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Environmental Impact Statement – Chapter 9: Downstream ecological assessment

# Warragamba Dam Raising

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# Contents



## List of Tables



## List of Figures

# 9 Downstream ecological assessment

This chapter provides an assessment of downstream biodiversity during construction and operation of the Warragamba Dam Raising. The relevant Secretary's Environmental Assessment Requirements (SEARs) are shown in Table 9-1.

*Table 9-1. Secretary's Environmental Assessment Requirements: Downstream ecological assessment*

| Desired performance outcomes | Secretary's Environmental Assessment Requirements[1] | Where addressed |
|---|---|---|
| **6. Biodiversity**<br>The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity.<br>Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation. | 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. | Sections 9.4 to 9.6 |
| | 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 Act), Fisheries Management Act 1994 (FM Act) and Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). | Section 9.4.11.<br>Chapter 11 (Aquatic ecology - impacts to biodiversity values associated with the FM Act) |
| **ATTACHMENT B** | | |
| 6. Biodiversity<br>The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity.<br>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 9.2<br>Section 9.3 |
| | 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 9.2<br>Section 9.3<br>Section 9.4 |
| | (b) Description and geo-referenced mapping of study area (and spatial data files), e.g. 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 9.2<br>Maps provided in Appendix F2 (Downstream ecological assessment, Appendix I) |
| | (c) Description of survey methods used, including timing, location and weather conditions. | Section 9.2 |
| | (d) Details, including qualifications and experience of all staff undertaking the surveys, mapping and assessment of impacts as part of the assessment. | Appendix F2 (Downstream ecological assessment, Appendix G) |
| | (e) Identification of national and state listed threatened biota known or likely to occur and their conservation status. | Appendix F2 (Downstream ecological assessment, Appendix E) |

| Desired performance outcomes | Secretary's Environmental Assessment Requirements[1] | Where addressed |
|---|---|---|
| | (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 9.4 |
| | (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 9.4.13 |
| | (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 9.4<br>Section 9.6 |
| | (i) Provision of specific Statement of Commitments relating to biodiversity. | Section 9.4.13<br>Section 9.5 |
| | Where an offsets package is proposed by a proponent for any downstream impacts to biodiversity this package should:<br>(a) Meet OEH's Principles for the use of biodiversity offsets in NSW, which are available at:<br>www.environment.nsw.gov.au/biocertification/offsets.htm.<br>(b) Identify the conservation mechanisms to be used to ensure the long-term protection and management of the offset sites.<br>(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 9.5.6 |
| | 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 9.5.3 |

1. This chapter specifically addresses SEAR 6 and SEAR Attachment B, in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1-1).

The downstream biodiversity assessment is supported by detailed investigations, which have been documented in the Downstream ecological assessment report (SMEC & Umwelt 2019, Appendix F2). Also relevant are:

- Biodiversity assessment report - upstream (SMEC 2020, Appendix F1)
- Biodiversity assessment report - construction (SMEC 2020, Appendix F3)
- Aquatic ecology assessment report (SMEC 2020, Appendix F4)
- Biodiversity Offset Strategy (EIS Chapter 13).

The proposed management and mitigation measures in this chapter are collated in Chapter 29 (EIS synthesis, Project justification and conclusion).

## 9.1 Project description

A Project description is provided in Chapter 5 (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 (FSL) for temporary storage of inflows (flood mitigation zone (FMZ)). 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 current design includes raising the dam side walls and roadway by 17 metres to enable adaptation to projected climate change.

In 2017, the NSW Government released the *2017 Metropolitan Water Plan*[1] which included the introduction of new variable environmental flows from Warragamba Dam to improve the health of the Hawkesbury-Nepean River (Metropolitan Water Directorate 2017). 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*.

The Project would delay downstream flooding, which would reduce current downstream flood peaks and increase the time taken for downstream water levels to recede. The dam would be subject to the following operational regimes, depending on the water level:

### Normal operations

Normal operations would occur when the dam storage level is at or lower than the 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 the FSL, after which environmental flow releases would cease and flood operation procedures would be implemented.

### Flood operations

Flood operations are shown on Figure 9-1 and would apply when the water level is higher than the FSL. The flood mitigation zone (FMZ) would provide capacity to capture temporarily around 1,000 gigalitres of water during a flood event. For larger floods the FMZ would be filled and uncontrolled discharge would occur over the central spillway, and potentially, auxiliary spillway of the dam. Operational objectives 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.

A frequency distribution of dam outflows and example hydrographs for various flood events are shown on Figure 9-2 and Figure 9-3 respectively. The Project would lower existing flood peaks, which would reduce current downstream flood peaks and increase the time taken for downstream water levels to recede.

[1] www.planning.nsw.gov.au/about-us/Sydney-Metropolitan-Water

*Figure 9-1. Flood operations*

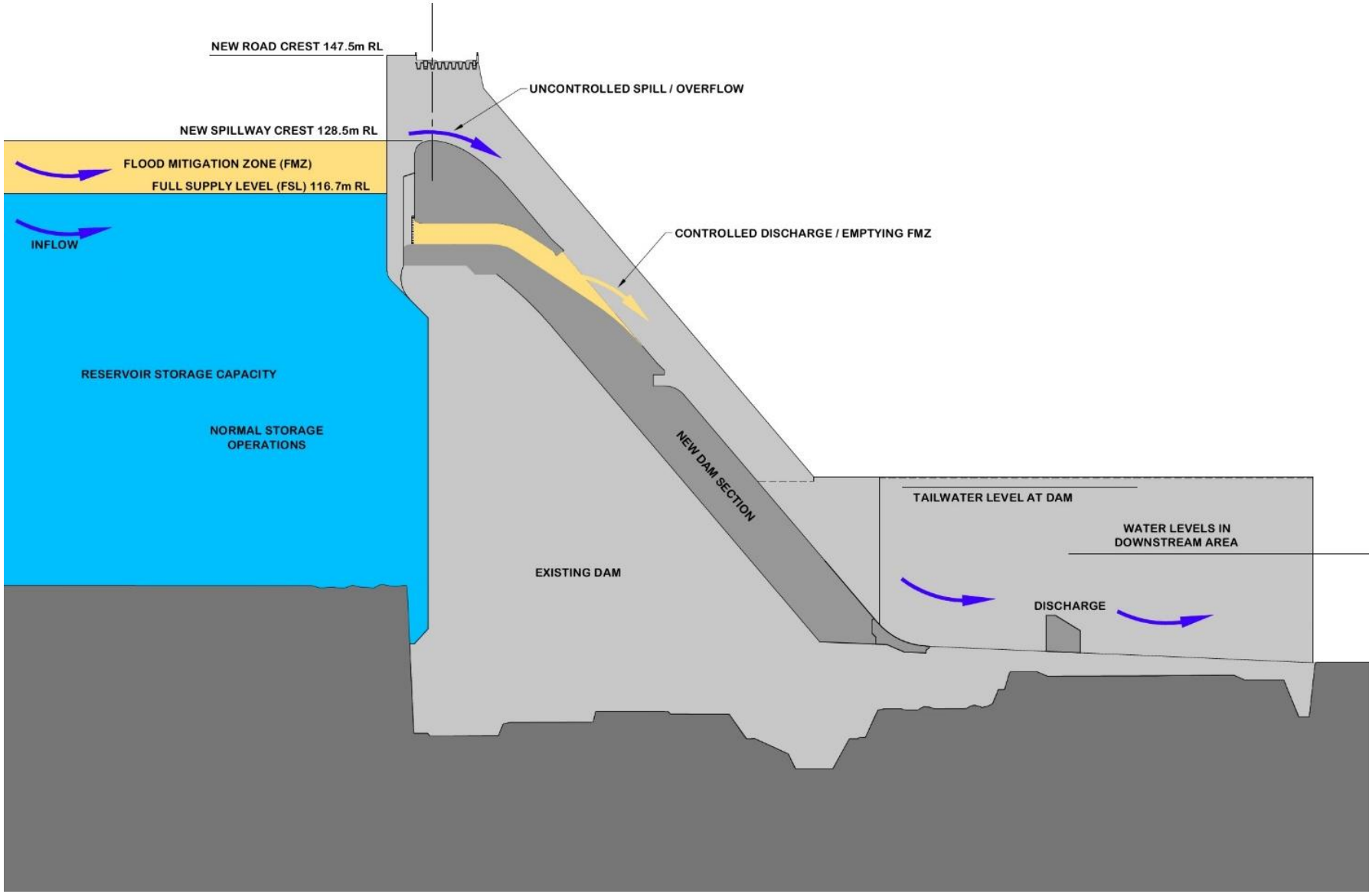
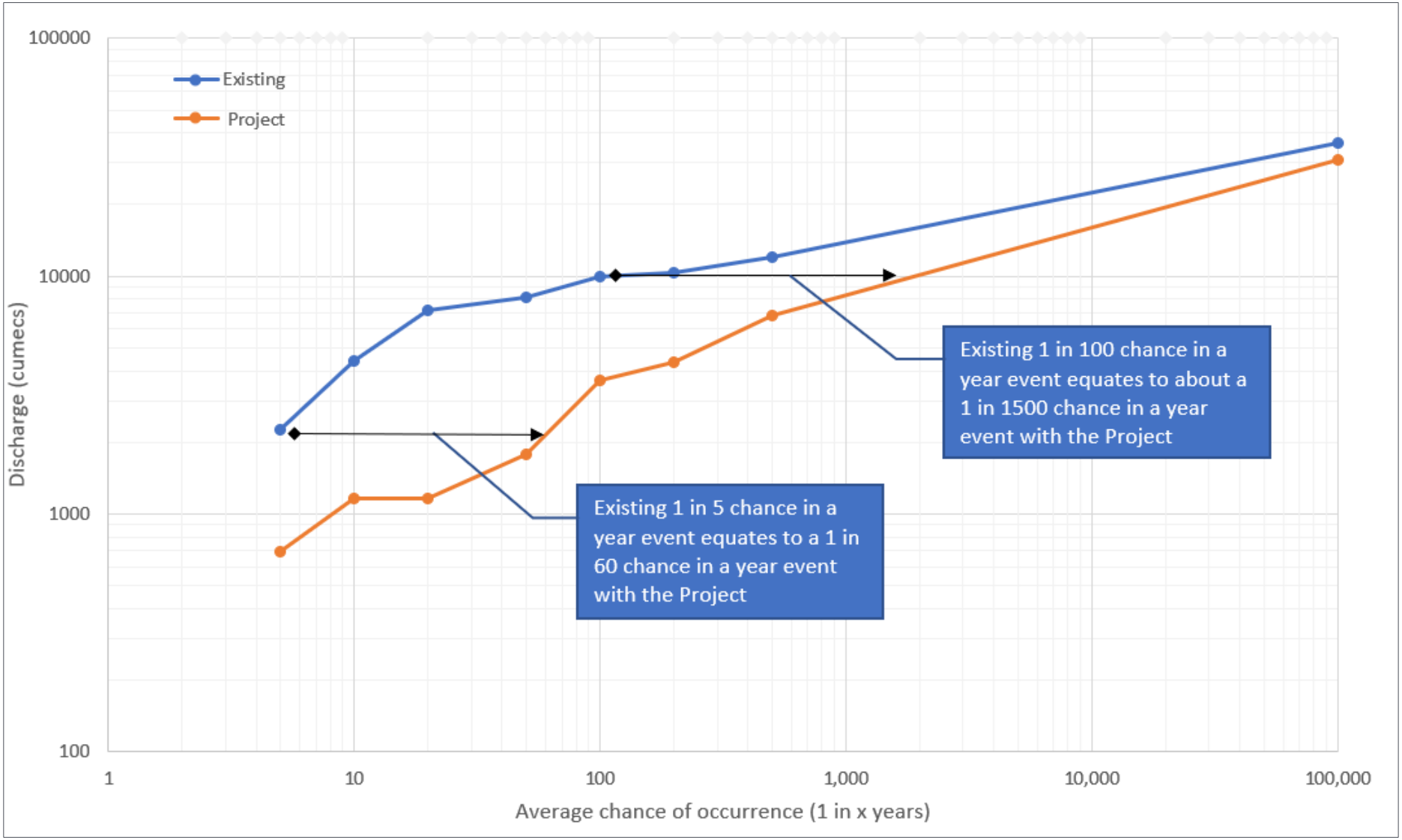
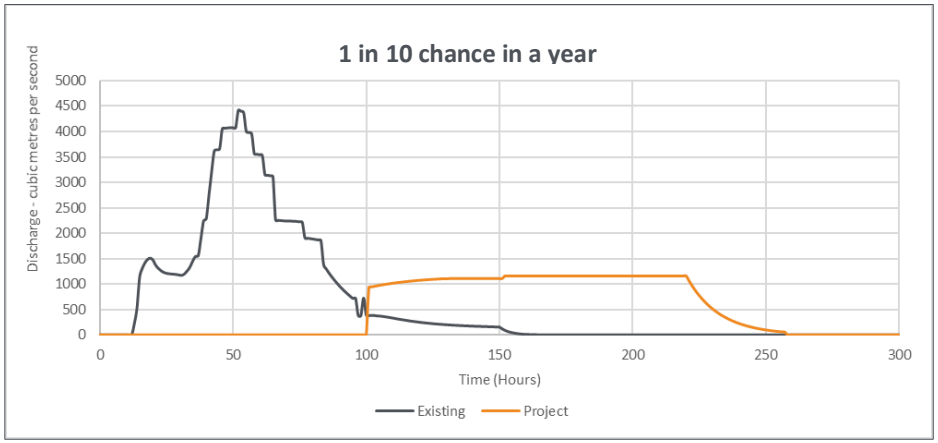


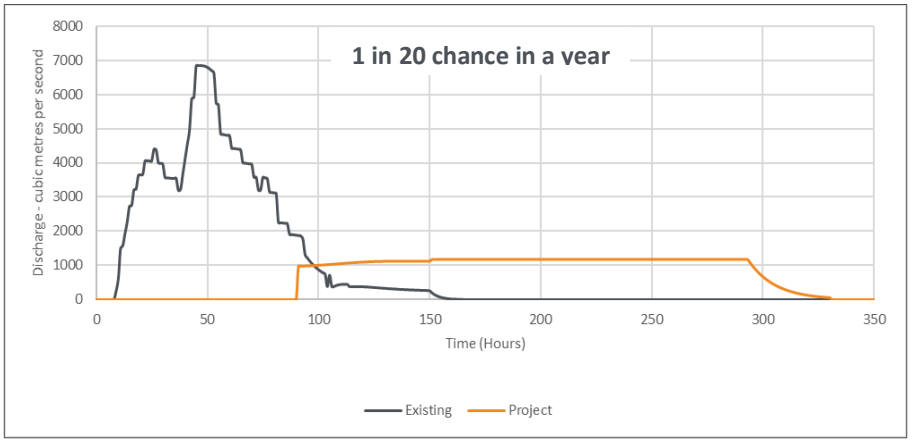
*Figure 9-2. Flood frequency distribution of dam outflows*

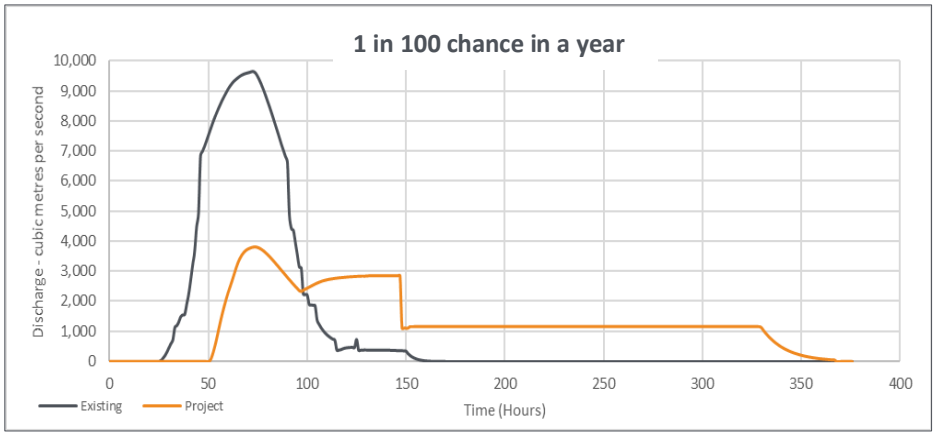


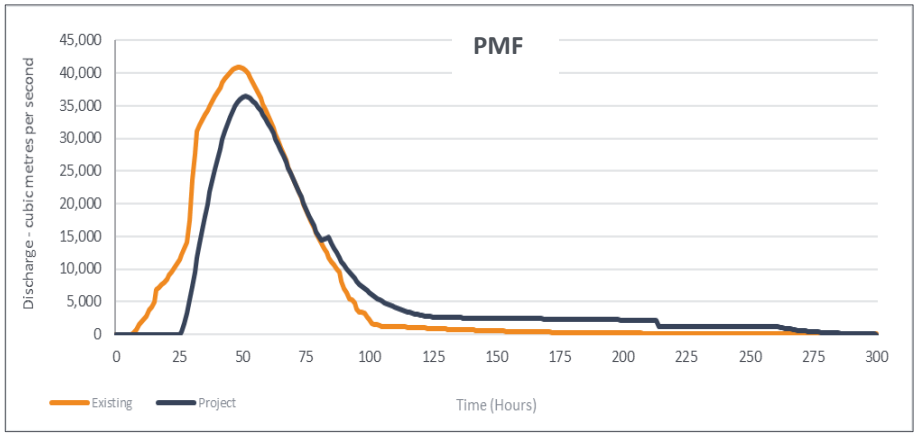

**Note:** Average exceedance probability does not apply for the PMF event

*Figure 9-3. Hydrographs: Outflows and discharge from Warragamba Dam*



## Study area

Warragamba Dam is located approximately 65 kilometres west of Sydney in a narrow gorge on the lower section of the Warragamba River, 3.3 kilometres before it joins the Nepean River. The Nepean River then becomes the Hawkesbury River at the junction of the Grose River at Yarramundi. The entire river is referred to as the Hawkesbury-Nepean River. The Project would affect areas downstream of Warragamba Dam including a short section of the Warragamba River, the Hawkesbury-Nepean River and its floodplain, and some of the tributaries of the Hawkesbury-Nepean River (such as South Creek) that experience backwater flooding affects. The Hawkesbury-Nepean catchment downstream of Warragamba dam is shown on Figure 9-4.

The extent of the downstream assessment was determined in consultation with the former Office of Environment and Heritage (OEH)[2] and former Commonwealth Department of the Environment and Energy (DoEE)[3]. The following was agreed:

- Department of Planning, Industry and Environment (DPIE): The 1 in 10 chance in a year flood event would have the greatest difference in inundation extent between the existing and Project flood scenarios. It was agreed that the 1 in 10 chance in a year flood inundation extent would represent the area for the downstream assessment. It was also agreed that survey and assessment within the downstream operational area of the Project would be truncated at the confluence of the Hawkesbury and Colo Rivers.
- DoEE: It was agreed that matters of national environmental significance would be assessed up to the existing probable maximum flood (PMF).

The downstream limit of the Project in terms of its influence on the environment, including biodiversity values, occurs around Wisemans Ferry.

Study assessment definitions are shown on Figure 9-5 and summarised below. More detailed maps are presented in Appendix F2 (see Appendix I of the report).

- **The survey area**: land within the existing 1 in 10 chance in a year flood event from Warragamba Dam to the confluence of the Colo River and Hawkesbury River, which was subject to on-ground biodiversity surveys
- **The study area**: the land within the existing probable maximum flood (PMF) from Warragamba Dam to the confluence of the Colo River and Hawkesbury River, which is the maximum scope of this ecological assessment.

The downstream biodiversity assessment focuses on the following:

- **Reduced flooding extent for 1 in 10 chance in a year event**: the areas subject to reduced inundation between the existing and Project one in 10 chance in a year event.
- **Flood mitigation zone (FMZ) discharge:** the downstream area that would be temporarily affected by inundation during emptying of the FMZ.

Consideration has also been given to potential impacts in the area defined by the existing 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 the PMF is highly unlikely to occur in nature given the collective area of the upstream catchments.

[2] OEH was dissolved on 1 February 2019 with all functions apart from heritage being transferred to the Environment, Energy and Science group within DPIE.

[3] DoEE ceased to exist 1 February 2020 when the Department of Agriculture, Water and the Environment (DAWE) commenced operation. The Environment portfolio within DoEE was incorporated into DAWE.

