased competition and predation on native species	High
Spread of disease and pathogens	Moderate

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The following impacts rated with a moderate or higher risk - outlined in the table above - are relevant to the lifecycle of the *Micromyrtus minutiflora*: ▪ Reduction of flooding extent in habitats. ▪ Changes to terrestrial woodland and forest communities ▪ Bank erosion and slumping resulting in vegetation community and habitat degradation ▪ Increased duration of inundation in habitats ▪ Spread of exotic species resulting in increased competition and predation on native species The life cycle of *Micromyrtus minutiflora*, including the pollination and breeding mechanisms are poorly documented in scientific literature. However, it is known that the *Micromyrtus minutiflora* has specific habitat requirements based on its limited distribution where it is found in Castlereagh Scribbly Gum Woodland, Ironbark Forest, Shale/Gravel Transition Forest, open forest on tertiary alluvium and consolidated river sediments (OEH 2017). It is suggested that regeneration of the species may be due to re-sprouting or germination of soil-stored seed (OEH 2019). The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is unknown whether the species relies on specific hydrological regimes for its life cycle. While the known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 246 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 270 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. About 4,555 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of Dillwynia tenuifolia primarily occur within the conserved habitats in the Cumberland Plain. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. It is unknown whether the species relies on specific hydrological regimes for its life cycle.

The habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Acacia pubescens* in the Windsor Downs locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Micromyrtus minutiflora is included in the Cumberland Plain Recovery Plan that was published in 2011 by the DECCW. The Cumberland Plain Recovery Plan identifies actions for implementation by local, State and Australian government authorities which are grouped under the following recovery objectives:

- *To build a protected area network, comprising public and private lands, focused on the priority conservation lands,*
- *To deliver best practice management for threatened species, populations and ecological communities across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with conservation,*
- *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program, and*
- *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened species, populations and ecological communities, and thereby improve capacity to manage these in a strategic and effective manner.*

The Cumberland Plain Recovery Plan seeks to focus recovery efforts on those lands which represent the best opportunities to secure viable, long-term conservation outcomes in the region (DECCW 2011). These lands have been identified as 'Priority Conservation Lands (PCLs)' (DECCW 2011). According to mapped extents of PCLs, *Micromyrtus minutiflora* is known to occur within the 'Castlereagh' PCL which is likely to be impacted by the Project (as it is within the study area). Therefore, the Project is inconsistent with the management objectives for this PCL that contains *Micromyrtus minutiflora*.

In addition to this approved recovery plan, the OEH has developed management objectives and plans for various threatened species as part of its Saving Our Species (SoS) programme. The stated management objective for *Micromyrtus minutiflora* under the program is '*The SoS strategy aims to secure the species in the wild for 100 years and maintain its conservation status under the BC Act*' (OEH 2019). The SoS program has identified one key management site, namely, Wianamatta Nature Reserve in Penrith LGA. This management site does not fall within the study area and therefore the proposed action is not inconsistent with the SoS management objectives and actions for *Micromyrtus minutiflora* under the SoS program.

Broadly the effects of the Project are inconsistent with the objectives or management actions of the recovery plan and the SoS program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed development will contribute (either directly or indirectly) to seven key threatening processes (KTPs), namely:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Clearing of native vegetation.

- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (Lantana camara L. sens. lat)
- Introduction and establishment of exotic rust fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
- Invasion of native plant communities by African Olive (Olea europaea subsp. cuspidata) (Wall. ex G. Don) Cif.

Although each of these processes are already in operation within the study area, the Project could exacerbate the aforementioned KTPs.

Conclusion

The Project may result in minor modifications to areas of known *Micromyrtus minutiflora* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary.

The Project **has the potential** to result in a significant impact on *Micromyrtus minutiflora* within the 10% AEP event changed flood extent.

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Persoonia nutans (Nodding Geebung)

Endangered under the BC Act
Endangered under the EPBC Act

Persoonia nutans was recorded during the surveys undertaken for this assessment in Wianamatta Regional Park, however the species has been previously recorded around Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs areas. The core distribution occurs within the Penrith area. *Persoonia nutans* is generally confined to aeolian and alluvial sediments and occur in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland, and a smaller number occurring in Cooks River/Castlereagh Ironbark Forests.

For this assessment, suitable habitat for *Persoonia nutans* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 724 (HN512) - Broad-leaved Ironbark – Grey Box – *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 725 (HN513) - Broad-leaved Ironbark – *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528) – Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542) - Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- PCT 958 (HN555) - Narrow-leaved Apple – Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion
- PCT 1067 (HN562) - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1395 (HN556) - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 4,110 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Persoonia nutans	126.08	14.88

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Persoonia nutans was recorded during the surveys undertaken for this assessment in Wianamatta Regional Park, however the local population of the species is known to also occupy Agnes banks Nature Reserve (NR), Wianamatta NR, Castlereagh NR, Windsor Downs NR and the remnant stands of native vegetation in between. According to the latest data from OEH, there are approximately 4000 individuals in this population (OEH, 2019). Peak flowering for this species is from November to March with sporadic flowering year-round. It is an obligate seed regenerator, with seed germination promoted by fire and by physical disturbance. Its plants appear to set abundant fruit, and its seed is likely to be dispersed, after consumption of the fruit, by large birds such as currawongs and large mammals such as wallabies, kangaroos and possums. Its abundance at sites appears to be related to disturbance history, with sites with higher abundance also appearing to be more disturbed. The key impacts for this species as a result of the Project are the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle. While the known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the local population of the species, about 126 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 15 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species. About 4,110 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. The known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. The longer period of time for inundation in the FMZ discharge area may result in temporary damage to individuals of this species, this may not permanent adverse effect on this species or its seed bank.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Persoonia nutans* primarily occur within relatively intact and connected habitats around Castlereagh Nature Reserve and Agnes Banks Nature Reserve. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle.

The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of *Persoonia nutans*.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A recovery plan was developed for *Persoonia nutans* by NPWS as part of the Department of Environment and Conservation (DEC 2005). The *P. nutans* recovery plan has the following six specific objectives:

- *To minimise the loss and fragmentation of Persoonia nutans habitat using land-use mechanisms.*
- *To identify and minimise the threats operating at sites where the species occurs.*
- *Develop and implement a survey and monitoring program that will provide information on the extent and viability of Persoonia nutans.*
- *To provide public authorities with information that assists in conserving the species.*
- *To raise awareness of the species and involve the community in the recovery program.*
- *To promote research projects that will assist future management.*

The Project is not consistent with any of the objectives outlined in the *Persoonia nutans* recovery plan.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.

Conclusion

The Project may result in minor modifications to areas of known *Persoonia nutans* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary.

The Project **has the potential** to result in a significant impact on *Persoonia nutans* within the 10% AEP event changed flood extent.

References

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Pilularia novae-hollandiae (Austral Pillwort)

Endangered under the BC Act
Not listed under the EPBC Act

Austral Pillwort (*Pilularia novae-hollandiae*) was not recorded during the surveys undertaken for this assessment. This species has not been recorded in the Project study area as the Sydney region is the northern extent of the known range of this species. A single record for Sydney is in a suburban area just outside of the existing Project study area in the suburb of Doonside near a railway line in a dried-out ditch as of 1966. This species appears to exhibit ephemerality based on water availability, and in the Albury-Urana area, most records are from table drains on the sides of roads.

For this assessment, suitable habitat for *Pilularia novae-hollandiae* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur. These are:

- PCT 835 (HN526) - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 24 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Pilularia novae-hollandiae	0	0

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Pilularia novae-hollandiae is a probably an ephemeral species, dependant on rain where it is found only in drying mud. The dispersal of species is assumed to be comparable to other species of Marsileaceae but there is no research to confirm this through literature it is accepted the secreted method of releasing the sporangia is the dispersal method. Noting the semi-aquatic and ephemeral nature of the species, it is possible that altered hydrological regimes could have an effect on life cycle of *Pilularia novae-hollandiae* if it occurs in the study area. The key impacts for this species as a result of the Project are the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. While the potential habitat for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events, most of this area is still predicted to receive flows during the 5% AEP and 1% AEP scenarios. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this this semi-aquatic species. As a result, the Project is **unlikely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) No habitat for the Austral Pillwort occurs in the FMZ discharge area or between the proposed and existing 10% AEP events. About 24 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. While the potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events, most of this area is still predicted to receive flows during the 5% AEP and 1% AEP scenarios. The longer period of time for inundation in the FMZ discharge area may result in temporary damage to individuals of this species, this is not expected to have a permanent adverse effect on this semi-aquatic species. (ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. No records of this species occur in the Project study area. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event area is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. No records of this species occur in the Project study area and it is unlikely that the habitat within the 10% AEP event area and FMZ discharge area is important for *Pilularia novae-hollandiae*.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan
OEH has developed a recovery plan and objectives for various threatened species as part of the Saving Our Species (SoS) Program, with the aim to use site managed sites for *Pilularia novae-hollandiae.* Two priority management sites were identified in NSW; Lake Cowal (Bland LGA) and Oolambeyan National Park (Murrumbidgee LGA). These sites have no overlap on the local population in the study area. The Project has no direct or indirect impacts on the objectives of the SoS program.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat) Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif.
Conclusion
The Project may result in minor modifications to areas of potential *Pilularia novae-hollandiae* habitat in the 10% AEP event, however flooding is expected to occur in this area during the 5% AEP and 1% AEP events. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project is **unlikely to result in a significant impact** on *Pilularia novae-hollandiae*.

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Pimelea curviflora var. *curviflora*

Vulnerable under the BC Act
Vulnerable under the EPBC Act

Pimelea curviflora var. *curviflora* was not recorded during the surveys undertaken for this assessment. The species has been previously recorded associated with relatively intact vegetation around Maraylya, Cattai, South Maroota and Lower Portland. It occurs on shale/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. It appears to survive for some time after fire or grazing without any foliage using the reserves in the tuberous toot system.

For this assessment, suitable habitat for *Pimelea curviflora* var. *curviflora* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 724 (HN512) - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528) - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 883 (HN542) - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1181 (HN586) - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- PCT 1395 (HN556) - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
- PCT 1106 (NR223) – River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 908 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Pimelea curviflora var. *curviflora*	179.74	118.65
Relevant impacts		**Impact risk ratings**
Reduction of flooding extent in habitats		High
Bank erosion and slumping resulting in vegetation community and habitat degradation		Medium
Increased duration of inundation in habitats		Low
Spread of exotic species resulting in increased competition and predation on native species		Very Low
Spread of disease and pathogens		Very Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Pimelea curviflora var. *curviflora* was not recorded during the surveys undertaken for this assessment. The species has been previously recorded associated with relatively intact vegetation around Maraylya, Cattai, South Maroota and Lower Portland. It occurs on shale/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. This species is able to recover from fire due to the tuberous tap root although altered fire regimes too frequent or too intense are identified as a threatening process for this species. It is not known if altered hydrological regimes will have an effect on life cycle of this species. The key impacts for this species as a result of the Project are the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species are typically on the ridgetops and slopes and extend beyond the extent of the Project study area suggesting that the species does not rely on frequent flooding events to persist. Minimal habitat is within the FMZ discharge area which will have an increase in low-level flooding and flows. As a result, the reduction in 10% AEP event flood extent and frequency is **unlikely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species within the Maraylya, Cattai, South Maroota and Lower Portland localities, about 180 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 119 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 908 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. While the known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species. (ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Pimelea curviflora* var. *curviflora* primarily occur within relatively intact habitats around Maraylya and Cattai. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species extend beyond the extent of the Project study area suggesting that the species does not rely on frequent flooding events to persist. It is thought that the tuberous tap root of *Pimelea curviflora* var. *curviflora* allows the species to tolerate some levels of disturbance and the species. The habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Pimelea curviflora* var. *curviflora*.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan
OEH has developed a recovery plan and objectives for various threatened species as part of the Saving Our Species (SoS) Program, with the aim to use site managed sites for *Pimelea curviflora* var. *curviflora.* Three priority management sites were identified in NSW; Muogamarra Nature Reserve (Hornsby LGA), John Moroney Correctional Centre (Penrith LGA) and Albion Park (Shellharbour LGA). These sites have no overlap on the local population in the Project. The Project has no direct or indirect impacts on the objectives of the SoS program.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Invasion of native plant communities by exotic perennial grasses ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat) ▪ Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif
Conclusion
The Project may result in minor modifications to areas of known *Pimelea curviflora* var. *curviflora* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The species persistence in habitats outside the Project study area suggests that the species is not reliant on regular flooding regimes. The Project is **unlikely to result in a significant impact** on *Pimelea curviflora* var. *curviflora* within the 10% AEP event changed flood extent.

References

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Saving Our Species (SoS) (2019). Help save the *Pimelea curviflora* var. *curviflora*. NSW Government. https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10629

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Pimelea spicata (Spiked Rice-flower)

Endangered under the BC Act
Endangered under the EPBC Act

Pimelea spicata was not recorded during the surveys undertaken for this assessment. The species has been previously recorded known around Camden, Narellan, Marayong, Douglas Park, Bankstown and Prospect Reservoir areas (OEH 2019; BioNet 2019). It grows in remnant bushland on Wianamatta shales and well-structured clay soils in open woodlands (particularly Cumberland Plain Woodland variants and Moist Shale Woodland grey box communities) and grasslands of *Eucalyptus moluccana, Eucalyptus crebra, Eucalyptus tereticornis, Bursaria spinosa* and *Themeda triandra* in the Western Sydney and Cumberland Plains.

For this assessment, suitable habitat for *Pimelea spicata* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 830 (HN524)- Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- PCT 835 (HN526) – Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528) - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 850 (HN529) - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 2,148 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Pimelea spicata	71.47	95.96

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Pimelea spicata was not recorded during the surveys undertaken for this assessment. The species has been previously recorded known around Camden, Narellan, Marayong, Douglas Park, Bankstown and Prospect Reservoir areas. It grows in remnant bushland on Wianamatta shales and well-structured clay soils in open woodlands (particularly Cumberland Plain Woodland variants and Moist Shale Woodland grey box communities) and grasslands *of Eucalyptus moluccana, Eucalyptus crebra, Eucalyptus tereticornis, Bursaria spinosa* and *Themeda triandra* in the Western Sydney and Cumberland Plains. The species mostly flowers in summer, especially following rainfall but may flower at any time of the year. Flowers may self-pollinate, but the seed production appears to be variable, seeds also have a poor dispersal with most seedlings germinating close to the adult. The soil seedbank is therefore important and is maintained with suitable irregular disturbance. It is estimated that *Pimelea spicata* can take at least three years to develop a taproot enough for regeneration, after disturbance a substantial depletion of the tap root can take time to recover before future disturbances. This species appears to respond well to disturbance once the plants are mature with the tap root providing the ability to rapidly re-sprout after occasional disturbances from grazing, fire or chemical application. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is not known whether the species relies on specific hydrological regimes for its life cycle. The known and potential habitats for this species within the 10% AEP event area is likely to experience a reduction in flooding during minor flood events, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species within the Camden, Narellan, Marayong, Douglas Park, Bankstown and Prospect Reservoir localities, about 71 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 96 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 2,148 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. The known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during

minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Pimelea spicata* occur within a range of disturbed and intact habitats on the floodplain. It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle. It is thought that the suckering mechanism of *Pimelea spicata* allows the species to tolerate some levels of disturbance and the species has high seed dormancy and long-lived persistent soil seedbanks (NPWS 2003b).

The habitat within the 10% AEP event area and FMZ discharge area is expected to be important for the local population of *Pimelea spicata*.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat has been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

OEH has developed a recovery plan and objectives for various threatened species as part of the Saving Our Species (SoS) Program, with the aim to use site managed sites for *Pimelea spicata.* Two priority management sites were identified in NSW, Prospect Nature Reserve (Blacktown LGA) and Narellan (Campbelltown LGA). These management sites have no overlap with the study area or any local population identified as part of this Project.

A national recovery plan has been adopted to assist in the long-term protection of *Pimelea spicata* (DEC 2006). Objectives of the recovery plan include:

- Conserve Pimelea spicata using land-use and conservation planning mechanisms.
- Identify and minimise the operation of threats at sites where Pimelea spicata occurs.
- Develop and implement a survey and monitoring program that will provide information on the extent and viability of Pimelea spicata.
- Provide the community with information that assists in conserving the species.
- Raise awareness of the species and involve the community in the recovery program.
- Conduct research that will assist future management decisions.

The Project is not inconsistent with achieving the management aspects of these two priority management sites or the objectives of the recovery plan.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif

Conclusion
The Project may result in minor modifications to areas of known *Pimelea spicata* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project **has the potential to result in a significant impact** on *Pimelea spicata* within the 10% AEP event changed flood extent.

References

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Pomaderris brunnea (Brown Pomaderris)

Endangered under the BC Act
Vulnerable under the EPBC Act

Pomaderris brunnea was not recorded during the surveys undertaken for this assessment. One occurrence of *Pomaderris brunnea* has been recorded in 2005 along the Colo River at Lower Portland in the Project study area. The species occurs in a variety of habitats. Records of this species often occur in moist woodlands and forests on clay soils, in more open woodlands, on alluvial floodplains, and along creek lines.

For this assessment, suitable habitat for *Pomaderris brunnea* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 1181 (HN586) - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.
- PCT 1183 (HN587)- Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion.
- PCT 1504 (HN647)- Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion.

The record of the species along the Colo River occurs in association with PCT 1106 (NR223) - River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 117 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Pomaderris brunnea	10.16	18.10

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Pomaderris brunnea was not recorded during the surveys undertaken for this assessment. One occurrence of *Pomaderris brunnea* has been recorded in 2005 along the Colo River at Lower Portland in the Project study area. The local population has been defined by this record for the purposes of this assessment. The species occurs in a variety of habitats. Records of this species often occur in moist woodlands and forests on clay soils, in more open woodlands, on alluvial floodplains, and along creek lines. The lifecycle of *Pomaderris brunnea* is thought to take between 10 and 20 years to complete. The time to reproductive maturity and ability to produce seed for an individual is approximately four to six years (OEH 2017). Seeds are likely dispersed by ants at a distance no greater three metres. There has been little research conducted into germination and pollination in *Pomaderris brunnea* however other species of *Pomaderris* have been shown to produce seed requiring fire for germination. It is not known if altered hydrological regimes will have an effect on life cycle of this species. The key impacts for this species as a result of the Project are the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. It is not known whether the species relies on specific hydrological regimes for its life cycle. While the known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the reduction in 10% AEP event flood extent and frequency **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species within the Lower Portland locality, about 10 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 18 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 117 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. The known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer

period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation following erosion, this is not expected to have a permanent adverse effect on this species.

(ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Pomaderris brunnea* primarily occur within relatively intact habitats around the Colo River. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and predicted longer dry periods in the 10% AEP event is has the potential to result in the loss of the species in the study area over the long-term. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. It is not known to rely on specific hydrological regimes for its life cycle, but it's preferred habitat adjacent to creeklines suggests this may be the case. . The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of *Pomaderris brunnea* in the Lower Portland locality.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A targeted strategy for managing *Pomaderris brunnea* has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *Pomaderris brunnea* has been assigned to the 'site-managed species' management stream. The following 4 priority management sites have been identified for this species:

- Oakwood property in the Mid-Western Regional LGA.
- Gundungurra Reserve/Spring Farm in the Camden LGA.
- Wirrimbirra Wildlife Sanctuary in Wollondilly LGA.
- Upper Nepean State Conservation Area in the Wingecarribee LGA.

The Project will not impact any of the listed priority management sites.

A national recovery plan for Pomaderris brunnea was developed in to recover and 'minimise the probability of extinction of *Pomaderris brunnea* in the wild and to increase the probability of populations becoming self-sustaining in the long term'. The national recovery plan sets out the following recovery objectives:

- Determine current status and threats.
- Determine habitat requirements.
- Protect and manage populations on public and private land.
- Monitor response of populations to active management.
- Identify key biological functions.
- Establish a population in cultivation.
- Build community support of conservation.

The Project has the potential to impact the occurrence of *Pomaderris brunnea* occurring along the Colo River at Lower Portland.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif

Conclusion
The Project may result in minor modifications to areas of known *Pomaderris brunnea* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of erosion is expected to be temporary. The Project **has the potential** to result in a significant impact on *Pomaderris brunnea* within the 10% AEP event changed flood extent.

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Pultenaea parviflora

Endangered under the BC Act
Vulnerable under the EPBC Act

Pultenaea parviflora was not recorded during the surveys undertaken for this assessment. This species has however, been previously recorded within the Project study area at Wianamatta Regional Park, near Wianamatta Nature Reserve, near Castlereagh Nature Reserve and near Cattai Creek and its tributaries. A smaller disjunct occurrence has been recorded in the north of the study area near Ebenezer.

Pultenaea parviflora habitat includes dry sclerophyll forest, woodlands, and grasslands supported by either Wianamatta Shale, laterite or Tertiary alluvium. Habitat is found on infertile sandy clay soils where the water table is low, and the supply of moisture is intermittent (Benson and McDougall 1996; DEWHA 2008). Canopy species associated with *Pultenaea parviflora* habitat include *Eucalyptus fibrosa*, *Eucalyptus sclerophylla, Eucalyptus sideroxylon, Angophora bakeri, Allocasuarina littoralis* and *Melaleuca decora*. Shrubs that have been recorded alongside *Pultenaea parviflora* include *Melaleuca nodosa*, *Acacia decurrens*, *Acacia elongata*, *Bursaria spinosa*, *Daviesia genistifolia*, *Hakea sericea*, *Kunzea ambigua* and *Olearia microphylla*.

According to OEH's BioNet system, *Pultenaea parviflora* is associated with the following PCTs mapped in the study area:

- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion.
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion.
- PCT 883 (HN542): Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion.

Pultenaea parviflora was also recorded in the following PCT mapped by SMEC but not listed as associated habitat as per the TBDC:

- PCT 849 (HN528): Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 4,588 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Pultenaea parviflora	199.04	24.79

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Low
Bank erosion and slumping resulting in vegetation community and habitat degradation	High
Increased duration of inundation in habitats	High
Spread of exotic species resulting in increased competition and predation on native species	Moderate
Spread of disease and pathogens	Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Pultenaea parviflora live for about 20 years and estimates have individuals reaching reproductive maturity between 3 and 6 years (Benson and McDougall 1996; OEH 2019). Flowering occurs between August and November however the vectors of pollination are unknown (DEWHA 2008). Reproduction is understood to occur only from the out-crossing of two individuals as there are no recorded observations of self-pollination or vegetative spread (suckering) (OEH 2019). Fire and ants play an important role in the lifecycle of *Pultenaea parviflora*. The presence of an elaiosome indicates that ants are a factor in the dispersal of seed. *Pultenaea parviflora* – with the help of ants - produces a soil-stored seedbank, a seedbank that requires fire to germinate. Fire induces recruitment of new individuals from the seedbank after it kills adult plants. OEH notes that germination from the soil-stored seedbank can be 'prolific after a moderate to high intensity fire' (OEH 2019). A reduction in peak flood extents and durations, along with a reduction in peak flood flows is unlikely to impact the lifecycle of *Pultenaea parviflora.* This species of *Pultenaea* occurs in dry habitat where the water-table is already low. A reduction to the extent and duration that this habitat is flooded is therefore unlikely to further reduce the water-table in *Pultenaea parviflora* habitat, or further dry out the habitat. Fire is important to the lifecycle of *Pultenaea parviflora*, as a result the modification of the fire regime a risk to this lifecycle. The Project may affect the fire regime within the study area by modifying the vegetation communities. The potential for an increased frequency of fire may place the local population of *Pultenaea parviflora* at risk of extinction. The known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or to affect its seed bank.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 199 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 25 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. About 4,588 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. This represents 5 percent of the local population of the species. (ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Pultenaea parviflora* primarily occur within the conserved habitats in the Cumberland Plain.

It is likely that the previous extent of the species has been reduced and fragmented through clearance in relation to agricultural and residential expansion. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The impacts of the changed flooding extents and predicted longer dry periods in the 10% AEP event has the potential to result in the loss of the species in the study area over the long-term. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. It is unknown whether the species relies on specific hydrological regimes for its lifecycle.

The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of *Pultenaea parviflora* on the Cumberland Plain.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A targeted strategy for managing *Pultenaea parviflora* has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *Pultenaea parviflora* has been assigned to the 'site-managed species' management stream. The following four priority management sites have been determined for *Pultenaea parviflora*:

- Scheyville in the Hawkesbury LGA.
- Castlereagh Nature Reserve in the Penrith LGA.
- Wianamatta Nature Reserve in the Penrith LGA.
- Colebee in the Blacktown LGA.

The Project will impact the Scheyville priority management site. Specifically, the Project is inconsistent with the following management objectives set out for the Scheyville priority management site:

- Reduce and maintain weed densities at low levels.
- Maintain appropriate fire regime for the species/community.

Pultenaea parviflora has been included in the Cumberland Plain Recovery Plan, a plan that provides the foundation for future biodiversity protection in western Sydney (DECCW 2010). The Cumberland Plain Recovery Plan outlines the following four recovery objectives:

- To build a protected area network, comprising public and private lands, focused on the priority conservation lands.
- To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary objectives are compatible with biodiversity conservation.
- To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practise standards for its management, and the recovery program.
- To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

The Project is inconsistent with objectives 1 and 2 of the Cumberland Plain Recovery Plan. The Project will impact protected areas - for example, Scheyville National Park, Windsor Downs Nature Reserve, Agnes Banks Nature Reserve, Wianamatta Regional Park - along with public and private lands that provide habitat for the biodiversity of the Cumberland Plain. This impact is inconsistent with the building or even maintenance of a protected area network. Impacting the protected, public and private lands that support biodiversity do not align with best practise management of threatened species, communities and ecological communities.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'Threatening process' means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the *Threatened Species Conservation Act 1995*. There are 37 listed key threatening processes under the *Threatened Species Conservation Act 1995*.

The Project has the potential to contribute to and increase the impact of seven Key Threatening Processes (KTPs) listed under the TSC Act. The following 7 KTPs potentially relate to *Pultenaea parviflora:* ▪ Clearing of native vegetation. ▪ Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands. ▪ Invasion and establishment of exotic vines and scramblers. ▪ Invasion of native plant communities by exotic perennial grasses. ▪ Invasion of native plant communities by African Olive, *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif. ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat). ▪ Ecological consequences of high frequency fires.
Conclusion
The Project may result in minor modifications to areas of known *Pultenaea parviflora* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project **has the potential** to result in a significant impact on *Pultenaea parviflora* within the 10% AEP event changed flood extent.

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Rhodamnia rubescens (Scrub Turpentine)

Critically Endangered under the BC Act
Not listed under the EPBC Act

Targeted surveys for *Rhodamnia rubescens* were not undertaken in the downstream study area for the Project. However, during the course of limited vegetation surveys undertaken, a total of 30 individuals of *Rhodamnia rubescens* were incidentally recorded in the survey area. The species has also been previously recorded around Grose Vale and Mulgoa. Before its rapid decline as a result of infection from myrtle rust, the species was often found in wet sclerophyll associations in rainforest transition zones and creek-side riparian vegetation. It also commonly occurred in all rainforest sub-forms except cool temperate rainforest. The species is known to occupy a range of volcanically derived and sedimentary soils and is a common pioneer species in eucalypt forests.

DPIE Biodiversity Assessor Update No. 28 advises that given the severity of the Myrtle Rust on this species, any individuals that are currently alive are potentially significant to the survival of the species. This assessor update states that a precautionary approach to assessing potential impacts on these species needs to be undertaken including the assumption that any individuals or populations that remain are potentially viable and that where feasible, these individuals or populations need to be afforded protection to optimise the survival and recovery of this species.

The Threatened Species Assessment Test of Significance Guidelines (DECC 2007) defines a local population of a threatened plant species as 'comprising those individuals occurring in the study area or the cluster of individuals that extend into habitat adjoining and contiguous with the study area that could reasonably be expected to be cross-pollinating with those in the study area'. The breeding system of *Rhodamnia rubescens* is poorly documented in scientific literature. Prior to the impacts of Myrtle Rust, *Rhodamnia rubescens* typically flowered intensively each year, but now flowering is generally rare and fruit production even rarer, with any fruit produced typically without seeds. DPIE presumes this be in part due to pollination constraints. Therefore, as per the Threatened Species Assessment Guidelines, each presumed cluster of individuals will be assessed as a local population within the study area and assessed separately.

For this assessment, suitable habitat for *Rhodamnia rubescens* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 877 - Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- PCT 1284 - Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion
- PCT 1292 – Water Gum – Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion (SMEC 2019)
- PCT 1181 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion (BioNet)

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 135 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Rhodamnia rubescens (Scrub turpentine)	39.70	39.33

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	High
Spread and increase impact of exotic species resulting in increased competition and predation on native species	Very Low
Spread and increase impact of disease and pathogens	Extreme

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Thirty individuals of *Rhodamnia rubescens* were incidentally recorded in the survey area within Maroota Ridge State Conservation Area near South Maroota. The species has also been previously recorded around Grose Vale and Mulgoa. The species is often found in wet sclerophyll associations in rainforest transition zones and creekside riparian vegetation. It commonly occurs in all rainforest sub-forms except cool temperate rainforest. The life cycle of *Rhodamnia rubescens* is poorly documented in scientific literature, although the susceptibility of all plant parts of the species to myrtle rust (*Austropuccinia psidii*) infection is well recognised. The key impacts for this species as a result of the Project is the predicted spread and increase of impacts of disease and pathogens, specifically Myrtle Rust. The reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur also are also identified as important impacts. While the hydrological requirements for *Rhodamnia rubescens* are not well-understood, it is likely that any changes to the existing hydrological regimes as a result of the Project will add stress to any individuals infected by Myrtle Rust that occur within the study area. Similarly, changes to the existing hydrological regimes may place stress on individuals not affected by myrtle rust, or less affected, such that this stress would make them more susceptible to infection. The Project is therefore expected to contribute to an increased susceptibility of a local viable population of *Rhodamnia rubescens* to myrtle rust infection by changing the existing environment through changed hydrological regimes. As a result, the reduction in 10% AEP event flood extent and frequency, and in the increased inundation frequency within the FMZ discharge area, **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(I Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species, about 40 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 39 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 135 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) The Project would cause fragmentation and isolation of suitable habitat in the study area (inclusive of survey area and various flood scenarios). Fragmentation and isolation are likely as the Project would change the hydrological regimes that have influenced the quality of the existing habitat within the study area. It is not known how a change to the hydrological regimes would affect existing habitat and therefore it has been assumed that the quality of suitable habitat will ultimately substantially differ as a result of the Project. Given that the dispersal and genetic exchange mechanisms of *Rhodamnia rubescens* are poorly understood, it is assumed that the gene flow and ability for the species to sustain a viable population within the study area will be affected through fragmentation and isolation

(iii) This question relates to the importance of habitat for the species in the locality, which in this instance is an assessment of the importance of the habitat in the study area. About 135 hectares of suitable habitat for *Rhodamnia rubescens* is present within the study area. However, the extent is an approximation only as the entire extent of the study area was not ground-truthed or surveyed. The extent of suitable habitat within the area of changed flood extent in the 10% AEP event is estimated to be about 40 hectares. *Rhodamnia rubescens* appears to have specific habitat requirements in that it prefers wet sclerophyll forest and rainforest vegetation types. These vegetation types which are relatively uncommon in parts of the study area such as the Cumberland lowlands due to clearing for development. These vegetation types are also susceptible to other threats such as fire and weed invasion, meaning that existing remnants should be prioritised for conservation purposes. In addition to the limited habitat for this species, populations of *Rhodamnia rubescens* are already in a steep decline due to the effects of myrtle rust infection, with many infected individuals failing to flower or set seed. To that end, the habitat within the study area is considered important to the long-term survival of the species in the locality, particularly in the context of a rapidly declining species with specific habitat requirements.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no recovery plan or threat abatement plan for *Rhodamnia rubescens.* A targeted strategy for managing *Rhodamnia rubescens* has been developed under the Saving Our Species Program. Proposed actions include (but are not limited to):

- Select a series of stratified monitoring sites to monitor on-going myrtle rust incidence, severity and symptomology
- Complete rapid field surveys across the entire species range to determine rust impact, identify rust resistant populations, sites or individuals.
- Control transformer weeds

The Project is unlikely to be consistent with the management actions outlined in the Saving Our Species program.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The Project would contribute (either directly or indirectly) to eight key threatening processes (KTPs), namely:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Clearing of native vegetation.
- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana *(Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (Olea europaea subsp. cuspidata) (Wall. ex G. Don) Cif.

Although each of these processes are already in operation within the study area, the action proposed is likely to exacerbate the aforementioned KTPs. Of particular importance, it is likely that the Project could create conditions conducive to the spread of exotic rust fungi, such as myrtle rust. This could through a change in localised conditions favourable to the transmission vectors for myrtle rust (which are largely unknown (Makinson 2018)) or it may be by causing additional stresses to *Rhodamnia rubescens* individuals such that their susceptibility to infection is increased or that those that are infected have a lower ability to cope with infection. In this context additional stresses would ultimately be a result of a changed hydrological regime or secondary impacts such as erosion, changed soil properties and other factors.

Conclusion
The Project has the potential to increase the susceptibility of *Rhodamnia rubescens* to myrtle rust as a result of coping with other stresses associated with the Project, for example a changed hydrological regime (or other secondary impacts). The species is experiencing a rapid decline due to myrtle rust and un-infected individuals are considered significant to the survival of the species (DPIE 2019). The Project has the **potential to result in a significant impact** on *Rhodamnia rubescens* within the 10% AEP event changed flood extent.

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Senna acclinis (Rainforest Cassia)

Endangered the BC Act
Not listed the EPBC Act

Senna acclinis was not recorded during the surveys undertaken for this assessment. The species has been previously recorded along the Colo River near Lower Portland and Colo in 2018. The species is often found on the margins of subtropical, littoral and dry rainforests.

For this assessment, suitable habitat for *Senna acclinis* includes the PCTs that the species was incidentally recorded within, PCTs that are associated with the species (as per the TBDC) and any other known vegetation types (as per scientific literature) for which the species may occur that have been mapped within 5 kilometres of any known records. These are:

- PCT 1284 (HN606) – Turpentine – Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion
- PCT 1504 (HN647) – Sydney Blue Gum – Deane's Gum – River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 78 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Senna acclinis (Rainforest Cassia)	1.93	10.66

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Senna acclinis was not recorded during the surveys undertaken for this assessment. The species has been previously recorded along the Colo River near Lower Portland and Colo in 2018. The species is often found on the margins of subtropical, littoral and dry rainforests. The species flowers in spring and summer and the fruit is ripe in summer and autumn. It is known to be pollinated by a variety of bees. It is not known if altered hydrological regimes will have an effect on life cycle of this species. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle and records of the species extend beyond the extent of the Project study area suggesting that the species does not rely on frequent flooding events to persist. As a result, the Project is **unlikely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species, about 2 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 11 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 78 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. While the known and potential habitats for this species within the 10% AEP event are likely to experience a reduction in flooding during minor flood events; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. (ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Senna acclinis* primarily occur within relatively intact habitats around the Colo River. It is unlikely that the changed flooding regime will increase fragmentation for this species. (iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the species in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle.

While the habitat within the 10% AEP event and FMZ discharge area is expected to be important for any local population of *Senna acclinis*, the impacts to this habitat are expected to be minor.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.
A targeted strategy for managing *Senna acclinis* has been developed under the Saving Our Species Program. Five priority management sites are proposed however none of these overlap with the study area for the Project. The Project is unlikely to be consistent with the management actions outlined in the Saving Our Species program.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Invasion of native plant communities by exotic perennial grasses ▪ Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae ▪ Invasion and establishment of exotic vines and scramblers ▪ Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat) ▪ Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif While each of these processes are likely already in operation within the study area, however the changed hydrological regimes of the Project are unlikely to exacerbate these processes.
Conclusion
The Project may result in minor modifications to areas of potential *Senna acclinis* habitat in the 10% AEP event; areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The Project is **unlikely to result in a significant impact** on *Senna acclinis* within the 10% AEP event changed flood extent.

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Seringia denticulata (*Seringia denticulate*)

(Synonym: *Keraudrenia corollata* var. *denticulata*)

Endangered under the BC Act
Not listed under the EPBC Act

This endangered population occurs within the Hawksbury local government area, isolated from other populations and at the southern limit of the species' geographic range. The endangered population range is only in the Colo River area between Lower Portland and Morans Rock. Previous records of the species occur around Morans Rock, Lower Portland and Gees Lagoon near the Colo River. Typically, this species occurs in tall open forest on sandstone in well drained low nutrient soils on the edge of flood plains or on road verges.

For this assessment, as all occurrences of the population are associated with *River-flat Eucalypt Forest EEC*, suitable habitat for *Seringia denticulata* includes the PCTs that conform to this TEC within 5 kilometres of any known records. These are:

- PCT 1183 (HN587) - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
- PCT 1284 (HN606) - Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion
- PCT 1504 (HN647) - Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 102 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Seringia denticulate endangered population	1.07	12.10

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	High
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Very Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
The *Seringia denticulata* endangered population occurs within the Hawksbury LGA, isolated from other populations and at the southern limit of the species' geographic range. The endangered population range is only in the Colo River area between Lower Portland and Morans Rock. Typically, this species occurs in tall open forest on sandstone in well drained low nutrient soils on the edge of flood plains or on road verges. The species grows in well-drained low nutrient soils on the edge of flood plains. There is limited knowledge regarding the lifecycle and cross-pollination mechanisms. The species is known to flower in spring and its response to fire is unknown. It is not known if altered hydrological regimes will have an effect on life cycle of this species. The key impacts for this species as a result of the Project is the potential for erosion as a result of the increased inundation period in the FMZ discharge when flood events occur. The change in 10% AEP event flooding extent is minimal in the upper reaches of the Colo River where the species is known to occur. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species extend beyond the extent of the Project study area suggesting that the species does not rely on frequent flooding events to persist. Specifically, the species appears to prefer areas that are well-drained. While the longer period of time for inundation in the FMZ discharge area may result in erosion and temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. As a result, the Project is **unlikely** to have an adverse effect on the life cycle of the population such that a viable local population of the species is likely to be placed at risk of extinction.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the range of the endangered population of the species within the Lower Portland locality, about 1.07 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 12 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species in the locality. About 102 hectares of potentially suitable habitat in associated TECs/PCTs occurs within the Project study area. While the longer period of time for inundation in the FMZ discharge area may result in erosion and temporary damage to vegetation, this is not expected to have a permanent adverse effect on this species or its seed bank. (ii) The native vegetation of the floodplain in the Hawkesbury-Nepean catchment is currently subject to high fragmentation due to land use and vegetation clearance due to agriculture and suburban development. The known records of *Seringia denticulata* primarily occur within relatively intact habitats near Wollemi National Park and Parr State Conservation Area. It is unlikely that the changed flooding regime will increase fragmentation for this species.

