Sydney Metro West
Eastern Creek Precast Facilities

Review of Environmental Factors

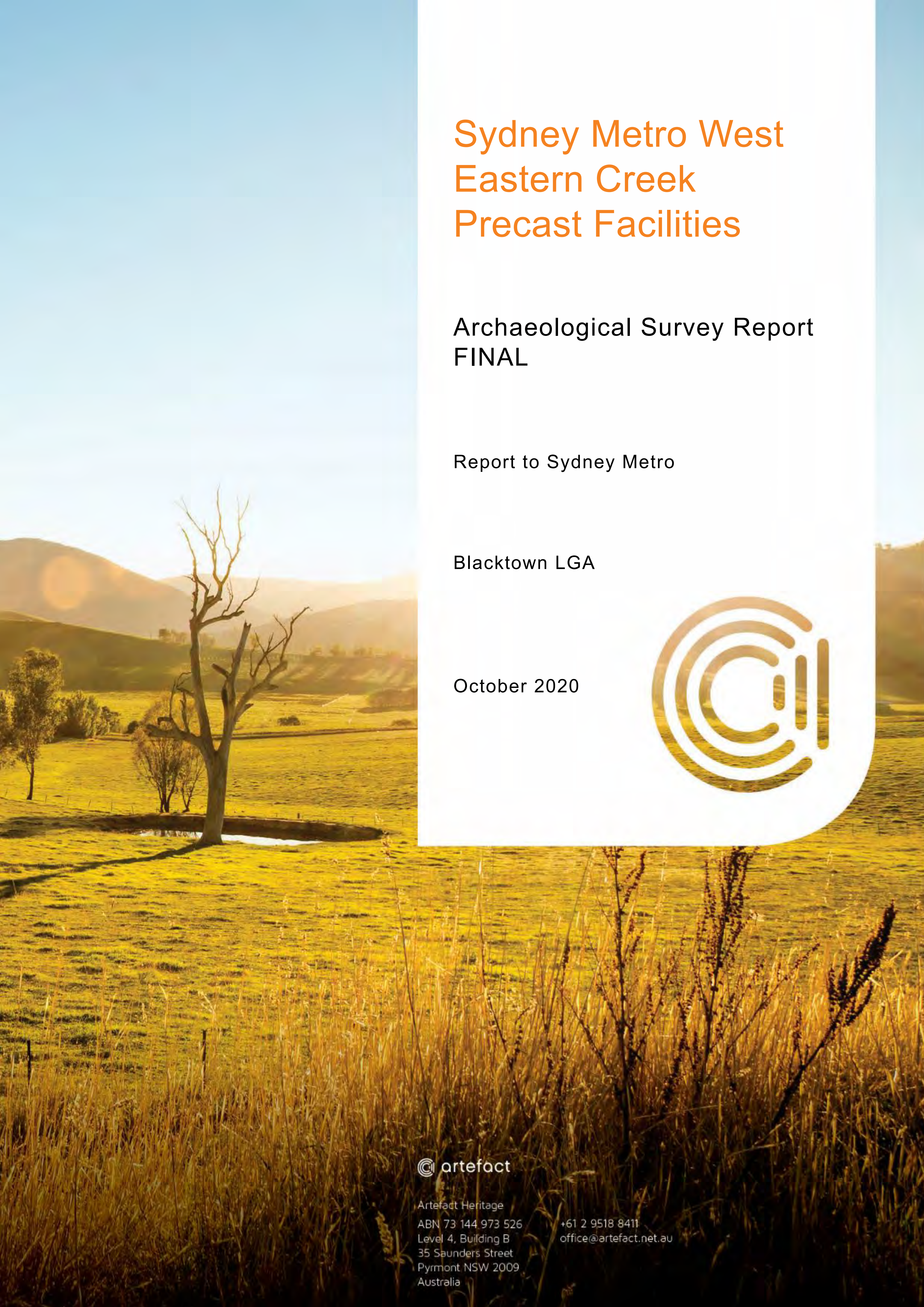
Volume 3 Technical Appendices G - J

November 2020

Cover: A precast facility used on the Sydney Metro City & Southwest project.