*Figure 9-4. Hawkesbury-Nepean catchment downstream of Warragamba Dam*

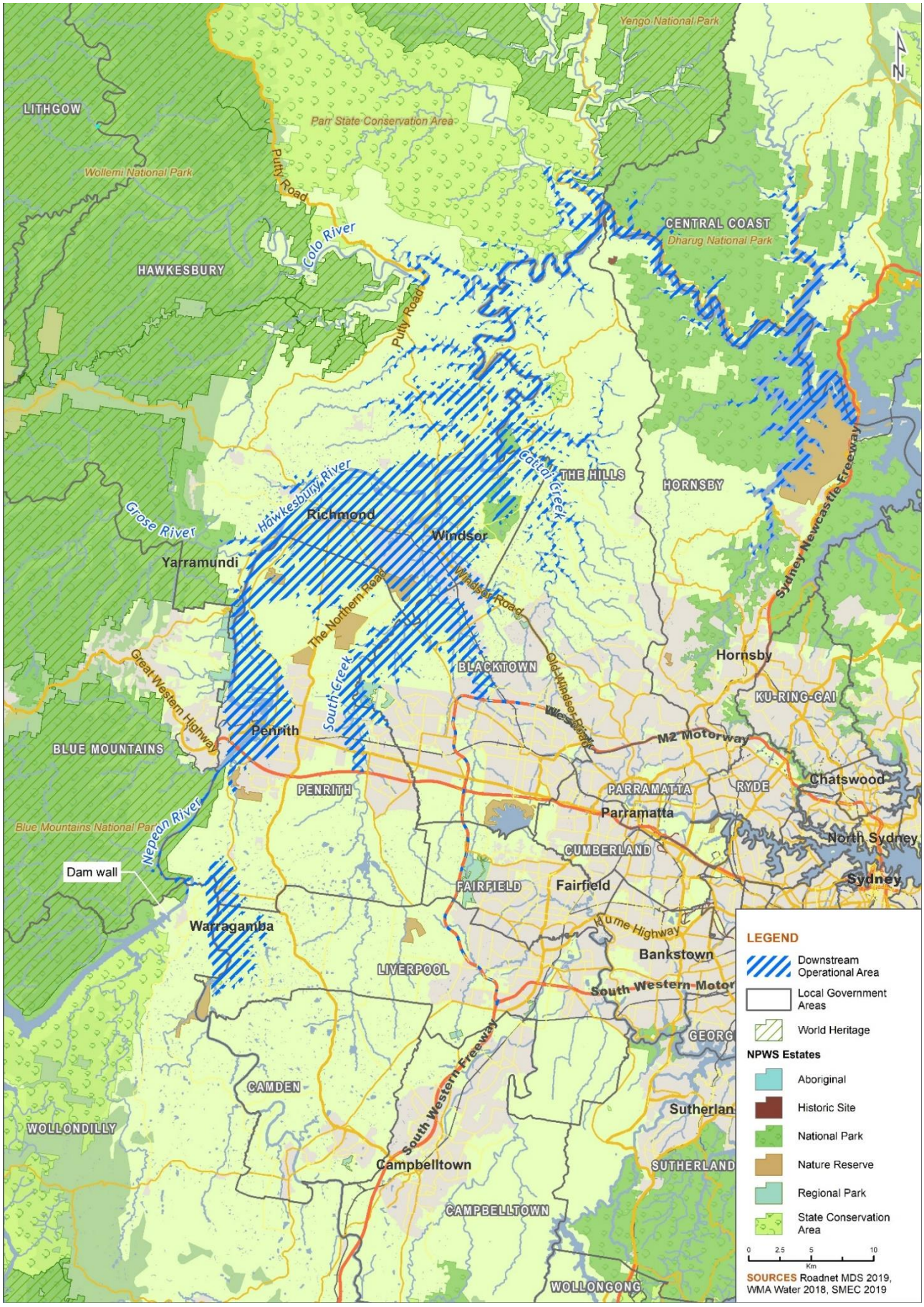
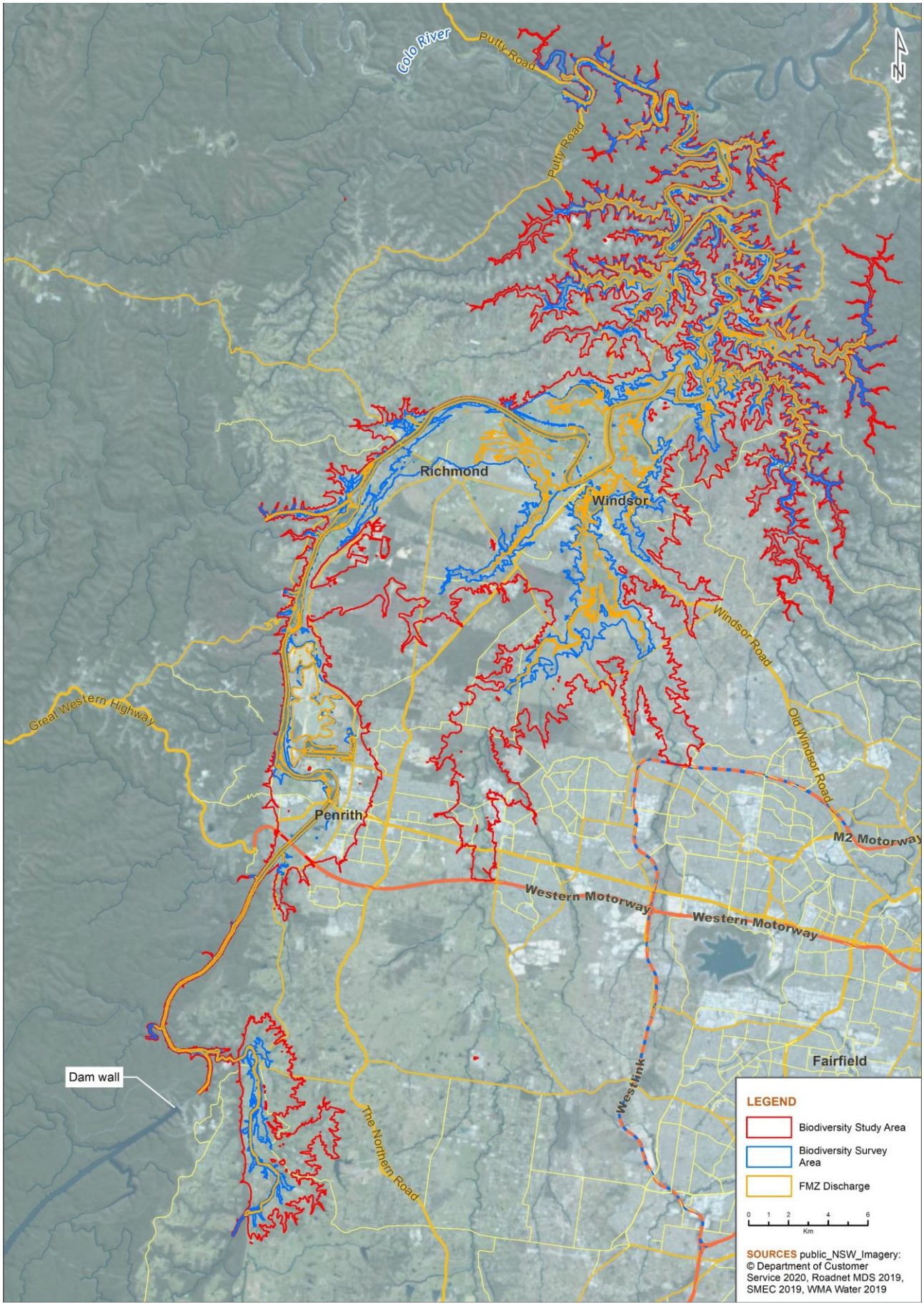


*Figure 9-5. Downstream study area*



## 9.2 Assessment methodology

### 9.2.1 Assessment requirements

Key assessment requirements are to address the requirements included in the SEARs (see Table 9-1). The assessment also addresses relevant regulatory requirements, which are discussed in Appendix F2 (Downstream ecological assessment, Section 3). Key legislation is summarised in Table 9-2.

*Table 9-2. Key legislation*

| Key legislation | |
|---|---|
| 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. |
| 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 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. |
| 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. |
| *Threatened Species Conservation Act 1995* (TSC Act) | The TSC Act was repealed when the BC Act commenced on 25 August 2017. However, the provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 provide for SSI projects to be assessed under the provisions of the TSC Act if the application for the SEARs was made prior to this date. The application was made prior to 25 August 2017 with the SEARs for the Project being issued on 30 June 2017. Updated SEARs for the Project were reissued on 13 March 2018.<br>The biodiversity assessment has been carried out in accordance with the relevant provisions of the TSC Act through the effect of the Biodiversity Conservation (Savings and Transitional) Regulation 2017. Consideration has also been given to relevant matters under the BC Act, particularly about threatened species, populations and ecological communities that may have been listed, or existing listings that may have been amended subsequent to the BC Act coming into force. |
| *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.<br>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 (amongst other types of development).<br>However, the transitional provisions of the *Biodiversity Conservation (Savings and Transitional) Regulation 2017* apply to this Project as application for the SEARs for the Project was made prior to the commencement of the new BC Act. Consequently, the Project has been assessed in accordance with the TSC Act.<br>When referring to the planning assessment provisions used for this assessment, the report uses TSC Act. When referring to threatened species, populations, or ecological community listings, this report uses the BC Act. |
| *Water NSW Act 2014* (WaterNSW Act) | In 2018, an amendment to the *Water NSW Act 2014* (WaterNSW Act) was enacted that related specifically to the Project and the potential impacts of temporary inundation on national parks and state conservation areas in the Warragamba Dam catchment. Under previous legislation, inundation of national park land was not permitted, however, the amendment of the WaterNSW Act provided a special provision to allow the temporary inundation of national park and state conservation area land in the Warragamba Dam catchment. |

| Key legislation | |
|---|---|
| | To ensure the mitigation of any impacts from temporary inundation, the special provisions also require:<br>▪ WaterNSW to prepare an Environmental Management Plan (EMP) in consultation with the Chief Executive of the OEH and NPWS if approval for the Project is given.<br>▪ The NPW Minister to determine the matters that are to be addressed by an EMP.<br>▪ The NPW Minister with the concurrence of the Minister for Water approve an acceptable EMP.<br>▪ The NPW Minister with the concurrence of the Minister for Water require an approved EMP to be updated or reviewed.<br>The NPW Minister with the concurrence of the Minister for Water may direct Water NSW to take specified actions in relation to the temporary inundation of national park land resulting from the Warragamba Dam project, including action relating to the monitoring of risks associated with the temporary inundation and relating to the rehabilitation or remediation of land.<br>WaterNSW to implement and monitor the EMPs.<br>Water NSW to notify the Chief Executive of the OEH if it is of the opinion that a flood event that may affect national park land in the vicinity of Warragamba Dam is likely to occur. |
| Other | ▪ *Fisheries Management Act 1994* (FM Act)<br>▪ *National Parks and Wildlife Act 1974* (NPW Act)<br>▪ *Wilderness Act 1987*<br>▪ *Biosecurity Act 2015*<br>▪ NSW Biodiversity Offsets Policy for Major Projects<br>▪ *Water NSW Act 2014*<br>▪ State Environmental Planning Policy No 44 - Koala Habitat Protection (SEPP 44) |

### 9.2.2 Information sources

Previous studies, reports and documentation relevant to the Project were reviewed. The main information sources are shown in Table 9-3.

*Table 9-3. Information sources*

| Information sources | |
|---|---|
| | **Data base** |
| 1 | BioNet Vegetation Classification System (OEH 2017b) |
| 2 | Spatial Information eXchange (Department of Finances and Services 2017) |
| 3 | NSW OEH Atlas of NSW Wildlife Database (OEH 2017b) |
| 4 | Atlas of Living Australia (CSIRO n.d.) |
| 5 | The Australian Virtual Herbarium (Council of Heads of Australasian herbaria n.d.) |
| 6 | Department of the Environment and Energy Protected Matters Search Tool (DoEE 2015) |
| 7 | DoEE Species Profiles and Threats database (SPRAT) (DoEE 2015) |
| | **Document** |
| | Blue Mountains National Park Plan of Management (National Parks and Wildlife Service (NPWS 2001) |
| 8 | Castlereagh, Agnes Banks and Windsor Downs Nature Reserves Plan of Management (NPWS 1999) |
| 9 | Cattai National Park Plan of Management (NPWS 1997) |
| 10 | Scheyville National Park Conservation Management Plan (NPWS 2009a) |
| 11 | Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 - Background Report (DECC 2007) |
| 12 | Warragamba Dam Raising Preliminary Environmental Assessment (BMT WBM Pty Ltd 2016)) |
| 13 | Yellomundee Regional Park Plan of Management (NPWS 2009b). |
| 14 | Other documents used are referenced where relevant. |

### 9.2.3 Database analysis

A search of relevant databases was undertaken to identify:

- records of all threatened species, populations, and ecological communities up to a two-kilometre distance from the edge of the study area
- additional listed areas of ecological importance, key habitat features, vegetation communities and aquatic habitat
- all current and preliminary listings under the BC Act, FM Act and EPBC Act.

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 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 assessed for each threatened entity: known, high, moderate, low and none. The criteria by which each rating was assessed are described in Table 9-4. The assessments of likelihood of occurrence are provided in Appendix F2 (Downstream ecological assessment report, Appendix A).

*Table 9-4. Likelihood of occurrence ratings and criteria*

| Likelihood rating | Rating criterion |
|---|---|
| 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. |

### 9.2.4 Vegetation mapping and flora surveys

#### 9.2.4.1 Introduction

Prior to the commencement of vegetation surveys, a comprehensive review of previously conducted vegetation mapping was undertaken. The most relevant mapping comprised:

- *Remnant Vegetation of the western Cumberland subregion 2013 Update. VIS_ID 4207* OEH (2015): 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 mapsheet* (OEH 2018): Covers the study area north of Sackville and along the Colo River
- *The Native Vegetation of Yengo and Parr Reserves and Surrounds* (DECC 2009): Covers the area north of the Colo River.

The assessment methodology involved:

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

#### 9.2.4.2 Vegetation mapping

Vegetation maps and data available from the VIS Classification Database were used to identify vegetation units within the study area, which were then aligned to an equivalent plant community type (PCT). 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.

Based on the minimum plot requirements specified in the Framework for Biodiversity Assessment (FBA, Table 1), plots/transect locations were located across the study area, which were mostly in national parks, conservation reserves and public land. Field surveys involved collecting plot and transect data within each PCT and condition class (vegetation zones). A total of 101 plot/transects were completed across the study area as shown on Figure 9-6. Data collected are shown in Table 9-5.

*Table 9-5. Vegetation survey data collection*

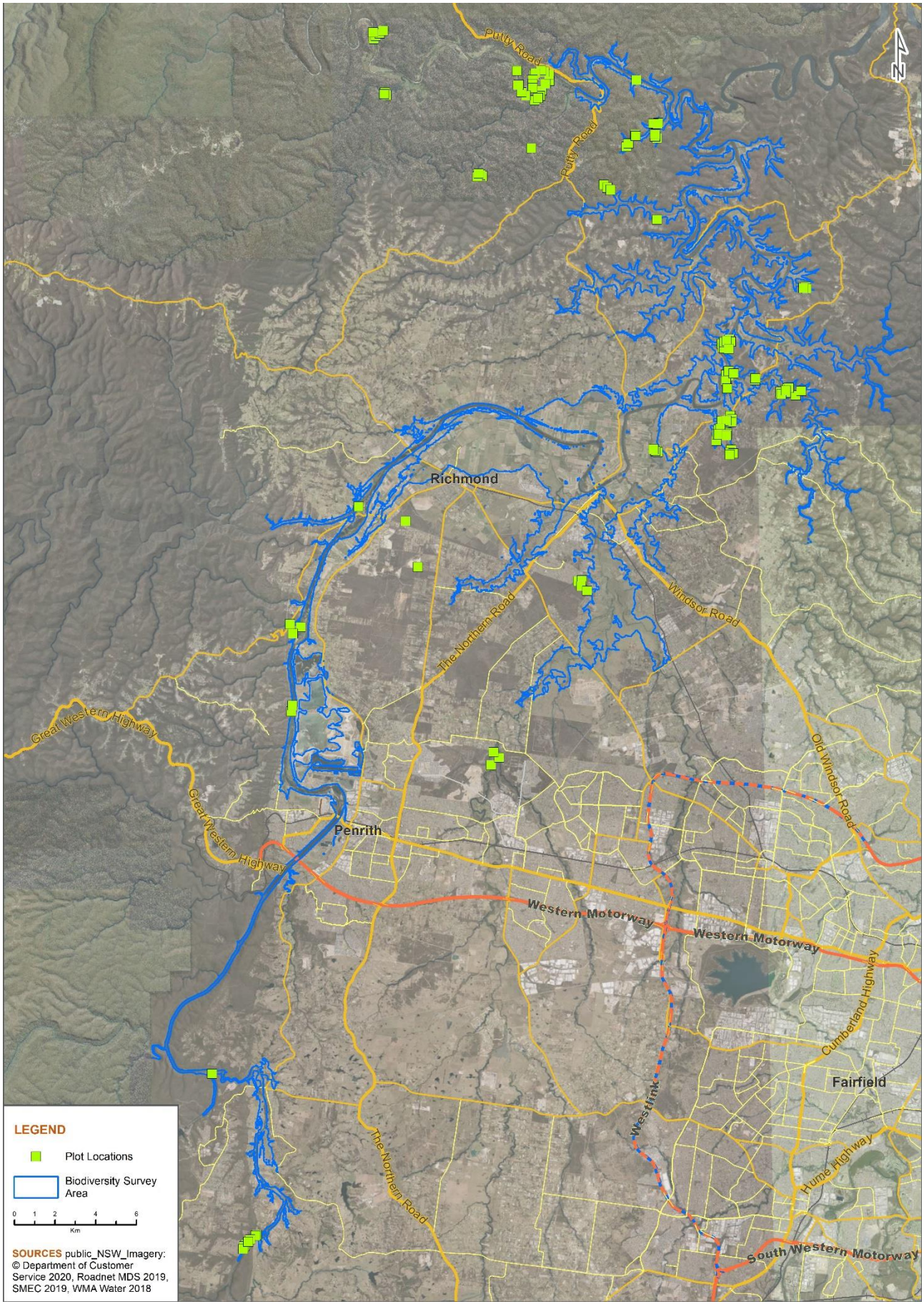
| | Vegetation survey data collection |
|---|---|
| 1. | FBA data for 20 x 20 m floristic plots:<br>▪ Stratum (and layer): stratum and layer in which each species occurs.<br>▪ Growth form: growth form for each recorded species.<br>▪ Species name: scientific name and common name.<br>▪ Cover: a measure or estimate of the appropriate cover measure for each recorded species.<br>▪ Abundance rating: a relative measure of the number of individuals or shoots of a species within the plot. |
| 2. | Biometric data for plots/transects:<br>▪ Native species richness recorded within each stratum of a 20 x 20 m sub-plot.<br>▪ Native overstory cover recorded at 10 points along a 50 m transect.<br>▪ Native midstorey cover recorded at 10 points along a 50 m transect.<br>▪ Native ground cover recorded at 50 points along a 50 m transect for three life forms (shrubs, grasses, and other).<br>▪ 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).<br>▪ Number of trees with hollows visible from the ground within the 20 x 50 m plot.<br>▪ The total length of fallen logs greater than 10 cm in diameter within the 20 x 50 m plot.<br>▪ The proportion of regenerating overstory species within the vegetation zone. |

Vegetation maps identified 21 PCTs that are stratified across six different condition classes, which are shown on maps in Appendix F2 (Downstream ecological assessment, Appendix I). Where applicable, PCTs were matched to corresponding threatened ecological communities. A description of the finalised vegetation condition classes is given in Table 9-6.

*Table 9-6. Vegetation condition classes*

| Vegetation condition class | Description |
|---|---|
| **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 (eg. residential gardens). |

*Figure 9-6. Locations of plot/transect surveys*



#### 9.2.4.3 Threatened flora surveys

Targeted threatened flora surveys were conducted 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)* (Department of Environment and Conservation (DEC, 2004). Around 200 hours of threatened flora transects and random meanders were completed between November 2017 and February 2018. Most species fall within the recommended survey times as per Bionet except for *Dillwynia tenuifolia* (August to October inclusive) and *Epacris purpurascens* var. *purpurascens* (September to October inclusive).

The survey effort comprised:

- targeted walking meanders through habitat types and PCTs associated with threatened species within the study area. Targeted threatened species are listed in Appendix F2 (Section 4.2.5)
- threatened flora population counts for *Acacia pubescens*
- recording of *Dillwynia tenuifolia* individuals.

Survey limitations are discussed in Appendix F2 (Downstream ecological assessment, Section 4.5) and include restricted access to private property, large extent of the study area, weed coverage and difficulty in differentiating condition classes.

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 was prepared by Dr Peter Weston and is presented in Appendix F2 (Downstream ecological assessment, Appendix J).

Final vegetation mapping was done using survey information, aerial photography, and interpretation of landscape information, such as soil profiles.

### 9.2.5 Fauna survey

A fauna habitat assessment was undertaken to:

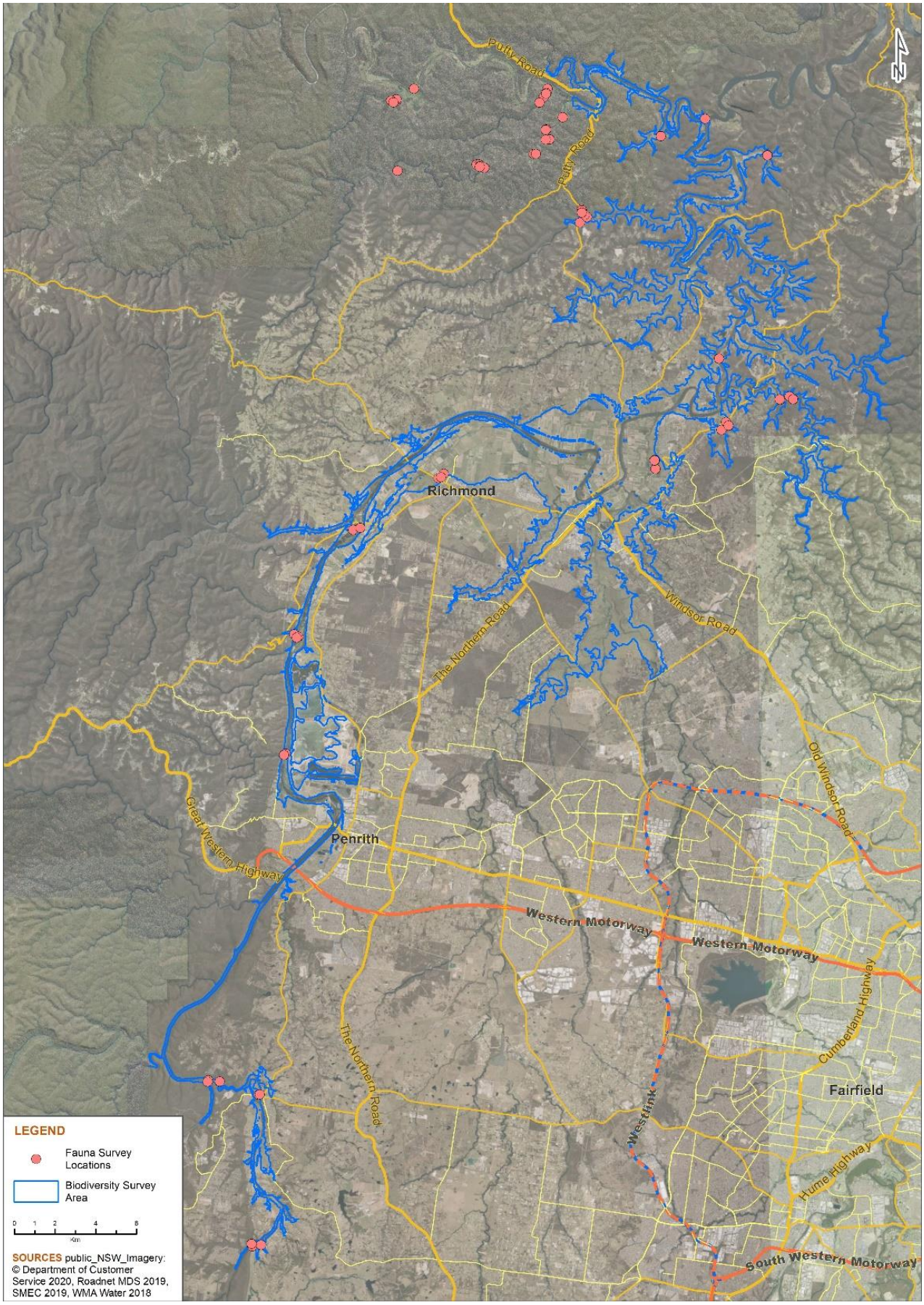
- assess the likelihood of presence of threatened fauna species
- assess habitat characteristics including the presence of hollow bearing trees, fallen logs, leaf litter and other ground debris, drainage lines, ponds, the structure of vegetation communities and the presence of fruiting/flowering plant species to assess the habitat suitability for a range of fauna species
- search 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
- record habitat information at each sampling site including: 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 human-made habitats.