(iii) The impacts of the changed flooding extents and potentially longer dry periods in the 10% AEP event is not considered likely to result in the loss of the population in the locality. Longer inundation in the FMZ discharge area may result in some vegetation damage and decline, however this is expected to be temporary. The species is not known to rely on specific hydrological regimes for its life cycle and known records of the species occur in well-drained areas.

While the habitat within the 10% AEP event area and FMZ discharge area is expected to be important for this highly restricted population of *Seringia denticulata*, the impacts to this habitat are expected to be minor.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat has been declared for this population.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

OEH has developed recovery plans and objectives for various threatened species as part of the Saving Our Species (SoS) Program. *Seringia denticulata* is managed under the Endangered population SoS management stream. The following broad actions have been identified:

- Undertake potential habitat survey and confirm known sites.
- Assess and map threats acting on sites.
- Notify and educate landholders with regards to location, site management implications and opportunities for conservation.
- Restrict and control access to sites especially from vehicles and stock.
- Increase protection status of sites.
- Prepare and implement Plan of Managements for sites.
- Ensure sites are considered and protected in future development assessment and planning matters.
- Develop and implement a threat management monitoring program for all sites.
- Remove weeds and control their further spread.
- Encourage restoration/regeneration in degraded areas using approved restoration techniques for EECs on the Cumberland Plain.
- Prepare and implement guidelines for road maintenance to minimise habitat disturbance.

No objectives or actions have been listed with this species program. There is no federal recovery plan or any other related recovery plans this species therefor the Project is not inconsistent with any plans.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat)
- Invasion of native plant communities by African Olive (*Olea europaea* subsp. *cuspidata*) (Wall. ex G. Don) Cif

Conclusion

The Project may result in minor modifications to areas of known *Seringia denticulata* population habitat in the FMZ discharge area, however vegetation damage as a result of this is expected to be temporary. The species persistence in habitats outside the Project study area suggests that the species is not reliant on regular flooding regimes and the species is known to prefer well-drained sites.

The Project is **unlikely to result in a significant impact** on *Seringia denticulata* within the 10% AEP event changed flood extent.

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Zieria involucrata

Endangered under the BC Act
Vulnerable under the EPBC Act

Field survey conducted for the Project confirmed the occurrence of *Z. involucrata* within Scheyville National Park. The occurrence of these individuals corresponded to PCT 1557 (HN665) and PCT 1292 (HN607), neither of which are listed in BioNet. Within the study area, Office of Environment and Heritage records show that the *Z. involucrata* distribution extends further north down the Hawkesbury River.

Zieria involucrata is endemic to the Sydney Basin Bioregion where it has been recorded from the hills and escarpments to the north-west and west of the Sydney Metropolitan area. According to the Draft Recovery Plan for *Zieria involucrata*, the species is known from 22 extant populations (NSW NPWS 2004). The size of populations ranges from a single plant to over 500, although 13 of the 22 known populations have fewer than 100 individuals. The exact size of the combined 22 populations is unknown, however estimates have the entire population being comprised of between 5,000 and 8,000 individuals (NSW NPWS 2004).

Within its distribution, *Z. involucrata* occurs on the mid – to lower slopes of rolling hills or steeper terrain. Within this terrain it usually occurs in neutral to slightly acid, sandy soils, often amongst sandstone outcrops and boulders. All but three populations occur in habitat supported by Hawkesbury Sandstone. Two of the outlier populations occur in habitat supported by a mix of Hawkesbury and Narrabeen Sandstone geologies. The third outlier population occurs on Quaternary alluvium of the Wiseman's Ferry soil landscape (NSW NPWS 2004). Canopy species characteristic of *Z. involucrata* habitat include *Syncarpia glomulifera* subsp. *glomulifera*, *Eucalyptus agglomerate*, *Allocasuarina torulosa* and *Angophora costata. Zieria involucrata* habitat usually supports a dense sub-canopy and shrub layer including species such as *Ceratopetalum gummiferum, Backhousia myrtifolia*, *Leptospermum trinervium* and *Elaeocarpus reticularis.* Smaller shrubs such as *Entolasia stricta, Lepidosperma laterale,* and *Dianella caerulea*, are common in *Z. involucrata* habitat.

According to OEH's BioNet system, *Z. involucrata* is associated with the following PCTs mapped in the study area:

- PCT 1504 (HN647): Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion.
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.
- PCT 1284 (HN606): Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion.
- PCT 1328 (HN613): Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast, Sydney Basin Bioregion.

As previously mentioned, *Z. involucrata* was recorded by SMEC in two PCTs that are not identified as habitat within the TBDC:

- PCT 1557 (HN665): Rough-barked Apple – Forest Oak – Grey Gum grassy woodland on sandstone ranges of the Sydney Basin
- PCT 1292 (HN607): Water Gum – Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 237 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Zieria involucrata	59.22	54.76

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Low
Bank erosion and slumping resulting in vegetation community and habitat degradation	Medium
Increased duration of inundation in habitats	High
Spread of exotic species resulting in increased competition and predation on native species	Very Low
Spread of disease and pathogens	Moderate

Assessment of significance

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The lifespan of *Z. involucrata* is uncertain however the Draft Recovery Plan for *Zieria involucrata* describes that it may live between 10 and 15 years (NSW NPWS 2004). *Zieria involucrata* produces both dormant and non-dormant seed. A study by Auld *et al.* (2000) estimated that dormant seed reached its half-life 4.9 years after release and raised the possibility that some seed may be viable up to two decades after the plant it was released from had died. Seed is dispersed via 'forcible ejection' from a coccus (Armstrong 2002). Seeds have elaiosomes indicating that secondary dispersal via ants is also likely. Regardless, seed dispersal is likely to be limited to a few metres (Auld 2001). Fire is important to the reproductive ecology of *Z. involucrate;* it has been described as a fire sensitive species that is capable of limited re-sprouting (Auld 2000; Armstrong 2002). Fire has been suggested as important to the germination of the seed bank. Heat or smoke – or a combination of the two- may be important to breaking seed dormancy and ensuring germination success (NSW NPWS 2004). A reduction in peak flood extents and durations, along with a reduction in peak flood flows is unlikely to impact the lifecycle of *Z. involucrata*. Increases in low-level flooding caused by the discharge of the FMZ may however impact the lifecycle of *Z. involucrata*, as the discharged water will reach occurrences of PCT 1504 (HN647), PCT 1181 (HN586), PCT 1284 (HN606), PCT 1328 (HN613), PCT 1292 (HN607), and PCT 1557 (HN665). The discharged water would likely inundate *Z. involucrata* habitat and individuals. The potential of the species to withstand temporary inundation is unknown.   neither of which have evolved to withstand flooding. The soil-stored seed bank produced by *Z. involucrata* may also be impacted by temporary inundation. As a result, the reduction in 10% AEP event flood extent and frequency, and the increased frequency of inundation within the FMZ discharge area, **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) About 59 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 55 hectares within the FMZ discharge area based on a 5 kilometre buffer around the record of the species in the locality. About 237 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) The *Zieria involucrata* habitat within the study area has been partially fragmented through agricultural and residential development. The extents of PCT 1284 (HN606) and PCT 1181 (HN586) are however often contiguous with larger areas of native vegetation that stretch outside of the study area. This makes the *Z. involucrata* habitat comparatively less fragmented than other native vegetation occurring within the central part of the Cumberland Plain. Despite the *Z. involucrata* habitat's partial connectivity with large areas of

native vegetation, the Project has the potential to further fragment its extent within all the impact boundaries listed in the introduction. The further fragmentation of *Z. involucrata* habitat will predominantly occur along the Nepean River, the Colo River, Wheeny Creek, Robert's Creek, Kelly's Creek, Little Cattai Creek, and around Maroota Ridge Conservation Area.

(iii) *Zieria involucrata* is endemic to the hills and escarpments that surround the north-west and west of the Sydney Metropolitan area. The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of *Zieria involucrata* on the Cumberland Plain

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A targeted strategy for managing *Zieria involucrata* has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *Z. involucrata* has been assigned to the 'site-managed species' management stream. The following priority management sites have been identified in the Saving Our Species program for *Z. involucrata*:

- Yengo – Parr, in the Hawkesbury LGA.
- Marramarra National Park in the Hornsby LGA.
- Maroota Ridge in The Hills Shire LGA.
- Blue Mountains in the Blue Mountains and Hawkesbury LGAs.

The Project will impact the Yengo- Parr and Maroota Ridge priority management sites. Specifically, the Project is inconsistent with the following management objectives:

- Maintain appropriate fire regime.
- Prevent weed invasion of the site.

A draft recovery plan has been written for *Z. involucrata*. The recovery plan outlines the following 6 objectives:

- Conserve *Z. involucrata* using land-use and conservation planning mechanisms.
- Implement a survey and monitoring program.
- Identify and minimise the threats operating at sites where the species occurs
- Provide public authorities and the community with information that assists in conserving the species.
- Raise awareness of the species and involve the community in the recovery program.
- Promote investigations into the ecology and biology of the species in order to provide information to assist future management decisions.

The Project is inconsistent with the Draft Recovery Plan for *Zieria involucrata*. Specifically, the Project is inconsistent with objectives 1 and 3. Objective 1 '*aims to increase the legislative protection afforded to these sites* (land currently not managed for conservation purposes)'. The Project will not increase the legislative protection of any sites or Z. involucrata habitat, in fact, it will impact sites that are protected and occur within National Parks and State Conservation Areas. Objective 3 aims '*to identify and manage these threats through the implementation of appropriate in situ threat abatement measures in accordance with management plans and site management statements*'. The Project would not contribute to the management of any threats.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'Threatening process' means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the *Threatened Species Conservation Act 1995*. There are 37 listed key threatening processes under the *Threatened Species Conservation Act 1995*.

The Project has the potential to contribute to and increase the impact of eight Key Threatening Processes (KTPs) listed under the TSC Act. The following 8 KTPs relate *Zieria involucrata:*

- Clearing of native vegetation.
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands.

- Invasion and establishment of exotic vines and scramblers.
- Invasion of native plant communities by exotic perennial grasses.
- Invasion of native plant communities by African Olive, *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. lat).
- Ecological consequences of high frequency fires.
- Infection of native plants by *Phytophthora cinnamomi*.

The alteration to the flow and extents of the Nepean and Hawkesbury Rivers along with their associated waterways, wetlands, and swamps will result in a reduction or modification of certain communities (including PCTs listed in section d). The reduction in the extent of this vegetation is considered by OEH to be clearing of native vegetation, even if only certain strata levels are impacted – including the soil seedbank.

A reduction in the coverage of native flora species may create an opportunity for the further spread and establishment of weeds and exotic species. Such species include African Olive, Lantana, and several perennial grasses, vines and scramblers. These species may out-compete native species such as *Z. involucrata*.

Frequent fire has been identified as detrimental to the reproductive ecology of *Z. involucrata* (NSW NPWS 2004). The Project has the potential to modify the vegetation assemblages within the impact boundaries which, may subsequently change the fire frequency within the *Z. involucrata* habitat. If fire becomes too frequent, seedlings may be killed before they reach reproductive maturity and release the seed that will become the next generation.

The dispersal of *Phytophthora cinnamomi* can be mediated through water and through eroded soil. The Project has the potential to facilitate the spread of *Phytophthora cinnamomi* throughout the study area and therefore contribute to the key threatening process.

Conclusion

The local population has been assessed as occurring within the study area from the individuals recorded during the surveys, from OEH records, and from the PCTs associated with its habitat. The Project has been assessed as impacting the lifecycle of the local population such that it will be placed at risk of extinction. The Project will also impact habitat assessed as important to the local population of *Z. involucrata*. The Project has been assessed as inconsistent with the recovery actions set out in the Saving Our Species Program for *Z. involucrata* and the Draft Recovery Plan for *Zieria involucrata*. The impacts of 8 key threatening processes relevant to *Z. involucrata* will also be increased by the Project.

The Project **has the potential** to result in a significant impact on *Z. involucrata* within the 10% AEP event changed flood extent.

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Anthochaera Phrygia (Regent Honeyeater)

Critically Endangered under the BC Act
Critically Endangered under the EPBC Act

The Regent Honeyeater was not recorded during the surveys undertaken for this assessment. The Regent Honeyeater inhabits dry open forest and temperate woodland particularly Box-Ironbark woodland and riparian forests of River Sheoak (*Casuarina cunninghamiana*) at scattered locations in south-eastern and eastern Australia (Higgins et al. 2001). Key tree species include Mugga Ironbark (*Eucalyptus sideroxylon*), Yellow Box (*Eucalyptus melliodora*), White Box (*Eucalyptus albens*), Broad-leaved Apple (*Angophora floribunda*) Swamp Mahogany (*Eucalyptus robusta*) and Spotted Gum (*Corymbia maculata*). The Regent Honeyeater has undergone a substantial, long-term decline and the total population currently comprises approximately 350-400 individuals (DoE 2016). Within the Regent Honeyeater's current distribution there are less than five key breeding areas (DoE 2016, Crates et al. 2018). The loss, fragmentation and degradation of breeding and foraging habitat for agriculture and residential development is the Regent Honeyeater's main threat. The loss of the majority of fertile Yellow Box-White Box-Blakely's Red Gum Woodlands in south-eastern Australia has been particularly detrimental for this species (DoE 2016). Competition with the Noisy Miner (*Manorina melanocephala*) whilst is another key threat to breeding and foraging.

The Regent Honeyeater was once a widespread and relatively common species on the Cumberland Plain. However, it has since declined considerably and is now rarely recorded in the study area or elsewhere on the Cumberland Plain. The most recent records of this species in the study area were in 1982 and 1983 (Pitt Town Bottoms) and 1985 (near Wallacia). Recent records from the region include three individuals at Agnes Bank Nature Reserve in 1998, seven at Castlereagh Nature Reserve in 2009 and eight at Windsor Downs Nature Reserve in 2010. A breeding event occurred within the Mulgoa area in 2014, although the exact location in relation to the study area has not been confirmed. Two breeding events were recorded during within one kilometre of the study area within the 2019-2020 breeding season, thought to be related to prolific blossom east of the Blue Mountains. This breeding event resulted three fledged juveniles; one juvenile fledged from the Mulgoa area, and two fledged from around the South Maroota area (R. Crates, pers comm).

No targeted Regent Honeyeater surveys were conducted in the study area by SMEC. For this assessment, it is assumed that the Regent Honeyeater could occupy any suitable habitat within the study area. Suitable habitat includes areas that have been mapped as the following PCTs:

- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 830 (HN524): Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 850 (HN529): Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 866 (HN554): Grey Gum - Smooth-barked Apple open forest of the dry hinterland of the Central Coast Sydney Basin Bioregion
- PCT 877 (HN538): Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- PCT 883 (HN542): Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain Sydney Basin Bioregion
- PCT 924 (HN552): *Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley Sydney Basin Bioregion
- PCT 958 (HN555): Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks Sydney Basin Bioregion
- PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion

- PCT 1081 (HN564): Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1106 (NR223): River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion
- PCT 1183 (HN587): Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
- PCT 1284 (HN606): Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion
- PCT 1292 (HN607): Water Gum - Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion
- PCT 1327 (HN612): Yellow Bloodwood - ironbark shrubby woodland of the dry hinterland of the Central Coast Sydney Basin Bioregion
- PCT 1328 (HN613): Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast Sydney Basin Bioregion
- PCT 1385 (HN577): Rough-barked Apple - Grey Gum grassy open forest of the hinterland hills of the Central Coast Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1504 (HN647): Sydney Blue Gum - Deane's Gum - River Peppermint shrubby riparian tall forest of the lower Colo River Sydney Basin Bioregion
- PCT 1557 (HN665): Rough-barked Apple - Forest Oak - Grey Gum grassy woodland on sandstone ranges of the Sydney Basin
- PCT 1718 (HN932): Swamp Mahogany - Flax-leaved Paperbark swamp forest on coastal lowlands of the Central Coast.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 8,419 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	**Potential habitat (hectares)**	
	10% AEP event	**FMZ discharge area**
Regent Honeyeater (*Anthochaera phrygia*)	723.57	1,554.63

Relevant impacts	**Impact risk ratings**
Reduction of flooding extent in habitats	**High**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**
Increased duration of inundation in habitats	**High**
Spread of exotic species resulting in increased competition and predation on native species	**Very Low**
Spread of disease and pathogens	**Very Low**

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
As per the Assessment of Significance Guidelines (DECC, 2007), 'local population' as the "population which occurs within the study area. The assessment of the local population may be extended to include individuals beyond the study area if it can be clearly demonstrated that contiguous or interconnecting parts of the population continue beyond the study area". Further to this, under these guidelines a local population of migratory or nomadic fauna species is defined as "individuals that are likely to occur in the study area from time to time" (DECC, 2007). The study area provides about 8,419 hectares of potential foraging habitat for the Regent Honeyeater. Individuals that forage in the study area are likely to be part of larger populations that are based around key breeding areas. Very few key breeding areas for this species have been identified, none of which occur within the study area. However, breeding events are known to occur on occasion within close proximity to the study area, the most recent being during the 2019-2020 breeding season thought to be the result of dry conditions west of the Great Dividing Range and prolific blossom east of the Blue Mountains. Breeding was recorded within two locations, Mulgoa and South Maroota, in habitat broadly consisting of retained remnant vegetation comprising *Eucalyptus tereticornis*, *Eucalyptus moluccana*, *Eucalyptus fibrosa*, and *Corymbia eximia*. As breeding habitat is broadly similar in composition and structure to foraging habitat, it is estimated that the study area provides about 8,419 hectares of potential breeding habitat for the species. Within the 2019-2020 breeding season, there were 20 nests across the known breeding distribution that made it to egg stage. Two of these nests, or 10 percent of known nests, occurred within close proximity to the study area. Of the 20 nests, five were successful, fledging 11 juveniles. Three of these juveniles were from the South Maroota nest and one was from the Mulgoa nest. In total, the juveniles that were fledged from nests within close proximity to the study area contributed to approximately 36 percent of the total number of known Regent Honeyeaters fledged this season. The predicted reduction of flooding extent within the 10% AEP event may result in adverse impacts or modifications to vegetation structure and floristics across about 724 hectares of potential breeding and foraging habitat. Increased inundation is expected to occur across about 1,555 hectares of potential breeding and foraging habitat in the FMZ discharge area, which may result in damage to fringing vegetation. This potential impact vegetation within the 10% AEP may result in modifications to the ecological characteristics that support Regent Honeyeater breeding and foraging such as nectar flows, fruit, lerp and honeydew availability, and vegetation structure. Whilst the 10% AEP does not possess a known key breeding area, the study area contains suitable breeding habitat that has been demonstrated to support breeding seasons during adverse environmental conditions, such as drought. Given the small population size, any potential impacts to breeding success could be detrimental to the local population. As a result, the reduction in 10% AEP event flood extent and frequency, and in the increased inundation frequency within the FMZ discharge area, **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable.

(d) In relation to the habitat of a threatened species, population or ecological community: (i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and (ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and (iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.
(i) The Project would likely result in the modification of about 724 hectares of potential breeding and foraging habitat within the 10% AEP event changed flooding extent and about 1,555 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population of the species. About 8,419 hectares of potentially suitable breeding and foraging habitat in associated PCTs occurs within the Project study area. All extents of suitable habitat are expected to be impacted by changes to the existing flow regimes. (ii) The Project is unlikely to fragment potential Regent Honeyeater habitat given that this species is capable of seasonal movements in response to the availability of food resources and no suitable habitat would directly be removed. It is more likely that the quality of existing habitat will be affected by the changes to the existing flow regimes. (iii) While the 10% AEP does not possess a known key breeding area, the study area contains suitable breeding habitat that has been demonstrated to support breeding seasons during adverse environmental conditions, such as drought. It is likely that the estimated 724 hectares of breeding and foraging habitat within the 10% AEP event changed flooding extent and the estimated 1,555 hectares in the FMZ discharge area that may be modified by the Project is important to the survival of the Regent Honeyeater in the locality.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan
OEH has developed a recovery plan and objectives for various threatened species as part of the Saving Our Species (SoS) Program, with the aim to use site managed sites for Regent Honeyeater. Four priority management sites are identified in NSW; Bundarra – Barraba (Gunnedah, Gwydir, Tamworth Regional and Uralla LGAs), Mudgee/Wollar (Mid-Western Regional, Muswellbrook and Upper Hunter LGAs), Lower Hunter Valley (Cessnock and Singleton LGAs) and the Capertee Valley (Lithgow City and Mid-Western Regional LGAs). These sites have no overlap on the local population in the Project. The Project has no direct impacts on the objectives of the SoS program. In addition to the SoS Program, a National Recovery Plan was prepared for the Regent Honeyeater in 2016 by the Commonwealth of Australia. The two overall objectives of the Recovery Plan (Commonwealth of Australia 2016) is to 'reverse the long-term population trend of decline and increase the numbers of regent honeyeaters to a level where there is a viable, wild breeding population, even in poor breeding years' and to 'Enhance the condition of habitat across the regent honeyeater range to maximise survival and reproductive success, and provide refugia during periods of extreme environmental fluctuation'. No breeding habitat for the Regent Honeyeater has been identified in the study area. Parts of the study area may occasionally be used for foraging; however, the Project is considered unlikely to have an adverse effect on this habitat.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process
The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species: ▪ Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. ▪ Clearing of native vegetation ▪ High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition ▪ Removal of dead wood and dead trees. These KTPs are unlikely to be exacerbated by the Project to the extent that they would adversely impact a local population of the Regent Honeyeater.

Conclusion
The Project may result in modification to up to about 724 hectares within the 10% AEP event changed flooding extent and up to about 1,555 hectares in the FMZ discharge area representing a reduction in the availability of potential breeding foraging habitat. The Project **has the potential to have a significant impact** on the Regent Honeyeater.

References

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Litoria aurea (Green and Golden Bell Frog)

Endangered under the BC Act
Vulnerable under the EPBC Act

The Green and Golden Bell Frog was not recorded during the surveys undertaken for this assessment. The species is an endemic Australian tree frog that is a member of the family Hylidae. Broadly, the species has been previously recorded as far as Yuraygir National Park on the North Coast of NSW to around Lakes Entrance in south-eastern Victoria (White and Pyke 2008). Breeding sites for the Green and Golden Bell Frog include a wide variety of natural waterbodies except fast flowing streams (White and Pyke 1996). It has been found they tend to prefer to breed in waterbodies that are still, shallow, ephemeral, unshaded, with aquatic plants and free of the Plague Minnow (*Gambusia holbrooki*) and other predatory fish (White and Pyke 1996). Breeding habitat also includes many human-created environments, including highly disturbed sites such as abandoned mines and quarries (Pyke et al. 2002) as well as artificial wetlands (Hamer et al. 2002; Darcovich and O'Meara 2008). Non-breeding habitat for the Green and Golden Bell Frog appears to be within 50 metres of waterbodies as the species is not found to disperse away from waterbodies into more terrestrial non-breeding habitats (100-300 metres from the breeding site) such that is the case for other Australian frog species (Lemckert 2004).

is assumed the Green and Golden Bell Frog could occupy any suitable habitat that occurs within its geographical range. Suitable habitat for the Green and Golden Bell Frog includes the following PCTs occurring within a 5 kilometre radius of known Green and Golden Bell Frog records:

- PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion
- PCT 1081 (HN564): Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1106 (NR223): River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1557 (HN665): Rough-barked Apple - Forest Oak - Grey Gum grassy woodland on sandstone ranges of the Sydney Basin
- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 781 (HN520): Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
- PCT 835 (HN526): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 877 (HN538): Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- PCT 883 (HN542): Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain Sydney Basin Bioregion
- PCT 958 (HN555): Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks Sydney Basin Bioregion

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 7,226 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Green and Golden Bell Frog (*Litoria aurea*)	584.68	996.91

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	**High**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Medium**
Increased duration of inundation in habitats	**Low**
Spread of exotic species resulting in increased competition and predation on native species	**High**
Spread of disease and pathogens	**High**

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The Green and Golden Bell Frog is considered highly dependent on its breeding sites for long term survival at the various remnant population sites (NPWS 2002). The species is known to be highly fecund (5,000+ eggs/spawn mass) with tadpoles developing over an approximate three month period (depending on prevailing conditions) (NPWS 2002). Some ephemeral breeding locations are prone to drying out before tadpoles have reached metamorphosis which is considered critical for some remnant populations (NPWS 2002). Metamorphlings are highly susceptible to predation (NPWS 2002). For assessment purposes, a viable local population of Green and Golden Bell Frog is assumed to be present in suitable habitat (the PCTs listed in the introduction) that occurs within 5 kilometres of known records and within the extents of the specified LGAs. However, as targeted survey was not undertaken it is possible that the local population may in fact be larger. The key impact for this species as a result of the Project is the predicted reduction of flooding extent. Should this occur in key breeding areas for Green and Golden Bell Frog it is likely that this would disrupt the life cycle. This is because the species is highly dependent on waterbodies (natural and artificial) for breeding and persisting, of which this habitat will be reduced. Within the study area, the species has historically been recorded in wetland habitats that will be subject to longer inundation and potential dry periods. It is not known how this may affect the life cycle of the Green and Golden Bell Frog specifically, but it could have negative implications for spread of *Gambusia holbrooki* and chytrid fungus – both of which are current known threats to the Green and Golden Bell Frog. As a result, the Project **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species may be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**
(i) Based on the local population of the species (a 5 kilometre buffer around records of this species), about 585 hectares of potentially suitable habitat occurs within the 10% AEP event. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. (ii) A reduction in peak flood extents and durations and a reduction in peak flood flows in the 10% AEP event is likely to cause fragmentation of Green and Golden Bell Frog habitat. As the Green and Golden Bell Frog does not tend to disperse far from its breeding or non-breeding habitat, this fragmentation may lead to isolation from other areas of Green and Golden Bell Frog habitat. While the Green and Golden Bell Frog has undergone considerable fragmentation of its once almost continuous state-wide distribution, most remaining populations are isolated by large distances and therefore are assumed to have a restricted gene flow between them (NPWS 2002). The risk of fragmentation therefore presents a real threat the long-term survival of the species in the locality.

(iii) Habitat where the Green and Golden Bell Frog has been recorded is considered likely to represent 'important' habitat within the locality. This is because the species has undergone a reduction in range and population declines in recent times (Mahony 1996). A reduction in peak flood extents and durations is expected to have a high risk for wetland and floodplain vegetation communities and habitats (as described in Table 6-3) thereby resulting in either loss or modification of these habitats.

As the habitat within the 10% AEP event is expected to be important for the local population of Green and Golden Bell Frog, the impacts to this habitat are expected to be high.

(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

OEH has developed a recovery plan and objectives for various threatened species as part of the Saving Our Species (SoS) Program, with the aim to use site managed sites for Green and Golden Bell Frog. Eight priority management sites were identified in NSW; Yuraygir National Park (Clarence Valley and Coffs Harbour LGAs), Crescent Head (Kempsey LGA), Broughton Island, Kooragang Island (Newcastle and Port Stephens LGAs), Homebush/Sydney Olympic Park (Canada Bay, City of Parramatta, Cumberland LGAs), Crookhaven (Shoalhaven LGA), Molonglo Floodplain (Queanbeyan-Palerang Regional LGA), Meroo (Shoalhaven LGA). These sites have no overlap on the local population in the Project. The Project has no direct impacts on the objectives of the SoS program.

In addition to the SoS Program, a Draft Recovery Plan was prepared for the Green and Golden Bell Frog in 2005 by the Department of Environment and Conservation (NSW) although it was never finalised. The two overall objectives of the Recovery Plan (DEC 2005) are to manage threats impacting on currently known populations of the Green and Golden Bell Frog, so as to stabilise and prevent further decline of the species, and to return the species to its former distribution, abundance and role in the ecosystem wherever possible (DEC 2005). The Project has direct and indirect impacts on the objectives of the Recovery Plan as it will likely impact known populations and habitat.

(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Project may constitute, and/or is part of, and/or is likely to result in the operation of, and/or increases the impact of, a number of key threatening process that particularly relate to this species:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands.
- Predation by the introduced Plague Minnow or Mosquito Fish *Gambusia holbrooki.*
- Infection of frogs by amphibian chytrid causing the disease *chytridiomycosis*.
- Clearing of native vegetation

Conclusion

The Project may result in modifications to up to 584.68 hectares of suitable habitat within the 10% AEP event representing a reduction in the availability of potential breeding habitat.

The Project **has the potential** to result in a significant impact on the Green and Golden Bell Frog.

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Meridolum corneovirens (Cumberland Plain Land Snail)

Endangered under the BC Act
Not listed under the EPBC Act

The Cumberland Plain Land Snail inhabits grassy, open woodland of the Cumberland Plain. Individuals live under bark, leaf litter, grass clumps and logs, or shelter in loose soil.

The limits of the Cumberland Plain Land Snail's distribution are Picton in the south, through to Windsor in the north and from Liverpool west to the Hawkesbury/Nepean River. Populations are likely to be small and isolated as a result of land use patterns.

No targeted searches for the Cumberland Plain Land Snail were undertaken by SMEC. It is assumed the Cumberland Plain Land Snail could occupy any suitable habitat that occurs within its geographical range. Suitable habitat includes the following PCTs occurring within a 5 kilometre radius of known Cumberland Plain Land Snail records:

- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 830 (HN524): Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 835 (HN536): Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 850 (HN529): Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 883 (HN542): Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain Sydney Basin Bioregion
- PCT 958 (HN555): Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks Sydney Basin Bioregion
- PCT 1067 (HN562): Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 9,262 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Cumberland Plain Land Snail (*Meridolum corneovirens*)	695.57	94.05

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	**Moderate**
Increases in low level flooding and flows during the discharge of the FMZ	**Moderate**
Changes to terrestrial woodland and forest communities and habitat	**High**
Bank erosion and slumping resulting in vegetation community and habitat degradation	**Moderate**
Increased duration of inundation in habitats	**Low**
Spread of exotic species resulting in increased competition and predation on native species	**Low**

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
As the name implies, the Cumberland Plain Land Snail occurs exclusively on the Cumberland Plain and it is likely that many isolated populations exist within the study area. The Cumberland Plain Land Snail relies on grass clumps, logs and other types of ground coverings for shelter, foraging and breeding. A tentative identification of the species was made from Longneck Lagoon in 2018, however, no detailed surveys were undertaken to determine the presence or absence in other areas of the study area. The following impacts rated with a moderate or higher risk - outlined in the table above - are relevant to the lifecycle of the Cumberland Plain Land Snail: ▪ Reduction of flooding extent in habitats ▪ Increases in low level flooding and flows during the discharge of the FMZ ▪ Changes to terrestrial woodland and forest communities and habitat ▪ Bank erosion and slumping resulting in vegetation community and habitat degradation. As a result, reduction in flooding extent and frequency in the 10% AEP event, and increase in flood frequency within the FMZ discharge area **has the potential** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable to a threatened species.
(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the local population of the species, about 696 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 94 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population(s) of the species in the locality. About 9,262 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) The native vegetation on the floodplain of the Hawkesbury-Nepean catchment has been previously fragmented by rural, agricultural and residential development. The known records of the Cumberland Plain Land Snail occur within this fragmented floodplain vegetation. (iii) The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of Cumberland Plain Land Snail.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)
No critical habitat has been declared for this species.

(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan
No recovery plan or threat abatement plan has been prepared for the Cumberland Plain Land Snail. The Cumberland Plain Land Snail is addressed as a threatened fauna species in the approved Cumberland Plain Recovery Plan (DECCW (NSW) 2010). The specific recovery objectives are: 1. To build a protected area network, comprising public and private lands, focused on the priority conservation lands 2. To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation 3. To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program 4. To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner. The Project is not inconsistent with the objectives of the Cumberland Plain Recovery Plan. A targeted strategy for managing the Cumberland Plain Land Snail has been developed under the Saving Our Species program. The majority of the Priority Management Area for this species lies within the study area, being located on the Cumberland Plain. The Project is therefore inconsistent with the Cumberland Plain Land Snail Saving Our Species Program.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process
The proposed development constitutes the KTP: ▪ Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.
Conclusion
The Project will modify habitat important to the lifecycle of the Cumberland Plain Land Snail. The modification of this habitat will impact the lifecycle of the local population likely placing it at risk of extinction. The Project has been assessed as **potentially** having a **significant impact** on Cumberland Plain Land Snail within the 10% AEP event changed flood extent.

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Pommerhelix duralensis (Dural Land Snail)

Endangered under the BC Act
Endangered under the EPBC Act

The Dural Land Snail occurs on shale-influenced habitats along the western and north-western fringes of the Cumberland IBRA subregion. There is currently a degree of uncertainty about the distribution and identity of the snails in this and related species. *Pommerhelix duralensis* in the strict sense, is found in an area of north-western Sydney between Rouse Hill - Cattai and Wiseman's Ferry, west from Berowra Creek.

The species has a strong affinity for communities in the interface region between shale-derived and sandstone-derived soils, within forested habitats that have good native ground-cover and woody debris. The Dural Land Snail favours sheltering under rocks or underneath bark. It does not burrow nor climb. The species has also been observed resting in exposed areas, such as on exposed rock or leaf litter, however it will also shelter beneath leaves, rocks and light woody debris.

Migration and dispersal is limited, with overnight straight-line distances of under one metre identified in the literature and studies. The species is active from approximately one hour after dusk until dawn with no confirmed diurnal activity ever being recorded. It exhibits no roost-site behaviour.

No targeted searches for the Dural Land Snail were undertaken by SMEC, however a couple of individuals were observed incidentally. It has been assumed the Dural Land Snail could occupy any suitable habitat that occurs within its geographical range. The following PCTs recorded within 5 kilometres of Dural Land Snail records have been classified as suitable habitat:

- PCT 724 (HN512): Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 725 (HN513): Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion
- PCT 830 (HN524): Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 849 (HN528): Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain Sydney Basin Bioregion
- PCT 850 (HN529): Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain Sydney Basin Bioregion
- PCT 1081 (HN564): Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain Sydney Basin Bioregion
- PCT 1181 (HN586): Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion
- PCT 1183 (HN587): Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
- PCT 1284 (HN606): Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion
- PCT 1395 (HN556): Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain Sydney Basin Bioregion.

The limited movement of the Dural Land Snail and its inability to inhabit even moderately disturbed habitat means that groups of individuals -determined from records – occurring in isolated stands of native vegetation should be treated as separate populations. The records at Cattai should therefore be treated as a separate population to the records at Maroota and those at Sackville.

The table below outlines the estimated extent of potential suitable habitat within the impact areas relevant for this assessment being the area of changed flood extent in the 10% AEP event and the FMZ discharge areas.

An estimated 921 hectares of habitat for this species occurs in the downstream Project study area based on equivalent PCTs mapped in *Remnant Vegetation of the western Cumberland subregion VIS_ID 4207* (OEH 2015).

Impacts relevant to this species are also listed and impact risk ratings provided as per Chapter 6 of this report.

Species	Potential habitat (hectares)	
	10% AEP event	FMZ discharge area
Dural Land Snail (*Pommerhelix duralensis*)	196.51	121.32

Relevant impacts	Impact risk ratings
Reduction of flooding extent in habitats	Low
Increases in low level flooding and flows during the discharge of the FMZ	Moderate
Changes to terrestrial woodland and forest communities and habitat	Moderate
Bank erosion and slumping resulting in vegetation community and habitat degradation	Moderate
Increased duration of inundation in habitats	Low
Spread of exotic species resulting in increased competition and predation on native species	Low

Assessment of significance

(a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction
The Dural Land Snail is likely to only occur in the north of the Study Area, corresponding to previous records at Cattai, Maroota and Sackville. The Dural Land Snail may occur in other areas in the north of the study area where suitable habitat occurs. The Dural Land Snail relies on a structurally complex ground cover of rocks, leaf litter and bark to provide shelter and breed. The following impacts rated with a moderate risk - outlined in the table above - are relevant to the lifecycle of the Dural Land Snail: ▪ Reduction of flooding extent in habitats ▪ Increases in low level flooding and flows during the discharge of the FMZ ▪ Changes to terrestrial woodland and forest communities and habitat ▪ Bank erosion and slumping resulting in vegetation community and habitat degradation Dural Land Snail is a shale-influenced-habitat specialist, which occurs in low densities along the western and northwest fringes of the Cumberland IBRA subregion on shale-sandstone transitional landscapes. The species is considered to be parapatric with Cumberland Plain Land Snail – that is the species' ranges are immediately adjacent to each other but do not significantly overlap. The species favours sheltering under rocks or inside curled-up bark. It does not burrow nor climb. The species has also been observed resting in exposed areas, such as on exposed rock or leaf litter, however it will also shelter beneath leaves, rocks and light woody debris. The key impacts for this species as a result of the Project is the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur. The species is not known to rely on specific hydrological regimes for its life cycle, however, given the species known distribution, it is unlikely. The known and potential habitats for this species within the 10% AEP event is likely to experience a reduction in flooding during minor flood events. Specifically, areas which are currently inundated every 10 years on average are predicted to be inundated every 20 years on average with the Project. While the longer period of time for inundation in the FMZ discharge area may result in temporary damage to habitat, this is not expected to have a permanent adverse effect on this species. As a result, the reduction in 10% AEP event flood extent and frequency is **unlikely** to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction
Not applicable to a threatened species.
(c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: **(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction** **(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**
Not applicable to a threatened species.

(d) In relation to the habitat of a threatened species, population or ecological community: **(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed** **(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action** **(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality**
(i) Based on the local population(s) of the species, about 197 hectares of potentially suitable habitat occurs within the 10% AEP event changed flooding extent and about 121 hectares in the FMZ discharge area based on a 5 kilometre buffer around the known population(s) of the species in the locality. About 921 hectares of potentially suitable habitat in associated PCTs occurs within the Project study area. (ii) The native vegetation on the floodplain of the Hawkesbury-Nepean catchment has been previously fragmented by rural, agricultural and residential development. The known records of the Cumberland Plain Land Snail occur within this fragmented floodplain vegetation. (iii) The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population of Cumberland Plain Land Snail.
(e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)
No critical habitat has been declared for this species.
(f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan
No recovery plan or threat abatement plan has been prepared for the Dural Land Snail. No targeted strategies for this species have been developed through the Saving Our Species program.
(g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process
The Project constitutes the following KTP: ▪ Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.
Conclusion
The Project may result in minor modifications to areas of known Dural Land Snail habitat in the 10% AEP event. Some potential habitat is expected to experience longer inundation in the FMZ discharge area, however habitat damage as a result of this is expected to be temporary. The Project is **unlikely to result in a significant impact** on Dural Land Snail within the 10% AEP event changed flood extent.