Appendix G

Archaeological Survey Report



Sydney Metro West Eastern Creek Precast Facilities

Archaeological Survey Report FINAL

Report to Sydney Metro

Blacktown LGA

October 2020

artefact

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EXECUTIVE SUMMARY

This Aboriginal Archaeological Survey Report (ASR) has been prepared by Artefact Heritage Services Pty Ltd (Artefact) on behalf of Sydney Metro (the proponent) in relation to construction and operation of two precast facilities and associated ancillary infrastructure (the proposal). The facilities would support the construction of Sydney Metro West.

A Review of Environmental Factors is being prepared for the proposal seeking approval under Part 5 of the *Environmental Planning and Assessment Act 1979*. The purpose of this ASR is to support the Review of Environmental Factors for the proposal.

This report meets the requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in* NSW (Department of Environment, Climate Change and Water, 2010a) and provides recommendations as to whether further archaeological investigation may be required in relation to the current proposal.

It was found that:

- Ten Aboriginal sites are located within the proposal site
  - Blacktown Southwest 11 (AHIMS ID 45-5-0563)
  - Blacktown Southwest 7 (AHIMS ID 45-5-0559)
  - RCIF 2 (AHIMS ID 45-5-3159)
  - RCAS 4 (AHIMS ID 45-5-3162)
  - RCAS 5 (AHIMS ID 45-5-3163)
  - AIF-06 (AHIMS ID 45-5-4599)
  - AIF-05 (AHIMS ID 45-5-4605)
  - RCAS09 (AHIMS ID 45-5-5355)
- RCAS 10 (AHIMS ID 45-5-5354)RCAS 11 (AHIMS ID 45-5-5353)The current assessment has identified an area of potential archaeological deposit (PAD) associated with the wider site extent of Aboriginal sites RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) as well as the area of PAD identified within RCAS 09 (AHIMS ID 45-5-5355)
- RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) would be subject to partial harm as a portion of their identified site extents are located outside of the current impact area
- All remaining identified surface artefact sites within the proposal site would be subject to total harm resulting in total loss of value to all remaining sites.

The following recommendations are made:

- Archaeological test excavation would be limited to the proposal site and undertaken in accordance with the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW (Department of Environment, Climate Change and Water, 2010a) to confirm the geographic extent of RCIF 2 (AHIMS ID 45-5-3159), Blacktown Southwest 11 (AHIMS ID 45-5-0559) and the area of PAD identified within Ropes Creek Artefact Scatter 09 (AHIMS ID 45-5-5355)
  Test excavation would be limited to areas subject to potential impacts by the proposed works and outside the area already salvaged as part of the St Mary's Wastewater System Augmentation

project. Archaeological test excavation would be undertaken in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010a)

- As part of the preparation of the test excavation methodology and ACHAR, comprehensive Aboriginal stakeholder consultation would be carried out in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (Department of Environment, Climate Change and Water, 2010b) and the National Parks and Wildlife Regulation 2019
- An AHIP would be submitted to the Department of Premier and Cabinet NSW (DPC) for those portions of the proposal site subject to impacts once test excavation is completed. The AHIP application would be supported by an ACHAR and test excavation report. An AHIP would be issued for the proposal prior to construction works commencing in areas where known Aboriginal sites and areas of PAD are located
- Sydney Metro would liaise with Transport for NSW regarding overlapping impacts to Aboriginal site AIF-06 (AHIMS ID 45-5-4599) and coordinating further assessment and management
- If suspected human remains are located during any stage of the proposed works, the Sydney "Metro Unexpected Finds Procedure" would be followed.

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ABBREVIATIONS

ACHAR	Aboriginal Cultural Heritage Assessment Report
AHIP	Aboriginal Heritage Impact Permit
AHIMS	Aboriginal Heritage Information Management System
Artefact Heritage	Artefact Heritage Services Pty Ltd
ASR	Archaeological Survey Report
ha	hectares
IMT	Indurated Mudstone/ Tuff
km	kilometres
m	metres
mm	millimetres
PAD	Potential Archaeological Deposit

1.0 INTRODUCTION

1.1 Introduction

This archaeological survey report (ASR) has been prepared by Artefact Heritage Services Pty Ltd (Artefact Heritage) on behalf of Sydney Metro in relation to construction and operation of two precast facilities and associated ancillary infrastructure (the proposal). The facilities would support the construction of Sydney Metro West.