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 specific reference to the size of the survey sites, broad scale vegetation communities and major sampling stratification units.

The fauna habitat assessment was completed between January and April 2018. Weather conditions are discussed in Appendix F2 (Downstream ecological assessment, Section 4.4). Survey locations are shown in Figure 9-7 with survey effort comprising the following:

- Infrared cameras and hair funnels: Four infrared camera traps and hair funnels were placed in two locations to target nocturnal and diurnal ground-dwelling mammalian fauna.
- Microchiropteran bat surveys: Ultrasonic call detectors were deployed at six sites, over a period of two nights. Locations were chosen as having suitable flyways to maximise the potential for bat detection.
- Diurnal bird surveys: Surveys were undertaken for both woodland and wetland birds, targeted wetlands and vegetation along the Hawkesbury River. Dawn and dusk bird surveys were undertaken at 11 sites.
- Nocturnal spotlight surveys and call playback: Call playback and spotlight searches were undertaken at three sites. Calls played during the survey included the Australasian Bittern (*Botaurus poiciloptilus*) and Eastern Grass Owl (*Tyto longimembris*).

*Figure 9-7. Fauna survey locations*



- Koala scat assessment: The Koala Spot Assessment Technique (KSAT) was used to derive a measure of koala activity. Three KSAT sites were surveyed and 30 trees were sampled at each site. Three sites were surveyed on 11 and 12 April 2018.
- Incidental Observations: Any incidental vertebrate fauna species detected were recorded.

A summary of survey effort is presented in Table 9-7.

*Table 9-7. Summary of fauna survey effort*

| Survey type | Target species | Dates | Survey effort |
|---|---|---|---|
| Infrared cameras | Spotted-tail Quoll, Southern Brown Bandicoot | 11/4/18 – 1/6/18 | 408 trap nights |
| Hair funnels | Southern Brown Bandicoot | 11/4/18 – 1/6/18 | 112 trap nights |
| Ultrasonic call detection | Large-eared Pied Bat, Southern Myotis | 17/1/18 – 12/4/18 | 30 nights |
| Diurnal bird surveys | Curlew Sandpiper, Blue-billed Duck, Black Bittern, Australian Painted Snipe, Freckled Duck, Magpie Goose | 17/1/18 – 10/4/18 | 24 hours, 48 mins |
| Call playback and spotlighting | Eastern Grass Owl, Australasian Bittern | 9/4/18 – 13/4/18 | 14 hours |
| KSAT | Koala | 11/4/18 – 12/4/18 | 3 sites (90 trees) |

## 9.3 Existing environment

### 9.3.1 Introduction

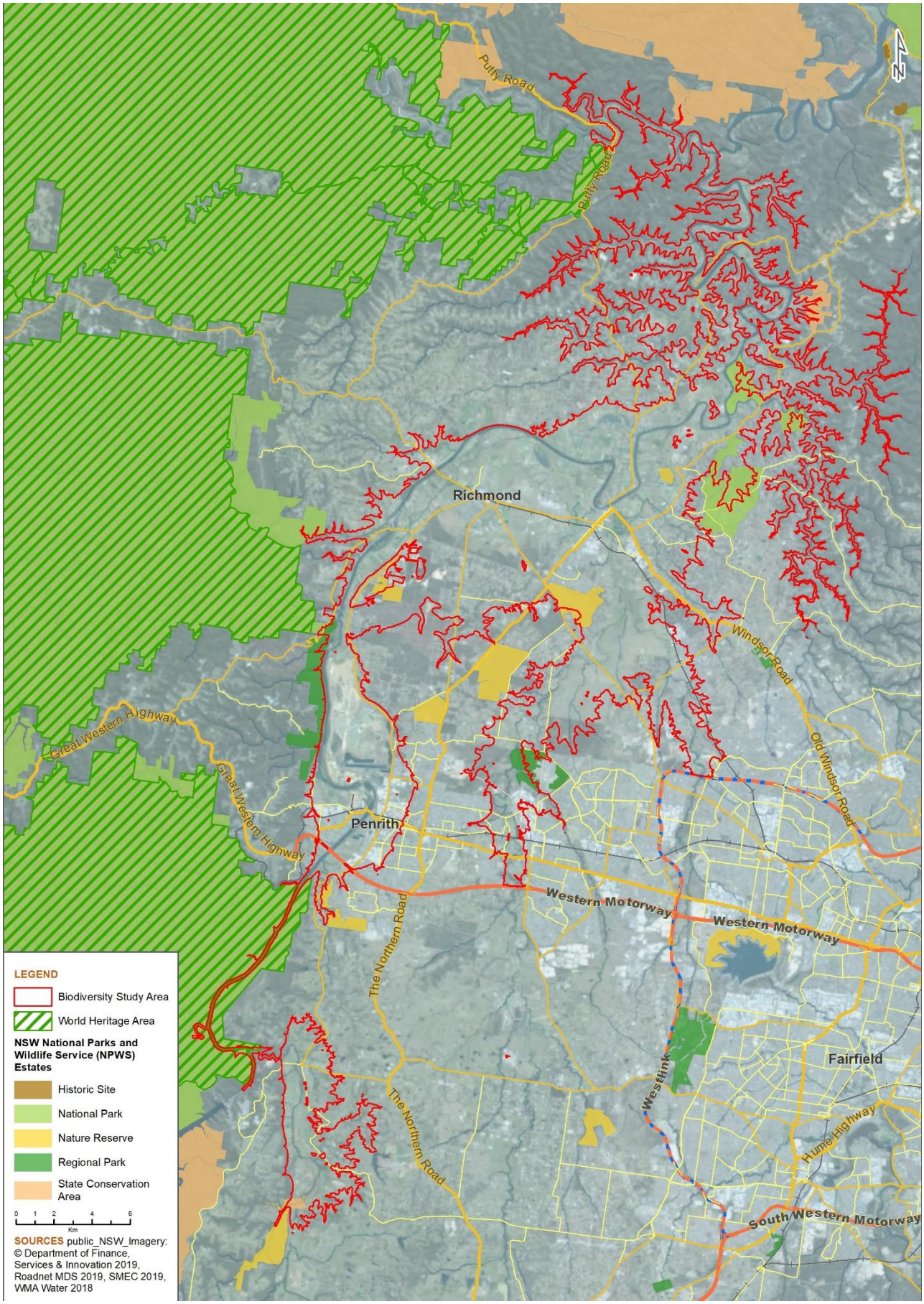
The Hawkesbury-Nepean River system covers approximately 21,400 square kilometres, from Lithgow in the west, Goulburn in the south, the Illawarra escarpment in the south-east and Gosford in the north ((DPIE, n.d.). Downstream of Warragamba dam the catchment covers approximately 12,350 square kilometres, of which the study area comprises the floodplain area of approximately 500 square kilometres (see Figure 9-5, Section 0). The catchment 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, and is known as having biological diversity.

The study area is within the Sydney Basin Bioregion (Interim Biogeographic Regionalisation for Australia - IBRA) and comprises three IBRA subregions; Cumberland, Yengo and Wollemi. There are varying landforms, from the Cumberland lowlands, north to the foot slopes of the Hornsby Plateau, Blue Mountains Plateau, and Macdonald Ranges. Most of the study area is characterised by a relatively uniform landform with undulating rises and alluvial flats. The topography is relatively flat, ranging from approximately 50 metres AHD to 88 metres AHD.

Conservation areas within and surrounding the study area are shown on Figure 9-8. National park areas including a portion of the Greater Blue Mountains World Heritage Area (GBMWHA) occur within the downstream catchment and are mostly located on the western and northern borders of the study area and within the sub-catchments of the Grose, Colo and Macdonald Rivers. Lands listed under the *National Parks and Wildlife Act 1974* that occur in the study area include:

- 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

*Figure 9-8. Conservation areas within and surrounding the downstream study area*



River reaches downstream of Warragamba Dam have been significantly modified since European settlement. A large urban area is centred around Penrith on the eastern side of the Hawkesbury-Nepean River, with numerous smaller urban areas along the length of the river to Pitt Town. Between these centres are agricultural areas, which occur on both sides of the Hawkesbury-Nepean River and in the sub-catchments of South Creek and Cattai Creek.

The mean annual rainfall varies considerably across the catchment, ranging from 542 millimetres at Warragamba, 628 millimetres at Sackville, 751millimetres at Lower Portland and 799 millimetres at Richmond (BOM, 2018).

### 9.3.2 Geology and soils

The Sydney Basin dominates the Hawkesbury-Nepean catchment with the Narrabeen Group and Hawkesbury sandstone subgroups covering most of the region. Underlying substrates that occur within the study area include:

- 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.

Seventeen soil landscapes have been identified using the eSPADE database (OEH, 2019), which are summarised in Table 9-8 and shown on detailed maps provided in Appendix F2 ( Downstream ecological assessment report, Appendix I).

*Table 9-8. Soil landscape descriptions*

| Soil landscape | Description |
|---|---|
| Agnes Banks | Low parallel sand dunes deposited on a flat Tertiary terrace. Local relief to 7 m, slopes generally less than 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 sedgeland 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 greater than 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 less than 10 m, slopes less than 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 less than 5%. The original vegetation has been completely cleared. |
| Falconbridge | Level to gently undulating crests and ridges on plateau surfaces of the Hawkesbury Sandstone.<br>Local relief less than 20 m, slopes less than 5%. Infrequent rock outcrop. Partially cleared eucalypt woodland. |
| Freemans Reach | Current active floodplain of the Nepean River. Level with minor (less than 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). |

| Soil landscape | Description |
|---|---|
| Gymea | Undulating to rolling rises and low hills on Hawkesbury Sandstone. Local relief 20–80 m, slopes 10-25%. Rock outcrop less than 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. |
| Hawkesbury | Rugged, rolling to very steep hills on Hawkesbury Sandstone. Local relief 40-200 m; slopes greater than 25%. Rock outcrop greater than 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 greater than 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 less than 1%). Splays and levees provide local relief (less than 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 less than 10 m, slopes less than 5%. Soils are deep (greater than 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 (between 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 less than 5 m; slopes are generally less than 5%. Elevation less than 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 less than 10%. Extensively to completely cleared low Eucalypt open-forest and low Eucalypt woodland with a sclerophyll shrub understorey. |

### 9.3.3 Hydrology

Downstream hydrology and flooding are addressed in Chapter 15 (Flooding and hydrology) and summarised below.

#### 9.3.3.1 River characteristics

The downstream catchment is shown on Figure 9-9 and comprises the Hawkesbury-Nepean River and several important sub-catchments including the Grose and Colo rivers, and South and Cattai creeks. The Hawkesbury-Nepean River system is a drowned river valley resulting from the last sea level rise during the Holocene period. This defines the pattern of flooding between confined sandstone gorges interspersed with alluvial floodplains. Hydrology of the Hawkesbury-Nepean River system has been highly modified due to the construction and operation of water supply dams including Warragamba, Avon, Cordeaux, Nepean, Cataract and the Cascades dams.

The *Coastal Management Act 2016* and State Environmental Planning Policy (Coastal Management) 2018 identify some 'coastal wetlands areas' and 'proximity to coastal wetlands' within the study area, north from Agnes Banks. These are shown on Figure 9-10.

*Figure 9-9. Downstream Hawkesbury-Nepean river system*

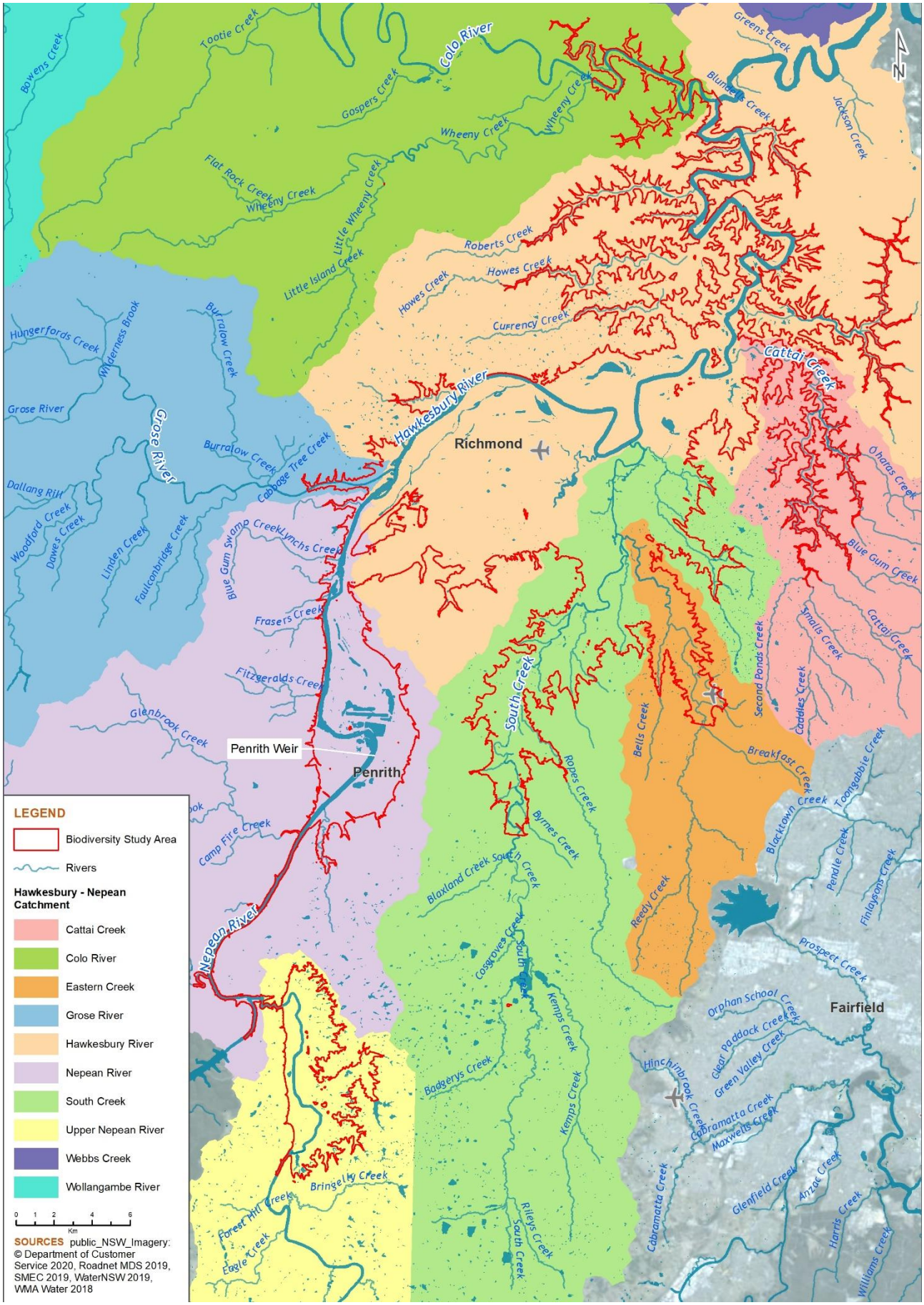
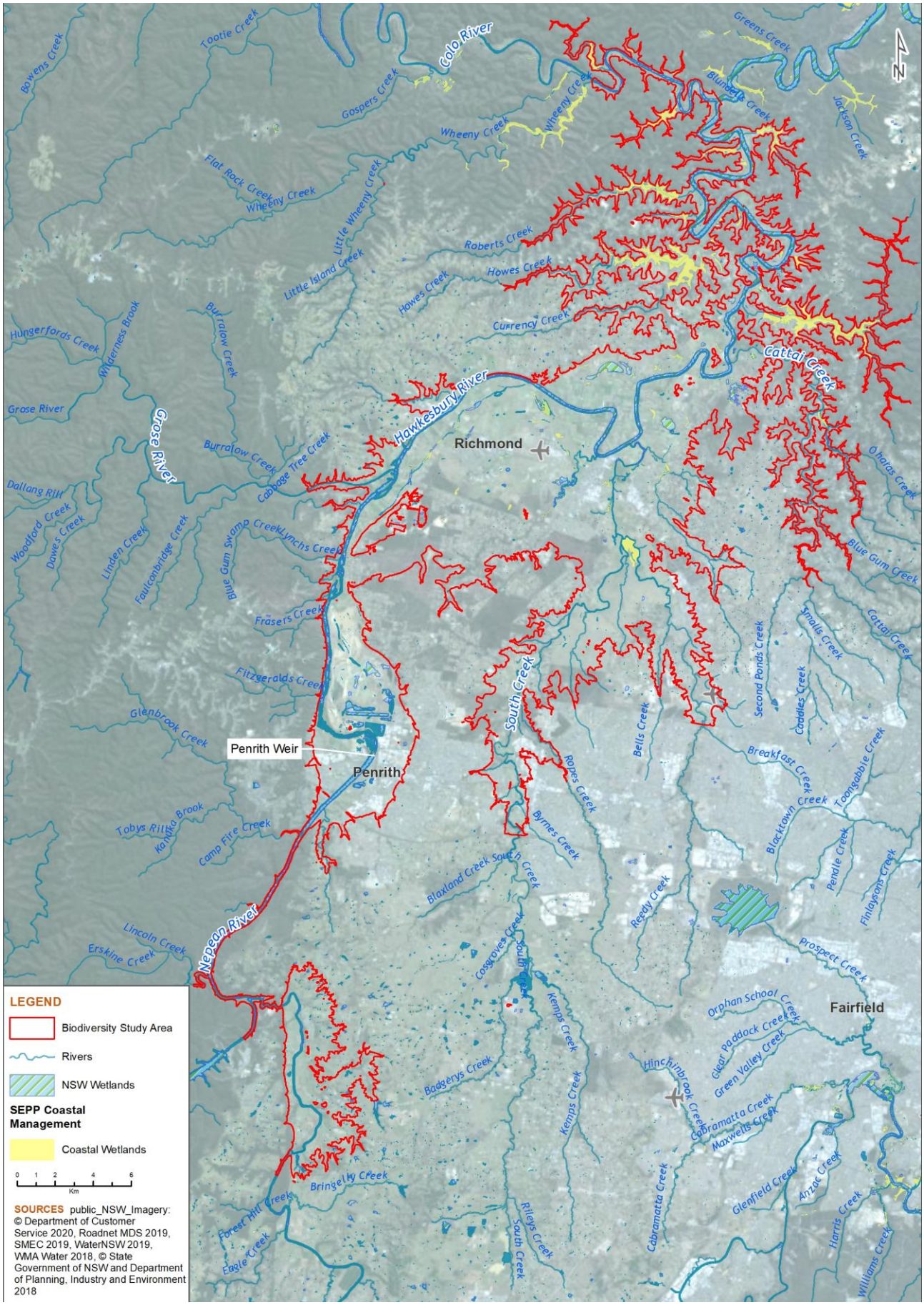


*Figure 9-10. Downstream wetland areas*



The Hawkesbury-Nepean River downstream of the Warragamba River junction has 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 the clearing of riparian vegetation (BMT WBM Pty Ltd, 2016). This has resulted in localised areas of bank instability, which has been further 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 impact of urbanisation along the river and land use changes across the floodplain have altered geomorphic features and river flow characteristics. Between Yarramundi and Windsor, the Hawkesbury River is wide and shallow with numerous shoals restricting navigability. This segment of river is also notably straighter than the other downstream river reaches and includes lagoons and wetlands across the floodplain and lowlands. The channel form and bank stability of this stretch of the river are largely influenced by the persistent low flows in the Hawkesbury River. Further downstream, between Cattai and Wisemans Ferry, the floodplain is narrow (typically less than 400 metres wide) and mostly non-existent where the river channel is bedrock-controlled and characterised by steep sandstone gorges.

Hydrological features along the river are further discussed and mapped in Appendix F2 (Downstream ecology assessment, Section 1.5 and Appendix I).

#### 9.3.3.2 Flooding

Flooding in the Hawkesbury-Nepean Valley is complex due to numerous tributaries and their catchments that contribute to floods. Floodwaters from these tributaries back up behind natural choke points created by narrow sandstone gorges, which can cause rapid, deep and widespread flooding (INSW 2019).

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.

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 seven 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 Valley 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.

### 9.3.4 Land use

The downstream study area includes the local government areas of Camden, Blue Mountains, Penrith, Blacktown, The Hills and Hawkesbury. Various local environmental plans (LEPs) include RU2 Rural Landscape; E1 National Parks and Nature Reserves; E3 Environmental Conservation; R5 Large Lot Residential and RE2 Private Recreation. The downstream study area includes natural protected areas, urban developments, and agricultural areas. Some areas have been identified for future medium to high density residential development.

Land use within the study area is shown on detailed maps in Appendix F2 (Downstream ecological assessment, Appendix I). Land use is also addressed in Chapter 21 (Socio-economic, land use and property).

### 9.3.5 Flora

#### 9.3.5.1 Introduction

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 due to historical land use practices such as agriculture and, more recently, urban development. Consequently, most 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 has been previously cleared, disturbed or dominated by exotic vegetation. Broad scale vegetation mapping for the study area is shown in Figure 9-11, with detailed mapping provided in Appendix F2 (Downstream ecological assessment, Appendix I).