References

Office of Environment and Heritage (2019). Dural Land Snail – profile. Accessed from https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=20283 on the 17/01/2020.

Office of Environment and Heritage (2019) Saving our Species – Help save the Cumberland Plain Land Snail. Accessed from https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1376&ReportProfileID=20283 on the 17/01/2020.

Appendix G Groundwater-dependent ecosystems

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Agnes Banks Woodland	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	7	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	5	High potential GDE
							6	High potential GDE
							8	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Apple-Forest Oak	DDSP	Low Lying	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	5	Moderate potential GDE
							7	Moderate potential GDE
					Other protected areas including Indigenous uses	n/a	10	High potential GDE
		Plateau	Uniform	Pittwater	Livestock grazing	KMMGS – Zone 8	6	Moderate potential GDE
					Minimal use	KMMGS – Zone 1	6	Moderate potential GDE
		Slope	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	6	Moderate potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 1	6	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Apple-Grey Gum-Turpentine	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - North	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin - North	8	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Apple-Red Bloodwood-Peppermint-Turpentine	DDSP	Low Lying	WSLW	Yengo	Irrigated agriculture	Sydney Basin - North	8	High potential GDE
							9	High potential GDE
					Livestock grazing	Sydney Basin - North	7	High potential GDE
					Minimal use	Sydney Basin - North	7	Moderate potential GDE
		Plateau	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin - North	8	High potential GDE
		Slope	WSLW	Yengo	Forestry	Sydney Basin - North	9	High potential GDE
					Livestock grazing	Sydney Basin - North	8	High potential GDE
					Minimal use	Sydney Basin - North	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Apple-Turpentine	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - North	9	Moderate potential GDE
					Livestock grazing	Sydney Basin - North	7	Low potential GDE
					Minimal use	Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	Moderate potential GDE
						Sydney Basin - North	7	Low potential GDE
							8	Moderate potential GDE
		Plateau	WSLW	Yengo	Forestry	Hawkesbury Alluvium	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin - North	9	Moderate potential GDE
		Slope	WSLW	Yengo	Irrigated agriculture	Sydney Basin - North	9	Moderate potential GDE
					Livestock grazing	Sydney Basin - North	9	Moderate potential GDE
					Minimal use	Sydney Basin - North	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	Moderate potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Bangalay-Blue Gum	DDSP	Low Lying	WSLW	Pittwater	Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	6	Moderate potential GDE
				Yengo	Forestry	Hawkesbury Alluvium	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin - North	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
					Irrigated agriculture	Sydney Basin - North	8	High potential GDE
					Minimal use	Sydney Basin - North	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	10	High potential GDE
					No data	Hawkesbury Alluvium	9	High potential GDE
					Other protected areas including Indigenous uses	n/a	10	High potential GDE
						Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin - North	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Waterbodies	n/a	10	High potential GDE
						Sydney Basin - North	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
		Plateau	WSLW	Yengo	Forestry	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin - North	9	High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - North	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	7	High potential GDE
							8	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
		Slope	Uniform	Pittwater	Irrigated agriculture	North Coast Fractured and Porous Rock Groundwater Sources	7	Moderate potential GDE
			WSLW	Yengo	Forestry	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - North	8	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - North	9	High potential GDE
					No data	Hawkesbury Alluvium	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	8	High potential GDE
							9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Banksia-Heath-Scribbly Gum-Apple	DDSP	Slope	Uniform	Pittwater	Minimal use	n/a	6	Low potential GDE
						KMMGS – Zone 8	4	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Blue Mountains – Shoalhaven Hanging Swamp	DDSP	Low Lying	WSLW	Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Blue Mountains Heath	ULHC	Low Lying	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	9	Low potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Burragorang-Nepean Hinterland Woodland	DDSP	Low Lying	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	9	Low potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Castlereagh Ironbark Forest Castlereagh Scribbly Gum Woodland	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	7	Low potential GDE
							8	Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Irrigated agriculture	Sydney Basin - Central	6	Low potential GDE
							8	Low potential GDE
								Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Minimal use	Sydney Basin - Central	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Low potential GDE
							7	Low potential GDE
								Moderate potential GDE
							8	Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
								High potential GDE
					Waterbodies	Sydney Basin - Central	9	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	8	Low potential GDE
							9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Low potential GDE
					Waterbodies	Sydney Basin - Central	6	Low potential GDE
	DDSP	Low Lying	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	10	Moderate potential GDE
					Waterbodies	Sydney Basin - Central	8	Moderate potential GDE
							10	Moderate potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	6	Low potential GDE
							7	Moderate potential GDE
							8	Low potential GDE
								Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin - Central	6	Low potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Minimal use	Sydney Basin - Central	8	Moderate potential GDE
							10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Low potential GDE
								Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
							8	Low potential GDE
								Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Waterbodies	Sydney Basin - Central	7	Low potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	9	Low potential GDE
								Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Castlereagh Shale-Gravel Transition Forest	DDSP	Low Lying	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin – Central	6	High potential GDE
							7	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
					Waterbodies	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin - Central	7	Moderate potential GDE
								High potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin - Central	6	Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
								High potential GDE
							8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					No data	Sydney Basin - Central	6	Low potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Moderate potential GDE
								High potential GDE
							7	Moderate potential GDE
								High potential GDE
							8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
					Waterbodies	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	6	Moderate potential GDE
							9	High potential GDE
					No data	Sydney Basin - Central	8	Low potential GDE
					Waterbodies	Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Castlereagh Swamp Woodland	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	6	High potential GDE
							7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	5	High potential GDE
							6	Low potential GDE
							7	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - Central	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	5	High potential GDE
							6	High potential GDE
							8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Bastard Mahogany Forest	DDSP	Low Lying	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	9	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	10	Moderate potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 8	7	Low potential GDE
			WSLW	Yengo	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	8	Moderate potential GDE
					No data	Hawkesbury Alluvium	10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Freshwater Lagoon	DDSP	Low Lying	Uniform	Pittwater	Minimal use	Sydney Basin - Central	5	High potential GDE
							6	High potential GDE
							10	High potential GDE
				Yengo	Minimal use	Sydney Basin - Central	6	High potential GDE
			WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	6	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
				Yengo	Forestry	Sydney Basin - Central	7	High potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	8	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
					No data	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
		Plateau	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
		Slope	Uniform	Pittwater	Minimal use	Sydney Basin - Central	7	High potential GDE
			WSLW	Yengo	Forestry	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
								High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							10	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	9	Moderate potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	7	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							8	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
					No data	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	6	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Headland Heaths	DDSP	n/a	Uniform	Pittwater	Minimal use	n/a	6	High potential GDE
						KMMGS – Zone 1	6	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
				Wyong	Nature conservation	North Coast Fractured and Porous Rock Groundwater Sources	1	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Sandstone Plateau Heath	DDSP	Low Lying	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin - Central	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
					Waterbodies	Hawkesbury Alluvium	10	Low potential GDE
								Moderate potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
		Slope	WSLW	Yengo	Irrigated agriculture	Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	Moderate potential GDE
							9	Low potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Sandstone Ridgetop Woodland	DDSP	Low Lying	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	9	Moderate potential GDE
					Minimal use	Sydney Basin – Nepean Sandstone	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	8	Moderate potential GDE
							10	Moderate potential GDE
				Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
						Sydney Basin – Nepean Sandstone	10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	Moderate potential GDE
							10	Moderate potential GDE
					Minimal use	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
						Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
				Yengo	Forestry	Sydney Basin - Central	7	Low potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin - Central	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	10	Moderate potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Waterbodies	Sydney Basin - Central	10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
		Plateau	WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
				Yengo	Other protected areas including Indigenous uses	Sydney Basin - Central	8	Moderate potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
				Wollemi	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
					Minimal use	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
						Sydney Basin – Nepean Sandstone	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
				Yengo	Forestry	Sydney Basin - Central	8	Moderate potential GDE
							9	Moderate potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	Moderate potential GDE
							10	Moderate potential GDE
					Minimal use	Sydney Basin - Central	8	Moderate potential GDE
							9	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	Low potential GDE
								Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	Moderate potential GDE
							9	Moderate potential GDE
		Plateau	WSLW	Wollemi	Minimal use	Sydney Basin - Central	9	Moderate potential GDE
		Slope	WSLW	Wollemi	Minimal use	Sydney Basin - Central	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Upland Swamp	DDSP	Slope	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	6	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Coastal Warm Temperate Rainforest	DDSP	Low Lying	Uniform	Pittwater	Minimal use	Sydney Basin - Central	4	Moderate potential GDE
							5	High potential GDE
							6	Low potential GDE
								Moderate potential GDE
							10	Moderate potential GDE
		Slope	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Cumberland Moist Shale Woodland	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	10	High potential GDE
		Slope	WSLW	Cumberland	Waterbodies	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Cumberland River Flat Forest	DDSP	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	8	High potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
								High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Nepean Sandstone	9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	7	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
				Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin - Central	9	High potential GDE
							10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Nepean Sandstone	9	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Nepean Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Nepean Sandstone	9	High potential GDE
				Yengo	Forestry	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	9	Moderate potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Minimal use	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					No data	Sydney Basin - Central	8	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	n/a	8	High potential GDE
						Hawkesbury Alluvium	7	High potential GDE
							8	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	7	High potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	7	High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
		Plateau	WSLW	Yengo	Forestry	Sydney Basin - Central	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	8	High potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	7	High potential GDE
							8	High potential GDE
							9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	8	Moderate potential GDE
							9	High potential GDE
					Waterbodies	Sydney Basin - Central	7	Low potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	Moderate potential GDE
						Sydney Basin - Central	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
				Yengo	Forestry	Hawkesbury Alluvium	9	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	7	Low potential GDE
								High potential GDE
							8	High potential GDE
							9	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	6	High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	7	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	Moderate potential GDE
								High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	7	High potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Irrigated agriculture	Hawkesbury Alluvium	2	High potential GDE
							5	High potential GDE
							6	High potential GDE
							7	High potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin - Central	7	Low potential GDE
								High potential GDE
							8	High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
					No data	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	n/a/	10	High potential GDE
						Hawkesbury Alluvium	6	Low potential GDE
								High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin - Central	6	High potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Nepean Sandstone	10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	5	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	n/a	8	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	8	Moderate potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
		Plateau	WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	Moderate potential GDE
						Sydney Basin - Central	10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
		Slope	WSLW	Cumberland	Forestry	Sydney Basin - Central	10	Moderate potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
					No data	Hawkesbury Alluvium	6	High potential GDE
							8	High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	7	High potential GDE
							8	Moderate potential GDE
								High potential GDE
					Waterbodies	Hawkesbury Alluvium	6	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
				Wollemi	Minimal use	Sydney Basin - Central	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Cumberland Shale Hills Woodland	DDSP	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	9	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	6	High potential GDE
							7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin - Central	10	High potential GDE
					Minimal use	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE
					Waterbodies	Sydney Basin - Central	8	High potential GDE
							10	Moderate potential GDE
								High potential GDE
		Plateau	WSLW	Cumberland	Waterbodies	Sydney Basin - Central	9	High potential GDE
		Slope	WSLW	Cumberland	Forestry	Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
							10	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
					Minimal use	Sydney Basin - Central	8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE
					Waterbodies	Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Cumberland Shale Plains Woodland	DDSP	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	6	High potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
							8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	7	Low potential GDE
								Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin - Central	9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
				Yengo	Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	10	Low potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	10	High potential GDE
					No data	Sydney Basin - Central	9	High potential GDE
					Other protected areas including Indigenous uses	n/a	10	High potential GDE
						Hawkesbury Alluvium	10	Low potential GDE
								High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	9	Low potential GDE
								High potential GDE
							10	High potential GDE
		Plateau	WSLW	Yengo	Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
					Minimal use	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	9	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
				Yengo	Irrigated agriculture	Sydney Basin – Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	9	Low potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
							9	Low potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
								High potential GDE
							7	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							8	Low potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	6	Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
								High potential GDE
							8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
								High potential GDE
							7	Moderate potential GDE
								High potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	7	Low potential GDE
							8	High potential GDE
					Livestock grazing	Hawkesbury Alluvium	10	High potential GDE
					Minimal use	Sydney Basin - Central	9	High potential GDE
							10	Low potential GDE
								High potential GDE
					No data	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	6	Low potential GDE
							10	High potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							7	Low potential GDE
								Moderate potential GDE
							8	Low potential GDE
								Moderate potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	6	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
		Slope	WSLW	Cumberland	Forestry	Sydney Basin - Central	6	Moderate potential GDE
							7	High potential GDE
							9	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
							7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	Low potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
							7	High potential GDE
							8	High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Cumberland Shale Sandstone Transition Forest	DDSP	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	7	Moderate potential GDE
						Sydney Basin - Central	9	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin – Richmond Sandstone	9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
				Yengo	Forestry	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Minimal use	Hawkesbury Alluvium	8	High potential GDE
							10	Low potential GDE
						Sydney Basin - Central	10	High potential GDE
					No data	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	7	High potential GDE
							9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
		Plateau	WSLW	Yengo	Irrigated agriculture	Hawkesbury Alluvium	8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	8	High potential GDE
		Slope	WSLW	Cumberland	Forestry	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	8	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
					No data	Hawkesbury Alluvium	6	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	7	High potential GDE
					Waterbodies	Sydney Basin - Central	7	Moderate potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
				Yengo	Forestry	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
							7	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
					Waterbodies	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin - Central	7	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	9	High potential GDE
							10	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
						Sydney Basin - Central	10	High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
					Waterbodies	Sydney Basin - Central	8	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
		Plateau	WSLW	Cumberland	Forestry	Sydney Basin - Central	8	Low potential GDE
				Wollemi	Other protected areas including Indigenous uses	Sydney Basin – Blue Mountain Sandstone	9	High potential GDE
		Slope	WSLW	Cumberland	Forestry	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - Central	8	High potential GDE
					No data	Sydney Basin - Central	8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
					Waterbodies	Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Estuarine Fringe Forest	DDSP	Low Lying	Uniform	Pittwater	No data	Sydney Basin - Central	10	High potential GDE
					Livestock grazing	Sydney Basin - Central	6	High potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	6	Low potential GDE
								High potential GDE
							7	High potential GDE
							8	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Nature conservation	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	7	High potential GDE
				Yengo	Minimal use	Sydney Basin - Central	7	High potential GDE
							10	High potential GDE
			ESLW	Yengo	Minimal use	Sydney Basin - Central	7	High potential GDE
							10	High potential GDE
		Plateau	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	7	High potential GDE
		Slope	Uniform	Pittwater	Minimal use	Sydney Basin - Central	6	High potential GDE
				Yengo	Minimal use	Sydney Basin - Central	7	High potential GDE
			WSLW	Yengo	Minimal use	Sydney Basin - Central	6	High potential GDE
							7	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Estuarine Mangrove Forest	DDSP	Low Lying	Uniform	Pittwater	Forestry	Sydney Basin - Central	7	High potential GDE
							8	High potential GDE
					Livestock grazing	n/a	8	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							10	High potential GDE
					Minimal use	n/a	7	Low potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Nature conservation	Sydney Basin - Central	6	Low potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	7	High potential GDE
				Yengo	Minimal use	n/a	7	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	7	High potential GDE
							10	High potential GDE
		Plateau	Uniform	Pittwater	Forestry	Sydney Basin - Central	8	Moderate potential GDE
					Livestock grazing	Sydney Basin - Central	7	Low potential GDE
					Minimal use	Sydney Basin - Central	7	High potential GDE
		Slope	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	6	High potential GDE
							8	Moderate potential GDE
					Minimal use	Sydney Basin - Central	6	Low potential GDE
							7	High potential GDE
				Yengo	Minimal use	n/a	7	High potential GDE
						Sydney Basin - Central	10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Estuarine Saltmarsh	DDSP	Low Lying	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	7	High potential GDE
					Minimal use	Sydney Basin - Central	6	High potential GDE
							8	High potential GDE
							10	High potential GDE
		Slope	Uniform	Pittwater	Forestry	Sydney Basin - Central	6	High potential GDE
							7	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Freshwater Melaleuca Swamp Forest	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
					Irrigated agriculture	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
								High potential GDE
							8	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	10	High potential GDE
						Sydney Basin – Richmond Sandstone	6	Low potential GDE
								Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
								Low potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Grey Myrtle Dry Rainforest	DDSP	Low Lying	WSLW	Cumberland	Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	10	High potential GDE
				Wollemi	Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
				Yengo	Irrigated agriculture	Sydney Basin - Central	10	High potential GDE
						Sydney Basin – Richmond Sandstone	10	High potential GDE
					No data	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							10	High potential GDE
					Waterbodies	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	Low potential GDE
								High potential GDE
		Slope	WSLW	Cumberland	Waterbodies	Sydney Basin – Richmond Sandstone	9	High potential GDE
				Yengo	Waterbodies	Sydney Basin – Richmond Sandstone	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Hawkesbury Arid Exposed Woodland	DDSP	Low Lying	WSLW	Yengo	Irrigated agriculture	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
							9	Moderate potential GDE
					Minimal use	Sydney Basin – Richmond Sandstone	3	Moderate potential GDE
							6	Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin - North	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	6	Moderate potential GDE
							7	Moderate potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Hawkesbury Sheltered Dry Forest	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
					Minimal use	Sydney Basin - North	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE
		Plateau	WSLW	Yengo	Irrigated agriculture	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
					Minimal use	Sydney Basin - North	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Heathy Scribbly Gum	DDSP	Plateau	Uniform	Pittwater	Forestry	KMMGS – Zone 7	6	Moderate potential GDE
			WSLW	Yengo	Forestry	Sydney Basin - North	6	Moderate potential GDE
					Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	6	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Hinterland Sandstone Gully Forest	DDSP	Low Lying	Uniform	Pittwater	Forestry	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	10	High potential GDE
					Livestock grazing	Sydney Basin - Central	2	High potential GDE
							4	Moderate potential GDE
							6	Moderate potential GDE
								High potential GDE
							7	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							10	Low potential GDE
								High potential GDE
					Minimal use	n/a	2	Moderate potential GDE
							9	Moderate potential GDE
						Sydney Basin - Central	4	Low potential GDE
								Moderate potential GDE
							5	High potential GDE
							6	Low potential GDE
								Moderate potential GDE
								High potential GDE
							7	Low potential GDE
								Moderate potential GDE
								High potential GDE
							8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
								Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	2	High potential GDE
							6	Moderate potential GDE
							7	Moderate potential GDE
				Yengo	Minimal use	Sydney Basin - Central	6	Moderate potential GDE
							7	Moderate potential GDE
								High potential GDE
							8	High potential GDE
			WSLW	Cumberland	Minimal use	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
						Sydney Basin - Central	7	High potential GDE
							8	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
							9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							10	High potential GDE
				Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
						Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Nepean Sandstone	9	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin – Blue Mountains Sandstone	8	Moderate potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin - Central	9	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Nepean Sandstone	9	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
							9	Low potential GDE
								High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
							10	High potential GDE
				Yengo	Forestry	Sydney Basin - Central	7	Moderate potential GDE
							8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	10	High potential GDE
					Minimal use	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin - Central	7	Moderate potential GDE
							10	Low potential GDE
								High potential GDE
					No data	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							7	Moderate potential GDE
								High potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	Low potential GDE
					Waterbodies	Sydney Basin - Central	9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	Low potential GDE
							10	High potential GDE
		Plateau	Uniform	Pittwater	Forestry	Sydney Basin - Central	8	High potential GDE
					Livestock grazing	Sydney Basin - Central	7	Moderate potential GDE
					Minimal use	Sydney Basin - Central	7	Low potential GDE
								Moderate potential GDE
				Yengo	Minimal use	Sydney Basin - Central	7	Low potential GDE
								Moderate potential GDE
			WSLW	Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	8	High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
		Slope	Uniform	Pittwater	Forestry	Sydney Basin - Central	6	Moderate potential GDE
							7	Moderate potential GDE
								High potential GDE
					Livestock grazing	Sydney Basin - Central	1	Moderate potential GDE
							4	High potential GDE
					Minimal use	n/a	6	Moderate potential GDE
						Sydney Basin - Central	5	Moderate potential GDE
							6	Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	Moderate potential GDE
				Yengo	Minimal use	Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
			WSLW	Cumberland	Irrigated agriculture	Sydney Basin – Nepean Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
				Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
					Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
						Sydney Basin – Richmond Sandstone	9	Low potential GDE
								High potential GDE
				Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - Central	9	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin - Central	7	Moderate potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	10	High potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
							10	High potential GDE
						Sydney Basin - Central	8	High potential GDE
		Plateau	WSLW	Wollemi	Minimal use	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
		Slope	WSLW	Cumberland	Forestry	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	10	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
				Wollemi	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Hunter Roughbarked Apple-Red Gum	DDSP	Low Lying	WSLW	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	10	Moderate potential GDE
					Irrigated agriculture	North Coast Fractured and Porous Rock Groundwater Sources	10	Moderate potential GDE
					Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
							7	Low potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 7	10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							10	Moderate potential GDE
				Yengo	Forestry	n/a	10	Moderate potential GDE
						Hawkesbury Alluvium	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - Central	10	Moderate potential GDE
						Sydney Basin - North	7	Moderate potential GDE
							8	Moderate potential GDE
							9	Low potential GDE
								Moderate potential GDE
							10	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
								Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Irrigated agriculture	Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Low potential GDE
								Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							8	Moderate potential GDE
					Minimal use	Hawkesbury Alluvium	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - North	6	Low potential GDE
							7	Low potential GDE
								Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	6	Low potential GDE
							10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
								Moderate potential GDE
							7	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
								High potential GDE
					No data	Hawkesbury Alluvium	10	Moderate potential GDE
						Sydney Basin - North	9	Moderate potential GDE
					Other protected areas including Indigenous uses	n/a	10	Moderate potential GDE
						Hawkesbury Alluvium	9	Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
						Sydney Basin - North	7	Low potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	5	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Waterbodies	n/a	10	Moderate potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - North	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Moderate potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
		Slope	WSLW	Yengo	Forestry	Sydney Basin - North	8	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Minimal use	Sydney Basin - North	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Illawarra Gully Wet Forest	DDSP	Low Lying	Uniform	Pittwater	Minimal use	Sydney Basin - Central	6	High potential GDE
							8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Ironbark	DDSP	Low Lying	WSLW	Pittwater	Irrigated agriculture	North Coast Fractured and Porous Rock Groundwater Sources	7	Moderate potential GDE
				Yengo	Forestry	Sydney Basin - North	9	Moderate potential GDE
							10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							10	Moderate potential GDE
					Minimal use	Sydney Basin - North	9	Moderate potential GDE
							10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin - North	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
					Waterbodies	Hawkesbury Alluvium	9	Moderate potential GDE
		Plateau	WSLW	Yengo	Livestock grazing	Sydney Basin - North	8	Moderate potential GDE
					Minimal use	Sydney Basin - North	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	6	Low potential GDE
							8	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
		Slope	WSLW	Yengo	Forestry	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
					Livestock grazing	Sydney Basin - North	8	Moderate potential GDE
					Minimal use	Sydney Basin – North	9	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
					Waterbodies	Hawkesbury Alluvium	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Ironbark-Redgum	DDSP	Low Lying	Uniform	Pittwater	Forestry	n/a	10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
							10	Moderate potential GDE
					Irrigated agriculture	Sydney Basin - North	8	Moderate potential GDE
					Livestock grazing	North Coast Fractured and Porous Rock Groundwater Sources	6	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Littoral Thicket	DDSP	Slope	Uniform	Pittwater	Minimal use	Sydney Basin - Central	6	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Lower Blue Mountains Wet Forest	DDSP	Low Lying	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	6	Moderate potential GDE
					Minimal use	Sydney Basin - Central	3	High potential GDE
							6	Moderate potential GDE
							10	High potential GDE
				Yengo	Minimal use	Sydney Basin - Central	7	Moderate potential GDE
			WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
							10	Low potential GDE
								High potential GDE
				Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - Central	7	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Waterbodies	Sydney Basin - Central	10	High potential GDE
		Plateau	Uniform	Pittwater	Minimal use	Sydney Basin - Central	6	Moderate potential GDE
							7	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
			WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
		Slope	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	6	Moderate potential GDE
			WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
	ULHC	Low Lying	WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	Low potential GDE
								High potential GDE
						Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Lowlands Scribbly Gum	DDSP	Low Lying	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	9	High potential GDE
			WSLW	Pittwater	Other protected areas including Indigenous uses	North Coast Fractured and Porous Rock Groundwater Sources	7	High potential GDE
		Plateau	Uniform	Pittwater	Livestock grazing	KMMGS – Zone 1	7	High potential GDE
					Minimal use	KMMGS – Zone 1	7	High potential GDE
			WSLW	Yengo	Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	7	High potential GDE
		Slope	WSLW	Yengo	Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	6	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Mahogany-Banksia Heath	DDSP	Low Lying	WSLW	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
				Yengo	Forestry	Sydney Basin - North	8	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	Low potential GDE
					Minimal use	Sydney Basin - North	10	Low potential GDE
								Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	10	Moderate potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	10	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	8	High potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin - North	9	High potential GDE
		Slope	Uniform	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	5	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Narrabeen East-Wollemi Sheltered Dry Forest	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - North	8	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	10	Low potential GDE
					Minimal use	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	8	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Narrabeen Goulburn Valley Exposed Woodland	DSP	Low Lying	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Narrabeen Sheltered Bluegum Forest	DDSP	Low Lying	WSLW	Wollemi	Minimal use	Sydney Basin – Richmond Sandstone	9	High potential GDE
				Yengo	Forestry	Sydney Basin - North	7	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin – Richmond Sandstone	7	Low potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	High potential GDE
					Minimal use	Sydney Basin - North	7	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	6	Low potential GDE
								Moderate potential GDE
							7	Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	7	Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	7	Low potential GDE
								Moderate potential GDE
							8	Moderate potential GDE
								High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
								High potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin - North	6	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	7	Low potential GDE
								Moderate potential GDE
							8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	8	High potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Richmond Sandstone	7	High potential GDE
							8	High potential GDE
							9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Paperbark	DDSP	Low Lying	Uniform	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	5	High potential GDE
							8	High potential GDE
							10	High potential GDE
					Irrigated agriculture	Sydney Basin - North	7	Low potential GDE
							8	High potential GDE
					Livestock grazing	KMMGS – Zone 8	10	High potential GDE
					Other protected areas including Indigenous uses	North Coast Fractured and Porous Rock Groundwater Sources	6	High potential GDE
							8	High potential GDE
			WSLW	Yengo	Forestry	Sydney Basin - North	6	High potential GDE
							10	High potential GDE
					Minimal use	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - North	8	High potential GDE
							10	High potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	6	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	North Coast Fractured and Porous Rock Groundwater Sources	5	High potential GDE
		Slope	Uniform	Pittwater	Livestock grazing	North Coast Fractured and Porous Rock Groundwater Sources	6	High potential GDE
				Yengo	Irrigated agriculture	Sydney Basin - North	7	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Peppermint-Apple-Turpentine	DDSP	Low Lying	WSLW	Pittwater	Forestry	KMMGS – Zone 1	6	Low potential GDE
					Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 1	7	Moderate potential GDE
				Yengo	Forestry	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							10	Low potential GDE
					Irrigated agriculture	Sydney Basin - North	8	Moderate potential GDE
					Minimal use	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin - North	7	Moderate potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							8	Low potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	7	Low potential GDE
							10	Moderate potential GDE
		Plateau	Uniform	Pittwater	Livestock grazing	KMMGS – Zone 8	6	Moderate potential GDE
			WSLW	Yengo	Forestry	Hawkesbury Alluvium	5	Moderate potential GDE
						Sydney Basin - North	7	Low potential GDE
					Minimal use	Sydney Basin - North	8	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	Moderate potential GDE
					Waterbodies	Sydney Basin - North	7	Low potential GDE
		Slope	WSLW	Yengo	Livestock grazing	Sydney Basin - North	8	Moderate potential GDE
							9	Moderate potential GDE
					Minimal use	Hawkesbury Alluvium	10	Moderate potential GDE
						Sydney Basin - North	6	Moderate potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
					Waterbodies	Hawkesbury Alluvium	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Rainforest	DDSP	Low Lying	WSLW	Pittwater	Forestry	KMMGS – Zone 1	7	High potential GDE
					Minimal use	KMMGS – Zone 1	6	High potential GDE
					Other protected areas including Indigenous uses	North Coast Fractured and Porous Rock Groundwater Sources	10	High potential GDE
				Yengo	Minimal use	Sydney Basin - North	9	High potential GDE
							10	High potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	10	High potential GDE
		Slope	WSLW	Yengo	Minimal use	North Coast Fractured and Porous Rock Groundwater Sources	6	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
River Mangrove	DDSP	Low Lying	Uniform	Pittwater	Forestry	Sydney Basin - Central	6	High potential GDE
							7	High potential GDE
					Minimal use	n/a	4	High potential GDE
							10	High potential GDE
						Sydney Basin – Central	4	High potential GDE
							5	High potential GDE
							6	High potential GDE
							7	High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	High potential GDE
							10	High potential GDE
				Yengo	Minimal use	Sydney Basin - Central	8	High potential GDE
			WSLW	Yengo	Minimal use	Sydney Basin - Central	7	High potential GDE
		Slope	Uniform	Pittwater	Livestock grazing	Sydney Basin - Central	3	High potential GDE
					Minimal use	Sydney Basin - Central	6	High potential GDE
							8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Roundleaved Gum - Turpentine	DDSP	Low Lying	Uniform	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Irrigated agriculture	Sydney Basin - North	7	Low potential GDE
						KMMGS – Zone 1	6	Low potential GDE
					Livestock grazing	KMMGS – Zone 8	10	Moderate potential GDE
					Minimal use	KMMGS – Zone 1	5	Low potential GDE
							7	Low potential GDE
							10	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
						North Coast Fractured and Porous Rock Groundwater Sources	9	High potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 1	1	Low potential GDE
							6	Low potential GDE
			WSLW	Pittwater	Irrigated agriculture	North Coast Fractured and Porous Rock Groundwater Sources	10	Moderate potential GDE
					Minimal use	KMMGS – Zone 1	7	Moderate potential GDE
						KMMGS – Zone 7	10	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
							10	Low potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 1	7	Low potential GDE
				Yengo	Forestry	n/a	10	Moderate potential GDE
						Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin - North	8	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
								Moderate potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Irrigated agriculture	Sydney Basin - North	10	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Livestock grazing	Sydney Basin - North	1	Low potential GDE
							7	Low potential GDE
					Minimal use	Hawkesbury Alluvium	9	Moderate potential GDE
							10	Moderate potential GDE
						Sydney Basin - North	2	Moderate potential GDE
							7	Low potential GDE
							8	Moderate potential GDE
							9	Moderate potential GDE
							10	Moderate potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	5	Low potential GDE
							6	Low potential GDE
							7	Low potential GDE
							10	Low potential GDE
								Moderate potential GDE
					Waterbodies	Sydney Basin - North	8	Moderate potential GDE
		Plateau	Uniform	Pittwater	Livestock grazing	KMMGS – Zone 1	7	Moderate potential GDE
						KMMGS – Zone 8	8	Moderate potential GDE
					Minimal use	KMMGS – Zone 1	7	Low potential GDE
					Nature conservation	KMMGS – Zone 8	5	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	KMMGS – Zone 8	6	Low potential GDE
				Yengo	Minimal use	Sydney Basin - North	6	Low potential GDE
			WSLW	Yengo	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	10	Low potential GDE
					Minimal use	Sydney Basin - North	6	Low potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	Moderate potential GDE
		Slope	Uniform	Pittwater	Forestry	KMMGS – Zone 1	7	Low potential GDE
						KMMGS – Zone 8	7	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Irrigated agriculture	North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Livestock grazing	KMMGS – Zone 8	6	Low potential GDE
						North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Other protected areas including Indigenous uses	KMMGS – Zone 8	7	High potential GDE
			WSLW	Yengo	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	7	Low potential GDE
					Livestock grazing	Sydney Basin - North	7	Moderate potential GDE
					Minimal use	Sydney Basin - North	9	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	Moderate potential GDE
					Waterbodies	Sydney Basin - North	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Sandstone Gorge Dry Rainforest	DDSP	Low Lying	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	8	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Sandstone Gorge Warm Temperate Rainforest	DDSP	Low Lying	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
							10	Moderate potential GDE
		Plateau	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	7	Moderate potential GDE
							8	Moderate potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin – Richmond Sandstone	9	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Sandstone Riparian Shrub	DDSP	Low Lying	Uniform	Pittwater	Forestry	Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE
					Minimal use	Sydney Basin - Central	4	High potential GDE
							6	Moderate potential GDE
							7	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							8	High potential GDE
							9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	6	High potential GDE
			WSLW	Cumberland	Minimal use	Sydney Basin - Central	8	High potential GDE
						Sydney Basin – Nepean Sandstone	8	Low potential GDE
								High potential GDE
					Other protected areas including Indigenous areas	Sydney Basin - Central	5	High potential GDE
							8	High potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	8	High potential GDE
				Yengo	Forestry	Sydney Basin - Central	6	High potential GDE
							7	Moderate potential GDE
							8	Moderate potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin - Central	10	Low potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	7	Moderate potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE
		Slope	WSLW	Yengo	Forestry	Sydney Basin - Central	9	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	Low potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
				Wollemi	Irrigated agriculture	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE
		Slope	WSLW	Wollemi	Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Seagrass Meadow (Zostera)	DDSP	Low Lying	Uniform	Pittwater	Minimal use	n/a	10	Low potential GDE
								Moderate potential GDE
						Sydney Basin - Central	6	Low potential GDE
							7	Low potential GDE
							8	Low potential GDE
							10	Low potential GDE
					Nature conservation	Sydney Basin - Central	10	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Smoothbarked Apple	DDSP	Low Lying	Uniform	Pittwater	Forestry	North Coast Fractured and Porous Rock Groundwater Sources	7	Moderate potential GDE
					Minimal use	n/a	10	High potential GDE
						KMMGS – Zone 1	6	Moderate potential GDE
							9	High potential GDE
		Plateau	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	7	Moderate potential GDE
		Slope	Uniform	Pittwater	Livestock grazing	KMMGS – Zone 8	6	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Southern Highlands Basalt Forest	DDSP	Low Lying	WSLW	Wollemi	Forestry	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	9	High potential GDE
							10	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Sydney Hinterland Transition Woodland	DDSP	Low Lying	WSLW	Cumberland	Forestry	Sydney Basin – Richmond Sandstone	8	Low potential GDE
					Irrigated agriculture	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
					Minimal use	Sydney Basin - Central	7	Moderate potential GDE
							8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
					Other protected areas including Indigenous uses	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
							10	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
							10	Low potential GDE
					Waterbodies	Sydney Basin - Central	10	High potential GDE
				Wollemi	Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
				Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Irrigated agriculture	Sydney Basin - Central	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin - Richmond	6	High potential GDE
							8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Minimal use	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					No data	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	10	Moderate potential GDE
								High potential GDE
						Sydney Basin - Central	7	High potential GDE
							8	Low potential GDE
								High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	Low potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
								High potential GDE
					Waterbodies	Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	High potential GDE
							10	Low potential GDE
								High potential GDE
		Plateau	WSLW	Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	10	High potential GDE
				Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	8	Moderate potential GDE
						Sydney Basin – Blue Mountains Sandstone	8	Low potential GDE
							9	Low potential GDE
								High potential GDE
						Sydney Basin - Central	6	Moderate potential GDE
							8	High potential GDE
							9	High potential GDE
					Minimal use	Sydney Basin - Central	8	Low potential GDE
								High potential GDE
							9	Low potential GDE
								High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin – Nepean Sandstone	9	High potential GDE
					Waterbodies	Sydney Basin - Central	9	Low potential GDE
								High potential GDE
				Wollemi	Minimal use	Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
						Sydney Basin - Central	9	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin – Nepean Sandstone	8	High potential GDE
				Yengo	Forestry	Hawkesbury Alluvium	9	Low potential GDE
								High potential GDE
						Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
					Irrigated agriculture	Hawkesbury Alluvium	7	Moderate potential GDE
						Sydney Basin - Central	8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	8	High potential GDE
							9	High potential GDE
						Sydney Basin - Central	8	High potential GDE
							9	High potential GDE
						Sydney Basin – Richmond Sandstone	9	Low potential GDE
								High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin – Richmond Sandstone	8	High potential GDE
							9	Low potential GDE
								High potential GDE
	ULHC	Low Lying	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	6	Moderate potential GDE
							7	Moderate potential GDE
								High potential GDE
							8	High potential GDE
							9	High potential GDE
							10	High potential GDE
						Sydney Basin – Blue Mountains Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Hawkesbury Alluvium	7	High potential GDE
							9	High potential GDE
							10	High potential GDE
		Slope	WSLW	Cumberland	Irrigated agriculture	Hawkesbury Alluvium	8	High potential GDE
						Sydney Basin - Central	9	High potential GDE
				Wollemi	Forestry	Sydney Basin - Central	10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Sydney Swamp Forest	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - Central	8	High potential GDE
							9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE
					Irrigated agriculture	Sydney Basin – Richmond Sandstone	8	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	8	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
							9	High potential GDE
							10	High potential GDE
					Waterbodies	Sydney Basin - Central	9	High potential GDE
						Sydney Basin – Richmond Sandstone	10	High potential GDE
		Slope	WSLW	Yengo	Irrigated agriculture	Hawkesbury Alluvium	9	Moderate potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - Central	9	Moderate potential GDE
								High potential GDE
						Sydney Basin – Richmond Sandstone	9	Moderate potential GDE
								High potential GDE
							10	Moderate potential GDE
								High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Watagan Blackbutt-Blue Gum	DDSP	Low Lying	Uniform	Pittwater	Minimal use	KMMGS – Zone 1	7	High potential GDE
							10	Moderate potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Yellow Bloodwood-Narrowleaved Apple	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - North	9	High potential GDE
					Minimal use	Sydney Basin - North	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	8	High potential GDE
						Sydney Basin – Richmond Sandstone	9	High potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin - North	9	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	9	High potential GDE

Vegetation Type	Topography	Landscape	Rainfall	Bioregion	Land use	Groundwater Management Area	IDE Likelihood	GDE Classification
Yellow Bloodwood-Stringybark	DDSP	Low Lying	WSLW	Yengo	Forestry	Sydney Basin - North	10	High potential GDE
					Irrigated agriculture	Sydney Basin - North	8	High potential GDE
					Minimal use	Sydney Basin - North	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
					Other protected areas including Indigenous uses	Sydney Basin - North	8	High potential GDE
							9	High potential GDE
							10	High potential GDE
		Slope	WSLW	Yengo	Minimal use	Sydney Basin - North	9	High potential GDE

Appendix H Curricula vitae

Rachel Musgrave

NSW/ACT Ecology Team Lead

Professional Overview

Rachel is the Team Lead of the NSW/ACT Ecology team in the SMEC Natural Resources Management team. Rachel has over ten years' experience in flora and fauna surveys, bushland management, fire management, environmental legislation and Environmental Impact Assessments. She has extensive experience performing threatened fauna surveys for civil construction companies for major infrastructure development.
As such, she has a strong working knowledge of the relevant legislation and planning guidelines relating to biodiversity within New South Wales.
Rachel has extensive experience undertaking peer-reviews for local, and state governments including specialist ecological peer review advice for biodiversity conservation strategies, development applications, and NSW Environmental Trust grants.