A Review of Environmental Factors has been prepared for the proposal seeking approval under Part 5 of the *Environmental Planning and Assessment Act 1979*. The purpose of this ASR is to support the Review of Environmental Factors for the proposal.

This report meets the requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010a) and provides recommendations as to whether further archaeological investigation and an Aboriginal Heritage Impact Permit (AHIP) may be required in relation to the current proposal.

1.2 Proposal site

The proposal site for this assessment consists of a portion of Lot 10 DP1157491. The proposal site is bounded by Lenore Drive to the south, Ropes Creek to the west and open grassland to the north and east (See Figure 1).

The proposal site includes an area designated as an environmental protection area which would not be subject to works.

The proposal site is within the Parish of Rooty Hill and the county of Cumberland. The proposal site is within the boundaries of Deerubbin Local Aboriginal Land Council (LALC).

Figure 1: Proposal site

1.3 Description of works

Sydney Metro is proposing to construct and operate two adjacent precast facilities (the proposal) to support construction of the proposed Sydney Metro West. The precast facilities which are the subject of this proposal would manufacture precast concrete segments for the purpose of lining the Sydney Metro West tunnels.

The proposed works are further described in Section 9.1.

1.4 Purpose and scope of this report

This technical paper is one of a number of technical papers that form part of the Review of Environmental Factors. The purpose of this technical paper is to identify and assess the potential impacts of the proposal in relation to Aboriginal heritage.

This report includes the following:

- A description of the proposal and identification of the proposal site
- A description of Aboriginal community involvement and Aboriginal consultation conducted for the ASR
- Discussion of the environmental context of the proposal site
- Discussion of the Aboriginal historical context of the proposal site
- A summary of the archaeological context of the proposal site including a discussion of previous archaeological work in the area
- Development of an archaeological predictive model
- Assessment of Aboriginal archaeological potential
- Description of Aboriginal sites within the proposal site
- Development of a significance assessment for these sites addressing archaeological values
- Impact assessment for Aboriginal sites in the proposal site
- Recommendations for management and mitigation measures for Aboriginal sites.

1.5 Authorship

Sandra Wallace (Director, Artefact Heritage) provided management input and technical review. Sandra has a Doctorate in archaeology and has over 17 years' experience in non-Aboriginal and Aboriginal heritage management.

Josh Symons (Principal, Artefact Heritage) provided management input and technical review. Josh has a Bachelor of Arts (Hons) in historic and prehistoric archaeology and has over 15 years' experience in non-Aboriginal and Aboriginal heritage assessments.

Alyce Haast (Senior Heritage Consultant, Artefact Heritage) managed the project and supervised the archaeological survey. Alyce also assisted in report preparation. Alyce has a master's degree in Professional Archaeology. Alyce has over five years' experience in Aboriginal and non-Aboriginal archaeology and has completed numerous projects within the Sydney region.

Gareth Holes (Heritage Consultant, Artefact Heritage) assisted in background research and report preparation. Gareth has a Master of Arts and has over 14 years' experience in archaeology in Australia and the United Kingdom.

1.6 Report structure

- **Section 2 – Legislative context**: outlines relevant legislation for this assessment
- **Section 3 – Environmental context:** Provides a succinct overview of the environmental context of the proposal site
- **Section 4 – Aboriginal historical and archaeological context:** Provides an overview of the Aboriginal history of the area and the results of previous archaeological investigation
- **Section 5 – Archaeological survey:** Describes the survey conducted for this assessment
- **Section 6 – Results:** Describes the Aboriginal sites present within the proposal site
- **Section 7 – Analysis and discussion:** Provides a discussion of the results of the site survey
- **Section 8 – Significance assessment:** Provides an assessment of the archaeological significance of the proposal site
- **Section 9 – Impact assessment:** Assesses potential impacts to identified Aboriginal sites and areas of archaeological potential
- **Section 10 – Management and mitigation measures:** Outlines relevant management and mitigation measures for the proposal
- **Section 11 – Recommendations:** Outlines recommendations for future assessment as required

2.0 LEGISLATIVE CONTEXT

2.1 State legislation

2.1.1 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* provides statutory protection to all Aboriginal Places and objects. An Aboriginal object is defined by the *National Parks and Wildlife Act 1974* as:

> *any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains.*

An Aboriginal Place is declared by the Minister for Energy and Environment, under Section 86 of the *National Parks and Wildlife Act 1974*, in recognition of its special significance with respect to Aboriginal culture. However, areas are only gazetted as Aboriginal Places if the Minister is satisfied that sufficient evidence exists to demonstrate that the location was and/or is of special significance to Aboriginal culture. Aboriginal Places gazetted under the *National Parks and Wildlife Act 1974* are listed on the State Heritage Register established under the *Heritage Act 1977*.