Most of the remaining native vegetation on the Cumberland Plain is listed as a threatened ecological community (TEC) under State and Commonwealth legislation. Much of this vegetation shows evidence of disturbance, such as weed invasion, resulting in alterations to vegetation structure and floristics. However, more intact areas exist in small pockets. Vegetation communities on the Cumberland Plain are primarily driven by substrate and landform/drainage patterns and generally include:

- Grassy woodlands dominated by *Eucalyptus tereticornis* and *Eucalyptus moluccana* occur on clay substrates on rolling hills above the water table.
- Castlereagh woodland communities occur on tertiary alluvium soil landscapes of varying drainage.
- River-flat forests occur on alluvial soils adjacent to creek lines.
- *Banksia* dominated heath communities occur on small pockets of aeolian sands, which are typical of coastal areas.
- Dry rainforest occurs in gullies, however, much of this vegetation type has now 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:

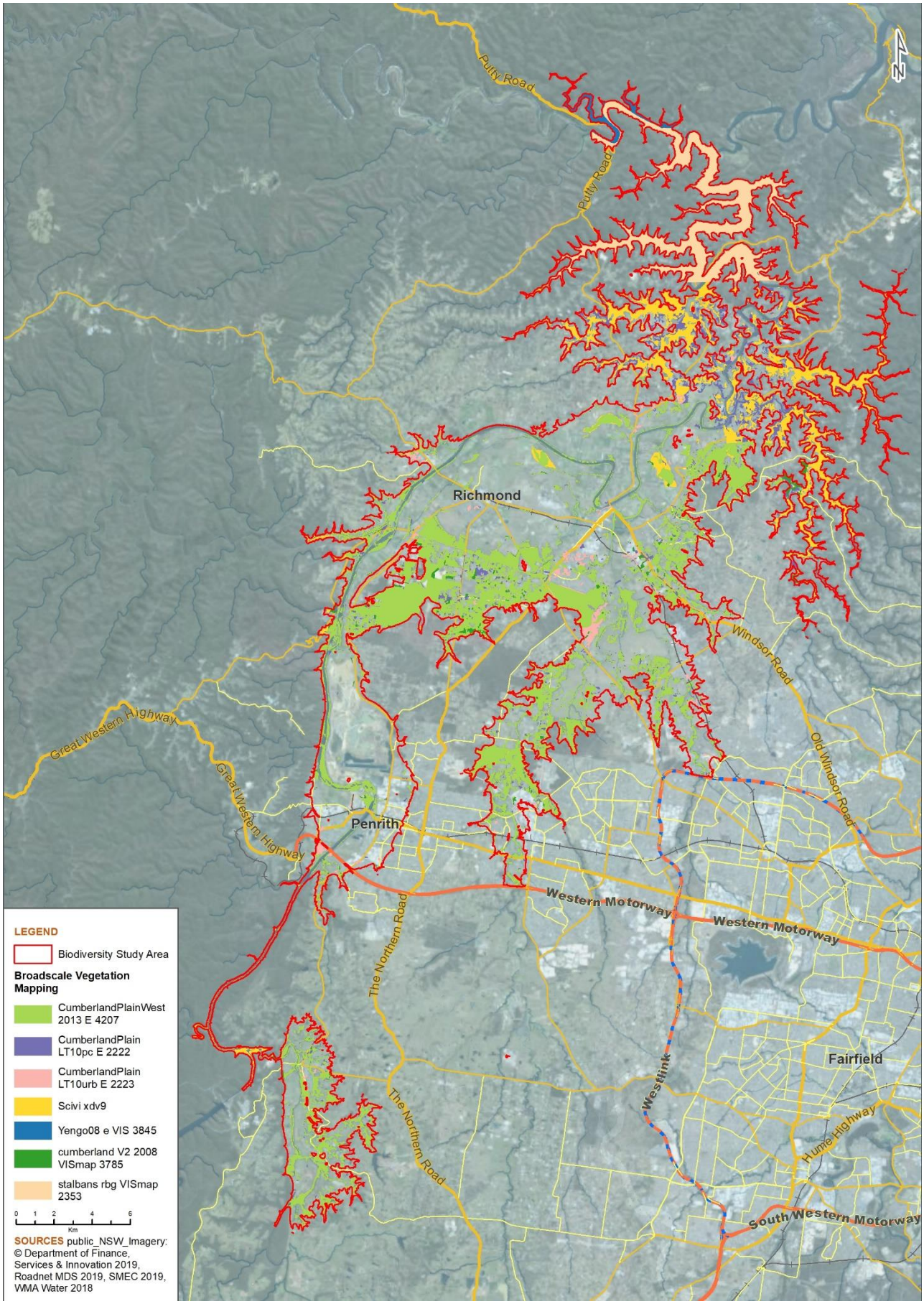
- Where the landscape is comprised of sandstone: sandstone heath, woodland, and forest communities are present and species composition and structure are driven by exposure, aspect and landscape position.
- Sheltered forests typically occur on south facing slopes and within gullies.
- Woodland and heath 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 due to 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. The highly 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.

Flora species are presented in Appendix F2 (Downstream ecological assessment, Appendix D). Field surveys identified a total of 422 species, of which 75 were identified as locally non-native.

*Figure 9-11. Broadscale mapping of intact vegetation within the downstream study area*



#### 9.3.5.2 Vegetation and habitat connectivity

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. 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 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 the agriculture, rural residential development and other suburban developments.

#### 9.3.5.3 Vegetation communities (Plant Community Types) and vegetation zones

Twenty-one (21) Plant Community Types (PCTs) were identified within the survey area, which are shown on Figure 9-12 and summarised in Table 9-9. 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-local invasive species. Large extents of the survey area have previously been cleared for agriculture and development creating large modified areas.

As outlined in Section 9.2.3, 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-local 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.

#### 9.3.5.4 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 F2 (Downstream ecological assessment, Appendix A). The database analysis identified 14 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, nine TECs have been assessed as occurring within the 1 in 10 chance in a year flood. Ten (10) of the PCTs assessed as occurring in the 1 in 10 chance in a year flood are components of the identified TECs. The PCT/TEC associations relevant to the vegetation in the survey area are shown on Figure 9-13 and listed in Table 9-10.

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.

#### 9.3.5.5 Threatened flora species

Review of existing studies and database analysis identified 126 threatened flora species as potentially occurring within the study area. A likelihood of occurrence assessment is provided in Appendix F2 (Downstream ecological assessment, Appendix A), which identified 40 threatened flora species as being recorded during the site survey or as having a moderate or higher likelihood of occurring in the study area. Of these, seven species were found during field surveys. Threatened flora species recorded or potentially occurring in study area are shown on Figure 9-14 and listed in Table 9-11.

*Table 9-9: Plant community types (PCTs) within the study area*

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 1067<br>HN562 | **Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion**<br>**Distribution within the study area:** This community has been mapped with a private property at Windsor Downs likely along a drainage depression. This PCT was not ground-truthed during the vegetation surveys.<br>**Condition and presence of weeds:** One condition class<br>▪ 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. | **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 story species are likely to include *Melaleuca decora, Melaleuca nodosa, Pultenaea villosa, Acacia longifolia, Goodenia umbellata, Schoenus apogon, Centella asiatica and Cheilanthes sieberi* subsp. *sieberi*.<br>**Conservation status:** Castlereagh Swamp Woodland Community (BC Act). | 3.6 |
| PCT 1106<br>NR223 | **River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion**<br>**Distribution:** Occurs mainly to the north of the study area along the banks of the upper Colo River.<br>**Condition and presence of weeds:** Four condition classes<br>▪ Moderate/good_good: Consisting of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout<br>▪ 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 grandifolium* (Balloon vine) and *Lantana camara* (Lantana)<br>▪ 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<br>▪ Moderate/good_derived: An open vegetation structure occurs with a high proportion of regenerating species native to this community. Weed management and in-fill planting would be required to sustain this condition class. | **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, Callistemon viminalis, Microlaena stipoides, Centella asiatica, Pratia purpurascens* and *Cynodon dactylon*.<br>**Conservation status:** None listed. | 151.3 |
| PCT 1181<br>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.**<br>**Distribution:** Occurs along sandstone gullies on the edge of the Cumberland Plain.<br>**Condition and presence of weeds:** Three condition classes<br>▪ Moderate/good_good: Consists of an intact canopy and midstorey with a moderately native groundcover. Some locally non-native species occur scattered throughout | **Structure/characteristics:** A forest community with a canopy dominated by *Angophora costata*, *Corymbia gummifera*, and *Eucalyptus piperita*. Common lower story species include *Banksia serrata, Persoonia linearis, Persoonia Levis, Phyllanthus hirtellus, Leptospermum trinervium, Entolasia stricta, Pteridium esculentum, Dianella caerulea and Smilax glyciphylla.*<br>**Condition and presence of weeds:** Three condition classes | 385.8 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| | ▪ 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)<br>▪ 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. | |
| PCT 1183<br>HN587 | **Smooth-barked Apple – Sydney Peppermint – Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** Two condition classes<br>▪ 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<br>▪ 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). | **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.*<br>Conservation Status: Not listed. | 12.8 |
| PCT 1284<br>HN606 | **Turpentine – Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion.**<br>**Distribution**: Occurs mainly the south of the Colo River within sheltered sandstone slopes and the gullies of Greens Swamp.<br>**Condition and presence of weeds:** Three condition classes<br>▪ 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<br>▪ 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)<br>▪ 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. | **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*.<br>**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 1 in 10 chance in a year. | 36.1 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 1292<br>HN607 | **Water Gum – Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** One condition class<br>▪ Moderate/good_good. Consists of an intact canopy and midstorey with a moderately native groundcover. Some locally non-native species occur scattered throughout. | **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*.<br>**Conservation status:** Not listed. | 7.1 |
| PCT 1327<br>HN612 | **Yellow Bloodwood – Ironbark shrubby woodland of the dry hinterland of the Central Coast, Sydney Basin Bioregion**<br>**Distribution:** This PCT has been mapped as occurring towards middle Colo, along the gullies and slopes of Wheeny Creek.<br>**Condition and presence of weeds:** One condition class<br>▪ 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 | **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 stricta* and *Hardenbergia violacea*.<br>**Conservation status:** Not listed. | 0.8 |
| PCT 1328<br>HN613 | **Yellow Bloodwood – Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast, Sydney Basin Bioregion.**<br>**Distribution:** 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.<br>**Condition and presence of weeds:** One condition class<br>▪ Moderate/good_good. The extent of the community within the study area likely consist of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species are likely to occur scattered throughout the community. | **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 umbellate and Pteridium esculentum*.<br>**Conservation status:** Not listed. | 0.4 |
| PCT 1385<br>HN577 | **Rough-barked Apple – Grey Gum grassy open forest of the hinterland hills of the Central Coast, Sydney Basin Bioregion**<br>**Distribution:** 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.<br>**Condition and presence of weeds:** Three condition classes<br>▪ Moderate/good_good: Consists of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout<br>▪ Moderate/good_medium: A native canopy exists with a midstorey and groundcover consisting of a mix of native and introduced species. Common weeds include | **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 Pratia purpurascens.*<br>**Conservation status:** Not listed. | 35.8 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| | *Cardiospermum grandifolium* (Balloon vine), *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet), and *Lantana camara* (Lantana)<br>▪ 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. | | |
| PCT 1395<br>HN556 | **Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland plain, S–dney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** Four condition classes<br>▪ 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<br>▪ 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)<br>▪ 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<br>▪ Moderate/good_derived: An open vegetation structure occurs with a high proportion of regenerating species native to this community. Weed management and in-fill planting would be required to sustain this condition class. | **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 *Eucalyptus punctata*. Dominant understorey species include *Allocasuarina littoralis, Bursaria spinosa* subsp. *spinosa, Ozothamnus diosmifolius, Hibbertia aspera, Lepidosperma laterale, Cheilanthes sieberi* subsp. *sieberi, Aristida vagans* and *Pratia purpurascens.*<br>**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). | 360.6 |
| PCT 1504<br>HN647 | **Sydney Blue Gum – Deane's Gum – River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** Four condition classes<br>▪ Moderate/good_good: Consists of an intact canopy and midstorey, with a moderately native groundcover. Some locally non-native species occur scattered throughout<br>▪ 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 | **Structure/characteristics:** A forest community with a canopy dominated by *Eucalyptus saligna* and *Eucalyptus deanei*, with *Eucalyptus 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,*<br>**Conservation status:** River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions. | 59.9 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| | vine), *Ligustrum sinense* and *Ligustrum lucidum* (Large and Small-leaved Privet) and *Lantana camara* (Lantana)<br>▪ 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<br>▪ Moderate/good_derived: An open vegetation structure with high proportion of regenerating species native to this community. Weed management and in-fill planting would be required to sustain this condition class. | | |
| PCT 1557<br>HN665 | **Rough-barked Apple – Forest Oak – Grey Gum grassy woodland on sandstone ranges of the Sydney Basin**<br>**Distribution within study area:** This PCT was recorded along the sandstone ridges and slopes around Cattai National Park.<br>**Condition and presence of weeds:** One condition class<br>▪ 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. | **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 *Corymbia eximia, Eucalyptus punctata and Angophora bakeri.* The shrub layer and sub-canopy includes species such as *Allocasuarina littoralis, Leptospermum trinervium, Persoonia linearis* and *Exocarpos strictus*. The groundcover assemblage includes *Lomandra longifolia, Lomandra obliqua, Lomandra filiformis, Lepidosperma laterale* and *Dianella caerulea*.<br>**Conservation status:** Hold-point. Require OEH's Vegetation classification system to be operational to make a definitive assessment on this PCTs association with any TEC. | 0.5 |
| PCT 1718<br>HU932 | **Swamp Mahogany – Flax-leaved paperbark swamp forest on coastal lowlands of the Central Coast**<br>**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.<br>**Condition and presence of weeds:** One condition class<br>▪ 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. | **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 of 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*.<br>**Conservation status:** Equivalent to Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions, an endangered ecological community under the BC Act. Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions is on the EPBC Act priority list as Temperate Swamp Sclerophyll Forest, a potentially endangered community. An assessment of this listing will be conducted before the 30 October 2019. | 4.1 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 724<br>HN512 | **Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion**<br>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 2002).<br>**Condition and presence of weeds:** Three condition classes were recorded:<br>▪ 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<br>▪ 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)<br>▪ 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). | **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.*<br>**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). | 62.3 |
| PCT 725<br>HN513 | **Broad-leaved Ironbark – *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain Sydney Basin Bioregion**<br>**Distribution within the study area:** A small area of this PCT was recorded (desktop analysis) within the Cumberland Plain occurring within the 1 in 10 chance in a year.<br>**Condition and presence of weeds:** One condition class<br>▪ 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. | **Structure/characteristics:** Woodland to open forest community with an open layer of sclerophyll shrubs Dominant canopy includes *Eucalyptus fibrosa* and *Melaleuca decora*.<br>**Conservation status:** Hold-point: waiting for OEH's VIS system to be operational to assess this vegetation association with any TECs. | 0.1 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 781<br>HN520 | **Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion**<br>**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.<br>**Condition and presence of weeds:** Three condition classes:<br>▪ Moderate/good: Dominated by native sedges, rushes, shrubs and ground cover species. Very few non-local species.<br>▪ Moderate/good_low: Very few native species. Dominated by introduced grasses such as *Chloris gayana, Paspalum dilatatum*, and *Cenchrus clandestinus*<br>▪ Moderate/good_other: An unnatural condition class. Some modification from surrounding land uses such as grazing which has altered the community. | **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.*<br>**Conservation status:** Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act). | 1086.6 |
| PCT 835<br>HN526 | **Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion**<br>**Distribution within the study area:** Occurs mainly throughout the Western Sydney region of the study area along stream banks and alluvial flats.<br>**Condition and presence of weeds:** Three condition classes:<br>▪ 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<br>▪ 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)<br>▪ Moderate/good_low: Very few remnant trees and native midstorey species. Generally, a low native species richness and low native species abundance<br>▪ 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. Weed management and in-fill planting would be required to sustain this condition class. | **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*.<br>**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). | 1,903.6 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 849<br>HN528 | **Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** Three condition classes:<br>▪ 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<br>▪ 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)<br>▪ 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. | **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.*<br>**Conservation status:** Cumberland Plain Woodland in the Sydney Basin Bioregion (BC Act) and Cumberland Plain Woodland (EPBC Act). | 275.7 |
| PCT 866<br>HU554 | **Grey Gum – Smooth-barked Apple open forest of the dry hinterland of the Central Coast, Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** One condition class:<br>▪ 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. | **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.*<br>**Conservation status:** This PCT does not align to any TEC under either the BC Act or EPBC Act. | 3.0 |
| PCT 877<br>HN538 | **Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion**<br>**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.<br>**Condition and presence of weeds:** One condition class<br>▪ 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. | **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.*<br>**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). | 9.2 |

| PCT code/ BVT code | PCT name, distribution and condition | Structure/characteristics and conservation status | Area (ha) |
|---|---|---|---|
| PCT 924<br>HN552 | ***Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion**<br>**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.<br>**Condition and presence of weeds:** One condition class:<br>▪ 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. | **Structure/Characteristics:** This vegetation is ground water dependant. usually consisting of a very dense stand of *Melaleuca linariifolia.* Other common species include*, Melaleuca. decora, Cynodon dactylon, Paspalum distichum and Phragmites australis.*<br>**Conservation Status:** Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act). | 36.5 |

*Table 9-10. PCT/TEC associations*

| BC Act status | EPBC Act status | PCTs | Total area (ha) in survey area | Total area (ha) in study area (PMF) |
|---|---|---|---|---|
| *Shale Gravel Transition Forest in the Sydney Basin Bioregion EEC* | *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC* | PCT 724 – Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion | 62.3 | 1379.6 |
| *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 | 1086.6 | 1106.7 |
| | | PCT 924 – *Melaleuca linariifolia* alluvial melaleuca thicket of the lower Blue Mountains and Capertee Valley, Sydney Basin Bioregion | 36.5 | 36.6 |
| *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 | 1903.6 | 3209.3 |
| | | PCT 1504 – Sydney Blue Gum – Deane's Gum – River Peppermint shrubby riparian tall forest of the lower Colo River, Sydney Basin Bioregion | 59.9 | 60.9 |
| | | PCT 1106 – River Oak riparian woodland of the NSW North Coast Bioregion and northern Sydney Basin Bioregion | 151.3 | 158.5 |
| *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 | 275.7 | 2165.5 |

| BC Act status | EPBC Act status | PCTs | Total area (ha) in survey area | Total area (ha) in study area (PMF) |
|---|---|---|---|---|
| *Cumberland Plain Woodland in the Sydney Basin Bioregion* | *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* | PCT 850 – Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion | - | 148.2 |
| *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 | 9.2 | 19.5 |
| *Castlereagh Swamp Woodland Community EEC* | Not listed | PCT 1067 – Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion | 3.6 | 437.4 |
| *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 | 360.6 | 708.8 |
| *Agnes Banks Woodland in the Sydney Basin Bioregion CEEC* | *Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion EEC* | PCT 958 – Narrow-leaved Apple – Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion | - | 86.3 |
| *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 | 0.1 | 412.2 |
| *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 | - | 6.9 |
| *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 | - | 900.5 |
| *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. | 4.1 | 5.9 |
| *Blue Mountains Shale Cap Forest in the Sydney Basin Bioregion EEC*<br>*Sydney Turpentine Ironbark Forest CEEC* | *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 | 36.1 | 36.9 |
| *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 | 12.8 | 13.0 |

*Table 9-11. Threatened flora species likely to occur within the study area*

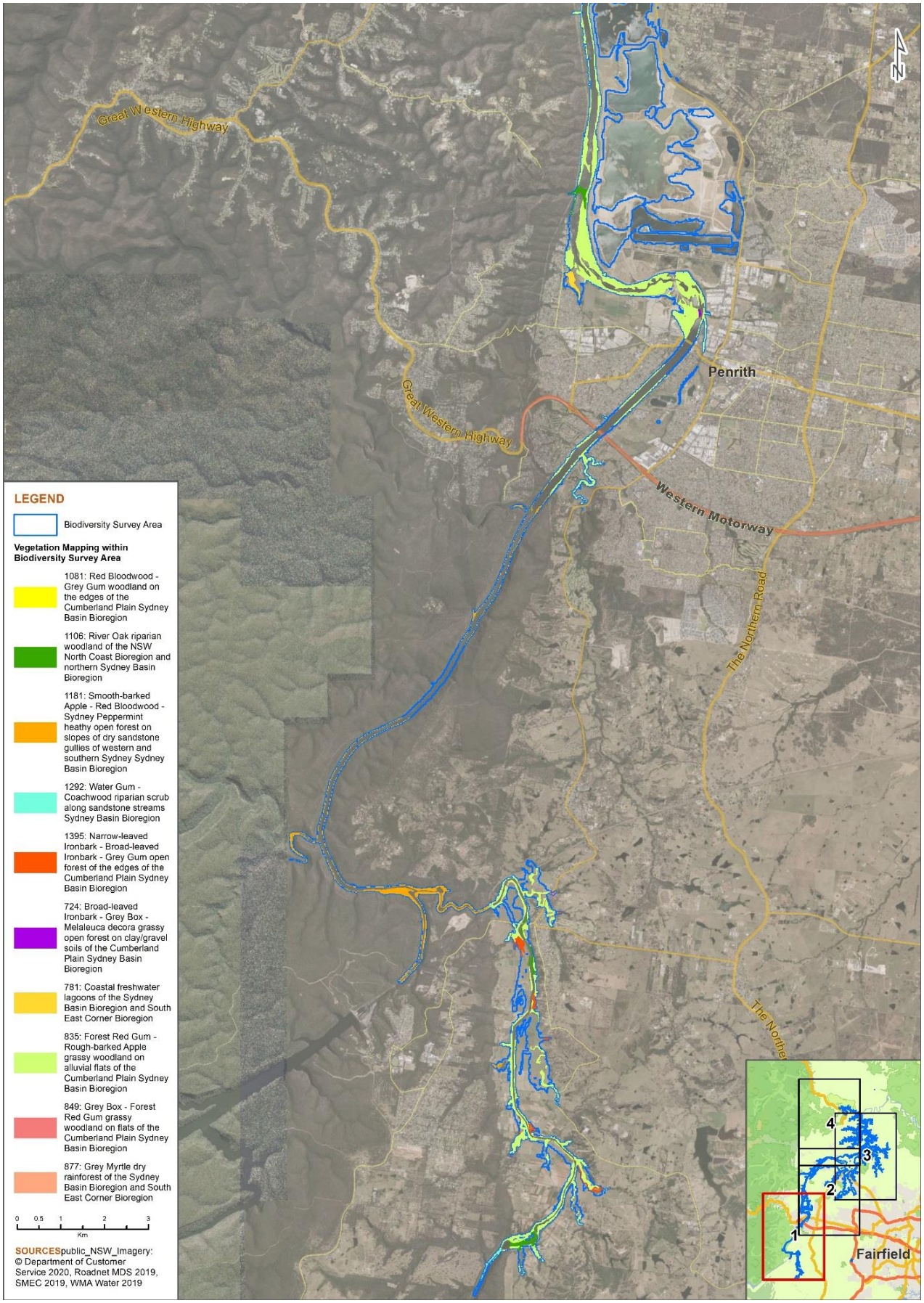
| Scientific name | Common name | Habitat and distribution | Likelihood |
|---|---|---|---|
| *Acacia bynoeana* | Bynoe's Wattle | Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park. | Moderate |
| *Acacia pubescens* | Downy Wattle | 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. | Recorded (Found during survey) |
| *Allocasuarina glareicola* | | 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 Red Gum, Broad-leaved Ironbark, Narrow-leaved Apple, Scribbly Gum and Paperbarks. | Moderate |
| *Callistemon linearifolius* | Netted Bottle Brush | 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. | Moderate |
| *Cynanchum elegans* | White-flowered Wax Plant | Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar. | Moderate |
| *Darwinia biflora* | | 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. | Moderate |
| *Dillwynia tenuifolia* | | 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 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. | Recorded (Found during survey) |
| *Dillwynia tenuifolia* - in the Baulkham Hills local government area | *Dillwynia tenuifolia Sieber* ex D.C. in the Baulkham Hills local government area | 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. | High |
| *Epacris purpurascens* var. *purpurascens* | | 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. | High |
| *Epacris sparsa* | Sparse Heath | 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. | Moderate |

| Scientific name | Common name | Habitat and distribution | Likelihood |
|---|---|---|---|
| *Eucalyptus benthamii* | Camden White Gum | 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 Nattai National Park. Requires a combination of deep alluvial soils and a flooding regime that permits seedling establishment. Occurs in open forest. | Recorded (Found during survey) |
| *Eucalyptus camfieldii* | Heart-leaved Stringybark | 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. | Moderate |
| *Eucalyptus* sp. *Cattai* | | 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. | Moderate |
| *Grammitis stenophylla* | Narrow-leaf Finger Fern | Moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest. | Moderate |
| *Grevillea juniperina* subsp. *juniperina* | Juniper-Leaved Grevillea | 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. | Recorded (Found during survey) |
| *Grevillea parviflora* subsp. *parviflora* | Small-flowered Grevillea | 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. | Moderate |
| *Grevillea shiressii* | | Grows along creek banks in wet sclerophyll forest with a moist understorey in alluvial sandy or loamy soils. | Moderate |
| *Gyrostemon thesioides* | | 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. | Moderate |
| *Hibbertia puberula* | | Occurs on sandy soil often associated with sandstone. Flowering time is October to November. | Moderate |
| *Kunzea rupestris* | | Grows in shallow depressions on large flat sandstone rock outcrops. Characteristically found in short to tall shrubland or heathland. | Moderate |
| *Lasiopetalum joyceae* | | 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 between Berrilee and Duffys Forest. Seventeen of these are reserved. Grows in heath on sandstone. | Moderate |
| *Leucopogon exolasius* | Woronora Beard-heath | Grows in woodland on sandstone. Restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park. | Moderate |
| *Leucopogon fletcheri* subsp. *fletcheri* | | Occurs in dry eucalypt woodland or in shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs. | Moderate |