Rachel has been involved in numerous ecological impact assessments of threatened species and endangered ecological communities in accordance with State and Commonwealth threatened species legislation. She has had experience in a broad range of environmental impact assessment projects, including REFs, EISs and biodiversity technical reports for large infrastructure, residential, and renewables developments.

Rachel has extensive experience in field assessments, including botany, fauna habitat assessment, fauna trapping and monitoring programs, Biobanking field assessment techniques and habitat condition assessment. Rachel completed her honours year researching the population genetics of Tasmanian Bettongs, thus has extensive field experience in Tasmania. Furthermore, Rachel has also participated in expeditions to poorly botanised mountains in Borneo, the Philippines, Venezuela, and Madagascar for the purposes of research and species-specific population monitoring.

Rachel is also an accredited person under the NSW Biodiversity Offset Scheme, as well as an accredited assessor under s142B(1)(c) of the Threatened Species Conservation Act 1995, therefore has a strong working knowledge of the principles for biodiversity offsetting in NSW and provides accurate and concise advice on major projects.

Relevant Project Experience

Warragamba Dam Raising EIS (Water), NSW
Dates: August 2017 - Present
Client: Water NSW

Ecology lead on a FBA Major Project Assessment of impacts associated with the raising of Warragamba Dam wall.

Role: Ecology Lead and Accredited Assessor

Responsibilities include all aspects of impact assessment including, but not limited to, management of ecology team undertaking flora and fauna surveys, logistical management, flora and fauna surveying, assessment in accordance with FBA, preparation of 3 x BARs and vegetation mapping.

Years of Industry Experience

10+ years

Qualifications and Memberships

- Bachelor of Science (Hons) Ecology
- Accredited Person – Biodiversity Offset Scheme.
- Former Accredited BioBanking Assessor – BioBanking Framekwork for Biodiversity Assessment and BioCertification

Key Skills and Competencies

- Biodiversity
- Project Management
- Ecological Surveys and Monitoring
- Vegetation Mapping
- Habitat Assessment
- Threatened Flora & Fauna Surveys
- GIS
- BioBanking Assessment Methodology
- Framework for Biodiversity Assessments
- Bio Certification Assessment Methodology
- Environmental Management Plans
- Biodiversity Offset Strategies
- Vegetation & Bushland Management Plans

Eurobodalla Southern Storage (EIS and Concept Design), NSW
Dates: September 2016 - Present
Client: Eurobodalla Shire Council

Ecology lead on a FBA Major Project Assessment of impacts associated with the construction of a water storage facility in Eurobodalla Shire Council.

Role: Ecology Lead and Accredited Assessor

Responsibilities include all aspects of impact assessment including, but not limited to, management of ecology team undertaking flora and fauna surveys, logistical management, flora and fauna surveying, assessment in accordance with FBA, reporting and mapping.

Granite Hills Wind Farm, NSW
Dates: April 2017 – Present
Client: Akuo Energy

Ecology lead on a FBA Major Project Assessment of impacts associated with the construction of a wind farm near Nimmitabel.

Role: Ecology Lead and Accredited Assessor

Responsibilities include all aspects of impact assessment including, but not limited to, management of ecology team undertaking flora and fauna surveys, logistical management, flora and fauna surveying, assessment in accordance with FBA, reporting and mapping.

Bathurst Second Circuit, NSW
Dates: October 2018 - Present
Client: Apex

Ecology lead on a BAM Major Project Assessment of impacts associated with the construction of a car racing circuit.

Role: Ecology Lead and Accredited Assessor

Responsibilities include all aspects of impact assessment including, but not limited to, management of ecology team undertaking flora and fauna surveys, logistical management, flora and fauna surveying, assessment in accordance with BAM, reporting and mapping.

Snowy 2.0 Feasibility Study (Review of Environmental Factors), NSW
Dates: April 2017 – August 2017
Client: Snowy Hydro

Preparation of REF's for Snowy Hydro 2.0 geotechnical investigations

Role: Biodiversity Specialist

Responsible for vegetation assessment and preparation of REFs pertaining to geotechnical works for the Snowy 2.0 Feasibility Study. Potential impacts on numerous EECs and threatened species were considered as part of the assessment process. Offsetting requirements calculated in accordance with FBA.

Pacific Highway Upgrade – Narara to Lisarow (Species Impact Statement), NSW
Dates: August 2016 – August 2017
Client: Roads and Maritime

Preparation of a Species Impact Statement for inclusion to the REF for N2L road upgrade

Role: Ecology Lead

Vegetation assessment and preparation of SIS in accordance with Secretary's Environmental Assessment Requirements pertaining to the upgrade of the Pacific Highway from Narara to Lisarow.
Potential impacts on numerous EECs and threatened species were considered as part of the assessment process. Offsetting requirements calculated in accordance with FBA.

Mona Vale Road Upgrade (Species Impact Statement), NSW

Dates: August 2016 – December 2016
Client: Roads and Maritime

Preparation of a Species Impact Statement for inclusion to the REF for Mona Vale Road upgrade

Role: Biodiversity Specialist

Vegetation assessment and preparation of SIS in accordance with Secretary's Environmental Assessment Requirements pertaining to the upgrade of Mona Vale Road. Potential impacts on numerous EECs and threatened species were considered as part of the assessment process. Offsetting requirements calculated in accordance with FBA.

Golden Highway (Biodiversity Assessment Reports), NSW
Dates: August 2016 - Present
Client: Roads and Maritime

Preparation of a Biodiversity Assessment Report for inclusion to the REF for Golden Highway road upgrade

Role: Ecology Lead

Vegetation assessment and Biodiversity Assessment Report pertaining to the upgrade of one section of Golden Highway in Singleton. Potential impacts on numerous EECs and threatened species were considered as part of the assessment process.

Bells Line of Road – Castlereagh (Strategic Environmental Assessment), NSW
Dates: August 2016 – October 2016
Client: Transport for NSW

Preparation of Biodiversity Technical Specialist Assessment Report for inclusion into a Strategic Environmental Assessment for a corridor study to investigate options for the preservation of a future transport corridor in north western Sydney.

Role: Biodiversity Specialist

Responsible for biodiversity inputs and authoring of the report.

Tuggerah Sports and Recreation Complex (Species Impact Statement), NSW
Dates: November 2015 – April 2016
Client: Wyong Council

Preparation of a Species Impact Statement development of a sports and recreation centre in Tuggerah

Role: Ecology Lead

Field Assessment and preparation of SIS in accordance with Secretary's Environmental Assessment Requirements pertaining to the development of Tuggerah Sports and Recreation Complex. Potential impacts on numerous EECs and threatened species were considered as part of the assessment process. Offsetting requirements were calculated in accordance with BBAM.

NSWGC Coastal Walk Upgrade (Species Impact Statement), NSW
Dates: August 2015 – August 2016
Client: Thompson Berrill Landscape Design/ Randwick City Council

Preparation of a Species Impact Statement development of a coastal walk in Randwick Council

Role: Ecology Lead

Field Assessment and preparation of SIS in accordance with Secretary's Environmental Assessment Requirements pertaining to the upgrade of the Coastal Walk through NSW Golf Course.
Potential impacts on numerous EECs and threatened species were considered as part of the assessment process. Offsetting requirements were calculated in accordance with BBAM.

Boco Rock Wind Farm (Environment), NSW
Dates: May 2013 – December 2014
Client: Downer Group

Project ecologist for wind farm construction

Role: Biodiversity Specialist: Project Ecologist

Implementation of Project Ecologist tasks outlined in State and Federally Approved Management Plans for the construction of a 70-turbine wind farm and 132Kv transmission line in Cooma Monaro LGA. Responsibilities include undertaking pre-clearance surveys for threatened reptile species and other native fauna present on site, relocation and monitoring of relocated individuals, habitat assessment, consistency reviews, fauna surveys and management, provision of expert advice.

Taralga Wind Farm
Dates: May 2013 – January 2016
Client: Downer Group

Project ecologist for wind farm construction

Role: Biodiversity Specialist: Project Ecologist

Implementation of Project Ecologist tasks outlined in State and Federally Approved Management Plans for the construction of a 60-turbine wind farm and 132Kv transmission line near Taralga NSW.
Responsibilities include undertaking pre-clearance surveys for threatened microbat species and other native fauna present on site, relocation and monitoring of relocated individuals, habitat assessment, consistency reviews, fauna surveys and management, provision of expert advice.

Threatened Species Habitat (Assessment & Preclearance Surveys), NSW
Dates: April 2011 – December 2011
Client: John Holland

Project ecologist for Glenfield to Leppington Trainline

Role: Biodiversity Specialist

Assessed potential habitat along the Glenfield to Leppington Rail Link for the following threatened species: Cumberland Plain Land Snail, Micro chiropteran Bats, Green and Golden Bell Frog.
Drafted survey and relocation methodology for Cumberland Plain Land Snail and Micro Chiropteran Bat Species.

Installation of Nest Boxes (Environment), NSW
Dates: August 2013 – November 2015
Client: Thiess / Leighton Contractors

Project ecologist for Glenfield to Leppington Trainline

Role: Biodiversity Specialist

Working directly with, and independently of, the Project Ecologist. Installation of 300+ nest boxes of variable sizes across the entire construction corridor. Data collection on location, type, aspect, surrounding and supporting vegetation type and species. All works as per State and Commonwealth approved Management Plans.

Larissa Abbott

Senior Ecologist

Professional Overview

Larissa's primary role as a consultant has been to use her expertise and experience in technical writing, threatened species ecology and management and knowledge of legislation to develop and write high quality project reports. This includes input on:

- >100 flora and fauna assessments of significance (EP&A and EPBC Acts)
- > 10 Preliminary Environmental Investigations and Environmental Impact Statements
- > 15 Construction and Environmental Management Plans, Nest box Monitoring Plans, threatened species monitoring plans and Vegetation Management Plans for construction projects
- Over 20 Reviews of Environmental Factors
- Two Species Impact Statements
- Project manager for the Kapooka and Termeil Creek ecological monitoring programs for Roads and Maritime
- One Commonwealth referral under the EPBC Act
- Preparation of three Environmental and Social Impact Assessments (EISA) to World Bank standard, two being in country placements:
    - Bayan Airag Gold Mine ESIA, Mongolia, 2010-2011. Client Bayan Airag Exploration LLC (Kerry Mining Ltd). Two month placement in Mongolia.
    - Bahr el Jebel Hydropower Projects Prefeasibility and Feasibility Studies, Southern Sudan, 2010. Three month placement in Kenya.
    - ESHIA Studies including IEE and EIA for 3 Chevron Natural Gas Field Projects and a Gas Compression Plant Project, Bangladesh, 2010-2011.

Relevant Project Experience

Warragamba Dam Raising EIS (Water), NSW
Dates: August 2017 - Present
Client: Water NSW

Ecologist on a FBA Major Project Assessment to assess the impacts associated with the raising of Warragamba Dam wall. Responsibilities include all aspects of impact assessment including, but not limited to, review of existing information, management of ecology fieldwork planning and logistics, undertaking fauna surveys, writing of assessment reports in accordance with FBA.

Communications Upgrade and Replacement Project
Client: John Holland Communications
TransGrid undertook a project to expand their telecommunications network by establishing twelve new communications sites across NSW. John Holland

Years of Industry Experience

10+ years

Qualifications and Memberships

- Bachelor of Science, Hons (Environmental Science)
- BAM training course
- AUSRIVAS Certification (NSW)
- White Card
- Work Safely at Heights
- Rail Industry Safety Worker Licence
- Level 1 tree access ropes
- Senior First Aid

Key Skills and Competencies

- Ecological constraints Data collation and review
- Management Plans
- Compliance tracking and management
- Environmental Impact Statements
- Biodiversity Assessment Reports
- Flora and fauna surveys
- Threatened species survey and monitoring

Professional History

2007-2012 | SMEC

Graduate Ecologist

2012 – 2017 | SMEC

Ecologist

2017 – Present | SMEC

Senior Ecologist

Communications (the construction contractor) commissioned SMEC to undertake Environmental Assessment and prepare Review of Environmental Factors for the twelve sites. Larissa assisted the field team in undertaking the field surveys and preparing the Environmental Assessments for approval.

Review of Environmental Factors for the installation of OPGW and ancillary works on Transmission Line 64 and 65
Client: John Holland Communications
TransGrid, undertook a project to replace their existing overhead earth wires with a new technology which serves the dual purpose of providing electricity and telecommunications – optical ground wires. To facilitate the installation of such technology, a range of ancillary works were required along line 64 and 65 such as the upgrading of access tracks, installation of stable earth pads on which to place elevated work platforms and minor vegetation clearing. The Review of Environmental Factors sought to assess the impact of the proposed activities on the environment. This involved site specific survey to determine the existing ecological and archaeological environment present in these locations to assess the impact, if any, on any items of significance. Mitigation measures including site rehabilitation were given in the REF with specific plans of management to ensure that any impacts of the proposed works would be minimised. Larissa was involved in the field survey, and preparing the REF and a detailed ecological report discussing the main ecological issues and providing mitigation measures for threatened species.

Environmental Data Survey and Processing
Client: TransGrid
Baseline flora and fauna survey was undertaken for all electrical transmission lines maintained by TransGrid across NSW. Survey was state-wide and involved background data collection, detailed desktop study and identification of ecological issues within all easements across the state. Larissa assisted with the data compilation and management which formed the basis of an internal EIA system to identify areas of ecological significance, to guide future maintenance work.

Northern Beaches Base Hospital EIS
Client: NSW Health Infrastructure
This was a major NSW Health Infrastructure project in Frenchs Forest, NSW. SMEC are delivering Environmental Project Management services for site preparation works and planning services for the 300 bed base hospital. Larissa was one of the team of Ecologists for SMEC for the project. SMEC services include strategic assessment of mitigation and offsetting options under the NSW Biobanking Scheme, including detailed biodiversity, bushfire, water and soils and heritage technical studies for delivery of an EIS (State Significant Infrastructure) under Part 5 of the Environmental Planning and Assessment Act in NSW. SMEC are also providing planning services for State Significant Site listing and planning approvals for State Significant Infrastructure and EPBC legislation.

Olympic Highway Realignment at Kapooka Ecological Monitoring, NSW
Dates: February 2016-ongoing
Client: Roads and Maritime Services
Roads and Maritime Services has realigned the Olympic Highway and replaced the existing bridge over the main southern railway line at Kapooka. SMEC was engaged to undertake compliance tracking, threatened species monitoring, writing of management plans and monitoring of the offset site for the project.

Larissa has been involved in writing the revegetation management plan, review of the offset site management plan against compliance conditions, annual monitoring of the threatened population of Squirrel Gliders, compliance tracking. Larissa is currently the Project Manager for this project.

Pacific Highway Upgrade, Narara to Lisarow, NSW
Dates: November 2015 – April 2017
Client: Roads and Maritime Services

Roads and Maritime Services has been investigating a future potential upgrade of Manns Road and the Pacific Highway between Narara Creek Road, Narara and Parsons Road, Lisarow. SMEC was engaged to undertake a biodiversity assessment of the project.

Larissa was responsible for field programming and preparation of general fauna surveys including spotlighting, trapping for Squirrel Gliders, diurnal bird surveys, frog searches, analysis of microbat ultrasonic calls and call playback. One of the target species recorded during the surveys was the Grey-headed Flying-fox. She also undertook threatened species searches for *Melaleuca biconvexa*.

Amy Nelson

Senior Scientist - Ecology

Professional Overview

Amy has a strong background in vegetation community identification, mapping and classification, flora and fauna assessment, targeted threatened species surveys and ecological monitoring. She has worked with clients across a range of sectors and has worked extensively on major projects throughout NSW. Amy has a solid understanding of Commonwealth and State legislation and is experienced in a range of terrestrial flora and fauna survey techniques. Specifically, Amy is experienced in classifying vegetation and collecting floristic attribute data in accordance with the NSW Biodiversity Assessment Method (BAM).

Amy has demonstrated experience working on large scale linear infrastructure projects such as the Parkes to Narromine and the Narrabri to North Star sections of the Melbourne to Brisbane Inland Rail (MBIR) Project. On these projects, Amy was the lead surveyor, classifying vegetation along the route and collecting biometric data in accordance with the Framework for Biodiversity Assessment (FBA) methodology. She also conducted many of the targeted threatened species surveys and was responsible for the input of biometric data into the FBA Calculator and providing technical input into the associated biodiversity assessment reports.

Amy displays excellent project management, fieldwork coordination, written and verbal communication skills with a focus on providing detailed and high-quality deliverables.

Relevant Project Experience

Framework for Biodiversity Assessment (FBA) Biometric Assessment for Parkes to Narromine section of Melbourne to Brisbane Inland Rail (MBIR) Project, NSW

Dates: 2015 – 2016

Client: ARTC

To prepare a Biodiversity Assessment Report in accordance with the Framework for Biodiversity Assessment (FBA) for the Parkes to Narromine Section of the Melbourne to Brisbane Inland Rail (MBIR) Project.

Role: Lead Field Surveyor and Author (Ecologist – Botanist)

Amy was the lead field surveyor for a major infrastructure project which required FBA and Biobanking assessments along its route. Amy collected biometric data for more than 100 plots/transects, undertook vegetation mapping and TEC identification as well as targeted threatened species surveys.

Framework for Biodiversity Assessment (FBA) Biometric Assessment for Narrabri to North Star section of Melbourne to Brisbane Inland Rail (MBIR) Project, NSW

Dates: 2015 – 2016

Client: ARTC

Years of Industry Experience

7+ years

Qualifications and Memberships

- Bachelor of Science (Environmental Studies and Biology)
- Advanced Plant Identification for Research and Environmental Assessment UNSW
- Senior First Aid and Remote Area First Aid
- Advanced 4WD and Vehicle Recovery
- Accredited BioBanking Assessor Licence 230 (FBA)
- Biodiversity Offsets Scheme Training (NSW)
- White Card
- Work Safely at Heights
- Level One Tree Access Systems
- Rail Industry Safety Worker Licence

Key Skills and Competencies

- Technical expertise in the identification, mapping, management, and impact assessment of threatened plant species and threatened ecological communities

Professional History

2018 – Present | SMEC
Senior Scientist - Ecology

2017 – 2018 | Holcim (Australia) Pty Ltd Planning and Environment Coordinator – NSW/ACT

2015 – 2017 | Umwelt
Ecologist – Botanist

2014 – 2015 | Biosis
Field Botanist

2012 – 2014 | GreenCollar Consulting Solutions (GCS)
Field Ecologist/2IC Field Team Leader

Referees

Catherine Fenton
Approvals Manager
Glencore Mount Owen Complex
Ph. (02) 6520 2686

Email:
catherine.fenton@glencore.com.au

To prepare a Biodiversity Assessment Report in accordance with the Framework for Biodiversity Assessment (FBA) for the Narrabri to North Star Section of the Melbourne to Brisbane Inland Rail (MBIR) Project.

Role: Lead Field Surveyor and Author (Ecologist – Botanist)

Amy was the lead field surveyor for a major infrastructure project which required FBA and Biobanking assessments along its route. Amy collected biometric data for more than 100 plots/transects, undertook vegetation mapping and TEC identification as well as targeted threatened species surveys.

Warragamba Dam Raising EIS Biodiversity Assessments, NSW
Dates: 2018-2019
Client: WaterNSW

To prepare a Biodiversity Assessment Report in accordance with the Framework for Biodiversity Assessment (FBA) for the Construction footprint, Upstream impact area and downstream impact area.

Role: Surveyor and Author (Ecologist)

Amy was involved in the field survey and reporting for the biodiversity assessments required for the proposed Warragamba Dam Raising Environmental Impact Statement. The project involved undertaking field survey within the southern Blue Mountains and Western Cumberland Plain including World Heritage and Declared Wilderness areas. Work carried out required significant organisational, communication and technical skills in a large, remote and poorly surveyed wilderness environment. Report preparation of an FBA complicated by unique impacts requiring a tailored approach to assessing impacts.

Preparation of a Referral under the EPBC Act
Dates: 2019
Client: Bathurst Regional Council

To prepare a Referral under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and in accordance with the significant impact guidelines for anticipated impacts to identified Matters of National Environmental Significance (MNES) within the impact area of the proposed Bathurst Second Circuit race track.

Role: Surveyor and Author (Ecologist)

Amy was involved in the preliminary field investigations to identify potential Matters of National Environmental Significance (MNES) that may be impacted by the proposed Bathurst Second Circuit race track. The main MNES identified was *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* listed as a Critically Endangered Ecological Community (CEEC) under the EPBC Act. Amy was also involved in the vegetation mapping, Plant Community Type (PCT) identification and delineation as well as the collection of floristic composition, structure and function attribute data in accordance the NSW Biodiversity Assessment Method (BAM).

Mount Owen Continued Operations Project Modification, Muswellbrook, NSW
Dates: 2018-2019
Client: Glencore Mount Owen Complex

To prepare a Biodiversity Assessment for the Proposed Modification IN accordance with the transitional arrangements under the *Biodiversity Conservation Act 2016* and therefore provide an assessment that is consistent with the NSW Biodiversity Offsets Policy for Major Projects and the Framework for Biodiversity Assessment (FBA).

Role: Surveyor (Ecologist – Botanist)

Amy was involved in the field survey and reporting for the biodiversity assessment. Specifically, Amy undertook the vegetation mapping, identifying and delineating the extent of *Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions*, listed as an Endangered Ecological Community (EEC) under the BC Act, *Swamp Oak Floodplain Forest of the NSW North Coast Sydney Basin and South East Corner Bioregions,* listed as an EEC under the BC Act and *Central Hunter Valley Eucalypt Forest and Woodland* listed as a Critically Endangered Ecological Community (CEEC) under the EPBC Act. Amy was also involved in targeted threatened flora and fauna surveys which included conducting parallel transects, hollow-bearing tree assessments, diurnal bird surveys, spotlighting, Koala Spot Assessment Technique (SAT) surveys, herpetological searches and anabat deployment.

Olympic Highway Realignment at Kapooka Ecological Monitoring, Wagga Wagga, NSW

Dates: 2019
Client: Roads and Maritime Services (RMS)

To undertake biodiversity monitoring in accordance with conditions of consent associated with the Olympic Highway Realignment Project.

Role: Surveyor (Ecologist)

Amy was involved in the monitoring of threatened fauna around the Olympic Highway realignment at Kapooka in southern New South Wales. The monitoring project involved undertaking nest box monitoring and squirrel glider trapping including microchipping and collection of DNA samples from individuals caught. This is because the Squirrel glider (*Petaurus norfolcensis*) population in Wagga Wagga Local Government Area is listed as Endangered Population under the BC Act and was thought to potentially be impacted by the Olympic Highway Realignment Project.

Biodiversity Offset Strategy for the Haerses Road Dixon Sand Quarry Extraction Area Modification Project, Maroota and Kenthurst, NSW
Dates: 2017
Client: Dixon Sands Quarry

To prepare a Biodiversity Offset Strategy for the Haerses Road Dixon Sand Quarry Extraction Area Modification Project.

Role: Surveyor and Author (Ecologist)

Amy undertook vegetation mapping, targeted threatened species searches for species credit species and collection of biometric data for 18 plots/transects across two BioBank sites in Maroota and Kenthurst. Targeted threatened species searches identified *Darwinia biflora*, Dural Land Snail (*Pommerhelix duralensis*) and *Tetratheca glandulosa*. Amy was also involved in the preparation of the Biodiversity Offset Strategy Report which was prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects and the Framework for Biodiversity Assessment (FBA).

Vegetation Field Surveys throughout NSW and Victoria for the Stand Condition Assessment of the Woody Vegetation Project
Dates: 2017
Client: Murray-Darling Basin Authority (MDBA)

To collect baseline stand condition data from black box (*Eucalyptus largiflorens*), river red gum (*Eucalyptus camaldulensis*) and coolabah (*Eucalyptus coolabah*) trees within the Murray-Darling Basin for the purposes of developing an ongoing, long-term monitoring program.

Role: Lead Field Surveyor (Ecologist)

Amy undertook a number of field surveys throughout NSW as part of the MDBA Woody Vegetation Project. Specifically, the field surveys involve Vegetation Condition Assessments within black box (*Eucalyptus largiflorens*), river red gum (*Eucalyptus camaldulensis*) and coolabah (*Eucalyptus coolabah*) trees within the Murray-Darling Basin. Amy collected data to help MDBA develop a satellite imagery-based tool for assessing the condition of woody vegetation stands across the Basin, which will be a cost-effective method for ongoing monitoring and evaluation. The project involved surveying almost 200 sites within NSW and Victoria. At each site, the surveys involved field teams marking out the four corners of the plot (typically 50 m x 50 m in size). Trees within the plot were marked with tree marking paint and a pre-stamped metal tree tag. Canopy extent and Diameter at Breast Height (DBH) of 30 target trees (black box, river red gum and coolabah) were recorded within the plot and all remaining tree species in the plot had DBH measured and recorded. A hemispherical (180 degree) photo was also taken within a central point of the plot at each site surveyed. Photos were captured horizontal to the ground facing the canopy and were required to be taken within two hours of sunrise or sunset, or during the day in overcast conditions. These photos underwent post-survey analysis for the necessary data extraction. In addition to the SCA methodology described, the surveys also involved recording state specific floristics within sub-plots of the larger Stand Condition Assessment plot.

Biodiversity Offset Strategy for United and Wambo Open Cut Coal Mine Project, Hunter Valley, NSW
Dates: 2016
Client: United Collieries

To prepare a Biodiversity Offset Strategy for the United and Wambo Open Cut Coal Mine Project.

Role: Surveyor and Author (Ecologist)

Amy undertook vegetation mapping and field surveys as part of preparing the Biodiversity Offset Strategy for United and Wambo Open Cut Coal Mine Project. Amy was also involved in the preparation of the Biodiversity Offset Strategy Report which was prepared in accordance with the NSW Biodiversity Offsets Policy for Major Projects and the Framework for Biodiversity Assessment (FBA).

Vegetation mapping and condition assessment of Southern Wallis Lake Foreshore, NSW
Date: 2016
Client: Great Lakes Council

To provide detailed vegetation mapping and condition assessment of Southern Wallis Lake foreshore on behalf of Great Lakes Council.

Role: Project Manager, Lead Field Surveyor and Author (Ecologist - Botanist)

Amy undertook surveys including baseline vegetation mapping, resilience (condition assessment,) community description, full inventory of native and exotic species present (primarily flora) targeted threatened species searches, baseline weed density mapping and identification of key threats to significant foreshore vegetation. Following the surveys, Amy provided a detailed report to Council which included vegetation maps, weed density maps, recommended restoration management actions and priority areas for restoration management.

Numerous Ecological Assessment for NBN Installation Works, NSW
Dates: 2015 – 2018
Client: Telstra/NBN Co.

To prepare Ecological Assessments for NBN Installation works (on behalf of Telstra) across the Hunter Region and Sydney Region.

Role: Project Manager, Lead Field Surveyor and Author (Ecologist – Botanist)

Amy was responsible for many ecological assessments for NBN installation works occurring across the Hunter and Sydney Regions.

Ecological Assessment Addendum to REF, NSW
Dates: 2019
Client: Sydney Trains

Ecological Assessment Addendum to a Review of Environmental Factors (REF) for culvert replacement and drainage works in the rail corridor at Koolewong, NSW.

Role: Surveyor and Author (Ecologist - Botanist)

Amy was responsible for preparing an Ecological Assessment to assess the impacts om biodiversity values associated with proposed culvert replacement and drainage works in the rail corridor at Koolewong, NSW. This involved undertaking a site inspection and desktop assessment to understand the biodiversity features within the site that may be impacted by the proposed works.

Flora and Fauna Assessment for Upgrades to Bells Line of Road, Mount Tomah, NSW
Dates: 2014
Client: Roads and Maritime Services (RMS)

To undertake a flora and fauna assessment for the Bells Line of Road Upgrade works.

Role: Surveyor (Botanist)

Amy undertook the field work and reporting for a flora and fauna assessment associated with upgrade works between Mount Tomah and Bells Line of Road.

Flora surveys and Targeted threatened ecological community (TEC) identification as part of the Nimmie-Caira Sydney Enhanced Water Delivery Project, Balranald, NSW
Dates: 2014
Client: NSW Office of Water

To undertake ecological surveys as part of the Nimmie-Caira Sydney Enhanced Water Delivery Project.

Role: Surveyor (Botanist)

Amy undertook plot-based surveys to identify Plant Community Types (PCTs) to inform the Nimmie-Caira System Enhanced Water Delivery Project in the Riverina District of NSW. This involved extensive surveys over 12 days with a team consisting of several zoologists, botanists, and aquatic ecologists. PCTs which were identified included: Lignum shrubland wetland of the semi-arid (warm) plains (mainly Riverina and Murray Darling Depression Bioregions), Black box-lignum woodland of the inner floodplains in the semi-arid zone; mainly in the Riverina and Murray-Darling Depression and River Red Gum - Lignum very tall open forest or woodland wetland on floodplains of semi-arid (warm) climate zone (mainly Riverina Bioregion and Murray Darling Depression Bioregion). Targeted threatened flora surveys were also incorporated into the survey effort for which the Mossgiel Daisy (*Brachyscome papillosa*) (Vulnerable, EPBC Act and TSC Act) was found to occur.

Dr. Ingrid Stirnemann

Associate Environmental Scientist - Ecology

Professional Overview

Ingrid is an Associate Environmental Scientist for SMEC. She spent 7 years conducting research into the ecology and threatened fauna, before resuming work as a consultant in 2018. Ingrid has a BSc (Hons) and PhD, centred on vertebrate conservation and landscape ecology. Ingrid has worked in habitats ranging from coastal swamplands to semi-arid rangelands and montane forests and has completed over 100 surveys for fauna and flora. She has been involved in designing surveys for a wide variety of terrestrial and arboreal mammals, amphibians and birds. She is also skilled in analysing complex spatial datasets using advanced programs, such as R and ArcGIS. She has published scientific papers in Australian and International Journals, as well as a variety of technical reports (i.e. Species Impact Statements, Baiting Plans, Monitoring Reports, Translocation Plans, and Environmental Assessments).

Select Project Experience

Warragamba Dam, NSW
Dates: 2018 -
Role: Associate Environmental Scientist
Data is currently being collected for the Environmental Impact Statement Warragamba Dam, the proposed pumped hydro-storage project located in NSW. Ingrid was involved in collating this large spatial dataset. She is proficient in using the excel, the program R and using ArcGIS. For example, Ingrid analysed the flora data for each of the Plant Community Types within the proposed project footprint areas for use in calculating offsets.

Solar Farm, NSW
Dates: 2018 -

Role: Associate Environmental Scientist

Ingrid undertook the field surveys and assessments for the development of a Solar farm in NSW. Monitoring on this project commenced in late 2018.

Shade Impacts on Fauna and Flora, ACT
Dates: 2018 - 2019

Role: Associate Environmental Scientist

In Canberra, Ingrid investigated the effects of construction and shade on endangered Golden Sun Moth (GSM) and their habitat. Surveys have been designed to allow comparison of before, during and after construction impacts on the GSM based on stratification by habitat and replication in both the affected areas and a control site. This process is part of a Construction Environmental Management Plan (CEMP) and is a condition of the *EPBC ACT* approval for construction.

Granite Hills Wind Farm, New South Wales – Environmental Assessment
Dates: 2018 -

Role: Associate Environmental Scientist

Years of Industry Experience

10+ years as an ecologist in research and consultancy

Qualifications

PhD – Landscape Ecology

The Australian National University, Canberra, Australia. 2011-2015

First Class Honours - Ecology

Flinders University, Adelaide, Australia. 2006

B. Sc. Waikato University, Hamilton, New Zealand 1999-2001 Major Ecology

Key Skills and Competencies

Technical expertise in: ArcGIS, statistical modelling in the program R, statistical interpretation, spatial mapping and analysis.

First aid training

4WD training

Professional History

2018 – Present | Associate Environmental Scientist, SMEC

2016 – 2017 | Post-doctoral Researcher, University of Munster, Germany

2015| Research Assistant, University of Canberra, Australia

2007-2008 & 2010 | Ecological Consultant, Kessels and Associates LTD, New Zealand

2009 | Ecological Consultant, Habitat LTD, United Arab Emirates

2004-2006 Research Technician, Hort-Research, New Zealand

Ingrid designed and oversaw biodiversity surveys at site and ensured the latest survey information was available to inform assessments required under the NSW legislation for level 2 bird and bat surveys.

Statistical Modelling of Disturbance and Topographical Drivers on Flora and Fauna, Kazakhstan
Dates: 2016-2017

Role: Post-doctoral Researcher

As a post-doctoral researcher, Ingrid examined the spatial patterns of flora and fauna within Kazakhstan, Eurasia. In Kazakhstan she undertook point counts for ground squirrels at different distances. By recording distances, she was able to determine the density of this species. She also developed statistical models within the program R predicting: the probability of occurrence and abundance of fauna, and examined how disturbance factors (fire), and how landscape features (hydrology and topography) influenced vegetation patterns. Ingrid used ArcGIS to collate spatial data, and ground-truthing data within the field.

Hauāuru mā raki –Waikato Wind Farm- Assessment of Ecological Effects, New Zealand
Dates: 2007 –2010
Client: Contact Wind Ltd

Ingrid was the environmental lead on this high-profile wind farm project planned for the west coast of New Zealand. The proposed wind turbines potentially impacted on resident and migratory bird species, as well as several other taxa. Ingrid's role was to design and lead a large-scale three-year monitoring project targeted at resident and migratory bird species in the wind farm envelope. She was involved in surveying, and collecting bird movement data, and developing a strike risk model. This strike risk model was used to calculate the probability of bird strike for select species under different scenarios. This informed the ecological impact assessment which identified, quantified and evaluated the potential impacts of the Hauāuru mā raki Wind Farm. Furthermore, it was her role to ensure specialists and relevant stakeholders had timely input into the project.

Te Uku Wind Farm Transmission Line- Assessment of Ecological Effects, New Zealand
Dates: Dec 2008 – March 2008
Client: WEL Networks Ltd

Ingrid was the environmental lead on examining the ecological effects of a proposed wind farm transmission line on flora and fauna. The proposed transmission line potentially impacted on Australasian Bittern (*Botaurus poiciloptilus)* and other wetland bird species. Further, the proposed transmission line impacted native vegetation. Ingrid's role was to survey for Australasian Bittern to inform assessments required under the New Zealand legislation and develop appropriate mitigation measures. She also was involved in undertaking vegetation assessments along this long linear transect.

Waitahora Wind Farm - Assessment of Ecological Effects, New Zealand
Dates: Jan 2007 – Jul 20107
Client: Contact Energy

The proposed Waitahora Wind Farm potentially impacted on resident native birds and bats within the wind farm envelope. Further, native vegetation clearance would occur if the work was approved. Ingrid's role was to design and undertake bird and bat surveys on site.

Khalifa Port and Industrial Zone Development - (U.A.E)
Dates: May – Jul 2009
Client: Khalifa Port Marine Consortium

Ingrid was the environmental lead on the Ecological Mitigation Component of the Khalifa Port and Industrial Zone Development in the UAE. Ingrid was responsible for implementing biodiversity compliance measures as required under the Abu Dhabi Emirate environmental legislation. This included undertaking pitfall trapping, spotting lighting and Elliott trapping to determine species presence and distribution patterns. She also ensured that specialists and relevant stakeholders had timely input into the project.

Abu Dhabi Emirate Wildlife Census - (U.A.E)
Dates: Jan 2009
Client: Abu Dhabi Environment Department

This project aimed to determine the status, population and distribution of desert antelopes within the Abu Dhabi Emirate, in the United Arab Emirates (UAE), with a focus on three native species. This included surveys on general age structures and genetic diversity. Ingrid's role as a senior ecologist on this project was to undertake aerial surveys for target species, improve sampling techniques, and collate aerial survey data. She was also involved in the collection of genetic samples for an analysis of the local populations. This study provides the UAE Government with a consolidated baseline of information regarding the various species of antelope within the UAE.

Livestock stations census in the Al Hyer/Shwaib (U.A.E)

Dates: Jul-Sep 2009
Client: PRP Architects International

Prior to the development of a new agricultural area in Al Hyer/Shwaib information was collected on the spatial distribution of existing livestock stations, fauna and native vegetation. Ingrid's role as a senior ecologist was to design the aerial survey and ensured the latest survey information and spatial mapping data was available to inform the project.

James Taylor

Experienced Scientist -Ecology (GIS)

Professional Overview

James is an Experienced Scientist in the SMEC Natural Resources Management team. James has an Environmental Science background with expertise in Geographic Information Systems (GIS). He has worked in a range of GIS focused positions within state and local government departments and the private sector. As such, he has strong technical skills and a wide range of experience working with GIS and applications.

James has been involved in a diversity of environmental mapping projects including landcover, landuse, flood extent, landslip mapping, erosion assessment, ground cover monitoring programs and major constraint projects including Warragamba Dam raising. He has experience in performing field surveys to provide the calibration and validation of remotely sensed imagery and derived products.

Relevant Project Experience

Warragamba Dam Raising (EIS), NSW | $4.7 million
Dates: June 2018 – Present
Client: Water NSW

GIS specialist and field survey team member on a FBA Major Project Assessment of impacts associated with the raising of Warragamba Dam wall.