The protection provided to Aboriginal objects applies irrespective of the level of their significance or issues of land tenure. Aboriginal objects and places are afforded automatic statutory protection in NSW whereby it is an offence to knowingly or unknowingly harm or desecrate an Aboriginal object or Aboriginal Place under Section 86 of the *National Parks and Wildlife Act 1974*.

In accordance with Section 89A any person who is aware of the location of an Aboriginal object must in the prescribed manner, notify the Chief Executive within a reasonable time after the person first becomes aware of that object. The prescribed manner is to complete an AHIMS Site Recording Form (Department of Environment, Climate Change and Water, 2010: 14).

In order to undertake a proposed activity which is likely to involve harm to an Aboriginal Place or object, it is necessary to apply to Heritage NSW for an AHIP. AHIPs are issued by the Heritage NSW under Section 90 of the *National Parks and Wildlife Act 1974*, and permit harm to certain Aboriginal objects or Aboriginal Places.

There are no gazetted Aboriginal Places in the proposal site. There are seven previously registered AHIMS sites within the proposal site. Three additional sites were recorded and registered as part of the current assessment. Previously registered AHIMS sites are discussed in Section 4.5 and shown in Figure 10.

One AHIP permit has previously been issued for a portion of the proposal site, AHIP C0000501, which is further discussed in Section 2.1.1.1.

2.1.1.1 AHIP C0000501

AHIP C0000501 was issued to Sydney Water Corporation in relation to the St Mary's Wastewater Sydney Augmentation Detailed Planning Stage 2 Project on 5 August 2014 (St Mary's Wastewater System Augmentation Project). The AHIP authorised salvage excavation, community collection and harm to Aboriginal objects through the proposed works. Two sites within the current proposal site (AHIMS ID 45-5-0559 and AHIMS ID 45-5-3159) were subject to salvage and partial harm in accordance with AHIP C0000501 (Figure 2). Salvage reporting associated with this AHIP was completed in 2015 and is detailed in Section 4.4.

The AHIP was surrendered on 10 July 2018 and poses no constraints to the current proposal.

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Figure 2: Portion of AHIP C0000501 located within the proposal site

2.1.2 Native Title Act 1994

The *Native Title Act 1994* was introduced to work in conjunction with the Commonwealth *Native Title Act 1993*. Native Title claims, registers and Indigenous Land Use Agreements are administered under the Act.

No Native Title Claims within the proposal site were identified on the National Native Title Tribunal *Native Title Vision* mapping service.

2.1.3 Aboriginal Lands Right Act 1983

The *Aboriginal Land Rights Act 1983* established Aboriginal Land Councils (at State and Local levels). These bodies have a statutory obligation under the *Aboriginal Land Rights Act 1983* to:

(a) take action to protect the culture and heritage of Aboriginal persons in the council's area, subject to any other law, and

(b) promote awareness in the community of the culture and heritage of Aboriginal persons in the council's area.

The proposal site is within the boundary of Deerubbin Local Aboriginal Land Council.

2.1.4 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process. The *Environmental Planning and Assessment 1979* requires that environmental impacts are considered prior to land development; this includes impacts on cultural heritage items and places as well as archaeological sites and deposits. The proposal is subject to assessment under Part 5 of the *Environmental Planning and Assessment Act 1979*.

The *Environmental Planning and Assessment Act 1979* also requires that local governments prepare planning instruments (such as Local Environmental Plans and Development Control Plans) in accordance with the *Environmental Planning and Assessment Act 1979*, to provide guidance on the level of environmental assessment required. The proposal site falls within the boundaries of the Blacktown Local Government Area. Schedule 5 of each Local Environment Plan lists items of heritage significance within each Local Government Area. If agreement is reached with the Aboriginal community, items or Aboriginal places of heritage significance are also listed within this schedule.

No Aboriginal places of heritage significance were identified within the Blacktown Local Environment Plan 2015.