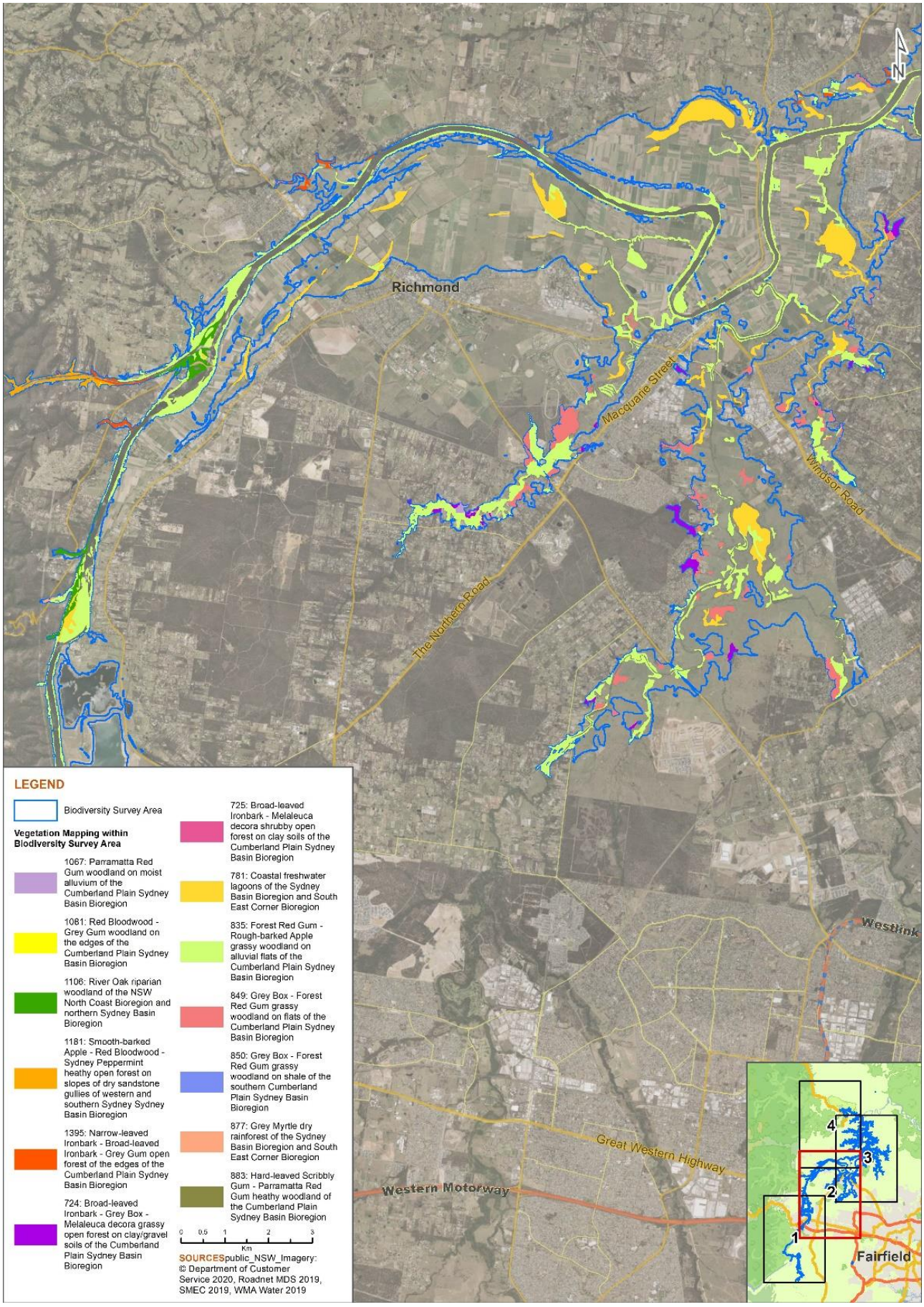
| Scientific name | Common name | Habitat and distribution | Likelihood |
|---|---|---|---|
| *Marsdenia viridiflora* subsp. *Viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas | | Grows in vine thickets and open shale woodland. | High |
| *Melaleuca deanei* | Deane's Melaleuca | Grows in wet heath on sandstone in coastal districts from Berowra to Nowra. | Moderate |
| *Micromyrtus minutiflora* | | Grows in Castlereagh Scribbly Gum woodland, Ironbark forest, Shale-Gravel Transition forest, open forest on tertiary alluvium and consolidated river sediments. | High |
| *Persoonia hirsuta* | Hairy Geebung | 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. | Moderate |
| *Persoonia nutans* | Nodding Geebung | 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. | Recorded (Found during survey) |
| *Pilularia novae-hollandiae* | Austral Pillwort | Grows in shallow swamps and waterways, often among grasses and sedges. It is most often recorded in drying mud as this is when it is most conspicuous. | Moderate |
| *Pimelea curviflora* var. *curviflora* | | 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. | Recorded |
| *Pimelea spicata* | Spiked Rice-flower | 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 occurs commonly in Coast Banksia open woodland with a better developed shrub and grass understorey. | High |
| *Pomaderris brunnea* | Brown Pomaderris/ Rufous Pomaderris | 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. | Recorded |

| Scientific name | Common name | Habitat and distribution | Likelihood |
|---|---|---|---|
| *Pterostylis saxicola* | Sydney Plains Greenhood | 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. | Moderate |
| *Pultenaea parviflora* | | 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. | Recorded |
| *Rhodamnia rubescens* | Scrub Turpentine | 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 *Rhodamnia rubescens* typically occur in coastal regions and occasionally extend inland onto escarpments up to 600 m asl. in areas with annual 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. | Recorded (Found during survey) |
| *Senna acclinis* | Rainforest Cassia | 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. | Recorded |
| *Seringia denticulata (syn. Keraudrenia corollata* var. *denticulata) population* | | Occurs in the Hawkesbury local government area, disjunct from other populations and at the southern limit of the species' geographic range. Collections of the endangered population from the Colo River area between Lower Portland and Morans Rock and near Gees Lagoon. Known sub-populations are very small and generally less than five plants. | Moderate |
| *Syzygium paniculatum* | Magenta Lilly Pilly/Magenta Cherry/Daguba/Scrub Cherry/Creek Lilly Pilly/Brush Cherry | 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. | Moderate |
| *Tetratheca glandulosa* | Glandular Pink-bell | 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 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. | Recorded |
| *Zieria involucrata* | | 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. | Recorded (Found during survey) |

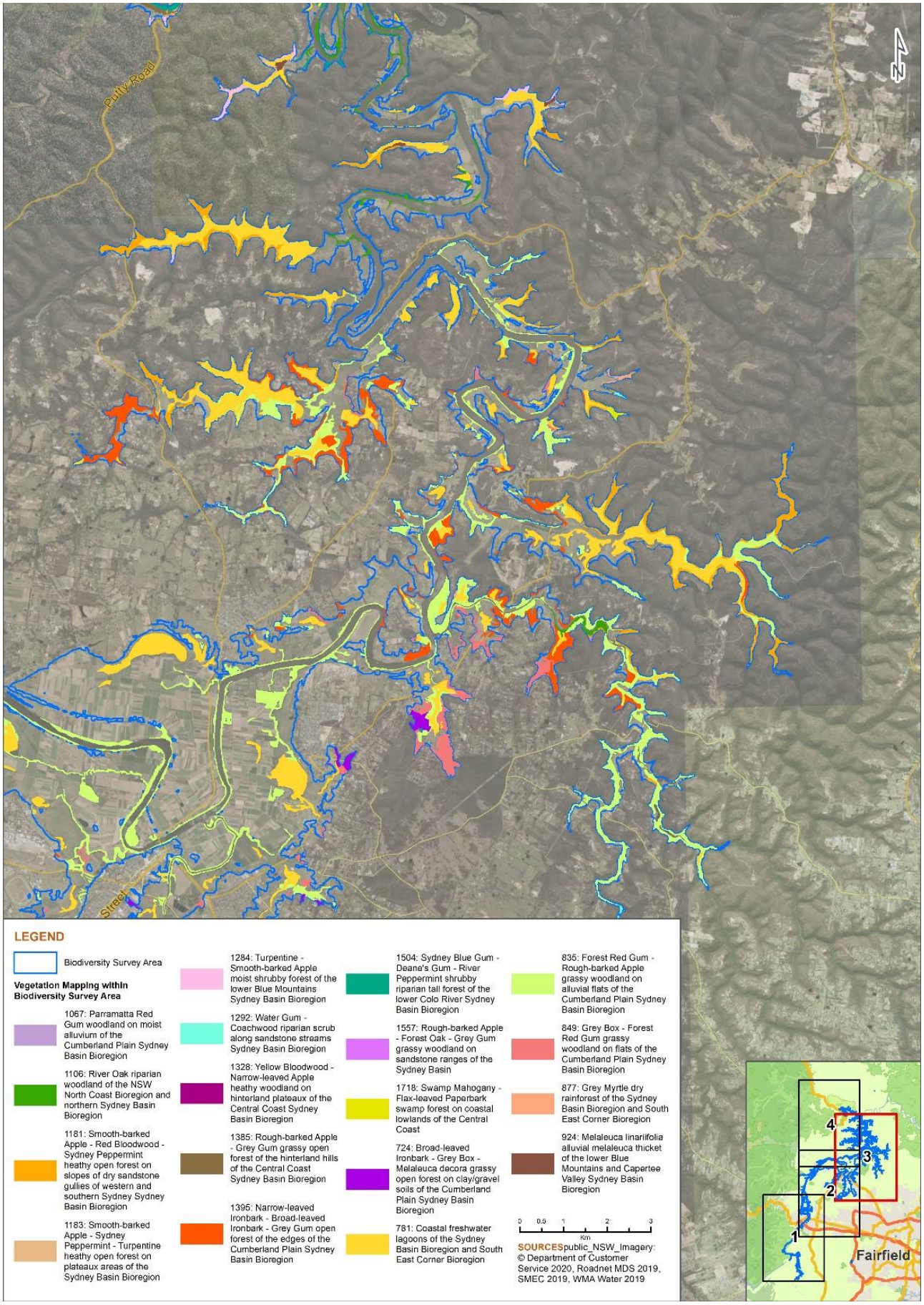
*Figure 9-12. Plant Community Types (PCTs) in the survey area (1 of 4)*



*Plant Community Types (PCTs) in the survey area (2 of 4)*



*Plant Community Types (PCTs) in the survey area (3 of 4)*



*Plant Community Types (PCTs) in the survey area (4 of 4)*

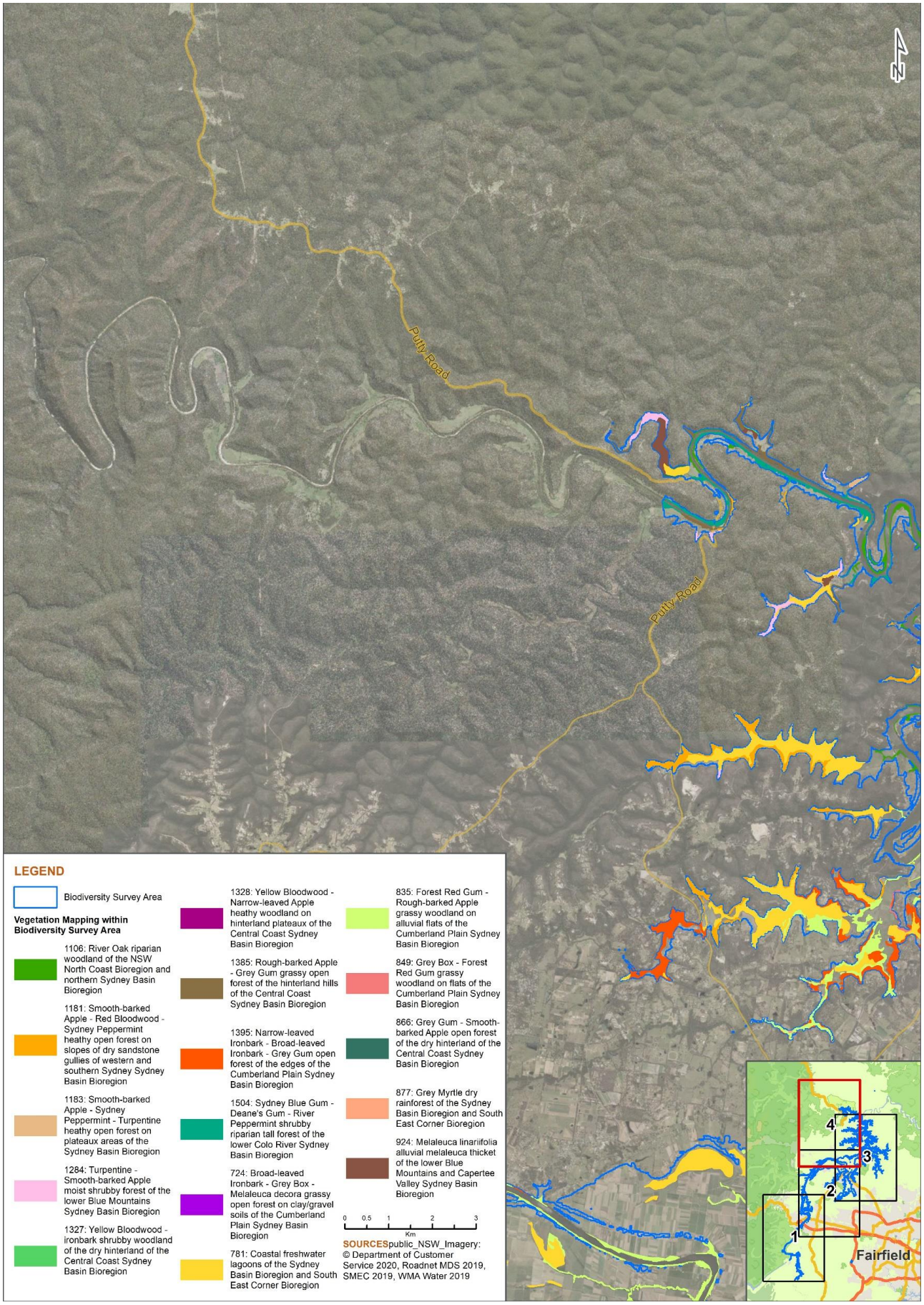


*Figure 9-13. Threatened ecological communities in the survey area*

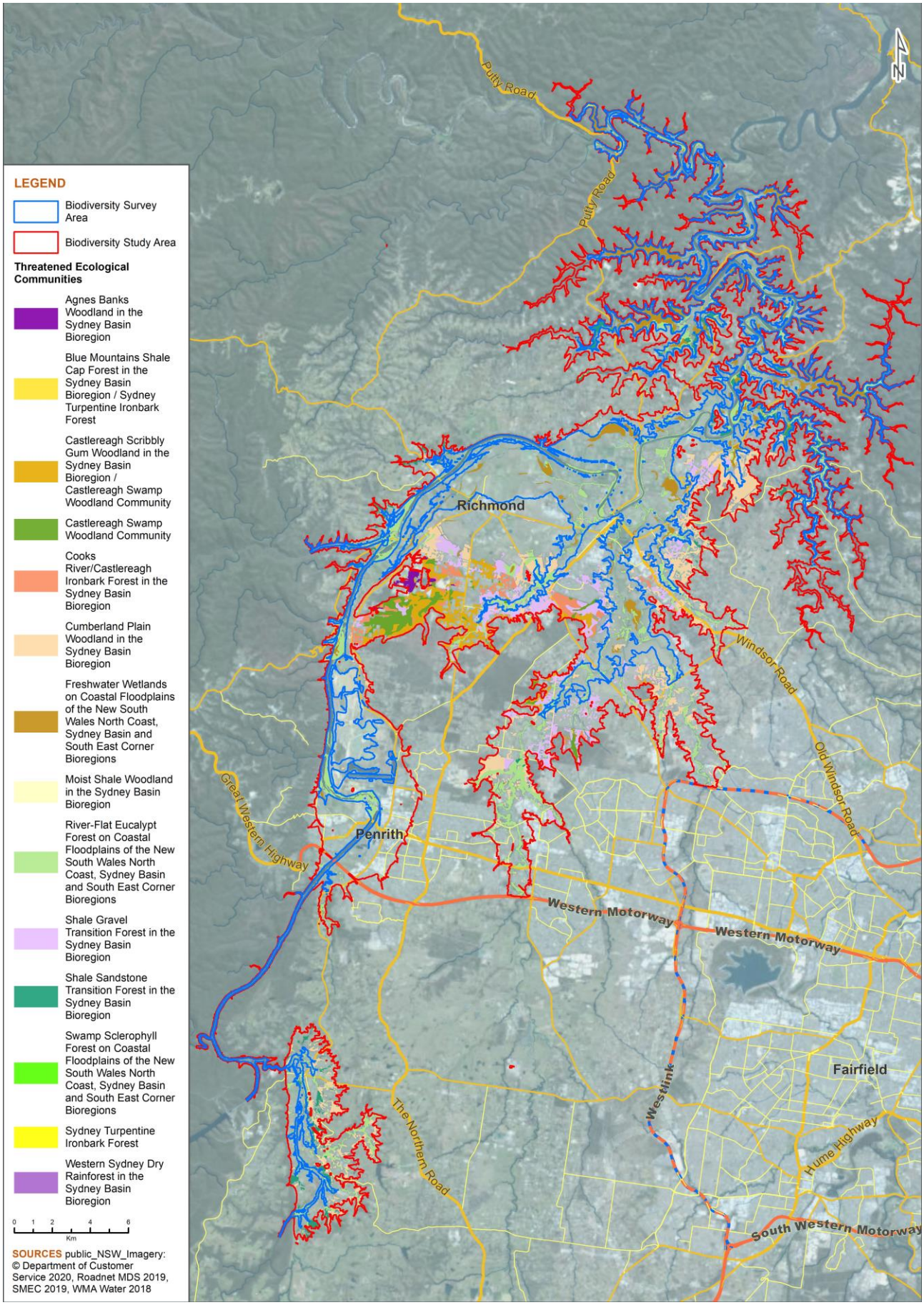
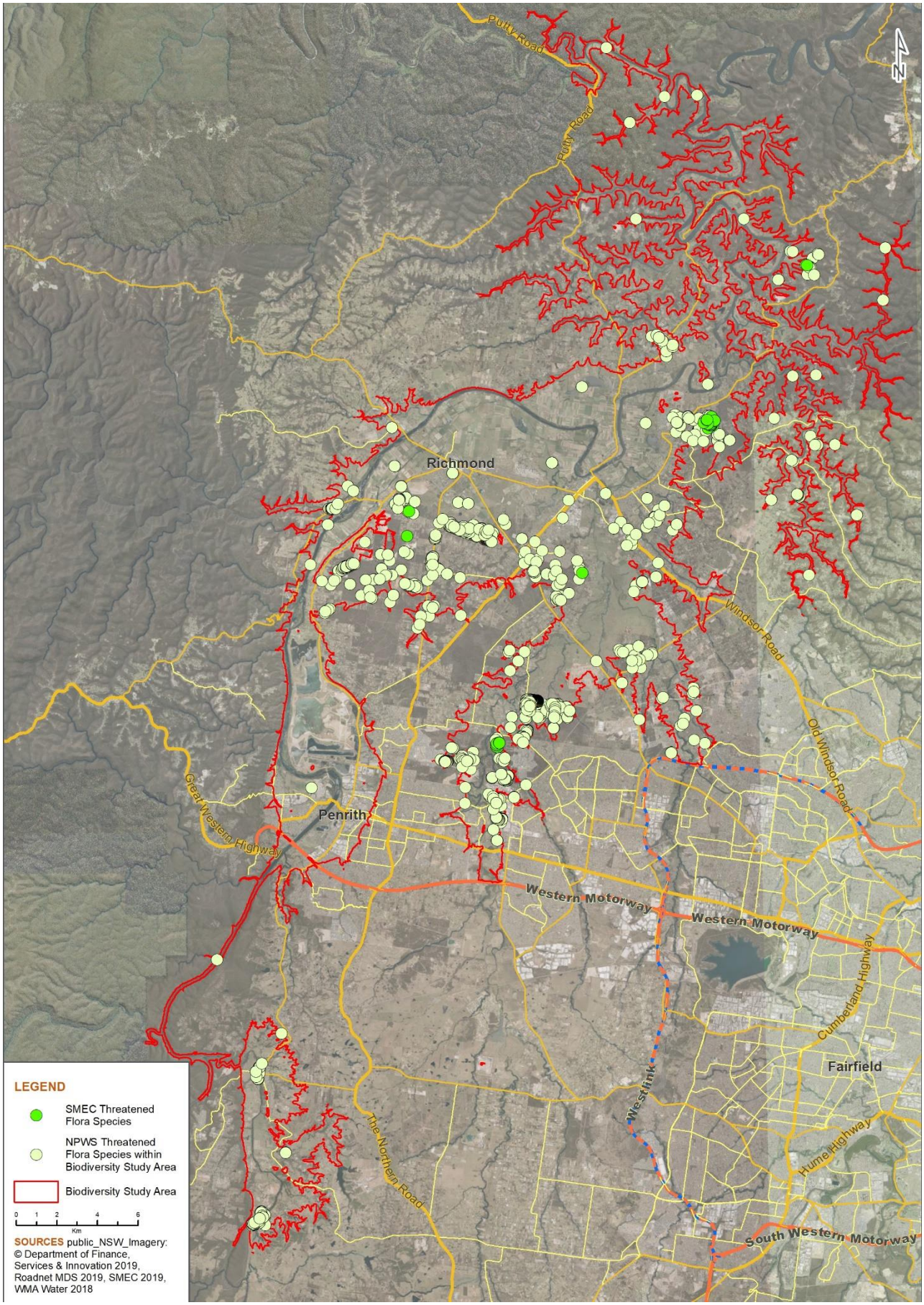


*Figure 9-14. Threatened flora species recorded or potentially occurring in study area*



### 9.3.6 Fauna

#### 9.3.6.1 Introduction

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, based on GIS analysis, 95.6 percent of the study area was exotic grassland and agricultural land use and urbanisation have simplified and/or removed most of the ground habitat features such as logs and rocks. The resultant landscape has 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 food and shelter.