Role: GIS Specialist

Responsibilities include vegetation mapping, identification and mapping of threatened flora and fauna species, management of collected field data and undertaking transect flora surveying assessments in accordance with FBA, reporting and mapping.

Heathcote Road Upgrade, NSW
Role: GIS Specialist Ecology
Dates: August 2018 – January 2019
Client: Roads and Maritime Services

Role: GIS Specialist

GIS specialist on the detailed design of approximately 2km of widening to dual carriageway on Heathcote Road, between Infantry Parade and The Avenue, Holsworthy. Responsibilities include vegetation mapping, area calculations, data conversion, interpretation of field data to provide ecological analyses, identification and mapping of threatened flora and fauna species, maintenance of spatial data.

Years of Industry Experience

9+ years

Qualifications and Memberships

- Bachelor of Environmental Science (Resource Management), Southern Cross University, 2007–2010

Key Skills and Competencies

- GIS
- Spatial data analysis
- Georeferencing
- Geocoding
- Imagery interpretation
- Database management
- Project management
- Biodiversity
- Vegetation mapping
- Land use mapping
- Flood extent mapping
- Erosion assessment
- Field Surveys and monitoring

Professional History

2018 – Present | SMEC, Experienced Scientist - Ecology

2017 – 2018 | RMS, Information Officer

2015 – 2017 | TomTom, Geographic Sourcing Analyst

2014– 2015 | OEH, GIS Officer

2010 – 2013 | QLD Government, Remote Sensing Scientist

Referees

Jose Carrasco
Information Manager, RMS
Ph. (02) 8849 2640

Stewart Watters
Senior Team Leader,
Office of Environment and Heritage (OEH)
Ph. (02) 9873 8561

Maintenance of Spatial Datasets | Roads and Maritime Services, NSW Government
Dates: February 2017 – June 2018
Client: Roads and Maritime Services

The maintenance of corporate spatial datasets, including road geometry, cadastral and topographic datasets.

Role: Information Officer

James' role as Information Officer required him to analyse journey information data, including spatial data, by undertaking information processing tasks, including geo-spatial, to support the client and customers' needs. James engaged with ESRI Software ArcGIS to update road geometry to immediately reflect updates on the network. In this role, he had the responsibility of completing weekly updates and ongoing maintenance of the legally enforceable Heavy Vehicle Network ensuring up to date routing information for the public webmap. James was also responsible for the development of spatial data to reflect affected emergency routes such as flooding and special events. Internal and external requests including vehicle route information, status, statistics, history, geocoding, mapping requests and supply of data.

Geographic Sourcing Analyst | TomTom
Dates: June 2015 – February 2017
Client: TomTom

TomTom Maps division team member responsible for updating and maintaining road geometry and managing project databases.

Role: Geographic Sourcing Analyst

This was a GIS mapping role creating and updating road network geometry and associated features including speed restrictions, signpost information, maneuverer attributions, traffic restrictions and road classification for routing information. In this role, James used ESRI Software ArcGIS and internal mapping software to georeference construction plans, integrate source data, geocode locations and perform data quality assurance procedures. He also was responsible for preparing documentation for projects and analysis to generate statistical reports.

Mapping of State Heritage Register items | NSW Office of Environment and Heritage
Dates: November 2014 – June 2015
Client: NSW Office of Environment and Heritage

Mapping of the NSW State Heritage Register items, such as places, buildings and objects valued by the people of NSW and particular groups in the community, such as Aboriginal, religious groups or people with a common ethnic background.

Role: GIS Officer

James was in a GIS mapping role and undertook mapping of State Heritage Register items and production of thematic maps for the Heritage division. He used ESRI ArcGIS to create and update mapping layers and records in Heritage department databases; produce thematic maps for internal records and public website; and manage the spatial database. The mapping duties included interpretation of site descriptions, and the georeferencing of survey plans and historic maps.

Statewide Landcover and Trees Study (SLATS) QLD | Queensland Government
Dates January 2010 – January 2013
Client: Queensland Government

Remote Sensing Scientist team member and contributed towards the major vegetation-monitoring program SLATS – which uses satellite imagery and field verification to accurately map wooded vegetation cover, including changes to the extent of Queensland's forests and woodlands. The program provides information for vegetation management planning and compliance across Queensland.

Role: Remote Sensing Scientist

James was responsible for processing and analysing satellite imagery, data from airborne platforms and field surveys to assess and monitor Queensland's landspaces; undertake image classifications to map and monitor landcover. He engaged with ESRI ArcGIS vector based editing and Erdas Imagine for raster based editing. James also performed unix command scripts to run automated classifications and retrieve imagery from department filestore database. James undertook field work for the calibration and validation of remotely sensed imagery and derived products, and operated field equipment including GPS and Tablet PC. The observations and data collected as part of the field verification included: the accuracy of the classification, the method of clearing used, site photograph, a visual estimate of the percentage of cleared timber removed or decayed, the replacement land cover, the maturity of timber cleared, the presence of regrowth, the original and current species, soil colour and the presence of termites and fire. The observations recorded at each site are used for site revisits during the next era of change classification.

The Queensland Land Use Mapping Program (QLUMP) QLD | Queensland Government
Dates: January 2010 – January 2013
Client: Queensland Government

Remote Sensing Scientist team member who contributed to the provision of spatial data on land use, and the mapping of land use for the State of Queensland. The program is part of the Australian Collaborative Land Use and Management Program (ACLUMP) coordinated by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and supported by the Queensland Government Reef Protection Package.

Role: Remote Sensing Scientist

James was responsible for processing and analysing satellite imagery, data from airborne platforms and field surveys to assess and monitor Queensland's landscapes; to map and monitor landcover and land use; and producing detailed land use maps and summary statistics for priority regions. James also undertook field work for the calibration and validation of remotely sensed imagery and derived products, and operated field equipment including GPS and Tablet PC. This work combined using satellite imagery, aerial photographs and field surveys to produce digital mapping.

Statewide Groundcover Monitoring Field Program, QLD | Queensland Government
Dates: January 2010 – January 2013
Client: Queensland Government

Remote Sensing Scientist team member and contributed towards the field measuring and monitoring program of groundcover across Queensland.

Role: Remote Sensing Scientist

James was responsible for processing and analysing satellite imagery, data from airborne platforms and field surveys to assess and monitor Queensland's landscapes; undertake image classifications to map and monitor landcover and land use. Responsibilities included undertaking groundcover transect surveys and using satellite imagery for the validation and development of the Queensland Government mapping system. Landholders, natural resource managers, and government agencies use the information to improve land management outcomes.

Joel Callaghan

Graduate Ecologist

Professional Overview

Joel joined the SMEC Environment Team as a graduate ecologist in 2017 after completing his Honours Degree working on the evolutionary ecology of the native mint *Plectranthus parviflorus*. The research was conducted in partnership with the Royal Botanic Gardens in Sydney and required Joel to collect plant material across the distribution of *P. parviflorus* for subsequent molecular and morphometric analyses. This work along with other volunteer work for the Royal Botanic Gardens has provided Joel with a good working knowledge and experience in plant identification and ecology. Since starting at SMEC Joel has worked on a range projects covering both targeted and general flora and fauna surveys, vegetation mapping, GIS and data management (see below for details).

Joel's studies and work have provided the opportunity to conduct fieldwork in numerous parts of the state, from Eden through to Byron Bay and as far west as Mount Kaputar. This fieldwork experience has given Joel exposure to a diverse range of vegetation types and plant communities.

Relevant Project Experience

Warragamba Dam Raising EIS, NSW | $1.5million
Dates: October 2017 – Present
Client: WaterNSW

Environmental assessment for the Warragamba Dam Raising project providing important data for the Environmental Impact Statement (EIS) which will be prepared in accordance with the *Environmental Planning and Assessment Act 1979* and the NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs).

Role: Joel has undertaken eight weeks of field surveys that have covered work on both flora and fauna. This included data collection for Biodiversity Assessment Methodology (BAM) vegetation plots, threatened flora species habitat mapping (e.g. *Eucalyptus benthamii*) and general vegetation community mapping. He has also completed diurnal bird aural/visual surveys, threatened owl call playback and spotlight surveys, spotlight surveys for threatened arboreal mammals, general frog surveys and the set-up and monitoring of cage traps and hair tube traps. Some of the species detected in these surveys include Barking Owls, Regent Honeyeaters, Dusky Wood-Swallows and both Greater and Yellow-Bellied Gliders. Other responsibilities included the set-up of safety equipment and safety procedures, data collection and management using QGIS and QField, conducting a likelihood of occurrence analysis and biobanking data entry.

Golden Highway Upgrade Biodiversity Assessment
Dates: February 2018 - present
Client: Roads and Maritime

Roads and Maritime engaged SMEC to advise the construction of the Golden Highway upgrade south of Singleton. The SMEC ecology team was responsible for assessing

Years of Industry Experience

2 years

Qualifications and Memberships

- Bachelor Science (Hons 1) Plant Ecology
- 4WD Training
- First Aid Training
- Member of Australasian Systematic Botany Society

Key Skills and Competencies

- Advanced Plant Identification
- Biodiversity and habitat assessment
- Project management
- Vegetation mapping
- Threatened flora and fauna surveys
- GIS
- BioBanking Assessment Methodology (BBAM)
- Plant identification

Professional History

2017 – Present | SMEC | Graduate Ecologist any impact to biodiversity associated with the construction and operation of the upgraded section of highway.

Joel completed the Biodiversity Assessment Reports (BAR) for the proposed upgrades to sections 3 and 4-7 of the Golden Highway. This included interpreting and assessing field-collected data for potential biodiversity issues and communicating this in a report that satisfies both NSW and Commonwealth environmental legislation and policy. Joel also lead the data collection for the BAM vegetation plots for the upgrade to section 3 of the Golden Highway.

Kembla Grange Flora and Fauna Assessment, NSW | $20,000 (biodiversity component)
Dates: October 2017 - present
Client: Private Developer

SMEC was engaged by Watts Development Consultancy as part of a development application proposing the subdivision of an existing rural allotment at Sheaffes Road, Kembla Grange. The role of the ecology team was to conduct an assessment of the biodiversity associated with the allotment and if would be impacted by the proposed development.

Role: Joel completed fieldwork that included conducting call play-back surveys for threatened owl species and general diurnal/visual bird surveys. He managed data collection, completed a likelihood of occurrence assessment and conducted assessments of significance for different microchiropteran bats.

Granite Hills Wind Farm, NSW | $500,000
Dates: September 2017 - present
Client: Granite Hills Wind Farm Pty Limited

SMEC was engaged by Granite Hills Wind Farm Pty Limited to advise the construction their proposed wind farm. The SMEC ecology team was responsible for assessing any impacts to biodiversity that may arise in the construction and operational phases. This project was unique in that it presented the challenge of assessing the potential impact of a wind farm located immediately adjacent to a National Park and in the migratory flight paths of a range of avian species.

Role: Joel completed a week of threatened owl surveys and owl habitat mapping, along with data collection and management using QField (a GIS program). Surveys included call playbacks with spotlighting and was successful in detecting Powerful Owls.

Eurobodalla Southern Storage EIS, NSW| $200,000 (biodiversity component)
Dates: September 2017 - present
Client: Eurobodalla Shire Council

SMEC was engaged by Eurobodalla Shire Council to review and update the concept design for a proposed 3000 ML water storage facility, Tuross River water offtake pipeline and pump station near Bodalla in southern NSW. The ecology team's role was to assess and determine any impacts to biodiversity that could result in the construction and operational phases of the water storage development.

Role: Joel's responsibilities included BioBanking data entry and management for 21 vegetation plots conducted to assess the impacts of flooding on ecological communities and threatened species.

Lachlan Laurie

Senior Scientist - Ecology

Professional Overview

Lachlan has had extensive experience in the preparation of over 50 Flora & Fauna Assessment reports and over 200 Assessments of Significance (TSC Act & EPBC Act). Additionally, Lachlan has authored numerous Vegetation Management Plans, Constraint Analysis Reports, Species Impact Statements, Bushland Management Plans, Monitoring Reports, Translocation Plans, Restoration Plans, Reviews of Environmental Factors, and offset assessments using the BioBanking Assessment Methodology (BBAM) and Framework for Biodiversity Assessment (FBA).

Lachlan has a wide range of experience in liaising with clients, stakeholders and government departments, and has been well informed of the BioBanking process since its inception, having undergone training and accreditation under the updated scheme in early 2015, and updated again in late 2017. He has extensive field experience in remote areas within Australia and overseas, linear projects and constraints reports.

Lachlan has managed and undertaken large scale projects across NSW requiring FBA and BBAM, including his role as senior botanist for the Warragamba Dam raising proposal, the Snowy Hydro 2.0 feasibility REFs and the Sunraysia Solar Farm.

As an advisor to all three levels of government, Lachlan has extensive ongoing experience relating to biodiversity constraints, impact avoidance and risk assessment.

Relevant Project Experience

<u>**Warragamba Dam proposed dam raising EIS, NSW**</u>
Dates: October 2017 – Present
Client: WaterNSW

Environmental assessment for the Warragamba Dam Raising project providing important data for the Environmental Impact Statement (EIS) which will be prepared in accordance with the *Environmental Planning and Assessment Act 1979* and the NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs).

Role: Senior Botanist

Remote field surveys for over 30 weeks (ongoing) within the southern Blue Mountains and Western Cumberland Plain including World Heritage and Declared Wilderness areas. Leading field survey teams carrying out included threatened flora species surveys and vegetation community and habitat mapping, with relevance to Framework for Biodiversity Assessment Methodology. Work carried out requires significant organisational, communication and technical skills in a large, remote and poorly surveyed wilderness environment. Report preparation of an FBA complicated by unique impacts requiring a tailored approach to assessing impacts.

Years of Industry Experience

15+ years

Qualifications and Memberships

- Certificate IV Workplace Training and Assessment
- Advanced Plant Identification for Research and Development UNSW SoA
- Farming Small Areas NSW TAFE SoA
- Biodiversity Offset Scheme (BOS) Accredited Assessor
- NSW Department of Lands Trustee
- Willoughby Council Bushland Advisory Committee
- NSW Nature Conservation Council Urban Bushland Advisory Committee
- Federal Government St Marys Macrofauna Management Committee

Key Skills and Competencies

- Technical expertise in the identification, mapping, management, and impact assessment of threatened plant species and threatened ecological communities

Professional History

2017 – Present | SMEC Senior Scientist, Ecology

2009 – 2017 | Total Earth Care Consulting, Senior Botanist

2002 – 2006 | TAFE NSW Lecturer Conservation and Land Management

2000 – 2007 | Ku-ring-gai Council Field Officer and Nursery Manager

1991 – 2017 | Wirreanda Native Production Nursery Nursery Manager and Senior Horticulturist

Snowy Hydro 2.0 Feasibility Study, NSW
Dates: May 2017 – March 2008
Client: Snowy Hydro

Production of ten REFs relating to geotechnical investigations for Snowy Hydro 2.0 alignment.

Role: Principal Botanist

Principal Botanist for flora surveys along the Snowy Hydro 2.0 alignment. Surveys included assessment of proposed bore-hole drill sites, including both road and air access impacts with relation to threatened flora and fauna species and threatened ecological communities.

Sunraysia Solar Farm, NSW
Dates: October 2016 – November 2016
Client: Sunraysia Solar

Proposal for the large solar farm outside of Mildura requiring assessment under the Framework for Biodiversity Assessment as part of the Environmental Impact Statement

Role: Principal field botanist

Collecting botanical data, as per the FBA methodology included linear transect searches and habitat assessment for threatened flora species, biometric vegetation plots surveys, fauna habitat assessments within biometric plots and mapping of hollow-bearing trees.

Boco Rock Wind Farm, NSW
Dates: June 2013 – June 2015
Client: Downer EDI

Project Ecologist implementing tasks outlined in State and Federally approved management plans for the construction of a 70-turbine wind farm and 132Kv transmission line in the Snowy Monaro LGA.

Role: Project Ecologist

Responsibilities include undertaking pre-clearance surveys for threatened reptile species and other native fauna present on site, relocation and monitoring of relocated individuals, habitat assessment, consistency reviews, fauna surveys and management, provision of expert advice

IUCN World Heritage Listing Advisor Mt Hamiguitan World Heritage Area, Philippines

Dates: June 2013– July 2013
Client: IUCN and Central Mindanao University

Technical specialist for field assessment of biotic World Heritage values to IUCN in collaboration with Central Mindanao University of rare and localised endemic summit flora.

Role: Technical Specialist

Field assessment of biogeographic patterns of Gondwanic relicts associated with montane ultramafic conditions and species population assessments.

Mt Keira Summit Park Preliminary Biodiversity Assessment
Dates: 2017
Client: Wollongong City Council

Role: Project Ecologist

Preparation of a Biodiversity Assessment Report including Biodiversity constraints analysis and mapping, including advice on likely requirements for further survey for impact assessment for a range of proposed development scenarios and activities

Rebecca Carman

Experienced Scientist - Ecology

Professional Overview

Rebecca is an ecologist with experience in a broad range of environmental impact assessment projects, including REFs, EISs and biodiversity technical reports for large road infrastructure. Rebecca has relevant skills in ecological assessment, including botany, fauna habitat assessment, fauna trapping and monitoring programs, BioBanking field assessment techniques, community consultation and habitat condition assessment. Rebecca has experience working with a variety of threatened flora and fauna species, including endangered ecological communities.

Prior to working as an ecologist, Rebecca spent five years working in a marsupial immunology research laboratory. She gained experienced in designing research projects, undertaking experiments and writing scientific reports.

Relevant Project Experience

Kapooka Environmental Monitoring, NSW
Dates: October 2015 – ongoing
Client: Roads and Maritime Services

Monitoring of threatened fauna around the Olympic Highway realignment at Kapooka in southern New South Wales.

Role: Ecologist/Field work coordinator

Rebecca's responsibilities included organisation and preparation of field surveys and providing input into technical reports. Rebecca lead a field team undertaking trapping and inspecting nest boxes for the presence of Squirrel Gliders and processing of any individuals identified.

Warragamba Dam proposed dam raising (EIS), NSW | $1.5 million
Dates: October 2017 – present
Client: WaterNSW

Environmental assessment for the Warragamba Dam Raising project providing important data for the Environmental Impact Statement (EIS), which will be prepared in accordance with the *Environmental Planning and Assessment Act 1979* and the NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs).

Role: Ecologist

Rebecca is involved in the preparation, coordination and execution of fauna surveys targeting numerous threatened species over a very large wilderness area. Rebecca is contributing to reports considering the impacts of the proposed dam raising in relation to threatened fauna species and their habitat within the study area.

Years of Industry Experience

7 years

Qualifications and Memberships

- Postgraduate Diploma in Wildlife Management, Macquarie University
- Master of Philosophy, Macquarie University
- Bachelor of Science, Macquarie University
- Australasian Network for Ecology & Transportation
- RIW card
- First Aid training

Key Skills and Competencies

- Ecological surveys and monitoring
- Animal handling
- Habitat assessment
- BioBanking field assessment techniques
- Scientific research
- Geographic Information Systems (GIS)
- Certified working at heights and tree climbing
- 4WD training

Professional History

2014 – Present | SMEC Experienced Scientist - Ecology

2012 – 2014 | UBM Ecological Consultants Ecologist

2011 – 2012 | University of Western Sydney Research Assistant

2009 – 2011 | Sydney University Research Assistant

2005 – 2008 | Macquarie University Research Officer

Hume Highway Bypasses Fauna Monitoring, NSW
Dates: February 2014 – November 2016
Client: Roads and Maritime Services

Monitoring of threatened fauna around the Holbrook, Woomargama and Tarcutta bypasses on the Hume Highway in southern New South Wales.

Role: Ecologist/Field work coordinator

Rebecca's responsibilities included organisation and preparation of field surveys and providing input into technical reports. Rebecca lead a field team undertaking trapping, spotlighting and inspecting nest boxes for the presence of Squirrel Gliders and processing of any individuals identified.

Nowra Bridge (REF), NSW | $2.4 million
Dates: March 2015 – June 2018
Client: Roads and Maritime Services

SMEC completed the Concept Design and EIS for the proposed new bridge over the Shoalhaven River at Nowra. The project investigated bridge location options to ensure this crossing copes with traffic now and into the future.

Role: Ecologist

Rebecca participated in general fauna surveys including spotlighting, diurnal bird surveys, frog searches and analysis of microbat ultrasonic calls. She also contributed to a Biodiversity Assessment Report, prepared to consider the impacts of the project on biodiversity.

Eurobodalla Water Storage Facility (EIS), NSW
Dates: September 2016 – August 2018
Client: Eurobodalla Shire Council

SMEC prepared a Biodiversity Technical Report assessing impacts of preliminary geotechnical investigations.

Role: Ecologist

Rebecca was a member of a team that completed extensive surveys for listed threatened species in the proposed site for a water storage facility. Fauna surveys included spotlighting, diurnal bird surveys, placement of hair tubes, analysis of microbat ultrasonic calls, koala scat surveys, call playback and identification and mapping of hollow-bearing trees. Rebecca also assisted with pre-clearing surveys for preliminary geotechnical investigations at the site.

Pacific Highway Upgrade – Narara to Lisarow (REF), NSW | $4.5 million
Dates: January 2015 – January 2018]
Client: Roads and Maritime Services

SMEC was commissioned by Roads and Maritime to undertake a Concept Design and REF for the Pacific Highway and Manns Road, Stage 4 upgrade. The project involved the upgrade of Manns Road and the Pacific Highway, between Narara and Lisarow, on the NSW Central Coast.

Role: Ecologist

Rebecca participated in general fauna surveys including spotlighting, trapping for Squirrel Gliders, diurnal bird surveys, frog searches, analysis of microbat ultrasonic calls and call playback. She also contributed to a Species Impact Statement prepared by the SMEC Ecology team.

Termeil Creek Biodiversity Monitoring
Dates: April 2017 – ongoing
Client: Roads and Maritime Services

An ongoing project monitoring threatened fauna species using crossing structures and nest boxes around the realignment of the Princes Highway at Termeil Creek, near Ulladulla in southern New South Wales.

Role: Ecologist/Field work coordinator

Rebecca coordinated the installation of cameras on the crossing structures and continues to monitor these and the nest boxes.

Dr David Sharpe

Senior Ecologist

Professional Overview

Dr David Sharpe has been conducted research, monitoring studies, impact assessment and conservation planning for over 20 years. Project work has been undertaken widely across NSW and Queensland in both coastal and inland ecosystems. David has wide experience in assessing and subsequently monitoring the impacts of a broad range of linear infrastructure, including highways, railways and pipelines. This has included long-term monitoring projects on the threatened squirrel glider associated with upgrades of the Hume Hwy and the realignment of the Olympic Hwy in southern NSW. David is currently engaged by the Australian Rail Track Corporation to undertake all ecological reviews for all stages of the Inland Rail Project in NSW and Queensland under State and Commonwealth legislation. This requires both a detailed understanding of the relevant legislation and a broad understanding of the plant communities and threatened species ecology of western NSW.

Relevant Experience

Review of ecological reports for the Inland Rail Project in NSW and Queensland

The Inland Rail Project will provide a 1300 km rail freight service between Brisbane and Melbourne. I continue to undertake reviews of all ecological assessment reports (scoping reports, survey method proposals, technical ecology survey and habitat modelling reports, impact assessment reports, EPBC referrals, etc) for all project stages (ranging from geotechnical investigations, identification of quarry sites, and the design, clearing and construction of the rail corridor including mitigation actions, CEMPs, etc) in NSW and Queensland

Monitoring the threatened squirrel glider on the Olympic Hwy upgrade, Kapooka, NSW

A rail bridge over the Olympic Hwy was realigned. Multiple impact and control sites are being trapped annually for five years. Surveys using a before-during-after/impact-control design, gliders individually marked (PIT tags) and assigned to age/sex classes, habitat assessment, mark-recapture analysis (modelling survival rates and population size estimates and trend), camera monitoring of arboreal crossing structures, statistical analysis, reporting. Client: NSW Roads and Maritime Services.

Monitoring the threatened squirrel glider on the Hume Highway bypasses of Tarcutta, Holbrook and Woomargama

Each of the three town bypasses were separate projects, each with multiple impact and control sites that were trapped twice-yearly for three years. Field surveys used a before-during-after/impact-control design, gliders individually marked (PIT tags) and assigned to age/sex classes, habitat assessment, mark-recapture analysis (modelling capture probability, survival rates and population size estimates and trend using Program MARK), camera monitoring of crossing structures, statistical analysis, reporting. Client: NSW Roads and Maritime Services.

Warragamba Dam wall raising

Targeted threatened fauna surveys and habitat assessment across the large dam catchment, which occurs in a wilderness area between two national parks, GIS

Years of Industry Experience

25 years

Qualifications

BAppSci (Hons 1), PhD

Key Skills and Competencies

- Fauna surveys and habitat assessment
- Hollow-bearing tree assessment
- Radio-tracking studies
- Home-range analysis
- Population viability analysis
- Mark-recapture analysis
- Distance sampling
- Threatened species management
- Impact assessment
- Monitoring studies
- Conservation planning
- Statistical analysis
- Proficient in Word, Excel, Powerpoint, ArcGIS, SPSS and specialist scientific software
- Construction Industry White Card
- Working Safely at Heights Card
- Tree climbing certificate
- 15 peer-reviewed scientific publications

analysis, assessment of project impacts on threatened fauna listed under the NSW Biodiversity Conservation Act 2016 and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. Client: WaterNSW.

Route selection studies for the Kin Kin Range Road Upgrade, south-east Queensland.

Fauna surveys targeting threatened species, impact assessment, advice on selection of the final route option and location of fauna underpass culverts. Client: Qld Department of Transport and Main Roads.

Barcaldine Solar Farm Project, Qld

Threatened fauna habitat assessment, mapping remnant vegetation, impact assessment for a proposed 75 ha site. Client: Elecnor.

Koala Management Plan for the Moreton Bay Rail Link, Brisbane.

Koala population assessment, assessment of habitat quality, review local status and threats, impact assessment and mitigation, conservation planning, reporting, development of clearing protocols. Client: Qld Department of Transport and Main Roads.

Koala Life Corridor Design Project, Lawnton to Brendale

The project required a Koala movement corridor to be designed and retro-fitted to an urbanised landscape. Field assessment of current habitat status (quality and connectivity) and urban impacts, conservation planning, analysis of road crossing options and movement over barrier fences, revegetation plans in relation to site suitability, corridor design. Client: Moreton Bay Regional Council.

Population assessment of the Eastern Pygmy Possum, Mona Vale Rd upgrade NSW

Field survey (nestboxes, trapping), detailed individual assessment upon capture, mark-recapture analysis, habitat assessment, assessment floral availability. Client: NSW Roads and Maritime Services.

Gateway Motorway Upgrade North arboreal fauna crossings structures (rope bridges)

Analysis of squirrel glider gap crossing ability in relation to upgrade of motorway from four to six lanes, advice on arboreal crossing structure locations, selection of tie-in trees, review rope bridge designs, review of squirrel glider use of arboreal crossing structures and design of automated camera monitoring program. Client: Qld Department of Transport and Main Roads.

Flora survey of proposed Kalbar Water Supply Pipeline route, south-east Queensland.

EVNT and MNES threatened species search, regional ecosystem mapping, flora survey, fauna habitat assessment. Client: South-east Queensland Water

Flora survey of proposed route of a water supply pipeline, Copmanhurst, NSW.

Flora survey, targeting threatened species, advice on final alignment based on field outcomes. Client: Egis Environmental Consultants.

Coombabah Sewage Treatment Plant upgrade, Gold Coast Qld

Targeted threatened and migratory fauna surveys, threatened plant surveys, assessment of Threatened Ecological Communities, supplementary Koala surveys to estimate size and density of local population (conducted using the Distance sampling statistical approach based on spotlighting data), preparation of EPBC referral. Client: Gold Coast City Council.

Cooroy to Curra upgrade of the Bruce Hwy (Sunshine Coast to Gympie), Qld.

Threatened plant surveys, koala habitat assessment and survey, threatened species habitat assessment, advice on the location of koala crossing structures, preparation of EPBC referral. Client: Queensland Department of Transport and Main Roads.

Population Viability Analysis of the Squirrel Glider in Fragmented Habitat in the South-eastern Brisbane Suburbs.

Field assessment of landscape context, corridor identification, GIS analysis, population viability analysis (computerised population simulation), liaison with Council staff (subsequently published as Goldingay and Sharpe 2004). Client: Brisbane City Council.

Analysis of Tomago Aluminium smelter small mammal capture data.

Analysis of population trends and bone fluoride concentration based on 32 years of trapping data using a two-factor (distance/time) regression analysis. Client: Tomago Aluminium Smelter.

Species Impact Statement for the Proposed Hutley Drive Extension, Lennox Head, NSW.

Lead fauna ecologist for targeted threatened field surveys, impact assessment, reporting, provision of ecological advice. Client: Ballina Shire Council.

Species Impact Statement for residential development at Emerald Beach, NSW.

Targeted threatened fauna surveys (including squirrel glider, wallum froglet, koala, common planigale), threatened flora surveys, assessment of Laced Fritillary Butterfly larval food plant, GIS analysis, reporting, develop management plans, liason with State agencies. Client: Pridel Investments. Will the upgrade of Old Cleveland Road, Brisbane, cause habitat fragmentation for the squirrel glider?

Flora and Fauna Management Plan, Tuckean Swamp Catchment (near Lismore), NSW

General and target flora and fauna surveys within an 11,000 ha catchment, mapping, reporting, catchment scale management planning. Client: NSW National Parks and Wildlife Service.

Sustainable Private Native Forestry: A review of Timber Production, Biodiversity and Soil and Water Indicators, and Their Applicability to Northeast NSW.

Literature review of ecological impacts of forestry, habitat assessment and general fauna surveys, reporting. Client: School of Forestry, Southern Cross University.

Professional History

1995
Botantist**,** Joint Old Growth Forests Project, Northern NSW (plant identification, tree hollow assessments, growth stage assessments)

1995 – 1998
Southern Cross University Demonstrator: Techniques in Plant Conservation

1995 – 2009
Southern Cross University, Demonstrator: Techniques in Animal Conservation

1994 – 1998
Freelance consultant

1999 – 2011
Partner, D & D Environmental Consultants

2011 – present
Senior Ecologist, SMEC

Leura Kowald

Undergraduate Environmental Scientist

Professional Overview

Leura has been employed as an undergraduate environmental scientist within the Environment team at SMEC since December 2017. In her role at SMEC, Leura has provided support on projects by undertaking database searches to inform and develop constraints mapping and survey requirements for biodiversity impact assessments. This work has assisted in the preparation of projects covering Environmental Impact Assessments, Environmental Impact Statements, Reviews of Environmental Factors, Preliminary Environmental Investigations and biodiversity technical reports. Leura has also assisted in field surveys to meet requirements under the NSW Framework for Biodiversity Assessment (FBA) and Biodiversity Assessment Method (BAM) and collated and managed the collected data for use in reporting and especially for determining Likelihood of Occurrence Tables. She has also further developed her community consultation skills providing support to the Community and Stakeholder team on projects. Leura provides support across the environment team with skills utilising various software programs such as Microsoft Excel, Arc Reader, Google Earth, Consultation Manager and also online data bases as required.

Relevant Project Experience

Warragamba Dam Raising Proposal (EIS), NSW
Dates: Dec 2017 – Present
Client: Water NSW

SMEC has been engaged to carry out the environmental impact assessment for the raising of Warragamba Dam for flood mitigation. This will involve raising the current wall by a proposed 14 metres resulting in new flood areas upstream of the dam and changes in flooding patterns downstream of the dam as well as clearing required to allow the construction of the additional section of the wall.

Role: Undergraduate Environmental Scientist

As part of the ecology team Leura conducted preparation for the ecological survey program and assisted in carrying out durnial bird surveys and FBA flora surveys; completed botanical identification of field samples; collated and entered data for the surveys including analysing camera trap records; formatted data into representative tables for reporting; updating likelihood of occurrence tables; desktop investigation for EPBC and TSC threatened species and EEC's; and utilised the Bureau of Meteorology website to access previous weather and climate data. She also researched the potential effects of the proposal on biodiversity by conducting desktop investigations of the existing environment in terms of soils, geological history, as well as Hydrological impacts on flora to the proposal and its possible effects on the ecological communities.

Leura was also part of the community & stakeholder engagement team that required researching community and business stakeholder groups and their interests; entering stakeholder queries and comments into the program Consultation Manager; organising static displays and pop-up sessions in councils, community centres and shopping centres; door knocking residents to gain property

Years of Industry Experience

1+ year

Qualifications and Memberships

- Bachelor of Arts and Science, 2019. Major in Physical Geography and Biodiversity
- Certificate III Horticulture, 2010
- General construction induction card (NSW – white card)

Key Skills and Competencies

- Survey planning
- Constraints analysis
- Data collation and management
- Botanical Identification

Professional History

2017 – Present | SMEC Undergraduate Environmental Scientist

2017 | UWICER Internship, Bumthang, Bhutan. Flora and fauna surveys

2016 | Care for Hedland work placement, Turtle Monitoring.

2015 – 2019 | University of New England, Student

2007 – 2017| Horticulturalist, Landscape Construction and Design.

access for ecology surveys, door knocking businesses as part of the socio-economic impact assessment investigation and also addressing stakeholder concerns both written and verbally.

Heathcote Road Upgrade (Biodiversity Assessment Report), NSW
Dates: March 2018 - Present
Client: NSW Roads and Maritime Services

SMEC is preparing the detailed design for upgrades of Heathcote Road Heathcote Road between Infantry Parade at Holsworthy and The Avenue at Voyager Point from two lanes to four lanes for approximately 2.2 kilometres.

Role: Undergraduate Environmental Scientist

Leura was part of the ecology team completed flora FBA surveys and fauna surveys as well as leaf litter and vegetation plots under the FBA methodologies. She also collated the tables and figures for reporting and assisted in the preparation of the BAR.

Golden Highway Upgrade (BAR), NSW
Dates: January 2018 - Present
Client: NSW Roads and Maritime Services

SMEC is preparing the concept and detailed design for upgrades to approximately 10 km of the Golden Highway, near Singleton NSW. The upgrades include a new bridge over Mudies Creek, road widening and new overtaking lanes.

Role: Undergraduate Environmental Scientist

Leura was part of the ecology team conducting species impact assessment, identifying and mapping of hollows, flora BAM surveys and fauna surveys as well as leaf litter and vegetation plots under the FBA and BAM methodologies.

She also undertook environmental database searches and conducted GIS mapping for the REF as well as collating and entering data obtained from the searches and surveys and produced representative tables and figures for reporting.

Nowra Bridge Preferred Option (REF), NSW
Dates: March 2018 – July 2018
Client: NSW Roads and Maritime Services

SMEC Australia has been engaged by RMS to develop the concept design and undertake a Review of Environmental Factors for a new bridge over the Shoalhaven River on the NSW South Coast.

Role: Undergraduate Environmental Scientist

Leura's Community & Stakeholder Engagement responsibilities included entering stakeholder queries and comments into Consultation Manager and drafting collateral for stakeholder engagement.

Eurobodalla Southern Storage (EIS), NSW

Dates: Jan 2018 - Present
Client: Eurobodalla Shire Council

SMEC have been engaged by Eurobodalla Shire Council to review and update the concept design for a proposed 3000 ML water storage facility, Tuross River water offtake pipeline and pump station near Bodalla in southern NSW; and to take this through to Detailed Design and Contract Documentation.

Role: Undergraduate Environmental Scientist

Leura as part of the ecology team identified collected flora field samples; collated field data; updated Likelihood of Occurrence tables; conducted desktop investigations for EPBC and TSC threatened species and Endangered Ecological Communities; co-ordinated GIS mapping and prepared BioBanking data.

Outer Newcastle Study (PEI), NSW
Dates: Feb 2018 – June 2018
Client: NSW Roads and Maritime Services

SMEC was engaged by Roads and Maritime Services (Roads and Maritime) to undertake the Outer Newcastle Study. As part of the study, Roads and Maritime requested that a Preliminary Environmental Investigation be prepared for six of the nine projects make up the study.

Role: Undergraduate Environmental Scientist

Leura organised the preliminary GIS mapping, ecological database searches and assessment of the fauna Likelihood of Occurrences for the six projects. She also co-authored the biodiversity sections of the six PEI's, and in particular the fauna, collating the available information into the report and providing assessments of the potential constraints that these represented in future developments of the study areas.

Austral Leppington North Infrastructure Project (REF), NSW
Dates: 2018 – Present
Client: Liverpool Council

SMEC Australia Pty Ltd (SMEC) has been engaged by Liverpool City Council to undertake investigation and detailed concept design of proposed flood mitigation and water quality control structures within 1662 hectares of the Austral and Leppington North precincts. The precincts of Austral and Leppington North are the latest release areas in the Liverpool and Camden Local Government Areas (LGA) for residential developments. Due to flat topography of the area and the proximity of three major water courses, significant lands are subject to flooding within the precinct area. The proposal involves the installation of 22 flood detention basins, 53 water quality basins, 29 culvert crossings, significant lengths of trunk drainage systems and overland flow paths in order to manage this flooding.

Role: Undergraduate Environmental Scientist

Leura conducted research of literature and previous reports as well as NSW heritage database and the Australian Heritage Database searches for the project for the non-aboriginal heritage section of the REF.

Bargo and Warragamba Waste Management Centres (Licence Monitoring) NSW
Dates: Dec 2017– Jan 2018
Client: Wollondilly Shire

Wollondilly Shire Council have two landfills; Bargo Waste Management Centre and Warragamba Waste Management Centre. Both landfills have quarterly water and gas monitoring as part of their EPA licence conditions. SMEC provided the monitoring and prepared the EPA report for the licence.

Role: Undergraduate Environmental Scientist

Leura collated data collected between the years of 2015 and 2017; analysed the current year's data records monitoring compliance within the EPA guidelines; applied climate data summaries from the Bureau of Meteorology records; and produced tables and graphs to represent the data in line with EPA requirements.

Appendix I Multipage figures

These have been provided as separate PDF files.