2.2 Commonwealth legislation

2.2.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* provides a legislative framework for the protection and management of matters of national environmental significance, that is, flora, fauna, ecological communities and heritage places of national and international importance. Heritage items are protected through their inscription on the World Heritage List, Commonwealth Heritage List or the National Heritage List.

Under Part 9 of the *Environment Protection and Biodiversity Conservation Act 1999*, approval is required for any action occurring within, or outside, a Heritage place that has, will have, or is likely to have a ‘significant impact’ on the heritage values of a World, National or Commonwealth heritage listed property (referred to as a ‘controlled action’ under the Act). A ‘significant impact’ is defined as:

> *An impact which is important, notable, or of consequence, having regard to its context or intensity. If an action is likely to have a significant impact depends upon the sensitivity, value and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.*

The *Environment Protection and Biodiversity Conservation Act 1999* stipulates that a person who has proposed an action that will, or is likely to, have a significant impact on a site that is listed on the World Heritage List, National Heritage List or Commonwealth Heritage List must refer the action to the Minister for Sustainability, Environment, Water, Population and Communities. The Minister will then determine if the action requires approval under the *Environment Protection and Biodiversity Conservation Act 1999*. If approval is required, an environmental assessment would need to be prepared. The Minister would approve or decline the action based on this assessment.

There are no World, National or Commonwealth heritage listed sites within the proposal site and therefore referral of the proposal under the *Environment Protection and Biodiversity Conservation Act 1999* in relation to Aboriginal heritage would not be required.

2.2.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* deals with Aboriginal cultural property (intangible heritage) in a wider sense. Such intangible heritage includes any places, objects and folklore that ‘are of particular significance to Aboriginals in accordance with Aboriginal tradition’. These values are not currently protected under the *National Parks and Wildlife Act 1974*.

There is no cut-off date, and the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* may apply to contemporary Aboriginal cultural property as well as ancient sites. The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* takes precedence over state cultural heritage legislation where there is conflict. The Commonwealth Minister who is responsible for administering the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* can make declarations to protect these areas and objects from specific threats of injury or desecration. The responsible Minister may make a declaration under Section 10 of the Commonwealth Act in situations where state or territory laws do not provide adequate protection of intangible heritage.

Where an Aboriginal individual or organisation is concerned that intangible values within the proposal are not being adequately protected, they can apply to the Minister for a declaration over a place.

No intangible places were identified during the preparation of this report.

3.0 ENVIRONMENTAL CONTEXT

The environmental context of the proposal site is to assist in the prediction of:

- The potential of the landscape over time to have accumulated and preserved Aboriginal objects
- The ways Aboriginal people have used the landscape in the past with reference to the presence of resource areas, surfaces for art, other focal points for activities and settlement
- The likely distribution of the material traces of Aboriginal land use based on the above.

3.1 Environmental background

The proposal site is located within the Cumberland Plain, which is typified by an undulating landscape of rolling hills and prominent rises. The underlying geology of the proposal site consists of late Triassic period Bringelly shale deposits belonging to the Wianamatta Group (Clark and Jones, 1991). These deposits consist predominantly of claystone and siltstone with thin laminate horizons. Areas of sandstone are minor and sporadic within the Bringelly formation. However, sandstone is prominent along north to south trending flat crest ridgelines from Minchinbury through Cecil Park to Leppington and from Orchard Hills through Luddenham and Bringelly to Cobbitty (Clark and Jones, 1991).

The western portion of the proposal site includes areas of Quaternary alluvium above the underlying Bringelly shale formations. The Quaternary alluvium is associated with Ropes Creek and is largely comprised of fine-grained silt, sand and clay (Clark and Jones, 1991).

A diatreme is located 1.2 kilometres to the north-east of the proposal site, known as Jv17 Minchinbury (Clark and Jones, 1991:71). The Hanson Wallgrove Quarry is located on the diatreme. Prior to quarrying activities, the diatreme featured an outcrop of volcanic breccia which had been pushed up through the surrounding Bringelly Shale.

A significant feature of the regional geological landscape included a significant source of silcrete at Plumpton Ridge, approximately eight kilometres north of the proposal site. Silcrete, a raw material used by Aboriginal people across the Sydney Basin, was extracted from underlying Tertiary period geology called the St Marys formation. The silcrete raw material source at Plumpton Ridge was an important and extensively used quarry where extraction and tool manufacture activities took place (Jo McDonald Cultural Heritage Management, 2006).