Cumberland Plain native vegetation originally comprised of various forms of open forest and woodland. The best remaining fauna habitats within the study area are associated with remnant areas of forest and woodland, with the highest quality habitat located within national parks and reserves. Outside of national parks and reserves, most remnants are mostly comprised of young trees with scattered older individuals. Tree hollows, particularly large hollows, are rare.

Despite the modified nature, the study area still offers broad habitat features for native fauna. These include:

- 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 some 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, 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.

#### 9.3.6.2 Fauna species and habitat

Fauna species are presented in Appendix F2 (Downstream ecological assessment, Appendix D). One-hundred and three (103) species of birds, three reptiles, 31 mammals and three frogs were recorded in the study area. Eleven (11) of these species (five birds and six mammals) were introduced species. The suite of species recorded varied between habitat types, which are described below.

##### Alluvial forests and woodlands

The woodland and open forest vegetation is predominantly contained within national parks and reserves. Elsewhere the woodland areas are relatively young, open and with a grassy groundcover. For more mobile species, the woodland patches provide connectivity between the more intact woodlands within the national parks and reserves. Other habitat values within the study area are associated with open forests and woodlands, which include:

- Fallen timber and woody debris are 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 shrub and tall tussock grass understorey. Understorey vegetation, and thus woodland structural complexity, provides nesting sites, refuge from predators and food. This vegetation is most diverse within national parks, reserves and state conservation areas. 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 would provide suitable foraging habitat for a range of nectarivorous 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 during blossoming periods.

### Grassy box woodlands

Grassy Box Woodlands are 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 and is the most significant landscape in the region in terms of conservation of faunal diversity. 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. Many Grassy Box Woodland species are locally extinct or close to extinction in the southern Cumberland Plain.

Grassy Box Woodlands are considered as 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.

### Grassland

Grassland habitat generally provides low fauna habitat 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 neutralised 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 because 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.

### 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. 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 & Warner 2003). Considerable changes to the wetlands of the Hawkesbury-Nepean River have occurred since European colonisation due to drainage, changes in land use, vegetation clearance and the construction of Warragamba Dam. 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. Some wetlands have been partly drained and only hold water for short periods after flooding and heavy rain whilst others have been dammed and are now permanent swamps.

In addition, farm dams 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*).

#### 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.

### 9.3.6.3 Threatened fauna species

Fifteen (15) threatened fauna species were recorded during the surveys (Figure 9-15) and a further 31 threatened fauna species have been being previously recorded in the study area. A list of species is given in Table 9-12.

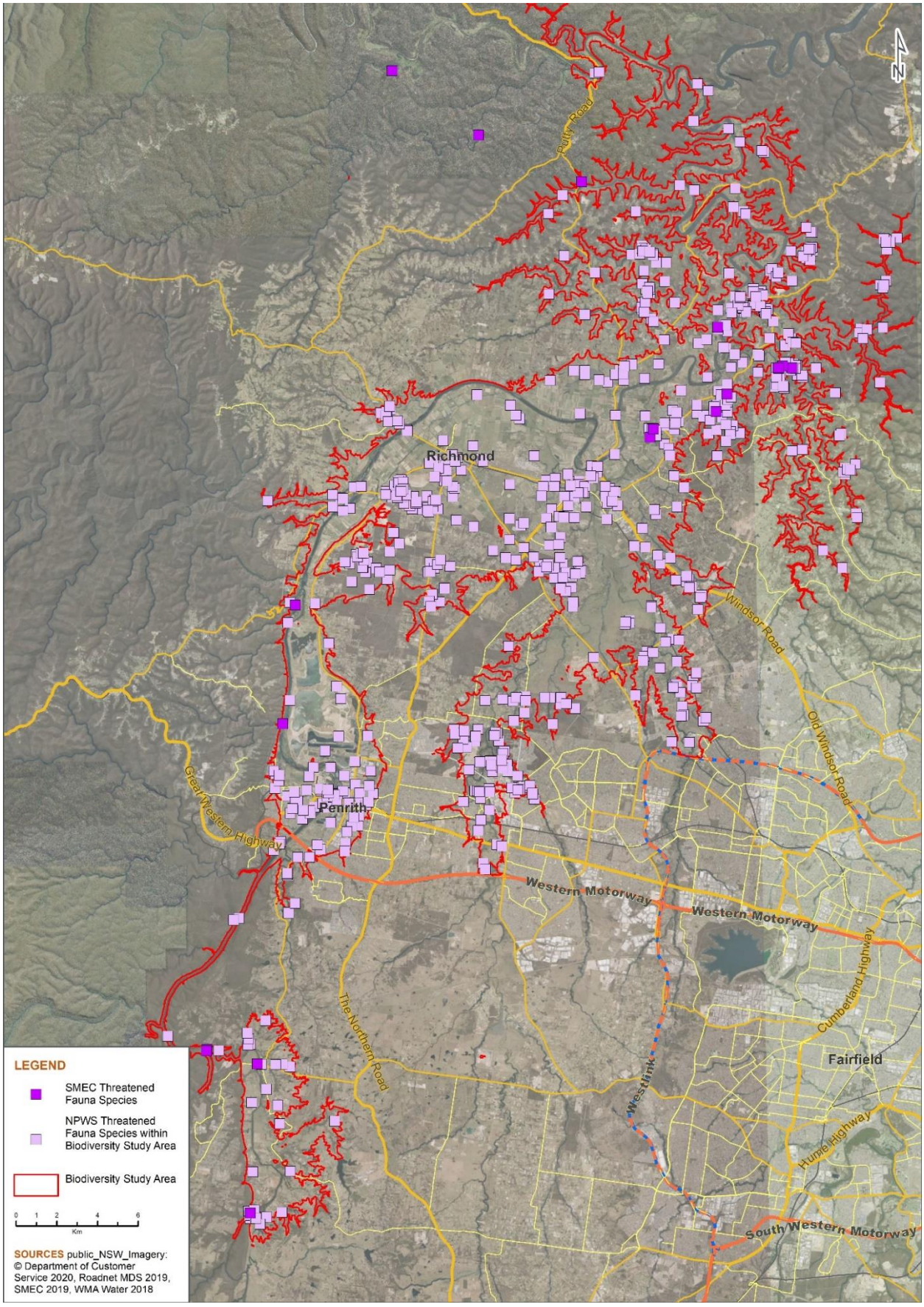
Further analysis of potentially occurring threatened fauna species is provided in the likelihood of occurrence assessment in Appendix F2 (Downstream ecological assessment, Appendix A).

*Table 9-12. Threatened species potentially in survey area*

| Species name | Common name | Location in the survey area | |
|---|---|---|---|
| *Anthochaera phrygia* | Regent Honeyeater | Recorded in the survey area reasonably regularly until the late 1980s however there have been very few records from the survey area since. | Recorded |
| *Artamus cyanopterus cyanopterus* | Dusky Woodswallow | Recorded in the survey area near Cattai and Wallacia. | Recorded |
| *Botaurus poiciloptilus* | Australasian Bittern | Recorded occasionally, particularly between Richmond and Pitt Town Lagoon. | Recorded |
| *Callocephalon fimbriatum* | Gang-gang Cockatoo | Recorded occasionally adjacent to the Colo and Hawkesbury Rivers. | Recorded |
| *Calyptorhynchus lathami* | Glossy Black-Cockatoo | Recorded in the survey area around Cattai and Lower Portland. | Recorded |
| *Calidris ferruginea* | Curlew Sandpiper | 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. | Recorded |
| *Chalinolobus dwyeri* | Large-eared Pied Bat | Hawkesbury River at Yellomundee NP and Cattai NP by SMEC in 2018 | Survey |
| *Chthonicola sagittate* | Speckled Warbler | Recorded in the vicinity of Longneck Lagoon, Scheyville N.P. Not known to occur elsewhere in the survey area. | Recorded |
| *Circus assimilis* | Spotted Harrier | Occasionally recorded in the survey area, particularly over the floodplain in the vicinity of Richmond/Wilberforce/Cornwallis. | Recorded |
| *Daphoenositta chrysoptera*) | Varied Sittella | Mitchell Park Yellomundee NP. Recorded in the study area adjacent to the Hawkesbury-Nepean River between Wallacia and Lower Portland. | Survey |
| *Dasyurus maculatus* | Spotted-tailed Quoll | Recorded on one occasion in the survey area in 1998 in Mitchell Park | Recorded |
| *Ephippiorhynchus asiaticus)* | Black-necked Stork | Last recorded in the survey area in 1978 in McGraths Hill, Windsor. | Recorded |
| *Falco subniger* | Black Falcon | Recorded occasionally, particularly in the Richmond/Windsor/Pitt Town area, but not since 1986. | Recorded |
| *Falsistrellus tasmaniensis* | Eastern False Pipistrelle | Bents Basin, Yellomundee NP and possibly Mitchell Park by SMEC in 2018 | Survey |
| *Haliaeetus leucogaster* | White-bellied Sea-Eagle | Nesting site identified at Pitt Town Nature Reserve in 2018. Also recorded at Nortons Basin and Gospers Lagoon. Occurs throughout the study area. | Survey |
| *Heleioporus australiacus* | Giant Burrowing Frog | A single record of the species exists in 2006 in swamp habitat in Cattai. | Recorded |
| *Glossopsitta pusilla* | Little Lorikeet | Scattered records in the survey area mostly upstream of Cattai along the Hawkesbury-Nepean River. | Recorded |
| *Hieraaetus morphnoides* | Little Eagle | Recorded occasionally in the survey area around Pitt Town Lagoon, Bushells Lagoon and Long Neck Lagoon. | Recorded |
| *Irediparra gallinacea* | Comb-crested Jacana | Last recorded in 1986 in Bushells Lagoon. | Recorded |
| *Ixobrychus flavicollis* | Black Bittern | Recorded occasionally along the Colo and Hawkesbury-Nepean Rivers. Several records during the past decade in the Richmond/Agnes Bank area. | Recorded |
| *Lathamus discolor* | Swift Parrot | Occasionally recorded in the survey area, most recently in 2016 in Richmond. | Recorded |
| *Limosa limosa* | Black-tailed Godwit | Recorded very occasionally in the Richmond/Windsor/Pitt Town area. Not recorded since 1982. | Recorded |

| Species name | Common name | Location in the survey area | |
|---|---|---|---|
| *Litoria aurea* | Green and Golden Bell Frog | Historically recorded in Longneck Lagoon and Pitt Town, however not since 1975. | Recorded |
| *Lophoictinia isura* | Square-tailed Kite | Recorded in the survey area along the Hawkesbury-Nepean River between Wallacia and Cattai. Most records from the past decade. | Recorded |
| *Meridolum corneovirens* | Cumberland Plain Land Snail | Long Neck Lagoon | Survey |
| *Miniopterus orianae oceanensis* | Large Bent-winged Bat | Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP, Longneck Lagoon and Wheeny Creek by SMEC in 2018 | Survey |
| *Mormopterus norfolkensis* | Eastern Coastal Free-tailed Bat | Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP, Longneck Lagoon and Wheeny Creek by SMEC in 2018 | Survey |
| *Miniopterus australis* | Little Bentwing-bat | Mitchell Park by SMEC in 2018 | Survey |
| *Myotis macropus* | Southern Myotis | Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP and Longneck Lagoon by SMEC in 2018. | Survey |
| *Neophema pulchella* | Turquoise Parrot | Last recorded near Castlereagh in 1977. | Recorded |
| *Ninox strenua* | Barking Owl | Last recorded near Rickabys Creek in Windsor in 1994 | Recorded |
| *Ninox strenua* | Powerful Owl | Recorded in the survey area around Maroota and Ebenezer. | Recorded |
| *Petaurus australis* | Yellow-bellied Glider | Recorded within the survey area in Cattai National Park. | Recorded |
| *Petaurus norfolcensis* | Squirrel Glider | Recorded as recently as 2019 in Cattai. | Recorded |
| *Petroica phoenicea* | Flame Robin | Recorded on one occasion in the survey area in 1981 near Bushells Lagoon. | Recorded |
| *Phascolarctos cinereus* | Koala | Upper Colo Reserve and Blaxlands Ridge. Historical records from Lapstone north to the Colo River, predominantly to the west of the Nepean River (NPWS database June 2018; DECCW 2011). A record in South Windsor from 2014 and Wianamatta Regional Park from 2004 (*Robert Close, pers. Coms*). | Survey |
| *Pommerhelix duralensis* | Dural Land Snail | Mitchell Park and Maroota State Conservation Area during November 2018. | Survey |
| *Pseudophryne australis* | Red-crowned Toadlet | Maroota State Conservation Area during November 2018. | Survey |
| *Pteropus poliocephalus* | Grey-headed Flying-fox | Nepean River at Silverdale and Yarramundi | Survey |
| *Rostratula australis* | Australian Painted Snipe | Recorded very occasionally at wetlands in the survey area, but not since 1985 in Bushells Lagoon. | Recorded |
| *Saccolaimus flaviventris* | Yellow-bellied Sheathtail-bat | Recorded in the survey area in 2013 near Wilberforce, Cattai and Ebenezer. | Recorded |
| *Scoteanax rueppellii* | Greater Broad-nosed Bat | Bents Basin, Yellomundee NP, Mitchell Park, Cattai NP and Longneck Lagoon by SMEC in 2018 | Survey |
| *Stictonetta naevosa* | Freckled Duck | Recorded at wetlands associated with the Hawkesbury-Nepean River, particularly Pitt Town Lagoon. | Recorded |
| *Tyto novaehollandiae* | Masked Owl | Recorded occasionally in the Richmond/Windsor/Pitt Town area. | Recorded |
| *Tyto tenebricosa* | Sooty Owl | Very rarely recorded in the survey area. Only record occurs in Cattai National Park in 2014. | Recorded |
| *Vespadelus troughtoni* | Eastern Cave Bat | Bents Basin and Cattai NP by SMEC in 2018 | Survey |

*Figure 9-15. Threatened fauna species recorded in the study area*



### 9.3.7 Groundwater dependent ecosystems

Groundwater characteristics are described in Appendix F2 (Downstream ecological assessment, Section 5.3). The State of the Catchments 2010 report for the Hawkesbury-Nepean region[4] identifies two groundwater management areas (GWMA) relevant to the Project, these being are the Hawkesbury Alluvium (alluvial GWMA) and the Sydney Basin–Central (porous rock GWMA). Herron *et al*. (2018) note the following with regard to the hydrogeological characteristics of the Sydney Basin bioregion:

> *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.*

Rainfall across the catchment is the primary mechanism for groundwater recharge, with smaller contributions from local flooding.

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 (see Figure 9-10). Important wetlands include Pitt Town Lagoon and Longneck Lagoon, 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 in the Groundwater Dependent Ecosystems Atlas (BOM 2019). Sixty-two (62) vegetation types were identified and classified according to their groundwater dependency potential, groundwater management area, position in the landscape and bioregion. GDEs are shown on Figure 9-16, with detailed maps provided in Appendix F2 (Downstream ecological assessment, Appendix F and Appendix I).

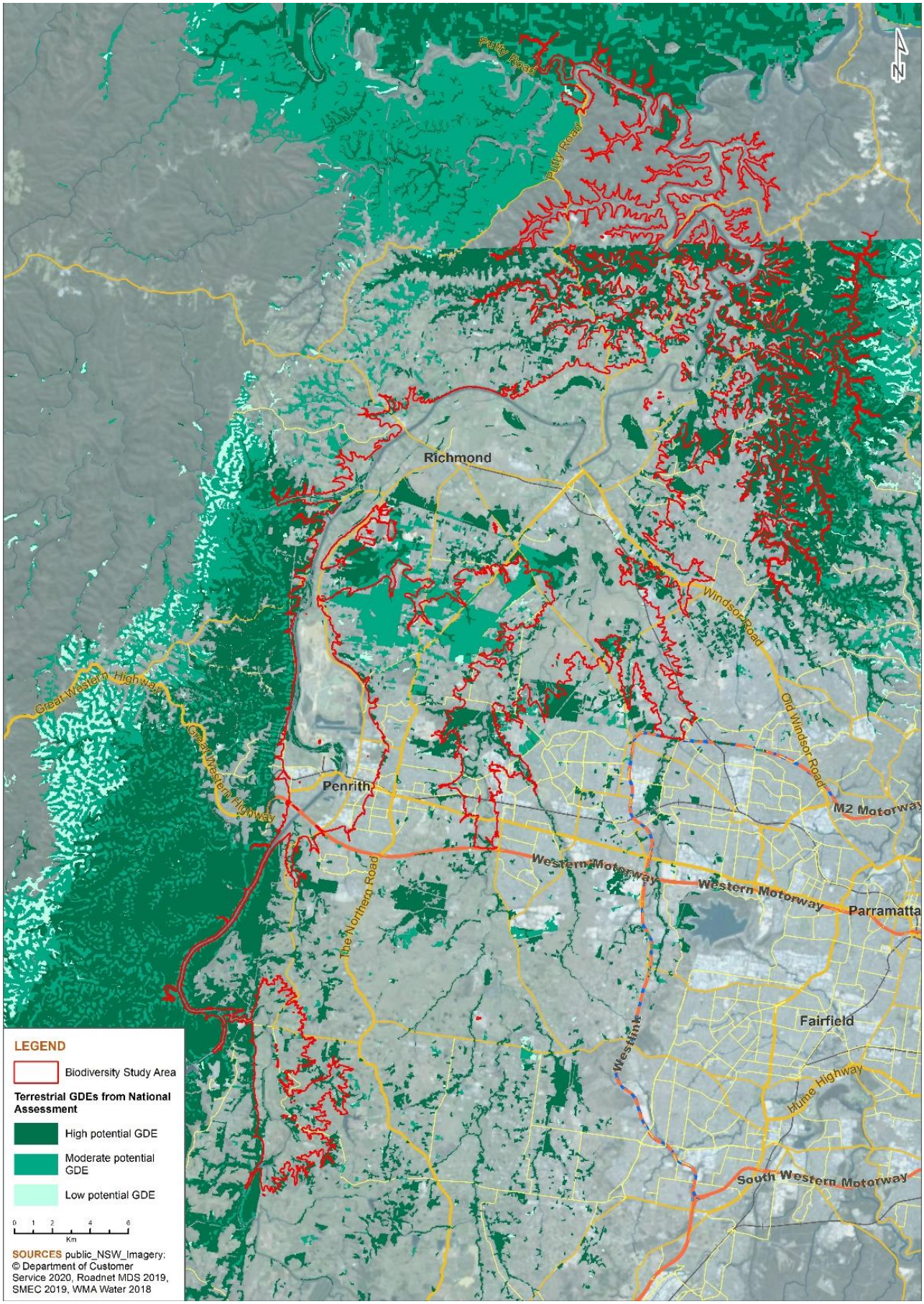
Appendix 4 to the background document for the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (NSW Office of Water 2011) identifies high priority GDEs in the Greater Metropolitan Region. Of these, the following are relevant to this assessment:

- 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 with regard to their ongoing viability. 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.

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

*Figure 9-16. Locations of GDEs*



## 9.4 Impact assessment

### 9.4.1 Introduction

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 & 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.

The catchment downstream of Warragamba Dam is characterised by numerous land uses and activities that have an existing impact on the environment. 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.