Appendix J Expert report

Expert report on the Sydney Plains Greenhood, *Pterostylis saxicola* in the area predicted to be affected by the Warragamba Dam wall raising project. 3. Downstream impacts

Peter H. Weston
Botanical Consultant
[redacted]

15 November 2019

Table of Contents

1. Introduction

1.1 Project context

WaterNSW, a corporation owned by the State Government of New South Wales, is planning to raise the wall of Warragamba Dam by approximately 14 metres for the purpose of flood mitigation in the Hawkesbury Nepean River catchment ("the project"). This is a Major Project of State Significant Infrastructure for which WaterNSW must conduct an Environmental Assessment and prepare an Environmental Impact Statement (EIS), as directed by the Secretary's Environmental Assessment Requirements (SEARs) (where "the Secretary" is the Secretary of the Department of Planning and Environment). The EIS will determine the impact of raising the dam wall on threatened species and ecological communities upstream of, downstream of, and in the immediate vicinity of the dam wall. The EIS will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation. The EIS must include plans for compensating for the damage caused by the project to native biodiversity, as specified in the State Government's NSW Biodiversity Offsets Policy for Major Projects. This policy requires WaterNSW to apply the Framework for Biodiversity Assessment (FBA) to assess impacts on biodiversity (NSW Office of Environment and Heritage 2014). The FBA specifies that each threatened species that is likely to be impacted by the project should be surveyed in the affected areas, or, if that is not feasible, that an export report be prepared to assess the presence, total area and geographic distribution of suitable habitat in the impacted areas

The FBA specifies that an expert report must:
6.6.2.3 … document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report.
6.6.2.5 … set out whether:
(a) for development sites – the species is unlikely to be present on the development site – in this case no further assessment of the species is required, or
(b) for all development sites – the species is likely to be present on the site – in this case the expert report must provide an estimate of the number of individuals or area of habitat to be impacted by the development or the management actions (according to the unit of measurement identified for the species in the Threatened Species Profile Database).

According to Section 6.5.2 of the Biodiversity Assessment Method (NSW Office of Environment and Heritage 2017), an expert report must also:

- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- include a description of how the estimate [of the number of individuals or area of habitat] was made
- identify the expert and provide evidence of their expert credentials.

1.2 Purpose of the expert report

In March 2019 I was engaged by SMEC Australia on behalf of WaterNSW to produce three expert reports on the distribution and abundance of an endangered species of orchid, *Pterostylis saxicola*, within the area predicted to be impacted by the Warragamba Dam wall raising project. This report is the third of these and deals with impacts in the area affected by controlled release of flood waters downstream from the dam wall (collectively termed "the survey area" herein). The aim of this exercise is to assess whether *P. saxicola* is native to the survey area and, if so, to assess where suitable habitat is located, to estimate the area occupied by *P. saxicola* in the survey area and to estimate the probability that populations of *P. saxicola* live there.

1.3 Survey area

The survey area for this report is located downstream of the Warragamba Dam construction site, west to north west of the Sydney Metropolitan Area, between latitudes 33° 23’ 32” S and 33° 56’ 25” S and longitudes 150° 34’ 42” E and 150° 59’ 06” E (figure 1). This survey area has been restricted to the 10% Annual Exceedance Probabability (AEP) flood inundation extent, truncated at the confluence of the Hawkesbury and Colo Rivers, Its area is 15316.37 hectares, running more or less adjacent, at varying widths, to the banks of the Warragamba, Hawkesbury and Nepean Rivers and affected tributaries. Elevation within the study area varies from approximately 40 m AHD to less than 10 m AHD.

1.4 Reasons for use of expert report

Pterostylis saxicola has never been collected or observed within the survey area. However, sites at which the species has been collected or observed, according to the BioNet Wildlife Atlas, are known from sites to the north, south, east, and west of the survey area, in several cases within 1 km of it. The survey area largely overlaps the extent of occupancy (EOO) of *P. saxicola*, suggesting that it is part of the distributional range of the orchid. Moreover, according to Tozer *et al.* (2010), several plant community types in which populations of *P. saxicola* are known to occur, are scattered throughout the survey area, raising the strong possibility that suitable habitat for *P. saxicola* might exist there. If this were so, *P. saxicola* might once have lived there, or still exist in the survey area as unrecorded populations.

Pterostylis saxicola is a perennial, deciduous herb that can only be identified with confidence when flowering in Spring (late September to early November). However, the cryptic coloration and small size of this plant render it a challenging subject for conventional surveying: aerial and “drive by” surveys are not feasible and even experienced orchid spotters need to be standing within a few metres of a flowering plant to notice it. Moreover, plants may not flower if climatic conditions during the growing season from March to December (see section 2.2 below) are poor. These limitations and the possibility that *P. saxicola* might be native to the survey area triggered the need for an expert report.

The alternative surveying approach used here involves the construction of a general habitat model for *Pterostylis saxicola*, which can then be used, in conjunction with environmental maps, to identify suitable habitat across the survey area.

1.5 Credentials of expert

I prepared this report as an independent botanical consultant but I am also currently an Honorary Research Associate at the National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust (the New South Wales state herbarium). In 2016, I retired from my role as a Senior Principal Research Scientist at the state herbarium, having worked there since 1982 as a Systematic Botanist and as curator of the herbarium’s collections of specimens of Orchidaceae (including *Pterostylis saxicola*) (see my Curriculum Vitae, attached). I now work, part-time, at the National

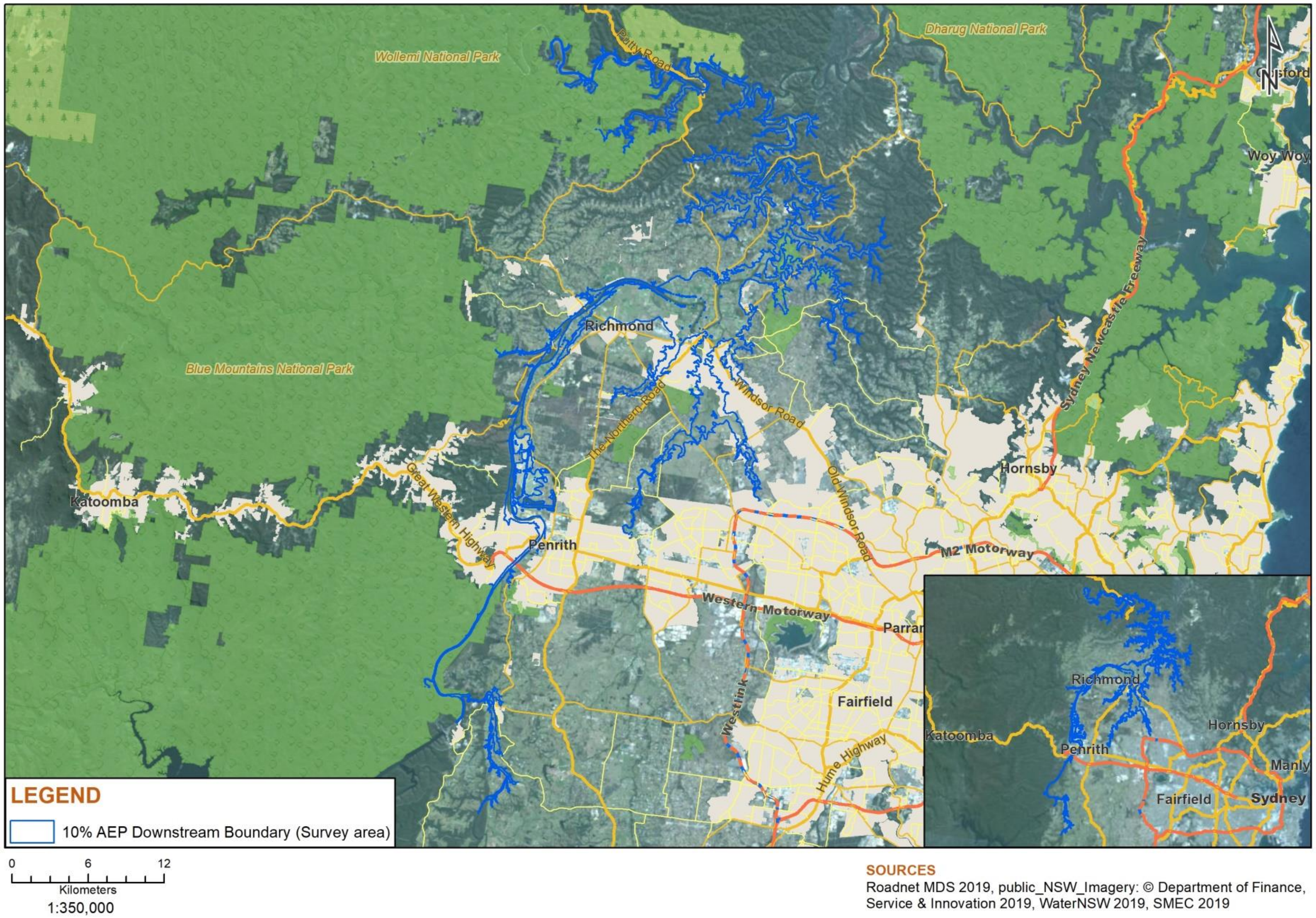


Figure 1. Map of the survey area, outlined in blue. Map provided by James Taylor, SMEC.

Herbarium of New South Wales as an Honorary Research Associate. I have published, either as sole author or as a co-author, 16 papers on the systematics and ecology of the Orchidaceae in the peer-reviewed scientific literature, including the most comprehensive phylogenetic analysis of the predominantly Australian subtribe Diurideae yet published (Weston et al. 2014). As curator of Orchidaceae at the state herbarium, I examined all specimens of *P. saxicola* incorporated into the collection between 1986 and 2016. I was invited to contribute to floristic treatments of the Orchidaceae for Flora of New South Wales, (see my Curriculum Vitae, attached). I was also asked to be lead author of the essay on the ecology of the Orchidaceae that accompanied the “Ecology of Sydney Plants” (Weston et al. 2005). Throughout my career I have participated in numerous collecting trips in the field, collecting specimens in all Australian states for the state herbarium. In documenting these specimens, I had to describe the habitat at each collecting site, including associated plant species, substrate, aspect, degree and kind of disturbance. I have also cultivated numerous species of *Pterostylis* as an orchid enthusiast and advised horticulturalists at the Royal Botanic Gardens on appropriate techniques for cultivating species of *Pterostylis* and other orchids.

In 2018 I was appointed to prepare expert reports on *Pterostylis saxicola* in the Greater Macarthur, Wilton, and Western Sydney Aerotropolis Growth Areas and in the Greater Penrith to Eastern Creek Urban Release Investigation Area (Weston unpublished a,b), during the preparation of which I characterised in detail the associated plant species and other ecological attributes of seven plots, each of 30 metre radius, centred on highly precise grid references of sites at which *P. saxicola* had previously been collected, at two of which I have found flowering plants of *Pterostylis saxicola*. I am personally familiar with this taxon and the habitats in which it lives.

In November 2018 I was approved by the Office of Environment and Heritage as a species expert for *Pterostylis saxicola* under section 6.5.2 of the Biodiversity Assessment Method. This approval is current for a period of six years.

2. Species information

2.1 Species description

The following morphological description of *Pterostylis saxicola* is a modified version of that published by Jones and Clements (1997), updated with data gathered from more recently collected specimens held by the National Herbarium of N.S.W (see figures 2, 3).

Tuberous, terrestrial herb. Tubers oblate, c. 15-20 mm wide. Leaves oblong-elliptical to ovate-elliptical or obovate, 10-45 mm long, 5-15 mm wide, 5-10 in a radical rosette, green, the margins entire, shortly petiolate, apex subacute to apiculate, often withered at anthesis. Inflorescence 10.5-35 cm tall, slender, with 3-6 ensheathing, lanceolate sterile bracts. Floral bracts lanceolate, 6-19 mm long, 3-4 mm wide, acuminate, closely sheathing. Pedicels 3-26 mm long, slender, straight or slightly curved. Ovary narrowly obovoid, 3-5 mm long, 1-2 mm wide, reddish brown. Flowers 1-10, porrect to semi-erect, 12-12 mm long, transparent with dark red-brown markings and suffusions in the galea, the lateral sepals wholly red-brown, shiny; galea gibbous at the base, curved medially, decurved suddenly to the apex; petal flanges poorly developed, not touching and not closing off the base of the galea. Dorsal sepal 11-13 mm long, cucullate, obliquely erect, Abruptly decurved in distal quarter, apical point c. 3 mm long, filamentous, acuminate. Lateral sepals deflexed, ovate in outline when flattened, fused part 7-10 mm long, 9-11 mm wide, shallowly concave, the margins strongly incurved, glabrous; sinus narrow; free points filamentous, c. 5 mm long, curved forwards, divergent, 8-10 mm apart at the tips. Petals ovate-lanceolate, 11-14 mm long, 3.5-5 mm wide, nearly straight, transparent, with brown basal markings and two or three brown lines, dorsal margin brown, ciliate, proximal flange poorly developed. Labellum highly irritable, attached by a ligulate basal claw c. 2 mm long, c. 2 mm wide; lamina broadly obovate, 4.5-6 mm long, 2.5-3.5 mm wide, dark red-brown, constricted in the proximal quarter, adaxial surface shallowly concave to broadly grooved, apex obtuse; marginal trichomes 3-5 pairs, white, the longest pair c. 3.5 mm long, arising near the proximal constriction, basal lobe large, with 1-3 pairs of trichomes c. 0-.7 mm long, abaxial surface with a narrow central channel extending from the basal lobe to the apex. Column porrect from the end of the ovary, 10-12 mm long, c. 2.5 mm wide; column wings c. 3.3 mm long, c. 2.5 mm wide, more or less rectangular, anterior margins ciliate. Stigma elliptical to broadly scutiform, c. 5 mm long, c. 2.5 mm wide, the upper margins irregular. Anther c. 1.2 mm long, obtuse. Pollinia linear-oblong to clavate, c. 2 mm long, yellow, mealy. Fruiting capsules obovoid, 7-8 mm long, c. 4-5 mm wide, brownish, erect.

2.2 Life cycle

Pterostylis saxicola is a perennial, deciduous, tuberous herb that germinates from a minute, dust-like seed. Like all other orchids, germination is reliant on invasion of the seed by the hyphae of a specific fungal associate, which, in the case of *P. saxicola*, is an unnamed species of *Ceratobasidium* (Basidiomycota: Cantharellales) (Sommerville et al. 2008). The first morphological change that an orchid seed undergoes during germination is swelling to form a protocorm, a rootless, shootless 'blob'. The orchid fungus forms an intracellular relationship with its host, usually in the roots and/or tubers and is thus classed as an endomycorrhiza. It forms hyphal coils, called pelotons, in the cells of its host, which are beneficial to the orchid in that they provide the host plant with nutrients such as soluble sugars (Rasmussen 1995). The duration of the association varies according to the life history of the particular orchid species, with some species of orchids being completely dependent on their mycorrhizal fungi for life while other species are capable of living without their fungi from shortly after germination. The ease of cultivation of *Pterostylis* species and the green colour of almost all plant parts strongly suggest that adult plants are not obligately dependent on their mycorrhizal associates as adult plants.

Plants of *Pterostylis saxicola*, like those of most other species in Orchidaceae subfamily Orchidoideae, are deciduous, with the whole shoot system growing anew every year from a dormant tuber. The new shoot usually starts growing from an apical meristem on the tuber in late summer, with new shoots usually breaking the soil surface by March. The shoot develops into a "rosette" of crowded leaves just above ground level and in late winter a terminal raceme starts growing from the centre of the rosette, reaching anthesis in spring. While the shoot is growing above ground, a new replacement tuber is growing below ground, from the base of the shoot. Some species of *Pterostylis* multiply and spread vegetatively by producing additional new tubers on the ends of long roots but the subgenus to which *P. saxicola* belongs, *Oligochaetochilus*, does not share this attribute (Jones 2006).

Almost all species of *Pterostylis* are deceptively pollinated by male flies that attempt to copulate with the labellum of the flower. The labellum mimics a female fly of a particular species (or species group) in size, appearance and texture and by exuding an allomone that is identical to the pheromone released by the female flies (Phillips et al. 2013, Kuiter & Findlater-Smith 2017). In species of *Pterostylis* for which the pollination process has been studied and described, the labellum is highly motile ("irritable"), like that of *Pterostylis* saxicola, and a male fly that lands on it is tossed inside the hood (galea) formed by the dorsal sepal and lateral petals, and trapped there. The only escape route provided by the flower is a tunnel through which the male fly must squeeze in order to escape. In the process of negotiating its exit, the fly is forced to rub past the stigma of the flower, depositing on it any pollinaria that it was already carrying. The fly is then forced to contact the anther, sticking a pollinarium on its thorax, before it can finally escape. The pollinator of *P. saxicola* is still unknown, but the pollinators of other species of *Pterostylis* subgenus *Oligochaetochilus*, where known, are males of unnamed species of *Orfelia* (Mycetophilidae) (Kuiter & Findlater-Smith

2017). Sexually deceptive pollination has evolved multiple times in the Australian terrestrial orchid flora, involving hundreds of species (Weston et al. 2014). Most of those for which pollinators have been identified are pollinated by the males of only one species of insect and *P. saxicola* is most likely pollinated by a single species of fly too.

Fruiting capsules of *Pterostylis saxicola* mature quickly, with the most proximal capsules sometimes dehiscing before the most distal flowers have withered. They split down six sutures to release thousands of minute, wind-dispersed seeds in November to early December.

Figure 2. Flowering plant of *Pterostylis saxicola*, at Scheyville National Park, showing the basal rosette of crowded leaves lying flat on the ground and a terminal, erect inflorescence, bearing one open flower from the side and an unopened flower bud.

Figure 3. Inflorescence of *Pterostylis saxicola*, at Simmos Beach Reserve, Macquarie Fields, showing two flowers, the lower one in frontal view, the higher one in lateral view, showing galea, labellum and paired lateral sepals.

2.3 Distribution and abundance

Records for *Pterostylis saxicola* are widely distributed across the Cumberland Plain and lower Blue Mountains in an area bounded by Scheyville, Freemans Reach, Euroka Campground, Douglas Park, Picnic Point, and Cattai, with two outlying records from the Gingra Range in Kanangra Boyd National Park and Anvil Hill in the Hunter Valley (BioNet Atlas, as held records received 22 February 2019; National Herbarium of New South Wales specimen database, accessed 8 April 2019) (figure 4). It has been recorded at altitudes ranging from 30 to 440 metres. It is very sporadically distributed, partly because much of this land has been cleared for agriculture and suburban development but large parts of the Warragamba catchment are remote and inaccessible. However, the outlying records suggest that any habitat model is unlikely to be a powerful predictor of the presence of populations at particular locations.

Plants of *Pterostylis saxicola* are usually gregarious, with most collectors and observers noting multiple plants co-occurring together. Counts of the number of individual plants at sites vary from one to 280, with a mean population size of 82. As *P. saxicola* does not usually multiply vegetatively (Jones 2006, as *Oligochaetochilus saxicola*), these clusters are most likely the result of seeds germinating close to their parents.

2.4 Habitat requirements

The habitat model published in the endangered species profile for *Pterostylis saxicola* (NSW Office of Environment and Heritage 2018) states that it is "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 *P. saxicola* occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils". This description applies accurately to the habitat associated with the type collection and with some other records in the southern half of the species' distribution but not to those found elsewhere. The distributional range and habitat requirements of *P. saxicola* can be subdivided into two main sub-populations and two outlying populations.

The northern sub-population is in an area bounded by Scheyville, Freemans Reach, The Ironbarks near Glenbrook, Toongabbie, Ryde, Glenhaven and Cattai. I have visited four sites with precise grid references at which *Pterostylis saxicola* has been observed or collected in this area and identified the plant community types found there (see section 4.4, appendix 1). The substrate underlying the sites at Scheyville and Freemans Reach, both of which I have visited, is deep Ashfield Shale (Wianamatta Group) and the Ryde record is also mapped to this substrate. I have also visited the Cattai and The Ironbarks sites, which are on Mittagong Formation substrates (transition zones between Ashfield Shale and Hawkesbury Sandstone). The Toongabbie record also maps to this substrate. All of these sites are in elevated, well-drained but gently rolling country, not on rugged sandstone outcrops.

The plant communities that I identified at the four sites mentioned above are the following:

- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (see figure 5);
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain (see figure 6).

Most records from the southern sub-population, in an area bounded by Macquarie Fields, Minto, Douglas Park, Woronora River and Picnic Point differ in habitat from the northern records. Although a recent record from Menangle is from Ashfield Shale, in most cases where they have highly precise locality data and/or detailed habitat descriptions, collections and observations from this area have been made on Hawkesbury Sandstone, on the rims and sides of the gorges of the Nepean, Georges

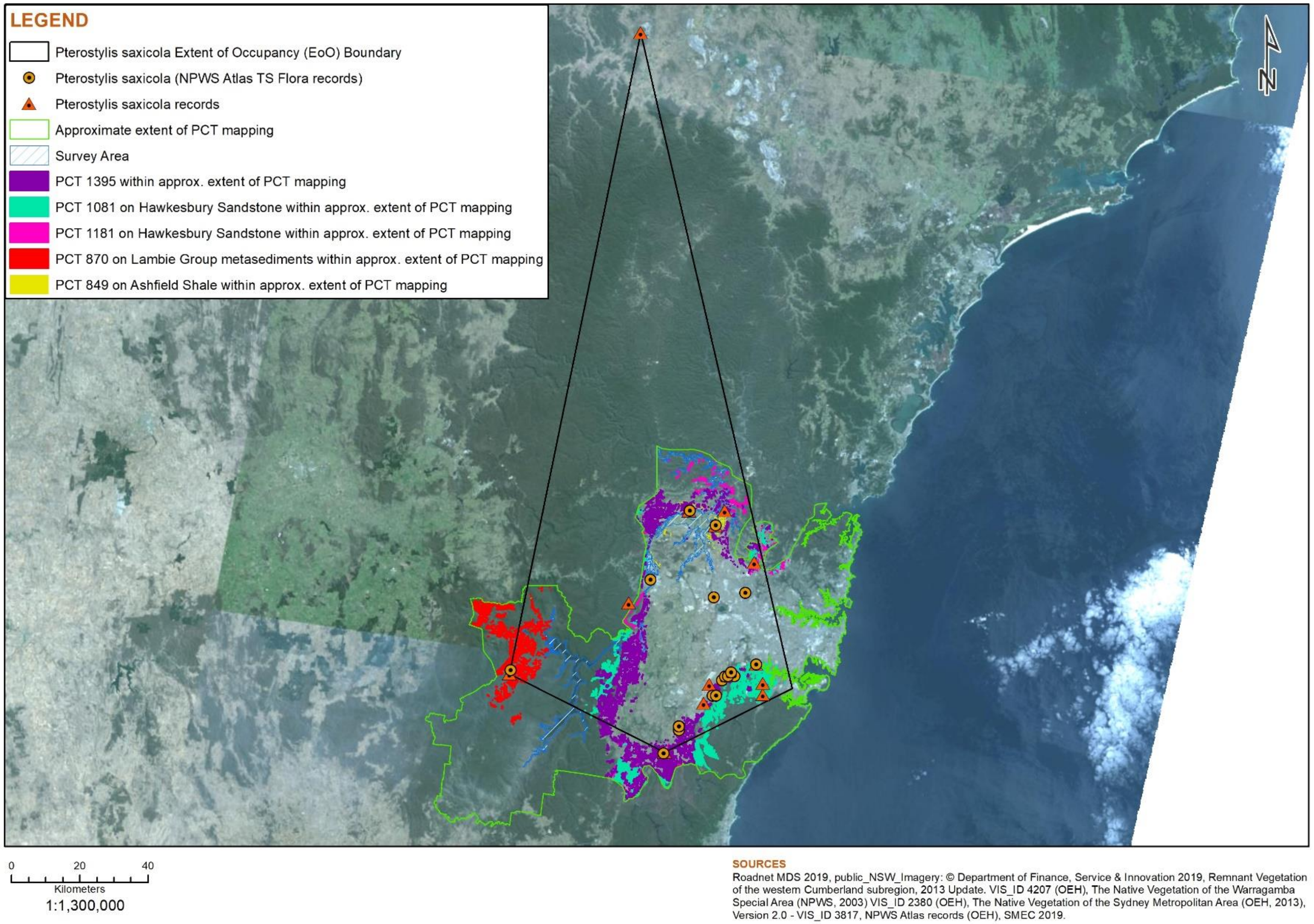


Figure 4. Map showing known records, extent of occupancy (EOO), outlined in black, and recorded habitats of *Pterostylis saxicola*. Map provided by James Taylor, SMEC.

Figure 5. PCT 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, on Ashfield Shale at Scheyville National Park (my site PS1, appendix 1).

Figure 6. PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, on Mittagong Formation at The Ironbarks (my site PS8, appendix 1).

Figure 7. PCT 1081 Red Bloodwood - grey gum woodland on the edges of the Cumberland Plain (my site PS3, appendix 1)

Figure 8. PCT 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, east of Appin.

Figure 9. PCT 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges, Gingra Range, Kanangra-Boyd National Park (my site PS 9, appendix 1).

and Woronora Rivers. I have visited four precisely georeferenced sites at which *Pterostylis saxicola* has been observed or collected in this area and identified the plant community types found there (see appendix 1). Observers' notes repeatedly describe the soils as very shallow sands overlying sandstone rock shelves, as stated in the published habitat model (NSW Office of Environment and Heritage 2018) and the four sites that I visited and characterised were consistent with this description. However, although all were elevated, well-drained sites, only some of them were recorded above cliff lines, contrary to the published model. All of these sites occur close to outcrops of Ashfield Shale, mostly downhill from them, but for some of these sites, the only evidence of shale influence on the environment seems to be associated plant community types. I identified the following plant community types at these sites:

- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain (see figure 7);
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (see figure 8);
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain.

In addition to the two main sub-populations, there are also two outlying, precisely georeferenced, herbarium records. One of this is from the Gingra Range in Kanangra Boyd National Park. This site is on metasediments of the Devonian Lambie Formation and was mapped by Tozer *et al.* (2010) to their map unit DSF p37 Kowmung-Wollondilly Grassy Gorge Woodland. According to the references cited in the BioNet Vegetation Classification, this is equivalent to the following PCT:

- 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges (see figure 9).

However, this site is so close to a mapped boundary between PCT 870 and PCT 1107 (River Peppermint - Narrow-leaved Peppermint open forest on sheltered escarpment slopes, Sydney Basin Bioregion and South East Corner Bioregion) that a field survey of the site was required in order to confidently identify the PCT or transition zone there. I visited this site on 2 April 2019 (see below) and confirmed that it is unequivocally located in PCT 870. The precise locality of the record occurs within an area mapped by Warragamba VIS map 2380 as the map unit Kanangra Gorge Sheltered Grey Gum Forest, which is a map unit that has been assessed as equivalent to PCT 870 by SMEC in the Upstream Assessment BAR for the upstream survey area.

The outlying population in the upper Hunter River Valley is represented by a specimen collected on the top of Anvil Hill, an isolated mesa composed of Narrabeen Group sandstone and conglomerate. This site is inaccessible, being surrounded by the Mangoola open-cut coal mine. However, the collectors' notes described the habitat as "Open woodland of *Eucalyptus crebra* with shrub layer dominated by *Notelaea microcarpa* and *Spartothamnella juncea*. Skeletal soils derived from Triassic sandstone and conglomerate". This is the only record of *Pterostylis saxicola* from a Narrabeen Group substrate. The plant community on Anvil Hill is not identifiable from the habitat description above but it is worth noting that *Eucalyptus crebra* is a co-dominant tree at three of the nine *P. saxicola* sites that I have characterised.

As well as identifying suitable habitats for *Pterostylis saxicola* it is also possible to identify habitats that are unequivocally unsuitable for this orchid. While many of these need not be listed because they are trivially obvious, such as perennially aquatic environments, some habitats are more subtly unsuitable. The most important of these in the context of this report are flood-prone habitats and areas on substrates of quarternary alluvium. *Pterostylis saxicola* has not been recorded in such environments nor have any of its close relatives. Moreover, these orchids are quite exacting in their horticultural requirements, especially with respect to watering. They require sufficient water to sustain growth when the shoots are actively growing or to prevent desiccation of the tubers during dormancy but not so much that the soil becomes soggy. Over-watering, especially when the plants are dormant, causes them to rot. Well-drained soils, combining course sand, loam and some organic matter, are recommended (Jones 2006). In cultivation, these plants will not tolerate more than very brief inundation, and it is most unlikely that wild populations would survive flooding of their habitat.

Pterostylis saxicola has mostly been recorded growing in intact native vegetation but there is one notable exception: a plant described in a "Car Park growing through bitumen", adjacent to a large area of bushland from which other substantiated records had been made. Several others have come from small patches of remnant urban bushland, in some cases less than a hectare in area, surrounded by highly disturbed land. However, no records mention heavily weed-infested habitats or evidence of heavy grazing by introduced herbivores. Sites with significant edge effects are probably not sustainable reserves for conserving this species.

3. Description of the survey area

3.1 Land use history

The first human inhabitants of the survey area were Aborigines who moved there many thousands of years ago. People of the Kurrajong, Cattai, Boorooberongal, Gomerrigal and Mulgoa bands of the Dharug language group were occupants of the survey area when the British first started to settle in the Sydney Region in 1788 (Kohen 1986). Their diet consisted primarily of "yams" (tubers of a diverse assemblage of flowering plant species) and game (possums, bandicoots, kangaroos, birds), but also included processed seeds of *Macrozamia* species, fern rhizomes, fruit, fish (mullet, eels, bass) and shellfish (mussels, crustaceans) caught in the Hawkesbury-Nepean and its major tributaries (Turbet 1989). If the Dharug practised agriculture (Pascoe 2014), their gardens would probably have been restricted to the extensive terraces of Quaternary alluvium that cover most of what is now the survey area (Kohen 1986). They used traps to catch fish from streams and fire-stick farming methods to manage game in the grassy woodlands and forests that dominated the Cumberland Plain (Turbet 1989). Although the Dharug would have used the natural landscape seasonally, taking advantage of different food sources depending on availability, archeological research has shown that they established numerous permanent camps on the margins of the survey area, on raised sites, mostly within 100 metres of permanent water courses, as well as many semi-permanent camps further from water (Kohen 1986).

When Governor Arthur Phillip led the first British expedition up the Hawkesbury River as far as its junction with the Grose River in 1789, the presence of flood debris 8-10 metres above the river level convinced him that the risk of flooding was too great to warrant the immediate establishment of a settlement in the area, despite the evident fertility of the alluvial soils. European occupation of the survey area did not commence until 1794, when Lieutenant-Governor Francis Grose approved 22 land grants, each of 12 hectares, along the eastern bank of the Hawkesbury, between the mouth of South Creek and Canning Reach at what is now Pitt Town. The settlers cleared their land, built huts and planted maize and wheat, later supplemented with barley and oats. By 1799, 1398 hectares were under cultivation in the Hawkesbury area, producing 15,000-20,000 bushels of wheat per annum, prompting Captain David Collins to call it “the granary of New South Wales” (Barkley & Nichols 1994). Disastrous floods in 1799, 1806, 1808, 1816 and 1817 destroyed crops, granaries and habitation but farming on the rich Quaternary alluvial soils repeatedly recovered from these setbacks. By 1821, 6040 hectares were under cultivation in the Hawkesbury area, 5454 hectares of which were planted with wheat and maize, while 11,720 head of cattle were grazing there, along with 16,855 pigs. By the 1830’s the flood plain of the Hawkesbury River had been colonised by Europeans and largely cleared for agriculture, primarily for the cultivation of wheat, although a wide variety of vegetable and fruit crops were also successful. The main limiting factor constraining diversification of commercial horticulture in the area was the time needed to transport fresh produce to markets in Sydney by ship (Boon 2017).

Several natural and anthropogenic processes interacted to dramatically change land use patterns on the Hawkesbury floodplain from the mid 19th century onwards. Competition from cereal-producing areas west of the Blue Mountains and the arrival of rust disease, which decimated the wheat crop of 1861, prompted the rapid replacement of wheat by maize as the dominant cereal crop (Barkley & Nichols 1994). Land clearing greatly increased the rate of erosion, causing the Hawkesbury River and its tributaries to gradually silt up, a process that was exacerbated by a series of catastrophic floods between 1857 and 1879. The head of navigation, which in 1789 had been near what is now Hawkesbury Heights, had shifted downstream to Sackville by 1880, rendering the docks at Richmond and Windsor obsolete. The opening of railway lines between Penrith and Sydney in 1863 and between Richmond, Windsor and the Penrith line in 1864, and their repair from flood damage in 1876, provided a faster and eventually more reliable option for transporting perishable horticultural produce to market. Fruit and vegetable horticulture and dairy farming consequently grew in commercial importance in the late 18th and early 19th centuries (Boon 2017). For example, by 1890, the Hawkesbury district was producing over 190,000 oranges per annum (Barkley & Nichols 1994) and by 1944 about 20% of all citrus trees in N.S.W. were located in the Hawkesbury area. However, the 1956 flood destroyed the citrus orchards on the flood plain and few of them were replanted (Boon 2017).

Another primary industry that exploited the alluvial deposits of the Hawkesbury River was sand, gravel and stone quarrying. In the 1880s, the Emu Gravel and Road Metal Company began selling sand and gravel extracted from its quarry at Emu Plains, to meet demand from construction firms responding to Sydney’s rapid expansion (Godden Mackay Logan Heritage Consultants 2010). Other quarries soon opened on other parts of the Hawkesbury flood plain between Agnes Banks and Castlereagh. From the 1950s, mining companies began buying farms in the Castlereagh-Cranebrook area on Cranebrook Formation alluvia to convert them to quarries but this resource was exhausted by 1990. The old sand and gravel pits then began being converted into lakes by the Penrith Lakes Development Corporation, for recreational use.

From the mid 20th century most agricultural industries in the Hawkesbury district declined in economic importance, with the exception of mushroom and turf farming. The Hawkesbury district now supplies about 25% of Australia's mushrooms, but these are produced intensively in large, temperature-controlled sheds with a small footprint (Boon 2017). Over the past 50 years, Sydney's suburban sprawl has created a huge demand for turf supplies. Lawn grasses are easily propagated, grow quickly, are more resilient to flooding than fruit trees and are now an economically competitive crop, so large parts of the Hawkesbury floodplain under cultivation have been converted into turf farms (Barkley & Nichols 1994). However, most cleared land in the survey area is now covered in pasture, most of which is grazed by cattle and horses.

Agrarian expansion soon attracted urban development on land that was less vulnerable to flooding than the survey area. In 1810, eleven months after his inauguration as Governor of N.S.W., Lachlan Macquarie gazetted the towns of Castlereagh, Richmond, Windsor, Pitt Town and Wilberforce on high ground adjacent to the survey area. Other towns established in the early 19th century, such as Penrith (1817) and Wallacia (1885), were similarly placed and planners have continued to restrict urban, suburban and industrial development to land above about 20 metres AHD, mostly outside the survey area.

3.2 Landscape context

The Sydney Basin is a geological entity that is shaped rather like a tilted, triangular, art deco saucer, with the city of Newcastle, and the towns of Gulgong and Batemans Bay at its corners. Its rocks are mostly sedimentary strata of Permian to Triassic age, up to five km thick, with a thin patina of Cenozoic alluvia covering large parts of the most low-lying, central part of the basin, the Cumberland Plain. The Permian to Triassic rocks are mostly shales and sandstones, although Permian coal measures are a relatively thin but notable component. Numerous small, volcanic intrusions and caps of Jurassic to Neogene age are also scattered across the basin (Martyn 2018).

The survey area is mostly located on the western edge of the Cumberland Plain, where relief is low and gentle, but extends north into the Hornsby Plateau, where the middle Hawkesbury River has cut a meandering but often steep-sided valley through uplifted strata of Hawkesbury Sandstone. It includes the river flats of the upper to middle Hawkesbury River and its major tributaries, as well as the banks of the lower 2 km of the Warragamba River, and the river flats and gorge of the lower-most 15 km of the Nepean River.

The most commonly exposed substrates in the survey area are Quaternary alluvia, the limits of which are closely associated with the boundaries of the survey area. These are unconsolidated clays, silts, sands and gravels and various mixtures of these sediments that have been deposited by floods of the Hawkesbury-Nepean River system over the past 2.58 million years (Martyn 2018). The source rocks from which these alluvia were eroded include the sedimentary and volcanic rocks of the Sydney Basin as well as metamorphic, plutonic and volcanic igneous rocks of the Lachlan Fold Belt, west and south west of the Sydney Basin, which are exposed in the headwaters of the Warragamba and Colo Rivers (Geological Survey of New South Wales 1966a,b, 1991). Although they vary in fertility and water-holding capacity, Quaternary alluvia were almost entirely cleared of native vegetation before 1830 (Boon 2017). The fertile, loamy soils of the Lowlands Formation are the most abundant Quaternary alluvia in the survey area, covering the wide floodplain of the upper

Hawkesbury River between Castlereagh and Cattai. These formed the soils that were the basis of the "Granary of New South Wales" in the early years of the colony and now support turf farms and pastures for grazing. The Cranebrook Formation, which covers the wide floodplain of the upper Hawkesbury River between Castlereagh and Lapstone largely consists of sand and gravel that was extensively mined between 1880 and 1990.

The most commonly exposed hard rock in the survey area is Hawkesbury Sandstone, a sedimentary rock that weathers to produce acidic, well-drained, siliceous, sandy soils of very low fertility. Although it outcrops for substantial distances along the banks of the Hawkesbury River and its tributaries, it covers a relatively minor proportion of the survey area because water courses have usually cut steep-sided valleys and gorges through it. The way that the survey area has been defined ensures that Hawkesbury Sandstone mostly occurs in narrow bands along the banks of streams or on the sides of flat-floored valleys. It outcrops most extensively on the banks and valley sides of tributaries of the middle Hawkesbury River, especially of Cattai, Little Cattai, and Roberts Creeks. It is also exposed narrowly on the upper-most 12 km of the Hawkesbury River and on the banks of the lower Warragamba River, the lower-most 2.5 km of the Nepean River, and the lower Grose River.

Shales of the Wianamatta Group are exposed patchily in the survey area. Bringelly Shale outcrops on both sides of the Eastern Creek flood plain, on the right bank of the Nepean River near Wallacia, and very narrowly on the left bank of the Hawkesbury River at The Terrace (Geological Survey of New South Wales 1991). Ashfield Shale, which has a significantly higher phosphate content than Bringelly Shale (Martyn 2018) outcrops in the survey area in small patches at Nortons Basin on the Nepean River, on the right bank of the Hawkesbury River at Castlereagh, on Longneck Creek, on the western rim of the Pitt Town fluvial terrace and on both sides of the flood plain of Killarney Chain of Ponds (Geological Survey of New South Wales 1991).

The Mittagong Formation is a thin layer of alternating very thin strata of sandstone and shale, positioned above Hawkesbury Sandstone and below Ashfield Shale (Martyn 2018). It is often mapped only as the boundary line separating those two, more extensive substrates and is most accurately conceived as the central part of the shale-sandstone transition.

Tributaries of the Hawkesbury River occasionally cut through Neogene alluvia in the survey area, such as through Londonderry Clay on the western side of Longneck Lagoon, on lower South Creek between Windsor and Mulgrave and on the right bank of the Hawkesbury River near Castlereagh.

The only volcanic outcrop in the survey area is a basaltic diatreme at Nortons Basin at the junction of the Nepean and Warragamba Rivers.

Weather station	Mean annual rainfall (mm)	Mean maximum temperature (°C)	Mean minimum temperature (°C)
Richmond UWS Hawkesbury (1881-)	799.4	29.4	3.2
Richmond RAAF (1993-)	728.4	30.4	3.5
Richmond RAAF (1928-1994)	815.7	29.6	3.6
Penrith Lakes AWS (1995-)	717.0	31.2	5.3
Orchard Hills (1883-)	821.7	28.5	5.3
Badgerys Creek AWS (1995-)	671.6	30.3	4.1
Badgerys Creek McMasters Field Station (1936-1996)	789.2	28.6	3.8

Table 1. Key climatic statistics for weather stations near the survey area.

The climate of the study area is warm-temperate and the whole survey area is subject to winter frosts. No weather stations are placed within the study area, so knowledge of geographic variation in climate needs to be inferred from data gathered by stations surrounding the area (table 1). Variation between averages from geographically very close weather stations (the three stations in the Richmond area and the two at Badgerys Creek) suggests that the mean values may lack precision. Nevertheless, these statistics indicate that climate does not vary greatly across the survey area.

3.3 Native vegetation communities

In terms of the plant community types recognised in the BioNet Vegetation Classification and their equivalent map units in the draft vegetation maps provided by SMEC (2019, table 4-1) for the survey area (received from Lachlan Laurie, 30 July 2019), the remnant native vegetation of the survey area consists of the plant community types listed in table 2 and mapped in figure 10.

PCT identification number	Descriptive name of PCT	Area (hectares)
724	Broad-leaved Ironbark – Grey Box – *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	56.70
725	Broad-leaved Ironbark – *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	0.10
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	1302.42
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	1933.79
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	309.35
866	Grey Gum – Smooth-barked Apple open forest of the dry hinterland of the Central Coast, Sydney Basin Bioregion	2.35
877	Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	7.28
924	*Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion	48.92
1067	Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	3.45
1106	River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion	147.02
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion	332.35
1183	Smooth-barked Apple – Sydney Peppermint – Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion	9.65
1284	Turpentine – Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion	103.53
1292	Water Gum – Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	4.88
1327	Yellow Bloodwood – Ironbark shrubby woodland of the dry hinterland of the Central Coast, Sydney Basin Bioregion	0.30
1328	Yellow Bloodwood – Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast, Sydney Basin Bioregion	5.37
1385	Rough-barked Apple – Grey Gum grassy open forest of the hinterland	32.03

	hills of the Central Coast, Sydney Basin Bioregion	
1395	Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	330.30
1504	Sydney Blue Gum – Deane's Gum – River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion	197.95
1557	Rough-barked Apple – Forest Oak – Grey Gum grassy woodland on sandstone ranges of the Sydney Basin Bioregion	0.31
1718	Swamp Mahogany – Flax-leaved paperbark swamp forest on coastal lowlands of the Central Coast	3.05

Table 2. Plant community types mapped in the survey area by SMEC (2019, table 4-1).

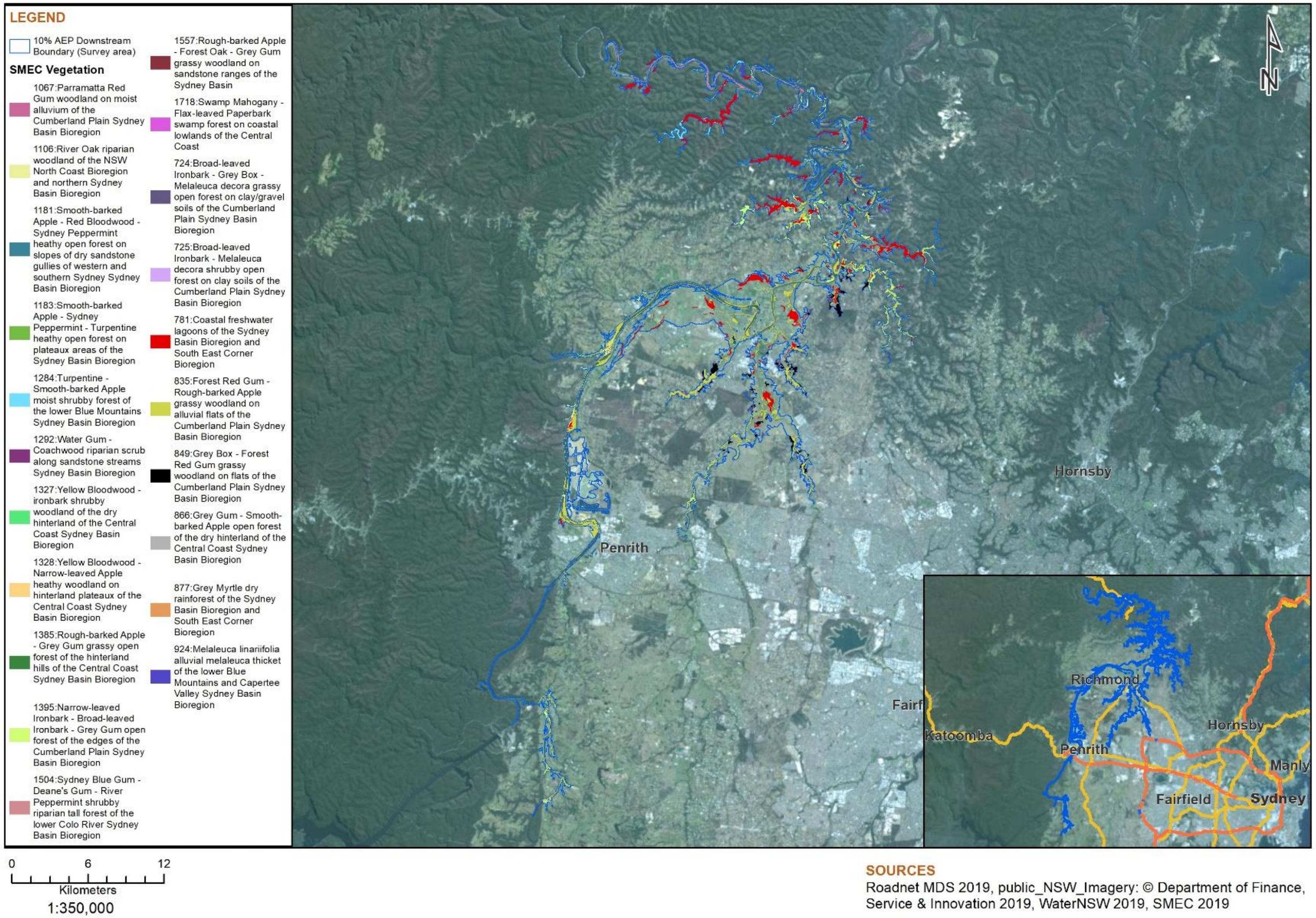
Of the 21 native plant community types that occur in the survey area, Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain (PCT 835) is the most abundant, accounting for 40% of the area's uncleared and secondary native vegetation. It is widespread, mostly as small remnant fragments, on Quaternary alluvia, the most abundant substrate in the survey area, but is also found on a variety of other substrates that are rarer there, including Londonderry Clay, Bringelly Shale and Ashfield Shale.

Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion (PCT 781) is the second most abundant plant community type in the survey area, accounting for 27% of the area covered by native vegetation. Freshwater wetlands are widely scattered along the floodplains of the Hawkesbury River and its major middle tributaries, on Quaternary alluvia, in depressions where water tables remain permanently close to the surface (Tozer *et al.* 2010).

All of the other native plant community types in the survey area occupy much smaller areas there. Of particular relevance to this report are the plant community types in which *Pterostylis saxicola* has been recorded – PCTs 849, 1181 and 1395 (see section 2.4). Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney Basin Bioregion (PCT 1181) accounts for almost seven percent of the remnant native vegetation of the survey area. It is represented there by scattered, narrow strips, all on Hawkesbury Sandstone, forming river banks or positioned between flood plains and the boundary of the survey area. Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion (PCT 1395) accounts for almost seven percent of the native vegetation cover of the survey area, on transitional soils derived from Ashfield Shale or Mittagong Formation sediments, or on Hawkesbury Sandstone with some shale colluvium. Grey Box – Forest Red Gumgrassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) occupies over six percent of the native vegetation of the survey area and is largely restricted to shales of the Wianamatta Group.

4. Assessment of species presence and habitat

The approach that I took in assessing the presence or absence of *Pterostylis saxicola* in the survey area started with the construction of a general habitat model for *P. saxicola*, from existing records and my own surveys outside the survey area but within the known geographical range of the orchid. I then used this model, in conjunction with environmental maps, to identify suitable habitat within the survey area. I then estimated the density of populations within each suitable habitat type and used these estimates, and the mapped area of each habitat type in the survey area, to calculate the expected number of populations of *Pterostylis saxicola* in the survey area as a whole and in each suitable habitat type within it.



SOURCES
Roadnet MDS 2019, public_NSW_Imagery: © Department of Finance, Service & Innovation 2019, WaterNSW 2019, SMEC 2019

Figure 10 Distribution of plant community types in the survey area. Map provided by James Taylor, SMEC.

4.1 Methodological limitations

Assessing the suitable habitat of *Pterostylis saxicola*, given the present state of knowledge of the biology of this species, has to be a largely descriptive exercise. The causal processes that constrain its distribution and abundance are largely unknown but probably include physiological limits to tolerance of temperature and humidity, the availability of mineral nutrients and water, factors limiting the distribution and abundance of its obligate symbionts – its pollinators and mycorrhizal associates, and the distribution and abundance of native herbivores, pathogens and parasites. Suitable habitat has to be estimated on the basis of associations between its distribution and environmental proxies such as substrate types and plant community types, and interactions between them. Multidimensional bioclimatic modelling would extend this approach to climatic variables but such analysis is beyond the scope of this report.

It could also be argued that predicting the presence of populations of *Pterostylis saxicola* in the survey area is based on questionable assumptions. The assumptions on which my predictions were based are as follows:

- Combinations of plant community type and substrate are reasonable indicators of environmental space. That is, they can be used to predict the distribution and abundance of species, such as *Pterostylis saxicola*, that did not figure prominently in the process by which the indicators were defined.
- Although *P. saxicola* is patchily distributed, the probability of its presence is equally spread across the geographic distribution of each combination of plant community type and substrate.
- The environmental preferences of *Pterostylis saxicola* do not vary across its distributional range.

These simplifying assumptions are testable in principle, although only the first one can be said to have been empirically tested to any extent. The fact that about 1500 plant community types have been recognised in New South Wales, but that *Pterostylis saxicola* has been recorded from only five of them suggests that plant community types do have useful predictive value.

In addition to the assumptions listed above, the method I have used to estimate the expected number of populations in each PCT-substrate combination (outlined in section 4.7.4) relies on the following implicit assumptions:

- The distributional range of *Pterostylis saxicola* is accurately circumscribed by existing records. This is likely to be an underestimate of the true distributional range.
-
- The PCT-substrate combinations in which *P. saxicola* has been recorded are assumed to be restricted to areas for which PCT maps are available as digital layers. This assumption had to be made because vegetation maps are available for only part of the total extent of occupancy of *P. saxicola*. This assumption is probably untrue and is likely to result in over-estimate the number of plants in the survey area.
- All populations of *P. saxicola* have already been discovered and are listed in the BioNet Atlas. This assumption is clearly unrealistic, as new populations of *P. saxicola* continue to be discovered, including two in October 2018, only one of which has already been recorded in the BioNet Atlas. However, discovery of new populations is so sporadic that it would be impossible to model the asymptote of a curve representing cumulative growth of observational records. The number of populations of *P. saxicola* used in my calculations should be regarded as a minimal estimate. My estimates of the number of individual plants

in each PCT-substrate combination and in the survey area as a whole, are therefore likely to be underestimates.

4.2 Existing records and surveys

As a designated sensitive species, unredacted records of *Pterostylis saxicola* collections and observations held in the BioNet Atlas are not publicly available, so I formally applied for these records, which I received by email on 22 February 2019. This table contains 62 records, most of which are unvouchered observations. To this collection can be added 10 herbarium specimen records held by the National Herbarium of New South Wales, to which I have access as an Honorary Research Associate.

Although several targeted surveys of this species seem to have been conducted since 2000, none has been done in the survey area. Teresa James surveyed for this species across the species' distribution in spring 2007, for the NSW Department of Environment Climate Change and Water, submitting an unpublished report, observational records at five sites and a herbarium specimen (Teresa James personal communication). From November 2010 to January 2011, Total Earth Care Pty Ltd conducted a survey of threatened plant species in the Simmos Beach Recreation Reserve, Macquarie Fields for Campbelltown City Council, submitting an unpublished report and observational records at eight sites (Lachlan Laurie personal communication). In spring 2011, *P. saxicola* was again targeted at Simmos Beach Recreation Reserve by a research group from The Royal Botanic Gardens and Domain Trust that investigated the mycorrhizal associates of the orchid, with the aim of identifying and culturing the relevant fungus or fungi, adding seeds of this species to the seed collection at the Australian Plantbank, and germinating seeds of the orchid in septic culture. Two scientific papers were published, and three herbarium specimens collected as part of this project.

Highly precise grid references associated with a number of the BioNet records enabled me to identify the plant community types (as mapped by Tozer *et al.* (2010) and substrates (as mapped by Geological Survey of New South Wales 1966a,b, 1969, 1985, 1991) at sites at which these records of *Pterostylis saxicola* occurred. They were:

- 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain, on Ashfield Shale;
- 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges, on Lambie Group metasediments;
- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, on Hawkesbury Sandstone;
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, on Hawkesbury Sandstone;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain, on Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone transitional substrates;
- An unidentified plant community type dominated by *Eucalyptus creba*, on Narrabeen Group sandstone and conglomerate.

4.3 Surveys completed for the Environmental Assessment

No targeted surveys for *Pterostylis saxicola* were conducted within the survey area for the Environmental Assessment for the reasons detailed in section 1.4 and because of the inaccessibility of the survey area.

4.4 Surveys completed for this expert report

4.4.1 Survey Methods

In the course of preparing this expert report and my earlier expert reports on *Pterostylis saxicola* in the Greater Macarthur and Wilton Growth Areas and for the upstream impacts and construction site of the Warragamba Dam wall raising project (Weston unpublished a, b, c, d), I characterised nine plots of native vegetation in detail, each plot being a circle of radius 30 m (an area of 2827 m^2), centred either on a plant of *P. saxicola* or on the grid point where an observation of it had been made (at times when *P. saxicola* could not be observed because it was dormant). All of those plots were sampled from outside the survey area in order to develop an improved habitat model for the species. At each plot I listed all vascular plant species that could feasibly be identified, taking photographs and sometimes specimens of plants for later reference in cases where the plant's identity was in question. The latitude and longitude of the centre of each plot was determined using a GPS instrument. The elevation of each site was determined later from 1:25,000 topographic maps. The soil and topography at each site was described and the substrate identified using the Wollongong – Port Hacking and Penrith 1:100,000 geological maps (NSW Department of Mineral Resources 1985, NSW Department of Minerals and Energy 1991) and the Sydney 1:250,000 geological map (Geological Survey of New South Wales 1966a). I identified the plant community type in each plot using the PCT identification tool in BioNet, and my list of plant species found in each plot.

4.4.2 Results of my surveys

Site and ecological data for my nine plots outside the survey area are shown in Appendix 1. According to my identifications of plant community types, *Pterostylis saxicola* was present in the following PCTs, on the following substrates in my plots:

- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain , on Ashfield Shale (2 plots);
- 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges on Lambie Group metasediments (1 plot);
- 1081 Red Bloodwood - grey gum woodland on the edges of the Cumberland Plain on Hawkesbury Sandstone (3 plots);
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney on Hawkesbury Sandstone (1 plot);
- 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain on Ashfield Shale- Mittagong Formation-Hawkesbury Sandstone transitional substrates (2 plots).

The results of my surveys corroborate results drawn from existing records regarding the habitats in which *Pterostylis saxicola* is known to occur. Although I did not sample any sites at which *P. saxicola* had been found on Narrabeen Group sandstone in my surveys, records of the species from a site with a precise grid reference has been mapped to this substrate (section 4.2).

4.5 An improved habitat model for *Pterostylis saxicola*

I have argued that the habitat model that was published as part of OEH's threatened species profile of *Pterostylis saxicola* (NSW Office of Environment and Heritage 2018a) needs updating (section 2.4 of this report, Weston unpublished a,b). It needs to be broadened to include habitats in which *P.*

saxicola has been recorded and habitats in which it has been inferred to occur, but which were not taken into account when the profile was written.

My improved habitat model is as follows:

Pterostylis saxicola occurs along an ecological gradient from:

- Clay soils derived from Ashfield Shale (Wianamatta Group) on gently hilly landscapes in PCT 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain;
- to: clay to sandy soils derived from Ashfield Shale – Mittagong Formation – Hawkesbury Sandstone substrates on gently hilly to steep landscapes, in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain;
- to: thin accumulations of humus-rich sandy soil on sheets and rock shelves of Hawkesbury Sandstone, on the rims and sides of river valleys, growing in PCT 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, or PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney.

This ecological gradient is inferred to extend to:

- thin accumulations of humus-rich sandy soil on sheets and rock shelves of Narrabeen Group sandstone, growing in PCTs 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain or 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (Weston 2019c).

Pterostylis saxicola also occurs on:

- Lambie group metasediments, in PCT 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges.

4.6 Assessment of species presence

4.6.1 Likelihood of species presence in the survey area

Given the small extent of suitable habitat that has been mapped there, the rarity of *Pterostylis saxicola* within its known distributional range and the low estimate of expected number of populations in the survey area (see section 4.8.5), my subjective assessment of the probability of *P. saxicola* occurring in the survey area is about 30%.

4.6.2 Justification for determining presence

Pterostylis saxicola has been recorded from three combinations of substrate and plant community type that have been mapped in the survey area. This habitat covers 750 hectares and it is estimated to be home to 0.3082 populations (see section 4.7.5). This does not mean that we literally expect a fraction of a population to live in the survey area. The estimate is probabilistic and should be interpreted as a calculation of the likelihood that any plants live there.

P. saxicola has been neither collected nor observed in the survey area but absence of evidence should not be treated as evidence of absence. Although the probability of *P. saxicola* occurring in the survey area is low, it is not zero. Moreover, my estimates of the number of populations in the survey area is more likely to be an underestimate than an over-estimate (see section 4.1).

4.7 Assessment of suitable habitat and abundance of populations of *Pterostylis saxicola* within the survey area

4.7.1 Suitable habitat for *Pterostylis saxicola* within the survey area

The following habitats that have been mapped in the survey area are potentially suitable habitat for *P. saxicola*:

- Clay soils derived from Ashfield Shale (Wianamatta Group) on gently hilly landscapes in PCT 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain;
- thin accumulations of humus-rich sandy soil on sheets and rock shelves of Hawkesbury Sandstone, on the rims and sides of river valleys, growing in PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney;
- clay to sandy soils derived from Ashfield Shale-Mittagong Formation- Hawkesbury Sandstone transitional substrates on gently hilly to steep landscapes, in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain;

4.7.2 Species polygons for *Pterostylis saxicola*

My species polygons for *Pterostylis saxicola* (figures 11 and 12) include all patches of the habitat listed in section 4.7.1 in the survey area. It was prepared with the assistance of James Taylor (SMEC), using the ESRI ArcGIS software package, from vegetation maps of the survey area produced by SMEC on 7 November 2019. A shape file for these polygons is held by SMEC. My arguments justifying these polygons have been set out in sections 2.3, 2.4, 4.1, 4.2, and 4.4 to 4.6.

4.7.3 Estimate of area of habitat of *Pterostylis saxicola* in the survey area

The areas estimated to represent suitable habitat for *Pterostylis saxicola* in figures 10 and 11 are as follows:

- PCT 849 on Ashfield Shale: 108 ha
- PCT 1181 on Hawkesbury Sandstone: 332 ha
- PCT 1385 on Ashfield Shale – Mittagong Formation – Hawkesbury Sandstone: 310 ha
- Total area of suitable habitat in the survey area: 750 ha.

These estimates were calculated with the assistance of James Taylor (SMEC), using the ESRI ArcGIS software package on 7 November 2019, from vegetation maps of the survey area produced by SMEC and from NSW Department of Planning and Environment (2018). My arguments justifying the polygons from which these estimates were calculated have been set out in sections 2.3, 2.4, 4.1, 4.2, and 4.4 to 4.6.

4.7.4 Method for estimating the expected number of populations of *Pterostylis saxicola* in the survey area

The following method was used to estimate the expected number of populations of *Pterostylis saxicola* in the survey area, given a set of simplifying assumptions, which are listed in section 4.1:

1. The known distributional range of *Pterostylis saxicola* was estimated by drawing the minimal convex polygon enclosing all records of the species.
2. Let **b, c, e** be the different combinations of plant community type and substrate in which *P. saxicola* has been recorded in the survey area.
3. Let $\mathbf{a_b}$ **ha** be the total area covered by PCT-substrate combination **b** within the known distributional range of *P. saxicola* for which PCT mapping was available. This was calculated for each PCT-substrate combination (**b, c, e**) from the draft vegetation maps provided by SMEC (received from James Taylor, 15 May 2019) and NSW Office of Environment and Heritage (2013), using the ESRI ArcGIS software package.
4. Let $\mathbf{n_b}$ be the number of populations of *P. saxicola* that have been recorded within PCT-substrate combination **b**.
5. Then $\mathbf{n_b/a_b = d_b}$ populations per hectare, is the density of populations of *P. saxicola* in PCT-substrate combination **b** within the known distributional range of *P. saxicola*.
6. The density $\mathbf{d_c, d_e,}$ of *P. saxicola* populations in PCT-substrate combinations **c, e** was calculated in the same way as for PCT-substrate combination **b**.
7. Let $\mathbf{A_b}$ **ha** be the total area covered by PCT-substrate combination **b** within the survey area. This was calculated for each PCT-substrate combination (**b, c, e**) from vegetation maps produced for the Environmental Assessment and from Tozer *et al.* (2010) using the ESRI ArcGIS software package.
8. Then $\mathbf{n_b/a_b = N_b/A_b}$, where $\mathbf{N_b}$ is the expected number of populations of *P. saxicola* in PCT-substrate combination **b** within the survey area.
9. Re-arranging, $\mathbf{N_b = A_b \times n_b/a_b}$.
10. Substituting $\mathbf{d_b}$ for $\mathbf{n_b/a_b}$, $\mathbf{N_b = A_b \times d_b}$.

The expected number of populations, $\mathbf{N_c, N_e,}$ of *P. saxicola* in PCT-substrate combinations **c, e** within the survey area was calculated in the same way as for PCT-substrate combination **b**.

4.7.5 Estimate of the number of populations of *Pterostylis saxicola* in the survey area

The PCT-substrate combination of PCT 849 on Ashfield Shale covers 3269 ha within the known distributional range of *P. saxicola* (its EOO polygon). The number of populations of *P. saxicola* that have been recorded from PCT 849 on Ashfield Shale is 4. Therefore, the density of populations of *P. saxicola* that have been recorded from PCT 849 on Ashfield Shale within its known distributional range is 0.001224 populations per hectare. The total area of PCT 849 on Ashfield Shale in the survey area is 108 ha. Therefore, the expected number of populations of *P. saxicola* in the survey area in this combination of PCT and substrate is estimated to be 0.1322.

The PCT-substrate combination of PCT 1181 on Hawkesbury Sandstone covers 5761 ha within the known distributional range of *P. saxicola* (its EOO polygon). The number of populations of *P. saxicola* that have been recorded from PCT 1181 on Hawkesbury Sandstone is 2. Therefore, the density of populations of *P. saxicola* that have been recorded from PCT 1181 on Hawkesbury Sandstone within its known distributional range is 0.0003472 populations per hectare. The total area of PCT 1181 on Hawkesbury Sandstone in the survey area is 332 ha. Therefore, the expected number of populations of *P. saxicola* in the survey area in this combination of PCT and substrate is estimated to be 0.1153.

The PCT-substrate combination of PCT 1395 on Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone covers 15278 ha within the known distributional range of *P. saxicola* (its EOO polygon). The number of populations of *P. saxicola* that have been recorded from PCT 1395 on Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone is 3. Therefore, the density of populations of *P. saxicola* that have been recorded from PCT 1181 on Hawkesbury Sandstone within its known distributional range is 0.0001964 populations per hectare. The total area of PCT 1395 on Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone in the survey area is 310 ha.

Therefore, the expected number of populations of *P. saxicola* in the survey area in this combination of PCT and substrate is estimated to be 0.06087.

The total expected number of populations of *P. saxicola* in the survey area in all PCT-substrate combinations is 0.3082. This should be interpreted as a probability of *P. saxicola* occurring in the survey area of about 30%.

4.8 Assessment of the impact of the project on populations of *Pterostylis saxicola* within the survey area

I argued in section 4.6, that the probability that a population of *Pterostylis saxicola* exists in the survey area is low but not zero. However, even if a population or populations of *P. saxicola* is living in the survey area, it is most unlikely that the Warragamba Dam wall raising project would harm it. In section 2.4 I noted that *P. saxicola* is not known from habitats that are periodically inundated. I also argued in section 2.4 that our knowledge of the horticultural requirements of *P. saxicola* strongly suggests that plants of this species would be killed by inundation. Clearly, *P. saxicola* does not rely on periodic flooding of the Hawkesbury-Nepean River system for its survival. Given that the primary purpose of the project is to moderate the depth of floodwaters downstream from the dam, it is most unlikely to have any deleterious effect on populations of *Pterostylis saxicola* that live there.

5. Information used in this assessment

My assessment was based on information obtained from a diversity of sources:

- Databases of observational and vouchered specimen records of *Pterostylis saxicola*:
    - National Herbarium of New South Wales specimen database;
    - BioNet Wildlife Atlas;
- Interviews with collectors, observers, propagators and scientists of *P. saxicola* (see section 6, acknowledgements);
- Fieldwork at 9 sites at which *P. saxicola* had previously been collected or observed (see Appendix 1);
- The scientific and scholarly literature (see section 7, references);

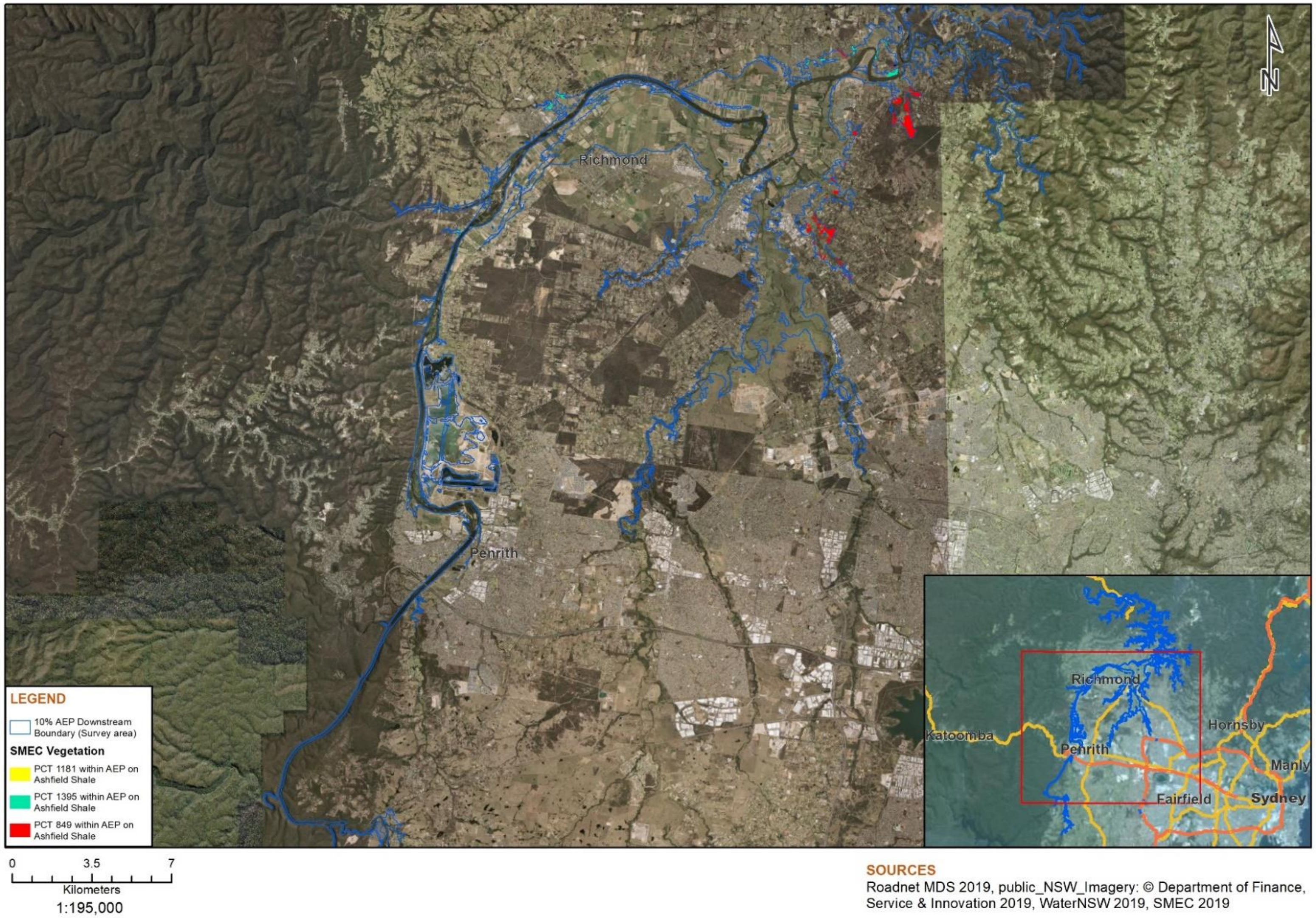


Figure 11. Polygons of suitable habitat for *Pterostylis saxicola* on Ashfield Shale in the survey area: PCTs 849 and 1395. Map provided by James Taylor, SMEC.

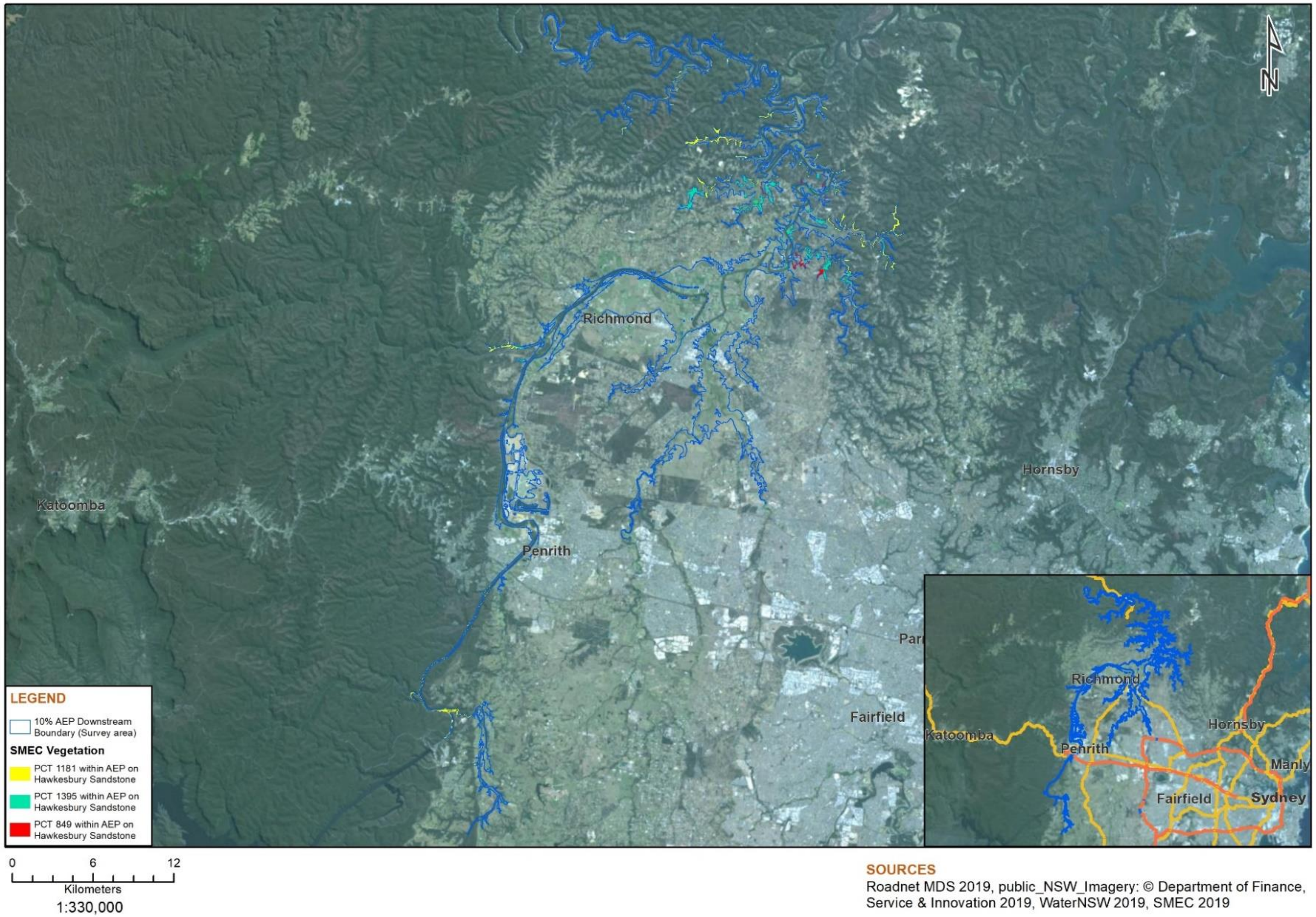


Figure 12. Polygon of suitable habitat for *Pterostylis saxicola* on Hawkesbury Sandstone in the survey area: PCTs 1181 and 1395. Map provided by James Taylor, SMEC.

- Background information on the survey area provided by SMEC;
- My personal knowledge and experience, gained from 40 years as a professional botanist specialising in the systematics and ecology of the Orchidaceae.

6. Acknowledgements

I am grateful to Lachlan Laurie (SMEC) for accompanying me to two sites at which *Pterostylis saxicola* had been recorded and helping me to survey the plant species there. Andrew Orme, Peter Ridgeway, Karen Sommerville, Greg Steenbeeke, Brian Towle and the late Teresa James generously shared their knowledge about *Pterostylis saxicola* with me. James Taylor (SMEC) assisted me in producing the maps in this report, using the ArcMap software package. Judith Fulham kindly permitted and assisted me to survey the habitat of *P. saxicola* on her property at Cattai. Jenny Linklater and Igor Maric (N.S.W. Department of Education) kindly facilitated my visit to Hawkesbury High School, Freemans Reach, after school hours, to survey the population of *P. saxicola* there. I am grateful to Lachlan Laurie and Rachel Musgrave (SMEC) for the provision of support and advice throughout this project and for critically reading an earlier draft of this report.

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8. Appendices

8.1 Appendix 1: Characterisation of habitat at selected sites

The tables on following pages record data that I collected at sites outside the survey area. Each site was centred on an arbitrarily selected plant of *Pterostylis saxicola*, or at a precisely specified latitude and longitude at which *P. saxicola* had been recorded. At each site the precise latitude and longitude, elevation, substrate, and soil description, were recorded. Also, at each site all plant species that could be reliably identified were recorded within a radius of 30 metres. Locations at which *P. saxicola* has been recorded by me and/or others have had their latitudes and longitudes transformed to the nearest 10 minutes.