### 9.4.2 Impact and risk assessment methodology

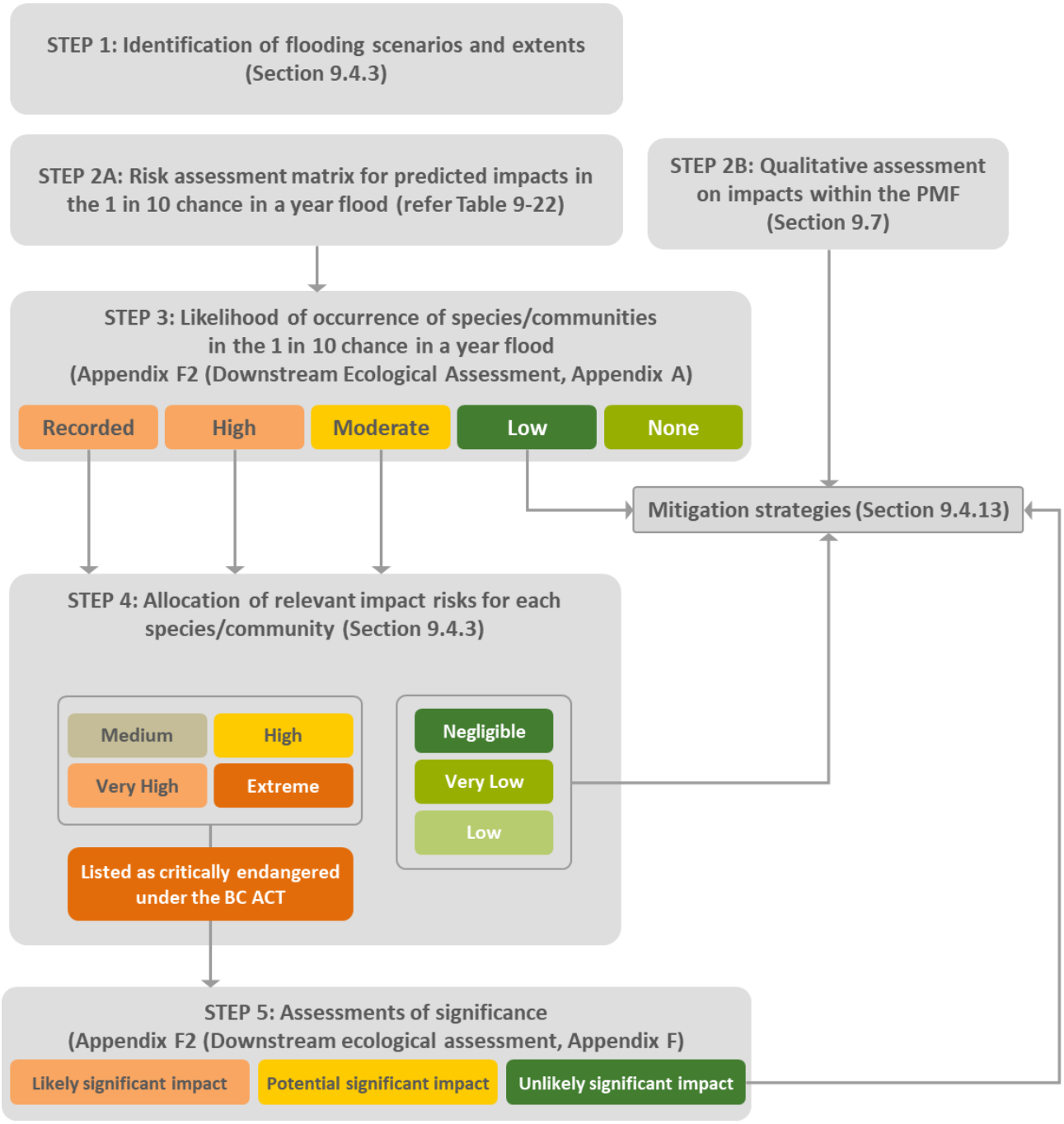
This assessment focuses on potential impacts associated with the survey area (1 in 10 chance in a year flood) and the increased duration of temporary inundation resulting from emptying of the FMZ. These events have been modelled using the best available information, however there remains a level of uncertainty on the frequency and extent of these flooding scenarios. Furthermore, the potential impacts on biodiversity will vary depending on the frequency, duration and extent of flooding experienced following the implementation of the Project and other stresses in the landscape.

A risk assessment framework was developed to identify and assess biodiversity features that are most likely to be sensitive to Project hydrological changes. The risk assessment process is shown on Figure 9-17, which was used to assess biodiversity impacts associated with threatened species and communities that have potential to occur within the survey area. Threatened entities that had a moderate or high potential to occur and were subject to a ‘Medium’ or greater impact risk were further assessed using an Assessment of Significance under the TSC Act.

Figure 9-17 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 9-17. Downstream impact and risk assessment methodology (from Appendix F2)*




### 9.4.3 Flooding scenarios and extents

The Project would delay and attenuate the progression of inflows coming from the upstream Warragamba catchment Activation 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 one in 100 chance in a year event

- increase flood durations within the FMZ discharge area, ranging from an additional five days for a 1 in 5 chance in a year event, up to eight days for a 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 1 in 5 chance in a year 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 1 in 10 chance in a year event becomes a 1 in 200 chance in a year event and the 1 in 100 chance in a year event becomes a 1 in 1,500 chance in a year event.

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 (see Appendix N2 - Geomorphology assessment report), however these impacts would not substantially alter local or regional flood conveyance and storage areas.

Project changes for selected flood events up to the 1 in 100 chance in a year event are summarised in Table 9-13 and shown on Figure 9-18, Figure 9-19, Figure 9-20 and Figure 9-21. These changes are based on the dam being full before a rainfall event and widespread rainfall within the upstream catchment.

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 1 in 5 chance in a year event. At the time the 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 catchment above Warragamba Dam. 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.

It is predicted that the 1 in 10 chance in a year event would likely have the greatest change in extent due to differences between the existing and with the Project flood extent scenarios, and comprises the area for targeted biodiversity surveys. Potential biodiversity impacts are therefore focused on the 1 in 10 chance in a year event (survey area). The survey area includes the FMZ discharge area, which is approximately equivalent to the 1 in 5 chance in a year event and comprises in-river flows and adjoining backwater flooded areas.

*Table 9-13. Assessment of Project flooding scenarios*

| Scenario | Predicted changes | Project change in flood levels[1] | |
|---|---|---|---|
| | | Location | metres |
| 1 in 5 chance in a year event | ▪ 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<br>▪ Reduction in peak flow changes from 2,271 $m^3/s$ to 810 $m^3/s$.<br>▪ Reduction of about 670 ha of native vegetation in the catchment previously subject to inundation in this event.<br>▪ Increased duration of inundation in FMZ discharge area of about 5 days instead of 2 days (that is an increase of 3 days).<br>▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area.<br>▪ 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 |
| 1 in 10 chance in a year event **(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<br>▪ Reduction in peak flow changes from 4,430 $m^3/s$ to 1,160 $m^3/s$.<br>▪ Reduction of about 955 ha of native vegetation in the catchment previously affected in this event.<br>▪ 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)<br>▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area.<br>▪ 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 |
| 1 in 20 chance in a year event | ▪ 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<br>▪ Reduction in peak flow changes from 6,860 $m^3/s$ to 1,160 $m^3/s$<br>▪ Reduction of about 960 ha of native vegetation in the catchment previously affected in this event.<br>▪ 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)<br>▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area.<br>▪ 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 in 100 chance in a year event | ▪ 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<br>▪ Reduction in peak flow changes from 9,660 $m^3/s$ to 3,800 $m^3/s$.<br>▪ Reduction of about 1,180 ha of native vegetation in the catchment previously affected in this event.<br>▪ Increased duration of inundation in FMZ discharge area of about 11 days instead of 4 days (that is an increase of 7 days).<br>▪ Increased inundation duration of up to 1,926 ha of wetland and floodplain habitats in the FMZ discharge area.<br>▪ 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 9-18. Existing and Project 1 in 5 chance in a year scenarios and FMZ discharge area*

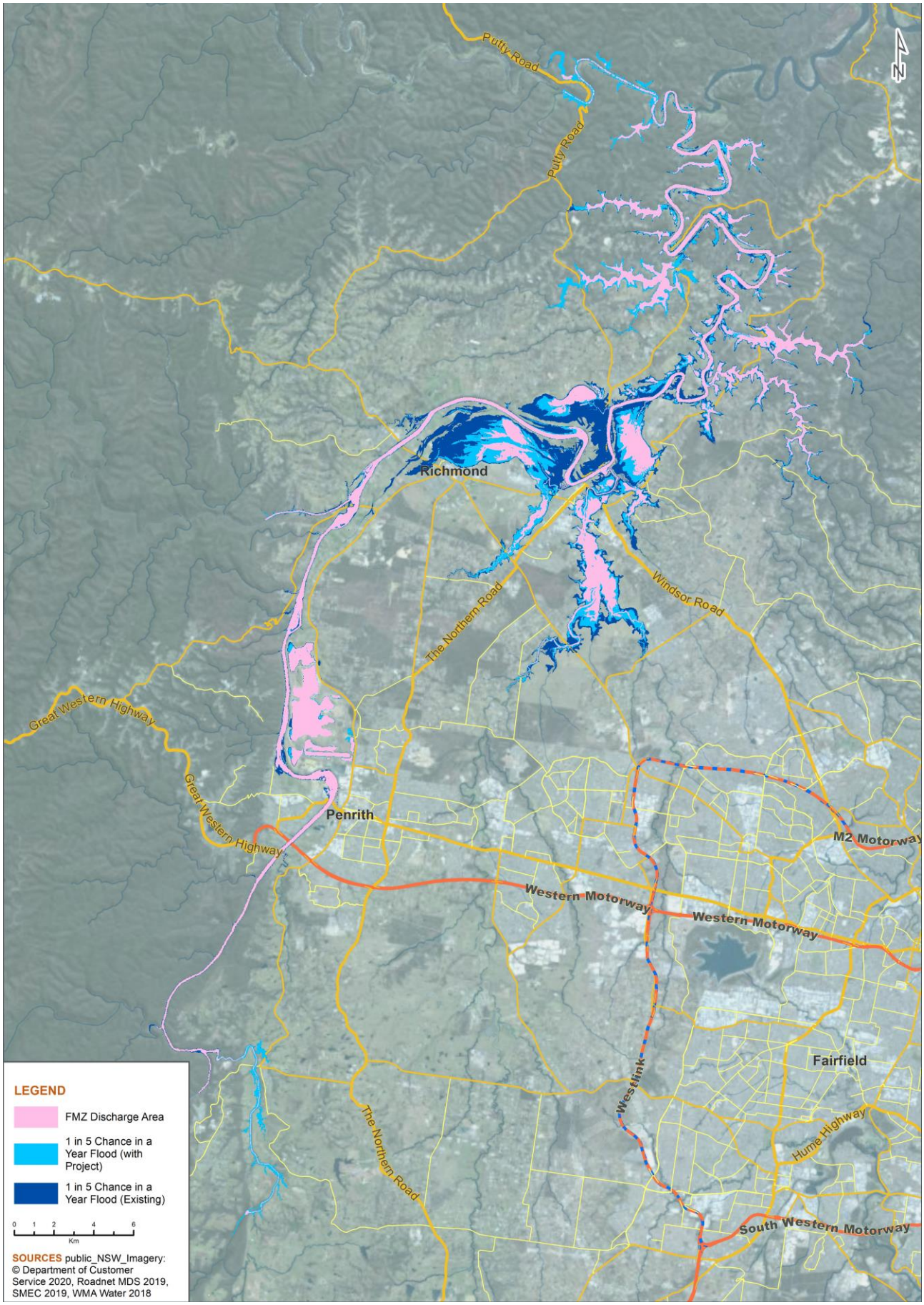


*Figure 9-19. Existing and Project 1 in 10 chance in a year scenarios and FMZ discharge area*

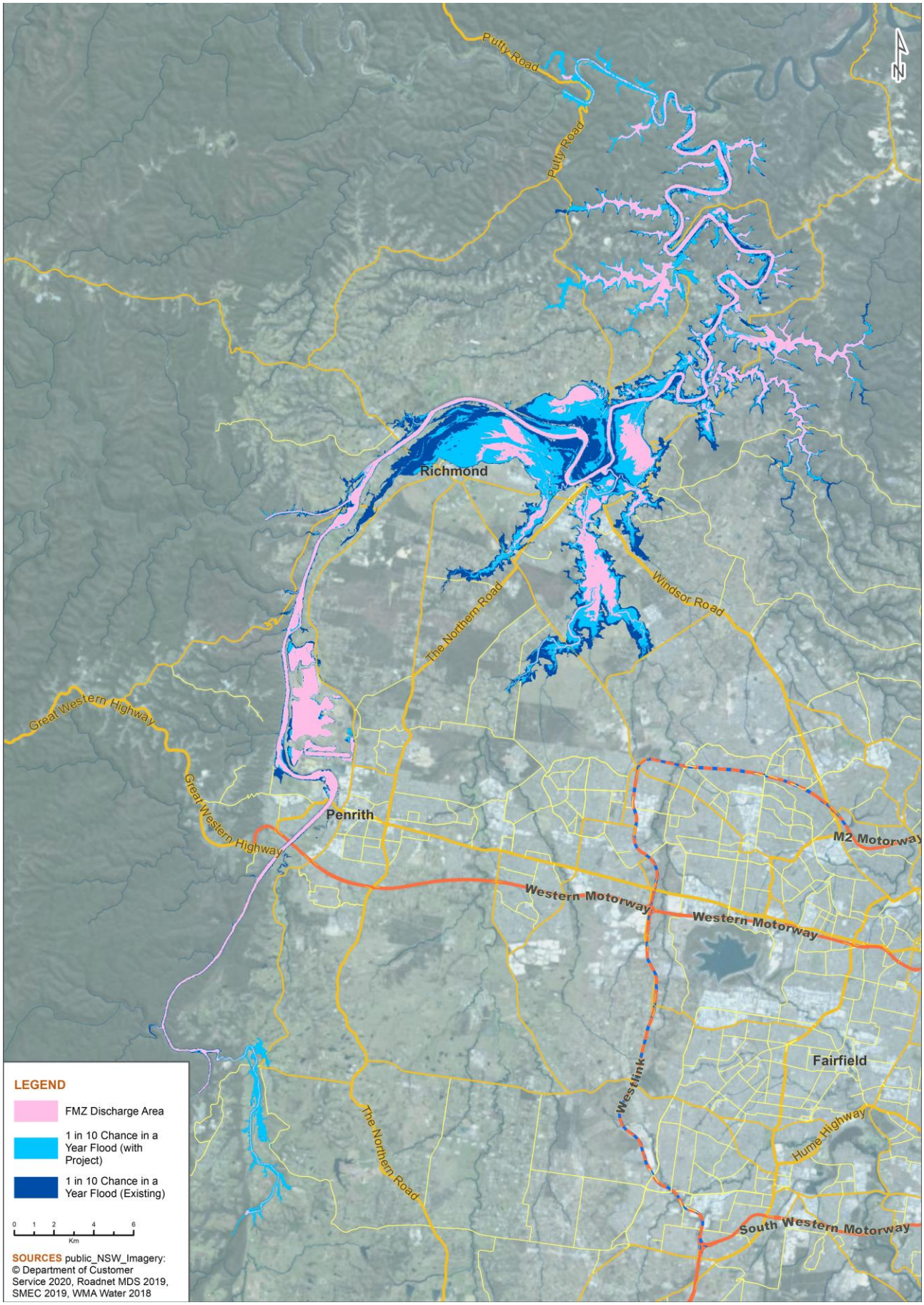


*Figure 9-20. Existing and Project 1 in 20 chance in a year scenarios and FMZ discharge area*

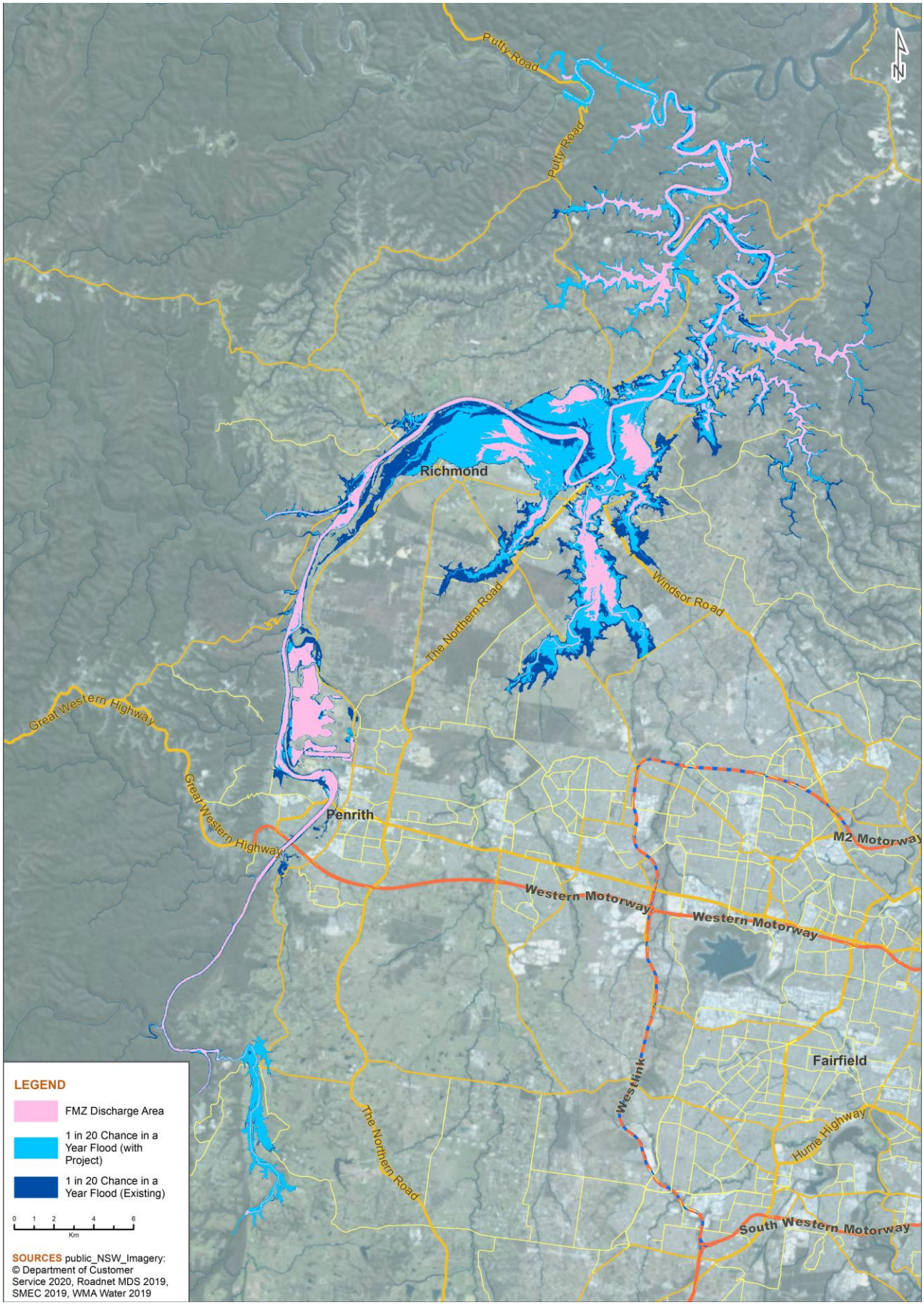
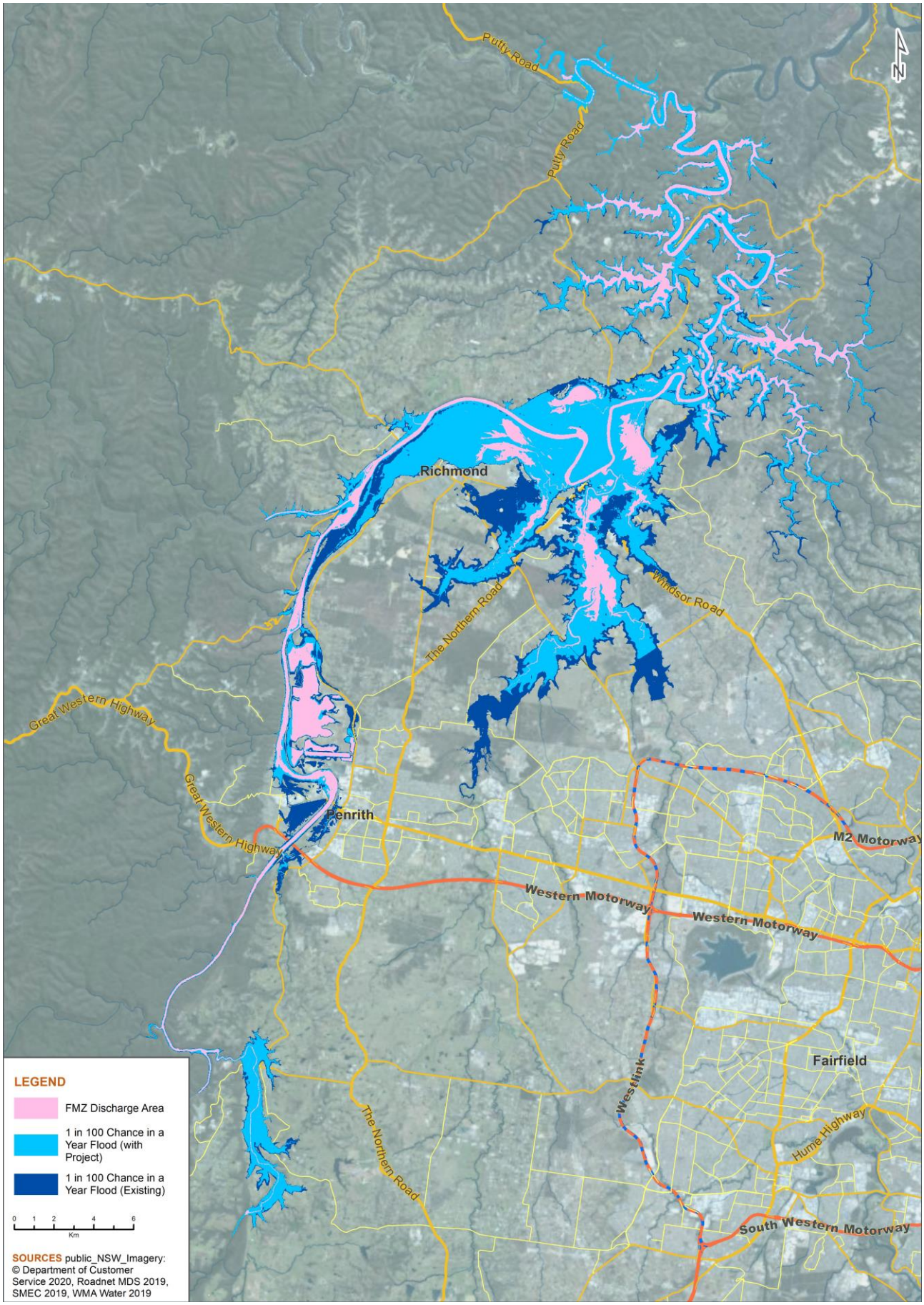


*Figure 9-21. Existing and Project 1 in 100 chance in a year scenarios and FMZ discharge area*



### 9.4.4 Impact risk assessment

A reduction in the flood area and duration across floodplains and associated wetlands may result in a reduction of suitable habitat for organisms that are dependent on the distribution of organic matter through the river system. Altered flow patterns contribute to the degradation of riparian zones, which reduces availability of suitable habitat for native species and increases 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 9-17 (see Section 9.4.2) outlines the impact risk framework guiding the assessment of the key biodiversity impacts.

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 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 9-22 and definitions given in Table 9-14. These definitions guided the assessors to allocate a risk rating to impacts in the following sections.

A biodiversity risk assessment is presented in Table 9-15. Impacts assessed with a risk score of 'Medium' or above are further discussed in the following sections.