Site	Location	Latitude	Longitude	Elevation (m)	Substrate
PS1	Old Schofield Trail, Scheyville National Park	33°40'S	150°50'E	70	Ashfield Shale
PS2	Simmos Beach Recreation Reserve Macquarie Fields	34°00'S	150°50'E	45	Hawkesbury Sandstone
PS3	Simmos Beach Recreation Reserve Macquarie Fields	34°00'S	150°50'E	43	Hawkesbury Sandstone
PS4	Boronia Rd Reserve, Peter Meadows Creek, Kentlyn	34°00'S	150°50'E	98	Hawkesbury Sandstone
PS5	Amberdale Reserve, Picnic Point	34°00'S	151°00'E	36	Hawkesbury Sandstone
PS6	Hawkesbury High School, Freemans Reach	33°30'S	150°50'E	40	Ashfield Shale
PS7	Mitchell Park Road, Cattai	33°30'S	150°50'E	25	Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone
PS8	Euroka Road, The Ironbarks	33°50'S	150°40'E	170	Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone
PS9	Gingra Range, Kanangra-Boyd National Park	34°00'S	150°10'E	435	Lambie Formation

Site	Soil description	Vegetation structure (canopy)	Vegetation structure (understorey)	PCT (my identification)
PS1	brown clay-loam	Dry sclerophyll forest	sparse shrubby understory	849
PS2	brown sand	Dry sclerophyll woodland	moderately dense shrubby understory	1081
PS3	dark brown humus-rich sand	dry sclerophyll forest	moderately dense shrubby understory	1081
PS4	dark brown humus-rich sand	Dry sclerophyll woodland	moderately dense shrubby understory under dense subcanopy	1081
PS5	dark brown humus-rich sand	Dry sclerophyll woodland	moderately dense shrubby understory	1181
PS6	red-brown clay with lateritic pebbles	dry sclerophyll forest	grassy, sparsely to densely shrubby understory	849
PS7	fine, mid-brown sand	dry sclerophyll forest	grassy, moderately to densely shrubby understory	1395
PS8	brown clay-loam	dry sclerophyll forest	moderately dense shrubby understory	1395
PS9	Dark brown clay-loam	dry sclerophyll forest	grassy, sparsely to densely shrubby understory	870

Appendix 1a: Environmental data for sites visited as part of this study

Associated species	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9
Acacia falcata	0	0	0	0	0	0	0	1	0
Acacia falciformis	0	0	0	0	0	0	0	0	1
Acacia floribunda	0	0	0	0	0	0	1	0	0
Acacia implexa	0	0	0	1	0	0	0	1	0
Acacia linifolia	0	1	1	0	1	0	0	0	0
Acacia parvipinnula	0	0	0	0	0	0	0	1	0
Acacia suaveolens	0	0	0	0	1	0	0	0	0
Acacia terminalis	0	1	1	0	1	0	0	0	0
Acacia ulicifolia	0	0	1	0	1	0	0	0	0
Acrotriche divaricata	0	0	0	1	0	0	0	0	0
Adiantum aethiopicum	0	0	0	0	0	0	0	0	1
Allocasuarina littoralis	0	0	0	1	1	0	1	0	0
Allocasuaruna torulosa	0	0	0	0	0	0	0	1	1
Angophora bakeri	0	1	1	1	1	0	1	0	0
Angophora costata	0	0	0	0	1	0	0	0	0
Angophora floribunda	0	0	0	0	0	0	0	0	1
Aristida ramosa	?	?	?	?	?	1	0	0	1
Aristida vagans	?	?	?	?	?	1	0	1	0
Arthropodium milleflorum	0	0	0	0	0	1	0	0	1
Asplenium flabellifolium	0	0	0	0	0	0	0	0	1
Astroloma pinifolium	0	0	0	0	1	0	0	0	0
Banksia serrata	0	0	0	0	1	0	0	0	0
Banksia spinulosa	0	1	1	1	1	0	0	0	0
Billardiera scandens	0	0	0	0	0	0	0	1	1
Brachyloma daphnoides	0	0	1	0	0	0	0	0	0
Brachyscome graminea	0	0	0	0	0	0	0	1	1
Breynia oblongifolia	1	0	0	0	0	1	0	0	0
Brunoniella australis	1	0	0	0	0	1	0	1	0
Bursaria spinosa	1	0	0	0	0	1	1	1	1
Calandrinia pickeringii	?	?	?	?	?	0	1	0	0
Calotis dentex	0	0	0	0	0	0	0	1	0
Cassytha sp.	0	0	0	0	0	0	0	1	0
Cheilanthes sieberi	1	1	0	1	0	1	1	1	1
Clematis aristata	0	0	0	0	0	0	?	0	1
Commelina cyanea	?	?	?	?	?	0	1	0	0
Commelina ensifolia	?	?	?	?	?	1	0	0	0

Appendix 1b (continued on following page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Associated species	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9
Coronidium scorpioides	0	0	0	0	0	0	0	0	1
Corymbia gummifera	0	0	0	1	1	0	0	0	0
Crassula sieberiana	?	?	?	?	?	0	1	0	0
Cymbidium suave	0	0	0	0	0	0	1	0	0
Daviesia ulicifolia	1	0	0	0	0	1	0	0	0
Daviesia squarrosa	0	0	0	0	0	0	0	1	0
Desmodium brachypodium	0	0	0	0	0	0	0	0	0
Desmodium gunnii	0	0	0	0	0	0	0	0	1
Desmodium rhytidophyllum	0	0	0	0	0	1	0	1	0
Dianella longifolia var. *stenophylla*	?	?	?	?	?	0	1	?	0
Dichondra repens	1	0	0	0	0	1	1	0	1
Dillwynia sieberi	1	0	0	0	0	0	0	0	0
Dodonaea triquetra	0	0	0	0	1	0	0	1	0
Doodia aspera	0	0	0	0	0	0	0	0	1
Echinopogon sp.	?	?	?	?	?	0	0	1	0
Einadia hastata	?	?	?	?	?	1	1	0	0
Entolasia stricta	0	0	0	0	0	0	1	1	1
Eremophila debilis	1	0	0	0	0	0	0	0	0
Eriostemon australasius	0	0	0	1	0	0	0	0	0
Eucalyptus beyeriana	0	0	0	0	0	0	0	1	0
Eucalyptus crebra	1	0	0	0	0	1	0	0	1
Eucalyptus eugenioides	0	0	0	0	0	0	0	0	1
Eucalyptus fibrosa	0	0	0	0	0	0	0	1	0
Eucalyptus globoidea	0	0	0	0	0	0	1	0	0
Eucalyptus moluccana	1	0	0	0	0	0	0	0	0
Eucalyptus piperita	0	0	0	0	1	0	0	0	0
Eucalyptus punctata	0	0	1	1	1	0	1	1	1
Eucalyptus sclerophylla	0	1	1	1	0	0	0	0	0
Eucalyptus sparsifolia	0	1	0	0	0	0	0	1	0
Eucalyptus tereticornis	0	0	0	0	0	1	1	0	1
Exocarpos cupressiformis	1	0	0	0	1	0	0	0	0
Exocarpos strictus	0	0	1	1	1	0	0	0	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Associated species	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9
Glycine tabacina	0	0	0	0	0	1	1	0	1
Glycine clandestina	0	0	0	0	0	0	1	1	0
Gompholobium grandiflorum	0	1	0	0	0	0	0	0	0
Goodenia hederacea	0	0	1	0	0	1	1	0	0
Grevillea sericea	0	0	0	0	1	0	0	0	0
Grevillea sphacelata	0	1	1	0	0	0	0	0	0
Hakea laevipes	0	1	1	1	0	0	0	0	0
Hakea sericea	0	1	1	1	1	0	0	0	0
Hardenbergia violacea	1	0	0	0	0	1	0	0	0
Hibbertia aspera	0	0	0	0	0	0	0	1	0
Hibbertia diffusa	?	?	?	?	?	1	1	1	0
Hibbertia obtusifolia	0	0	0	0	0	0	0	0	1
Hypericum gramineum	0	0	0	0	0	0	0	0	1
Hypoxis hygrometrica	?	?	?	?	?	0	0	1	0
Imperata cylindrica	0	0	0	0	0	0	1	0	0
Indigofera australis	0	0	0	0	0	0	0	0	1
Isopogon anemonifolius	0	1	1	1	0	0	0	0	0
Jacksonia scoparia	0	0	0	1	0	0	0	0	0
Kunzea ambigua	0	1	1	1	1	0	1	0	0
Lagenophora gracilis	0	0	0	0	0	0	0	1	1
Lagenophora stipitata	0	0	0	0	0	1	1	0	0
Lambertia Formosa	0	1	1	0	1	0	0	0	0
Laxmannia gracilis	?	?	?	?	?	0	1	0	0
Lepidosperma laterale	0	0	0	0	0	0	1	1	1
Leptospermum parvifolium	0	1	0	0	0	0	0	0	0
Leptospermum trinervium	0	1	1	1	1	0	1	0	0
Leucopogon juniperinus	0	0	0	0	0	0	0	0	1
Lissanthe strigosa	0	0	0	1	0	0	0	1	0
Lobelia purpurascens	?	?	?	?	?	1	1	1	1
Lomandra longifolia	0	0	0	0	1	0	1	0	1
Lomandra multiflora	0	0	0	0	0	0	1	1	1
Lomandra obliqua	0	1	1	1	1	0	0	0	0
Lomatia silaifolia	0	0	0	0	1	0	0	0	0
Macrozamia spiralis	0	0	0	1	0	0	0	0	0
Melaleuca nodosa	0	0	1	0	1	0	0	0	0
Microlaena stipoides	?	?	?	?	?	1	1	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Associated species	PS1	PS2	PS3	PS4	PS5	PS6	PS7	PS8	PS9
Monotoca scoparia	0	0	1	1	1	0	0	0	0
Notelaea longifolia	0	0	0	0	1	0	0	0	1
Olearia viscidula	0	0	0	0	0	0	0	0	1
Opercularia diphylla	?	?	?	?	?	1	1	1	1
Oplismenus imbecilis	?	?	?	?	0	0	1	0	0
Oxalis perennans	?	?	?	?	?	0	1	0	1
Ozothamnus diosmifolius	1	0	1	0	0	1	0	1	0
Pandorea pandorana	0	0	0	0	0	0	0	0	1
Panicum simile	?	?	?	?	?	0	0	1	0
Parsonsia straminea	0	0	0	0	0	0	1	0	0
Pellaea falcata	0	0	0	0	0	0	0	0	1
Persoonia levis	0	1	1	1	1	0	0	0	0
Persoonia linearis	0	0	1	1	1	0	0	1	1
Petrophile sessilis	0	1	0	1	1	0	0	0	0
Phyllanthus hirtellus	0	0	0	0	0	0	0	1	0
Pittosporum undulatum	0	0	0	0	1	0	0	0	0
Plantago debilis	?	?	?	?	?	1	0	0	1
Plectranthus sp.	0	0	0	0	0	1	0	0	1
Pomax umbellata	0	0	0	0	0	0	0	1	0
Pteridium esculentum	0	0	0	0	1	0	0	0	0
Pterostylis saxicola	1	?	1	?	?	1	?	?	?
Pultenaea villosa	0	0	0	0	0	0	0	1	0
Ricinocarpos pinifolius	0	0	0	0	1	0	0	0	0
Sigesbeckia orientalis	0	0	0	0	0	0	0	0	1
Solanum prinophyllum	1	0	0	0	0	1	1	1	1
Stellaria pungens	0	0	0	0	0	0	0	0	1
Stylidium laricifolium	0	0	0	1	0	0	0	0	0
Stypandra glauca	0	0	0	0	0	0	0	0	1
Themeda triandra	0	0	0	0	0	1	1	0	0
Tricoryne elatior	?	?	?	?	?	1	1	0	0
Tylophora barbata	0	0	0	0	0	0	0	0	1
Viola hederacea	?	?	?	?	?	0	1	0	0
Xanthorrhoea concava	0	0	0	0	1	0	0	0	0
Xanthorrhoea media	0	1	1	0	1	0	0	1	0
Xanthosia pilosa	0	0	0	0	1	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

8.2 Appendix 2: Peter Weston's curriculum vitae

Personal details

[redacted]

Academic Qualifications

i) **B.Sc.** (first class honours; equal first in order of merit) School of Biological Sciences, University of Sydney; 1975-78, conferred 7 April 1979.
Thesis title: "The evolution and classification of *Boronia* Sm."

ii) **Ph.D.**, School of Biological Sciences, University of Sydney, 1979-83; conferred 18 May 1985.
Thesis title: "Systematics and biogeography of the Persooniinae (Proteaceae)".

Awards, Fellowships and Scholarships

2014	Nancy Burbidge Medal (awarded by the Australasian Systematic Botany Society to a person who has made a longstanding and significant contribution to Australasian systematic botany. It is the foremost award that can be conferred by ASBS).
2014	Australian Biological Resources Study-sponsored Winston Churchill Fellowship for an established career researcher in taxonomy.
2009	Grady L. Webster Structural Botany Publication Award for 2008 and 2009 from the Botanical Society of America. The BSA component of the award (it is awarded in alternate years by the BSA and the American Society of Plant Taxonomists) recognizes the most outstanding paper published in the *American Journal of Botany* in the field of structural and developmental botany (i.e., anatomy and morphology) over a two-year period. It was awarded to Gregory J. Jordan, Peter H. Weston, Raymond J. Carpenter, Rebecca A. Dillon and Timothy J. Brodribb for: "The evolutionary relations of sunken, covered, and encrypted stomata to dry habitats in Proteaceae," American Journal of Botany, Volume 95, Issue 5; May 2008.
2006	Carrick Award for Australian University Teaching from the Australian Learning and Teaching Council (one of five members of a teaching team from the University of New England cited for Outstanding Contributions to Student Learning).
1992-93	Posting to Royal Botanic Gardens, Kew, as Australian Botanical Liaison Officer.
1982	Charles Gilbert Heydon Travelling Fellowship for the biological sciences (not taken up).
1980-82	University of Sydney Postgraduate Scholarship.

1979-82	Commonwealth Postgraduate Award.
1977	G.S. Caird Scholarship for Third Year Botany, University of Sydney.
1976	Slade Prize for Practical Plant Biology, University of Sydney.

Employment

Present Position: Honorary Research Associate, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney and independent botanical consultant.

Previous positions held:
2008-2016 Senior Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

2000-2008 Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1994-2000 Senior Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1989-1994 Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1982-1989 Scientific Officer, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1979-82 Part-time demonstrator, School of Biological Sciences, University of Sydney.

Adjunct and visiting university appointments

2018-	Visiting Fellow, Western Sydney University.
2013-	Adjunct Associate Professor, La Trobe University.
2011-2016	Adjunct Associate Professor, University of New South Wales.
2006	Visiting Lecturer, Rhodes University, Grahamstown, South Africa.
2004-2009	Adjunct Associate Professor, University of New England.
2000-2004	Adjunct Senior Lecturer, University of New England.

Administrative/management experience

2009	Acting Manager Plant Diversity
2002-2003	Member, Plant Diversity Research Program Leaders Committee
1998-99	Systematics Liaison Officer
1997-98	Member RBGS Market testing working party
1997	Member, RBGS advisory committee for restructuring senior management
1990-91	Systematics Co-ordinator
1996-98	Member, RBGS Joint Consultative Committee

Membership of Learned Societies

1996-	Society of Australian Systematic Biologists
1984-	Willi Hennig Society (Elected Fellow, 1992-, Council member, 1998-2000)
1979-	Society of Systematic Biologists (member, Editorial Board 1993-95)

1978- Australasian Systematic Botany Society (formerly Australian Systematic Botany Society: President, 2009-2012, Vice President, 2008-2009, Chairman, Hansjörg Eichler Research Fund Committee, 1998-2002, Council member, 1996-2002)

Membership of External Committees

2015- Financial Grants Standing Committee (formerly the Grants Policy Standing Committee) of the Australasian Systematic Botany Society

2012-2013 Conference Organising Committee of *Systematics Without Borders*, a joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, University of Sydney (Chairman)

2011- Editorial Board, *Phytotaxa*

2008-2009 Corresponding Member, Editorial Advisory Committee, *Australian Systematic Botany*

2006-2014 Ira Butler Memorial Trophy Committee (a joint committee of the Australasian Native Orchid Society and the Orchid Society of New South Wales) (Chairman)

2004- Editorial Advisory Board, *Kew Bulletin*

2001-2006 Panel of Judges, Eureka Prize for Biodiversity Research

2000-2012 Bushland Management Advisory Committee, Lane Cove Council (Chairman, 2008-2010)

1999-2004 Editorial Advisory Committee, *Australian Systematic Botany*

Spoken presentations at conferences (not including presentations delivered by others)

2015 Building Our Botanical Capital, annual conference of the Australasian Systematic Botany Society: “A database of variation in floral characters in the Proteaceae, and implications for key questions in floral evolution”.

2014 Next Generation Systematics, annual conference of the Australasian Systematic Botany Society: Nancy Burbidge Memorial Lecture: “Problems and progress in plant systematics since Nancy Burbidge”

2013 Genetics Society of Australasia conference, Sydney *Genetics in the Harbour City*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2013 Joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, Sydney, *Systematics Without Borders*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2012 Australasian Systematic Botany Society conference, Perth, *Local knowledge, global delivery*: “Contested, Uncontested and Potentially Controversial Taxonomic Changes in the Proteaceae: How Do They Differ?”

2011 37th annual conference of the South African Association of Botanists, *Plants in a Changing World* and 9th conference of the South African Society of Systematic Biologists, *Biodiversity Matters*; plenary address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

2011 XVIII International Botanical Congress, Melbourne: “Floral evolution in animal-pollinated Australian angiosperm clades: patterns and potential explanations”.

2010 VI Southern Connection Congress, Bariloche: “Cladistic biogeography, molecular dating, fossils and the Proteaceae”

2010 VI Southern Connection Congress, Bariloche: “Diversification of the Proteaceae in Mediterranean hotspots of the Southern Hemisphere and in tropical rainforests”

2010 Australian Systematic Botany Society conference *Systematic Botany Across the Ditch: Links Between Australia and New Zealand*; Keynote address: "Cenozoic environmental change and the systematics of southern hemisphere plants"
1999 XVI International Botanical Congress, Saint Louis: "Historical biogeography of Proteaceae".
1997 II Southern Connection Congress, Valdivia: "Cladistic biogeography of a key woody group: Proteaceae".
1997 First Biennial International Conference of the Systematic Association, Oxford: "Rolf Sattler's Plant Morphology and Cladistic Analysis".
1996 *An International Symposium on the Biology of Proteaceae*, Melbourne: "ITS squence variation in the Proteaceae and what it tells us about phylogeny".
1993 Joint conference of The Systematics Associations and The Linnean Society on *Models in Phylogeny Reconstruction*, London: "Direct methods for polarising character transformation series".
1990 IXth meeting of the Willi Hennig Society, Canberra: "Transoceanic cladistic patterns in the Proteaceae".
2003 The Third International Conference on *the Comparative Biology of the Monocotyledons*, Ontario: "Co-evolution of *Chiloglottis* (Orchidaceae) and its Thynnine wasp pollinators".
2005 XVII International Botanical Congress, Vienna: "Food is good but sex is better: the evolution of deceptive pollination in the tribe Diurideae (Orchidaceae)".
2006 Australian Systematic Botany Society conference, Cairns, *Plant Diversity in the Tropics*: "A new suprageneric classification of the Proteaceae".
2007 5th Southern Connection Congress, Adelaide: "'I'm not dead yet' – Gondwana (the Proteaceae are at least partially congruent with Gondwanic fragmentation)".
1989 Australian Systematic Botany Society symposium, on *Gondwanan Elements in the Australian Flora*, Sydney: "Transpacific cladistic patterns in the Proteaceae and Elaeocarpaceae".
1988 Symposium on *Panbiogeography of New Zealand*, Wellington: "Problems with the statistical testing of panbiogeographic hypotheses".
1985 Australian Flora Foundation Symposium on *Waratahs*, Canberra: "Drifting waratahs or continents?"
1984 Australian Systematic Botany Society symposium on *Cladistics, Systematics and Phylogeny*, Canberra: "A reappraisal of Nelson's direct method of character analysis".

Refereeing manuscripts, grant applications, reports and examining postgraduate theses (last five years)

2018: *Candollea*; *Flora of the Hunter Region*; *Journal of Biogeography.*
2017: *Australian Systematic Botany*; *Evolution*; *New Zealand Journal of Botany*; *Nuytsia*; *South African Journal of Botany.*
2016: *Australian Systematic Botany*; *Botanical Journal of the Linnean Society*, *National Research Foundation* (South Africa).
2015: *American Journal of Botany*; Australian Research Council (4); *Australian Systematic Botany*; *Muelleria*; *Nuytsia*; *Phytotaxa*; *PLOS One*; *Telopea* (6).
2014: Australian Research Council (3); *Australian Systematic Botany* (2); *Cunninghamia*; *Journal of Biogeography* (2); *Muelleria*; National Research Foundation (South Africa); *Orchadian*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Plant Systematics and Evolution*; *Telopea* (3).

Research

My research has been in the theoretical and practical aspects of systematic botany, with emphasis on the theory and practice of phylogenetic analysis, and the broader uses to which phylogenetic knowledge may be applied. I have phylogenetically analysed groups in the plant families Proteaceae, Fabaceae, Orchidaceae, Rutaceae, Winteraceae and Lauraceae, contributed to more general analyses of angiosperm phylogeny, and used the results of these analyses to improve biological classification and to test theories of historical biogeography, trait evolution, co-evolution and adaptation. I have earned an international reputation for my contributions to both theoretical and empirical developments in this field.

Herbarium curation and collections

My curatorial responsibilities at the National Herbarium of New South Wales have included the families Rutaceae (1982-1998), Proteaceae (1982-2016), Orchidaceae (1986-2016) and Fabaceae subfamily Faboideae (1986-2016). I have collected plant specimens (mostly angiosperms) in Australia, England, New Zealand, New Caledonia, Chile, South Africa, and Argentina, mostly for the herbarium and living collections of the Royal Botanic Gardens and Domain Trust, Sydney. Duplicates of my collections have been distributed to over 20 herbaria in 8 different countries.

Teaching

I have been actively involved in the preparation and teaching of four third year undergraduate courses in biosystematics:
Western Sydney University (2015-2018): “Principles of Evolution” (unit 300980), “Botany” (unit 300836).
University of New South Wales (2010-2016): “Assembling the Tree of Life” (BIOS3221)
University of New England (2000-2010): Biosystematics (Biosyst 301, Biosyst 302, Evol 301/501).
Botany Department, Rhodes University, Grahamstown, South Africa (February-March 2006): “Plant Biodiversity” course in collaboration with Associate Professor Nigel Barker.

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I have examined 14 honours and postgraduate theses:
Australian National University (Ph.D., 2003, 2007, 2008)
University of Melbourne (Ph.D., 1995, 2011)
University of Newcastle (M.Phil., 2003)
University of Queensland (Ph.D., 2003)
University of Sydney (Ph.D., 1991, 1994, 1997, 2009)
University of Wollongong (B.Sc. Hons., 2001, 2003)
Victoria University (Ph.D., 2007)

Competitive Research and Infrastructure Grants

Peakall, R., Pichersky, E., Linde, C., Weston, P.H. (2015-2019) The biosynthesis and evolution of novel semiochemicals in orchids. $644,800, Australian Research Council Discovery Grant DP150102762.

Hoebee, S.E., Weston, P.H., & Edwards, T.J. (2015-19) Evolution in action or the demise of iconic Australian flora? $217,700, Australian Research Council Discovery Grant DP150100508.

He, T., Lamont, B., Weston, P.H., & Cowling, R. (2012-2014) Origin and evolution of plant functional traits in relation to fire. $310,000, Australian Research Council Discovery Grant DP120103389.

Rossetto, M., Crayn, D.M. & Weston, P.H. (2008-2010) Integrating molecular and morphological data for generic delimitation and species identification in Lauraceae. $73,333, Australian Biological Resources Study.

Cantrill, D., Murphy, D. & Weston, P.H. (2008-10) Understanding the origins of the Australian flora by integrating molecular phylogenies and fossil data in the Proteaceae. $88,900, Hermon Slade Foundation.

Rossetto, M. & Weston, P.H. (2007-2009) Speciation in the Australian flora: testing explanatory hypotheses in waratahs and their allies. $78,000, Hermon Slade Foundation.

Considine, J.A., Krauss, S.L. & Weston, P.H. (2002-2004) A biological basis for the efficient breeding of native plants for export markets: a case study with the Australian Goodeniaceae. $168,126, ARC – Linkage (Krauss and Weston representing industry partners)

Whelan, R.J., Ayre, D.J., England, P., Auld, T.D., & Weston, P.H. (2000-2002) Ecology and genetics of fire-sensitive *Persoonia* species: threatened species recovery and management. $126,480, Australian Research Council (ARC– SPIRT, Auld and Weston representing industry partners).

Trent, R. *et al.* (2000) Enhancement of DNA sequencing equipment for the Sydney University and Prince Alfred Molecular Analysis Centre. $600,000, Australian Research Council (ARC-REIF).

Weston, P.H. (1999-2001) Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae). $75,000, Hermon Slade Foundation.

Weston, P.H. (1997-2000) Taxonomic revision of *Dillwynia* (Fabaceae: Faboideae: Mirbelieae). $62,836, Australian Biological Resources Study.

Weston, P.H. & Thomson, J.A. (1993) A molecular approach to the evolution and biogeography of the Queensland tree waratahs. $4000, Queensland Wet Tropics Management Authority

Weston, P.H. & Thomson, J.A. (1991-92) A molecular approach to the evolution and biogeography of the waratahs. $80,100, Australian Research Council (large grants scheme).

Weston, P.H. (1984) Establishment of a data bank for eucalypt specimens held by NSW. $20,000, Australian Biological Resources Study.

Scientific Publications

[the numbers in square brackets following a reference indicates: 1. the journal's 2016-17 impact factor according to ISI Web of Knowledge, then the number of literature citations for the paper found by Google Scholar, as of 13 Feb 2019]

H-index = 34, total number of citations = 4081 as of 13 Feb 2019

1. Craw, R.C. & **Weston, P.H.** (1984) Panbiogeography: a progressive research program? *Systematic Zoology* 33: 1-13. [8.917, 90]

2. **Weston, P.H.**, Carolin, R.C., & Armstrong, J.A. (1984) A cladistic analysis of *Boronia* Sm. and *Boronella* Baill. (Rutaceae). *Australian Journal of Botany* 32: 187-203. [0.793, 49]

3. Morrison, D.A. & **Weston, P.H.** (1985) Analysis of morphological variation in a field sample of *Caladenia catenata* (Smith) Druce (Orchidaceae). *Australian Journal of Botany* 33: 185-195. [0.793, 11]

4. Crisp, M.D. & **Weston, P.H.** (1987a) Waratahs - how many species? Pp. 3-15, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 13]

5. Crisp, M.D. & **Weston, P.H.** (1987b) Cladistics and legume systematics, with an analysis of the Bossiaeeae, Brongniartieae and Mirbelieae. Pp. 65-130, in C.H. Stirton (ed.) *Advances in Legume Systematics Part 3* (Royal Botanic Gardens: Kew). [-, 131]

6. **Weston, P.H.** (1987) *Persoonia* (Proteaceae). Pp. 348-350, in N.G. Marchant *et al*. (eds.) *Flora of the Perth Region* (Western Australian Herbarium: Perth). [-, 0]

7. **Weston, P.H.** & Crisp, M.D. (1987) Evolution and biogeography of the Waratahs. Pp. 17-34, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 14]

8. **Weston, P.H.**, Wilson, P.G., & Hill, K.D. (1987) Identification of *Cannabis*. *Department of Agriculture New South Wales Miscellaneous Bulletin* 25: 148-150. [-, 0]

9. **Weston, P.H.** (1988a) A revision of *Hicksbeachia* (Proteaceae). *Telopea* 3: 231-239. [0.6, 3]

10. **Weston, P.H.** (1988b) Indirect and direct methods in systematics. Pp. 27-56, in C.J. Humphries (ed.) *Ontogeny and Systematics* (Columbia Univ. Press: New York). [-, 76]

11. **Weston, P.H.** (1989) Problems with the statistical testing of panbiogeographic hypotheses. *New Zealand Journal of Zoology* 16: 511. [0.811, 7]

12. **Weston, P.H.** (1990) Notes on *Boronia* (Rutaceae) in New South Wales, including descriptions of three new species. *Telopea* 4: 121-128. [0.6, 6]

13. **Weston, P.H.** & Johnson, L.A.S. (1991) Taxonomic changes in *Persoonia* (Proteaceae) in New South Wales. *Telopea* 4: 269-306. [0.6, 9]

14. Crisp, M.D. & **Weston, P.H.** (1991) *Almaleea*, a new genus of Fabaceae from south-eastern Australia. *Telopea* 4: 307-311. [0.6, 10]

15. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae), a new genus from New Guinea and eastern Australia. *Telopea* 4: 497-507. [0.6, 12]

16. **Weston, P.H.** (1991) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium*, *Pultenaea* and *Dillwynia* (Fabaceae). Pp. 2-19, 452-455, 456-461, 481-497, 499-504, in G. Harden (ed.) *Flora of New South Wales* vol. 2 (New South Wales Univ. Press: Sydney). [-, 0]

17. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae) and *Almaleea* (Fabaceae). Pp. 29-30, 497-498, in G. Harden (ed.) *op. cit.* [-, 0]

18. **Weston, P.H.** & Porteners, M.F. (1991) *Boronia*, *Eriostemon* and *Phebalium* (Rutaceae). Pp. 227-236, 250-254, 255-263, in G. Harden (ed.) *op. cit.* [-, 0]

19. Porteners, M.F. & **Weston, P.H.** (1991) *Correa* and *Crowea* (Rutaceae). Pp. 247-249, 254-255, in G. Harden (ed.) *op. cit.* [-, 0]

20. Crisp, M.D. & **Weston, P.H.** (1991) *Telopea*. Pp. 30-31, in G. Harden (ed.) *op. cit.* [0.6, 0]

21. Gross, C.L. & **Weston, P.H.** (1992) *Macadamia jansenii* (Proteaceae), a new species from central Queensland. *Australian Systematic Botany* 5: 725-28. [0.75, 8]

22. Crisp, M.D. & **Weston, P.H.** (1993) Geographic and ontogenetic variation in morphology of Australian waratahs (*Telopea*: Proteaceae). *Systematic Biology* 42: 49-76. [14.387, 76]

23. Gilmore, S., **Weston, P.H.**, & Thomson, J.A. (1993) A simple, rapid, inexpensive and widely applicable technique for purifying plant DNA. *Australian Systematic Botany* 6: 139-148. [0.75, 41]

24. **Weston, P.H.** (1993) Key to genera, *Cyrtostylis*, *Cryptostylis*, *Zeuxine*, *Cheirostylis*, *Pseudovanilla*, *Erythrorchis*, *Epipogium*, *Gastrodia*, *Oberonia*, *Liparis*, *Dendrobium*, *Calanthe*, *Phaius*, *Geodorum*, *Dipodium*, *Cymbidium*, *Sarcochilus*, *Rhinerrhiza*, *Peristeranthus*, *Papillilabium*, *Schistotylus*, *Plectorrhiza*, *Taeniophyllum* (Orchidaceae). Pp. 134-138, 218-219, 219-221, 221-233, 236-247, in G. Harden (ed.) *Flora of New South Wales* vol. 4 (New South Wales Univ. Press: Sydney). [-, 0]

25. **Weston, P.H.** & Hill, K.D. (1993) *Bulbophyllum* (Orchidaceae). Pp. 233-236, in G. Harden (ed.) *op. cit.* [-, 0]

26. **Weston, P.H.** & Crisp, M.D. (1994) Cladistic biogeography of Waratahs and their allies (Embothrieae: Proteaceae) across the Pacific. *Australian Systematic Botany* 7: 225-249. [0.75, 73]

27. **Weston, P.H.** (1994) The Western Australian species of subtribe Persooniinae (Proteaceae: Persoonioideae: Persoonieae). *Telopea* 6: 51-165. [0.6, 19]

28. **Weston, P.H.** & Johnson, L.A.S. (1994) Three new species of *Persoonia* (Proteaceae) from Queensland. *Telopea* 6: 31-37. [0.6, 1]

29. **Weston, P.H.** (1994) Methods for rooting cladistic trees. Pp. 125-155, in D.J. Siebert, R.W. Scotland and D.M. Williams (eds.) *Models in Phylogeny Reconstruction* (Oxford Univ. Press: Oxford). [-, 38]

30. Crisp, M.D. & **Weston, P.H.** (1995) Mirbelieae. Pp. 245-282, in J.J. Doyle and M.D. Crisp (eds.) *Advances in Legume Systematics Part 7: Phylogeny* (Royal Botanic Gardens: Kew). [-, 37]

31. Crisp, M.D. & **Weston, P.H.** (1995) Subtribe Embothriinae (Proteaceae). *Flora of Australia* 16: 382-390. [-, 0]

32. Crisp, M.D., Linder, H.P. & **Weston, P.H.** (1995) Cladistic biogeography of plants in Australia and New Guinea: congruent pattern reveals two endemic tropical tracks. *Systematic Biology* 44: 457-473. [8.917, 121]

33. Thomson, J.A., **Weston, P.H.** & Tan, M.K. (1995) A molecular approach to tracing the major lineages in *Pteridium*. Pp. 21-28, in R.T. Smith and J.A. Taylor (eds.) *Bracken: an Environmental Issue* (University of Leeds: Leeds). [-, 13]

34. **Weston, P.H.** (1995) Key to the genera of Proteaceae in Australia, Subfamily Persoonioideae, Subfamily Bellendenoideae, Subtribe Gevuininae, Subtribe Hicksbeachiinae. *Flora of Australia* 16: 41-46, 47-125, 125-127, 409-410. [-, 0]

35. Bernhardt, P. & **Weston, P.H.** (1996) The pollination ecology of *Persoonia* (Proteaceae) in eastern Australia. *Telopea* 6: 775-804. [0.6, 48]

36. **Weston, P.H.** & Crisp, M.D. (1996) Trans-Pacific biogeographic patterns in the Proteaceae. Pp. 215-232, in A. Keast & S.E. Miller (eds.) *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processes* (SPB Academic Publishing: Amsterdam). [-, 34]

37. **Weston, P.H.** & Johnson, L.A.S. (1997) *Persoonia hindii* (Proteaceae), a new species from the Newnes Plateau, New South Wales. *Telopea* 7: 199-203. [0.6, 6]

38. Jobson, P.C. & **Weston, P.H.** (1998) *Dillwynia glaucula* (Fabaceae: Mirbelieae), a new species from the Southern Tablelands, New South Wales. *Telopea* 8: 1-5. [0.6, 1]

39. **Weston, P.H.** (1999) *Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8: 159-164. [0.6, 5]

40. Crisp, M.D., Gilmore, S.R. & **Weston, P.H.** (1999) The phylogenetic relationships of two anomalous species of *Pultenaea* (Fabaceae: Mirbelieae) from molecular and morphological data, and description of a new genus. *Taxon* 48: 701-714. [2.447, 21]

41. Jobson, P.C. & **Weston, P.H.** (1999) Two new species of *Dillwynia* (Fabaceae: Mirbelieae), from the Southern Tablelands of New South Wales. *Telopea* 8: 363-369. [0.6, 0]

42. Thomson, J.A., **Weston, P.H.** and Tan, M.K. (1999) A molecular approach to tracing major lineages in *Pteridium*: update and amendment. Pp. 35-36 in J.A. Taylor & R.T. Smith (eds.) *Bracken Fern: Toxicity, Biology and Control* (International Bracken Group: Aberystwyth). [-, 1]

43. **Weston, P.H.** (2000) Process morphology from a cladistic perspective. Pp. 124-144 in R. Scotland & T. Pennington (eds.) *Homology and Systematics: Coding Characters for Phylogenetic Analysis* (Taylor & Francis: Basingstoke). [-, 24]

44. Indsto, J. & **Weston, P.H.** (2000) Near-ultraviolet reflectance in *Dendrobium* (Orchidaceae). Pp. 326-334 in K.L. Wilson and D.A. Morrison (eds.) *Monocots: Systematics and Evolution*. (CSIRO: Melbourne). [-, 5]

45. Kores, P.J., **Weston, P.H.**, Molvray, M., & Chase, M.W. (2000) Phylogenetic relationships within the Diurideae (Orchidaceae); inferences from plastid *mat*K DNA sequences. Pp. 449-456 in K.L. Wilson and D.A. Morrison (eds.) *Monocots: Systematics and Evolution*. (CSIRO: Melbourne). [-, 60]

46. Savolainen, V., Fay, M.F., Albach, D.C., Backlund, A., van der Bank, M., Cameron, K.M., Johnson, S.A., Lledo, M.D., Pintaud, J.-C., Powell, M., Sheahan, M.C., Soltis, D.E., Soltis, P.S., **Weston, P.H.**, Whitten, W.M., Wurdack, K.J., & Chase, M.W., (2000) Phylogeny of the eudicots: a nearly complete familial analysis based on *rbc*L gene sequences. *Kew Bulletin* 55: 257-309. [0.577, 467]

47. Crisp, M.D. & **Weston, P.H.** (2000) *Telopea* (Proteaceae) Pp. 115-117 in G.J. Harden, D.W. Hardin & D.C. Godden (eds.) *Proteaceae of New South Wales* (New South Wales Univ. Press: Sydney). [-, 0]

48. **Weston, P.H.** (2000) *Persoonia* (Proteaceae) Pp. 89-105 in G.J. Harden, D.W. Hardin & D.C. Godden (eds.) *Proteaceae of New South Wales* (New South Wales Univ. Press: Sydney). [-, 0]

49. **Weston, P.H.** & Crisp, M.D. (2000) *Alloxylon* (Proteaceae) P. 115 in G.J. Harden, D.W. Hardin & D.C. Godden (eds.) *Proteaceae of New South Wales* (New South Wales Univ. Press: Sydney). [-, 0]

50. Hill, R.S. & **Weston, P.H.** (2001) Southern (austral) ecosystems. Pp. 361-370 in S.A. Levin (ed.) *Encyclopedia of Biodiversity* vol. 5 (Academic Press: San Diego). [-, 1]

51. Kores, P.J., Molvray, M., **Weston, P.H.**, Hopper, S.D., Brown, A., Cameron, K.M., and Chase, M.W (2001) A phylogenetic analysis of Diurideae (Orchidaceae) based on plastid DNA sequence data. *American Journal of Botany* 88: 1903-1914. [3.05, 135]

52. Jobson, P.C. & **Weston, P.H.** (2001) *Dillwynia rupestris* (Fabaceae: Mirbelieae), a new species from the New England Tableland of New South Wales. *Telopea* 9: 323-327. [0.6, 0]

53. Barker, N.P., **Weston, P.H.**, Rourke, J.P., & Reeves, G. (2002) The relationships of the southern African Proteaceae as elucidated by internal transcribed spacer (ITS) DNA sequence data. *Kew Bulletin* 57: 867-883. [0.577, 33]

54. Mant, J.G., Schiestl, F.P., Peakall, R., & **Weston, P.H.** (2002) A phylogenetic study of pollinator conservatism among sexually deceptive orchids. *Evolution* 56: 888-898. [4.201, 96]

55. **Weston, P.H.** (2002) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium* (Fabaceae), Pp. 3-20, 622-632 in G.J. Harden (ed.) *Flora of New South Wales* vol. 2, second, revised edition (New South Wales Univ. Press: Sydney). [-, 0]

56. **Weston, P.H.** & Duretto, M.F. (2002) *Boronia* (Rutaceae). Pp. 265-276 in G.J. Harden (ed.) *Flora of New South Wales* vol. 2, second, revised edition (New South Wales Univ. Press: Sydney). [-, 3]

57. **Weston, P.H.** & Harden, G.J. (2002) *Correa, Philotheca*, *Eriostemon, Crowea, Phebalium, Nematolepis*, *Leionema* (Rutaceae) Pp. 289-310, in G.J. Harden (ed.) *Flora of New South Wales* vol. 2, second, revised edition (New South Wales Univ. Press: Sydney). [-, 4]

58. **Weston, P.H.** & Jobson, P.C. (2002) *Dillwynia* (Fabaceae). Pp. 542-549 in G.J. Harden (ed.) *Flora of New South Wales* vol. 2, second, revised edition (New South Wales Univ. Press: Sydney). [-, 0]

59. **Weston, P.H.** & de Kok, R. (2002) *Pultenaea* (Fabaceae). Pp. 549-565 in G.J. Harden (ed.) *Flora of New South Wales* vol. 2, second, revised edition (New South Wales Univ. Press: Sydney). [-, 1]

60. **Weston, P.H.** & Kooyman, R.M. (2002) Systematics of *Eidothea* (Proteaceae), with the description of a new species, *E. hardeniana*, from the Nightcap Range, north-eastern New South Wales. *Telopea* 9: 821-832. [0.6, 15]

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