*Table 9-14. Risk assessment definitions*

| Score | Description |
|---|---|
| **Likelihood** | |
| Almost Certain | Very high or certain probability that impact will occur or event is of a continuous nature. |
| Likely | 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). |
| Remote | 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** | |
| Significant | 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. |
| Insignificant | No measurable impact. |

1. As per definition in TSC Act

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 in Appendix F2)

*Figure 9-22. Biodiversity risk assessment 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 9-15. Biodiversity risk assessment*

| 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 (1 in 10 chance in a year) (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.<br>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 may directly result from these changes to erosive processes for riparian, floodplain and wetland communities.<br>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. |

| Potential impacts | Impact risk assessment | | | Description of change |
|---|---|---|---|---|
| | Likelihood | Consequence | Risk for biodiversity | |
| 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. |
| 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. |

| Potential impacts | Impact risk assessment | | | Description of change |
|---|---|---|---|---|
| | Likelihood | Consequence | Risk for biodiversity | |
| 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 elevated river flows and soil saturation during periods of extended inundation. Changes to vegetation structure, composition, and condition may 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.<br>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.<br>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*). |

| Potential impacts | Impact risk assessment | | | Description of change |
|---|---|---|---|---|
| | Likelihood | Consequence | Risk for biodiversity | |
| | | | | 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 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.<br>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. |

### 9.4.5 Risk of impacts to biodiversity features

#### 9.4.5.1 Native vegetation and TECs

As outlined in Table 9-15, 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 9-16 presents the areas of PCTs that would no longer be flooded during the 1 in 10 chance in a year flood and the areas of PCTs that would experience increased periods of inundation due to the FMZ discharge. 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 9-16 with an impact risk of 'Medium' or 'High' have been further assessed through an Assessment of Significance in Appendix F of this report. The outcomes of these assessments are summarised in Section 9.6.

Notwithstanding the risk assessment process, TECs listed as critically endangered under the BC Act were assigned a 'High' risk rating.

*Table 9-16. Impacts to PCTs and TECs within the 1 in 10 chance in a year flood event area and the FMZ discharge area*

| Plant community type (PCT) | Threatened ecological community (TEC) | Area within changed 1 in 10 chance in a year flood (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 *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC* under the EPBC 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 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 | *River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North* | 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 |

| Plant community type (PCT) | Threatened ecological community (TEC) | Area within changed 1 in 10 chance in a year flood (ha) | Area within FMZ discharge (ha) | Impact risk | Justification |
|---|---|---|---|---|---|
| Bioregion and northern Sydney Basin Bioregion | *Coast, Sydney Basin and South East Corner Bioregions EEC* under the BC Act | | | | 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** | | |
| **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 1 in 10 chance in year scenario 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<br>*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<br>*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 | Not listed | 0.04 | 0 | **Low** | PCT 1327 will not be impacted by the discharge of the FMZ (increased flooding frequency). PCT 1327 is not |

| Plant community type (PCT) | Threatened ecological community (TEC) | Area within changed 1 in 10 chance in a year flood (ha) | Area within FMZ discharge (ha) | Impact risk | Justification |
|---|---|---|---|---|---|
| dry hinterland of the Central Coast Sydney Basin Bioregion | | | | | 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 1 in 10 chance in a year and the FMZ discharge area. |
| PCT 1328: Yellow Bloodwood - Narrow-leaved Apple heathy woodland on hinterland plateaux of the Central Coast Sydney Basin Bioregion | 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). PCT 1328 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 1 in 10 chance in a year 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<br>*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 1 in 10 chance in a year 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** | | |

#### 9.4.5.2 Threatened flora species

As outlined in Table 9-15, 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 'Medium or 'High' likelihood of occurrence. or that have been previously recorded in the survey area are listed in Table 9-17.

Where species are listed as critically endangered under the BC Act, the impact risk has been assigned as 'High'.

A total of 18 flora species were determined to have a medium or higher impact risk. These were further assessed in an Assessment of Significance in Appendix F2 (Downstream ecological assessment, Appendix F) and summarised in Section 9.6.

*Table 9-17. 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 1 in 10 chance in a year | Impact risk | Justification |
|---|---|---|---|---|---|
| *Acacia bynoeana* | E | V | Moderate | **Low** | Species is located within current PMF 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 current PMF 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 existing PMF. 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 existing PMF, 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. |
| *Darwinia biflora* | V | V | Moderate | **Low** | Located near the edge of the current PMF, 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 existing PMF. 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 existing PMF. 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 existing PMF. 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. |

| Threatened flora species | BC Act | EPBC Act | Likelihood of occurrence in 1 in 10 chance in a year | Impact risk | Justification |
|---|---|---|---|---|---|
| *Eucalyptus camfieldii* | V | 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. |
| *Eucalyptus sp. Cattai* | CE | CE | Moderate | **High** | 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. |
| *Grammitis stenophylla* | 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. |
| *Grevillea juniperina* subsp. *juniperina* | V | - | Recorded | **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. |
| *Grevillea parviflora* subsp. *parviflora* | V | V | 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. |
| *Grevillea shiressii* | 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. |
| *Gyrostemon thesioides* | E | - | Moderate | **Low** | 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. |
| *Hibbertia puberula* | E | - | Moderate | **Low** | Not recorded within 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. |
| *Kunzea rupestris* | V | V | Recorded | **Low** | 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. |
| *Lasiopetalum joyceae* | 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. |
| *Leucopogon exolasius* | V | V | Moderate | **Low** | 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. |
| *Leucopogon fletcheri* subsp. *fletcheri* | E | - | 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. |

| Threatened flora species | BC Act | EPBC Act | Likelihood of occurrence in 1 in 10 chance in a year | Impact risk | Justification |
|---|---|---|---|---|---|
| *Marsdenia viridiflora R. Br.* subsp. *viridiflora population* | EP | - | High | **Medium** | Listed as critically endangered under the BC Act. |
| *Melaleuca deanei* | V | V | 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. |
| *Micromyrtus minutiflora* | E | V | High | **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. |
| *Persoonia hirsuta* | E | E | 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. |
| *Persoonia nutans* | E | E | Recorded | **Medium** | 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. |
| *Pilularia novae-hollandiae* | E | - | Moderate | **Medium** | 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. |
| *Pimelea curviflora* var. *curviflora* | V | V | Recorded | **Medium** | 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. |
| *Pimelea spicata* | E | E | High | **Medium** | 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. |
| *Pomaderris brunnea* | E | V | Recorded | **Medium** | 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. |

| Threatened flora species | BC Act | EPBC Act | Likelihood of occurrence in 1 in 10 chance in a year | Impact risk | Justification |
|---|---|---|---|---|---|
| *Pterostylis saxicola* | E | E | 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 study area, the species is unlikely to occur in areas subject to flooding regime changes. |
| *Pultenaea parviflora* | E | V | Recorded | **Medium** | 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. |
| *Rhodamnia rubescens* | CE | - | Recorded | **High** | 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. |
| *Senna acclinis* | E | - | Recorded | **Medium** | 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. |
| *Seringia denticulata (syn. Keraudrenia corollata* var. *denticulata) population* | EP | - | 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. |
| *Syzygium paniculatum* | E | V | 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. |
| *Tetratheca glandulosa* | V | - | Recorded | **Low** | 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. |
| *Zieria involucrata* | E | V | Recorded | **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. |

#### 9.4.5.3 Threatened fauna species

As outlined in Table 9-15, 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 'Medium or 'High' likelihood of occurrence or species that have been previously recorded in the survey area are outlined in Table 9-18. Species listed as 'migratory' under the EPBC Act with a moderate or high likelihood of occurrence are not included 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'.

Four fauna species were determined to have a medium or high impact risk. These were further assessed in an Assessment of Significance in Appendix F2 (refer Appendix F of the report) and summarised in Section 9.6.

*Table 9-18. 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. |
| 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. |

| Species | BC Act | EPBC Act | Likelihood of occurrence | Impact risk | Justification |
|---|---|---|---|---|---|
| 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. |
| 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. |

| Species | BC Act | EPBC Act | Likelihood of occurrence | Impact risk | Justification |
|---|---|---|---|---|---|
| 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. |
| 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. |

### 9.4.6 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 F2 (Downstream ecological assessment, Appendix F). A summary of assessment results is provided in Table 9-19.

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 will be prepared as part of Appendix F5 (Matters of national environmental significance - biodiversity).

*Table 9-19. Summary of findings of Assessment of Significance under the EP&A Act*

| Threatened species, populations, or communities<br>Y= Yes (negative impact), N= No (no impact), X= not applicable. | 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 |
| *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 |

| Threatened species, populations, or communities<br>Y= Yes (negative impact), N= No (no impact), X= not applicable. | Assessment question | | | | | | | Significant impact? |
|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g | |
| *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 involucrata* | 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 |

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

As discussed in Section 9.4.1, 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 in 100 chance in a year event 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. This is demonstrated in

Table 9-10 (refer Section 9.3.5.4), which shows large areas of terrestrial woodland potentially impacted in the study area but only 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 minimal impacts or benefits due to the reduction in the extent of the PMF with the Project.

### 9.5.1 Impacts on groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are discussed in Section 9.3.7. 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 and all would continue to be inundated by the 1 in 5 chance in a year event and larger events with the Project.

Groundwater dependent ecosystems in the study area are listed in Appendix F2 (Downstream ecological assessment, Appendix G).

### 9.5.2 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.

Indirectly, fragmentation can 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 remnant 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.

### 9.5.3 Impacts to national park estates

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 9-20. 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 9.4.4 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 9-20. Potential impacts to national park estate*

| National park estate | Potential impacts |
|---|---|
| Blue Mountains National Park | Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios.<br>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.<br>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.<br>Increase in flood duration and longer periods of above average water velocities within the FMZ discharge area.<br>Coastal Freshwater Wetlands EEC and Sydney Turpentine Ironbark Forest CEEC is 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.<br>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.<br>Increase in flood duration within FMZ discharge area.<br>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.<br>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.<br>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.<br>Increase in flood duration and velocity within FMZ discharge area.<br>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.<br>Increase in flood duration within FMZ discharge area.<br>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.<br>River Flat Eucalypt Forest EEC, Coastal Freshwater Wetlands EEC and Sydney Turpentine Ironbark Forest known to occur within the national park. |

| National park estate | Potential impacts |
|---|---|
| Parr State Conservation Area | Minor reduction in flood extent, depth, and duration between existing and with Project flood scenarios.<br>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.<br>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. |

### 9.5.4 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 the Commonwealth Matters Report provided in Appendix F5 (Matters of national environmental significance).

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 9-21. 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 9-21. Key threatening processes associated with 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.<br>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 Hawkesbury-Nepean River which could result in the loss of vegetation within these areas.<br>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 encourage 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 encourage 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 encourage 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*. |

| Key threatening process | EPBC Act equivalent | Details |
|---|---|---|
| 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 encourage 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 encourage 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 encourage 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. |
| 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 encourage 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 encourage 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 encourage 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 encourage 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 encourage 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 |

| Key threatening process | EPBC Act equivalent | Details |
|---|---|---|
| | | 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. |

### 9.5.5 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 9-22 provides a summary of these projects and their determined/proposed impact. For the purposes of the cumulative impact assessment, the impacted areas provided in Table 9-22 encompass all types of impacts, including the impacts associated with temporary inundation and alterations to hydrological flows discussed in detail in Appendix F1 (Biodiversity assessment report - upstream) and this report, as well as vegetation clearing related impacts from construction activities.

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 9-22. Past, present, and future projects*

| Project | Construction impact | Operational Impact |
|---|---|---|
| **Warragamba Dam Raising – Upstream**<br>▪ upstream operational impacts associated within the Project. | Appendix F1 (Upstream BAR). | Appendix F1 (Upstream BAR). |
| **Warragamba Dam Raising – Construction**<br>▪ construction impacts associated within the Project. | Appendix F3 (Biodiversity assessment report - construction area). | N/A. |
| **Warragamba Dam Raising – Downstream**<br>▪ downstream operational impacts associated within the Project. | Appendix F2 (Downstream ecological assessment). | Appendix F2. |
| **Western Sydney Airport**<br>▪ located approximately 8.5 km east of Warragamba Dam<br>▪ construction commenced. | ▪ removal of 318.5 ha of native vegetation<br>▪ removal of 141.8 ha of fauna habitat<br>▪ direct and indirect impacts to threatened biota. | ▪ bird and bat strike<br>▪ terrestrial fauna strike<br>▪ noise and vibration<br>▪ light<br>▪ alterations to hydrology and GDEs. |
| **M12 Motorway**<br>▪ 16 km motorway between M7 at Cecil Hills and Northern Road, Luddenham<br>▪ located approximately 10 km east of Warragamba Dam<br>▪ proposal under assessment. | ▪ removal of 118.0 ha of native vegetation<br>▪ removal of 334 threatened plants<br>▪ removal of 1.6 ha of threatened fauna habitat. | ▪ changes to hydrology<br>▪ habitat fragmentation<br>▪ edge effects<br>▪ fauna mortality<br>▪ risk of establishment of weeds and pathogens. |
| **Northern Road Upgrade**<br>▪ upgrade of Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park<br>▪ located approximately 10 km east of Warragamba Dam<br>▪ construction commenced. | ▪ removal of 39.6 ha of native vegetation<br>▪ removal of threatened flora and fauna habitat<br>▪ removal of 39 threatened plants. | ▪ changes to hydrology<br>▪ habitat fragmentation<br>▪ edge effects<br>▪ fauna mortality<br>▪ establishment of weeds and pathogens. |
| **Hume Coal Project**<br>▪ development of an underground mine to extract metallurgical and industrial coal | ▪ removal of 64 paddock trees<br>▪ removal of 8.3 ha of threatened fauna habitat. | ▪ potential changes to surface and subterranean hydrology<br>▪ habitat fragmentation |

| Project | Construction impact | Operational Impact |
|---|---|---|
| ▪ located approximately 70 km south-west of Warragamba Dam<br>▪ proposal under assessment. | | ▪ edge effects<br>▪ fauna mortality<br>▪ establishment of weeds and pathogens. |
| **Gunlake Quarry Extension**<br>▪ extension of operations at Gunlake Quarry<br>▪ located approximately 170 km south-west of Warragamba Dam<br>▪ proposal determined. | ▪ removal of 54.1 ha of native vegetation<br>▪ removal of threatened flora and fauna habitat. | ▪ erosion and sedimentation<br>▪ habitat fragmentation<br>▪ edge effects<br>▪ fauna mortality<br>▪ establishment of weeds and pathogens. |

### 9.5.6 Avoidance and management measures

#### 9.5.6.1 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.

#### 9.5.6.2 Offsetting

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 that 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 (refer Appendix F2 Downstream biodiversity assessment, Appendix F).

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 (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 due to quantifying and qualifying the nature and scale of potential impacts, especially when the potential impact occurs at a landscape scale and any impact would be gradual over the long term.

There are currently numerous activities that have an existing impact on the downstream 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 will, to greater or lesser degrees, be occurring concurrent with 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.

With regard to the NSW biodiversity offset policy principles, the Project would seek to minimise unavoidable impacts through development of the operational protocol for the FMZ which would seek to minimise potential impacts on downstream vegetation from temporary inundation subject to meeting operational priorities for protection of life and property (refer Table 9-23).

However, due to the extent of the downstream 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.

### 9.5.7 Summary of impact assessment

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.

Project impacts would be mainly associated with:

- operation of the FMZ, and related extended period of inundation
- reduced extent of flooding associated with the Project for all flood events considered. The effect of these impacts is considered negligible.

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 on 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 are 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 will, 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.

## 9.6 Environmental management measures

The Project has sought to avoid and minimise impacts, however, not all biodiversity impacts can be avoided. Management will mainly involve managing water discharges from the FMZ so that downstream flooding extents are reduced as much as possible. This is summarised in Table 9-23.

Management measures have been incorporated in the Environmental Management measures in Chapter 29 (EIS synthesis, Project justification and conclusion).

*Table 9-23. Management measures*

| Impact | ID | Environmental management measure | Outcome | Timing | Responsibility |
|---|---|---|---|---|---|
| Inundation of native vegetation | BDS1 | 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 | Prior to operation | WaterNSW |

## 9.7 Risk assessment

An environmental risk assessment was carried out in accordance with the SEARs, using the methodology provided in Appendix C (Risk assessment procedure). A Project risk matrix was developed and risk ranking evaluated by considering:

- the likelihood (L) of an impact occurring
- the severity or consequence (C) of the impact in a biophysical and/or socio-economic context, with consideration of:
  - whether the impact will be in breach of regulatory or policy requirements
  - the sensitivity of receptors
  - duration of impact, that is, whether the impact is permanent or temporary
  - the areal extent of the impact and/or the magnitude of the impact on receptors.

The likelihood and consequence matrix is shown on Figure 9-23.

Once the consequence and likelihood of an impact are assessed, the risk matrix provides an associated ranking of risk significance: **Low**; **Medium**; **High** or **Extreme,** as shown in Table 9-24**.** The residual risk was determined after the application of proposed mitigation measures.

The risk analysis for potential downstream biodiversity impacts is provided in Table 9-25. This includes the residual risk of the potential impact after the implementation of mitigation measures.

*Table 9-24: Risk ranking definitions*

| Risk definitions | |
|---|---|
| **Extreme 21 – 25** | Widespread and diverse primary and secondary impacts with significant long-term effects on the environment, livelihood and quality of life. Those affected will have irreparable impacts on livelihoods and quality of life. |
| **High 15 – 20** | Significant resources and/or Project modification would be required to manage potential environmental damage. These risks can be accommodated in a project of this size, however comprehensive and effective monitoring measures would need to be employed such that Project activities are halted and/or appropriately moderated. Those impacted may be able to adapt to change and regain their livelihoods and quality of life with a degree of difficulty. |
| **Medium 9 – 14** | Risk is tolerable if mitigation measures are in place, however management procedures will need to ensure necessary actions are quickly taken in response to perceived or actual environmental damage. Those impacted will be able to adapt to changes. |
| **Low 1 – 8** | On-going monitoring is required however resources allocation and responses would have low priority compared to higher ranked risks. Those impacted will be able to adapt to change with relative ease. |

The risk analysis for potential downstream biodiversity impacts is provided in Figure 9-23. This includes the residual risk of the potential impact after the implementation of mitigation measures.

*Figure 9-23. Risk matrix*

| | | Consequence | | | | |
|---|---|---|---|---|---|---|
| | | Negligible | Minor | Medium | Major | Extreme |
| | LEGAL | No legal consequences | No legal consequences | Incident potentially causing breach of licence conditions | Breach of licence conditions | Breach of licence conditions resulting in shutdown of Project operations. |
| | SOCIO-ECONOMIC | Impacts that are practically indistinguishable from the social baseline or consist of solely localised or temporary/short-term effects with no consequences on livelihoods and quality of life. | Short-term or temporary impacts with limited consequences on livelihoods and quality of life. Those affected will be able to adapt to the changes with relative ease and regain their pre-impact livelihoods and quality of life. | Primary and secondary impacts with moderate effects on livelihoods and quality of life. Will be able to adapt to the changes with some difficulty and regain their pre-impact livelihoods and quality of life. | Widespread and diverse primary and secondary impacts with significant long-term effects on livelihoods and quality of life. Those affected may be able to adapt to changes with a degree of difficulty and regain their pre-impact livelihoods and quality of life. | Widespread and diverse primary and secondary impacts with irreparable impacts on livelihoods and quality of life and no possibility to restore livelihoods. |
| | HEALTH | No health consequences | Accident or illness with little or no impact on ability to function. Medical treatment required is limited or unnecessary. | Accident or illness leading to mild to moderate functional impairment requiring medical treatment. | Accident or illness leading to permanent disability or requiring a high level of medical treatment or management. | Accident, serious illness or chronic exposure resulting in fatality. |
| | ENVIRONMENT | Localised (on-site), short-term impact on habitat, species or environmental media | Localised or widespread medium-term impact to habitat, species or environmental media | Localised degradation of sensitive habitat or widespread long-term impacts on habitat, species or environmental media. Possible contribution to cumulative impacts. | Widespread and long-term changes to sensitive habitat, species diversity or abundance or environmental media. Temporary loss of ecosystem function at landscape scale. Moderate contribution to cumulative impacts. | Loss of a nationally or internationally recognised threatened species or vegetation community. Permanent loss of ecosystem function on a landscape scale. Major contribution to cumulative effects |
| | | **A** - negligible | **B** - minor | **C** - medium | **D** - major | **E** - extreme |
| Expected to occur during the Project or beyond the Project | **a** - expected | **13** | **14** | **20** | **24** | **25** |
| May occur during the Project or beyond the Project | **b** - may | **8** | **12** | **19** | **22** | **23** |
| Possible under exceptional circumstances | **c** - possible | **6** | **7** | **11** | **18** | **21** |
| Unlikely to occur during the Project | **d** - unlikely | **4** | **5** | **10** | **16** | **17** |
| Rare or previously unknown to occur | **e** - rare | **1** | **2** | **3** | **9** | **15** |

| **Risk Definition** (see Table 9-24) | Low | Medium | High | Extreme |
|---|---|---|---|---|

*Table 9-25. Biodiversity downstream: risk assessment*

| Biodiversity: downstream | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Key impacts** | **Risk before mitigation** | | | **Mitigation and management** | **Risk after mitigation** | | | **Residual risk** |
| | **L** | **C** | **R** | | **L** | **C** | **R** | |
| The Project would result in:<br>▪ a decrease in the extent, frequency and variability of downstream flooding.<br>▪ some floodplain areas would be affected by the discharge of the FMZ and would be inundated for longer.<br>Potential biodiversity impacts relate to:<br>▪ reduction of flooding extent in wetland and floodplain vegetation communities and habitats<br>▪ bank erosion and slumping resulting in vegetation community and habitat degradation<br>▪ displacement of habitat for fauna dependent on riparian or wetland habitats.<br>**1. Impacts on PCTs with medium or higher risk**<br>▪ Freshwater communities = 43.4 ha<br>▪ Floodplain and riparian communities = 45.7 ha<br>▪ Dry sclerophyll and grassy communities = 3.2 ha<br>**2. Impact on threatened flora and fauna species**<br>Potential or likely impacts were determined for 18 threatened biotas which include:<br>▪ five TECs<br>▪ 12 threatened flora species<br>▪ Six threatened fauna species. | b | C | 19 | BDS1 | b | B | 12 | Downstream flooding has been significantly altered since construction of Warragamba Dam, land clearing and urbanisation. The Project would result in some additional changes to small floods, mainly through reduced inundation extent and longer inundation durations during emptying of the FMZ.<br>Development of the operational protocol for the FMZ (BDS1) would seek to minimise potential impacts on downstream vegetation from temporary inundation subject to meeting operational priorities for protection of life and property.<br>This would reduce risk to a Medium level. |

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