Soils across the proposal site consist of the residual Blacktown soil landscape (Bannerman & Hazelton 1990). The Blacktown soils are shallow (<100 cm) hard setting mottled red and brown podzolic soils on crests and yellow podzolic soils on lower slopes and along drainage lines (Bannerman & Hazelton, 1990). The Blacktown soil landscape is generally associated with gently undulating rises. The soils are primarily poorly drained with very little erosional activity.

The proposal site runs parallel to Ropes Creek, a major water source in the region. Ropes Creek flows into South Creek, which eventually drains into the Hawkesbury River, approximately 22 kilometres to the north. Several smaller unnamed tributaries branch from Ropes Creek including one first order tributary across the northern portion of the proposal site (SixMaps, 2020). Based on historical aerials, additional unmapped drainage lines also cross the proposal site in several locations.

Other prominent watercourses nearby include Eastern Creek four kilometres to the east and the Nepean River 17 kilometres to the west.

3.2 Historical background and land use

European expansion throughout the Cumberland Plain displaced Aboriginal people from their traditional land and effectively cut off access to many resources. The first European activity in the area was exploratory; with Governor Arthur Phillip leading an expedition party west from Sydney Cove, climbing what would later be known as Prospect Hill (approximately ten kilometres east of the proposal site) (Office of Environment and Heritage, 2001). From here, Phillip stated that he was able to view 'for the first time since we landed, Carmarthen Hills' (Phillip, 15 May 1788), later known as the Blue Mountains. At this time, Phillip named the hill 'Bellevue'. The hill was an exceptional vantage point, used by expedition parties as a reference point.

In 1789, Captain Watkin Tench made an official journey west, using Prospect Hill as a reference. He was taken by the beauty of the rugged Blue Mountains to such a degree that the hill became known as Tench's Prospect Hill, later shortened to Prospect (Pollon, 1991: 210).

The first land grants in the Blacktown region were located at Prospect Hill. Governor Phillip granted a total of 13 plots to emancipated convicts in July 1791, ranging in size from 30 to 70 acres (Historical Records of NSW, 1978). Land parcels in and around the proposal site were also granted during this time. The land in which the proposal site resides forms part of the original 1100-acre land granted to John Thomas Campbell in 1819 (NSW LRS). Campbell would go on to name the property 'Mount Philos'.

In 1856 the parcel on which the proposal site is located was sold to Thomas William Shepherd, David Shepherd and Patrick Lindsay Crawford Shepherd (NSW LRS). The Shepherd brothers would go on to combine the land with their portion of the Erskine Park Estate to the west of Ropes Creek and opened "Chatsworth Nursery", a family extension from Darling Nursery in Chippendale (Australian Town and Country Journal, 20 July 1872).

The early years of the nursery were prosperous, and the land harvested an array of fruits, vegetables, plants and flowers (Shepherd and Co's Catalogue, 17 March 1894). An 1887 newspaper account of the nursery paints the surrounding landscape as:

> *The nursery gardens are some three miles from the station, and are reached by a bush track, which, crossing the now-deserted Western road, meanders through half-cleared country that rolls greenly underfoot, rising and falling like the broad waves of the Pacific, in undulating lines as far as the eye can reach…. Wonderfully fruitful is the red soil which is found on the 16a of nursery land before us. Emerging from a pretty house on the estate, Mr F.W.Creswick… welcomes us to the spot… Not far away we find a greenhouse specially built for the accommodation of the camellia… another 10,000 specimens of various ages (are) stored in a bush house, which covers an acre of ground. (The Daily Telegraph, 3 December 1887)*

Land within the proposal site, and around Prospect continued to be utilised for agricultural purposes throughout the remainder of the nineteenth century and into the twentieth century.

Aerial imagery from the c1960s indicate that built structures within the proposal site were limited to a number of rural residences and associated outbuildings, barn structures, open paddocks and crop fields. As depicted in Figure 3, no structures are noted within the proposal area in the 1960s. A 2004 aerial (Figure 4) depicts the location of a small outbuilding or shed to the north-eastern corner of the proposal site. This structure appears to have been demolished by 2012.

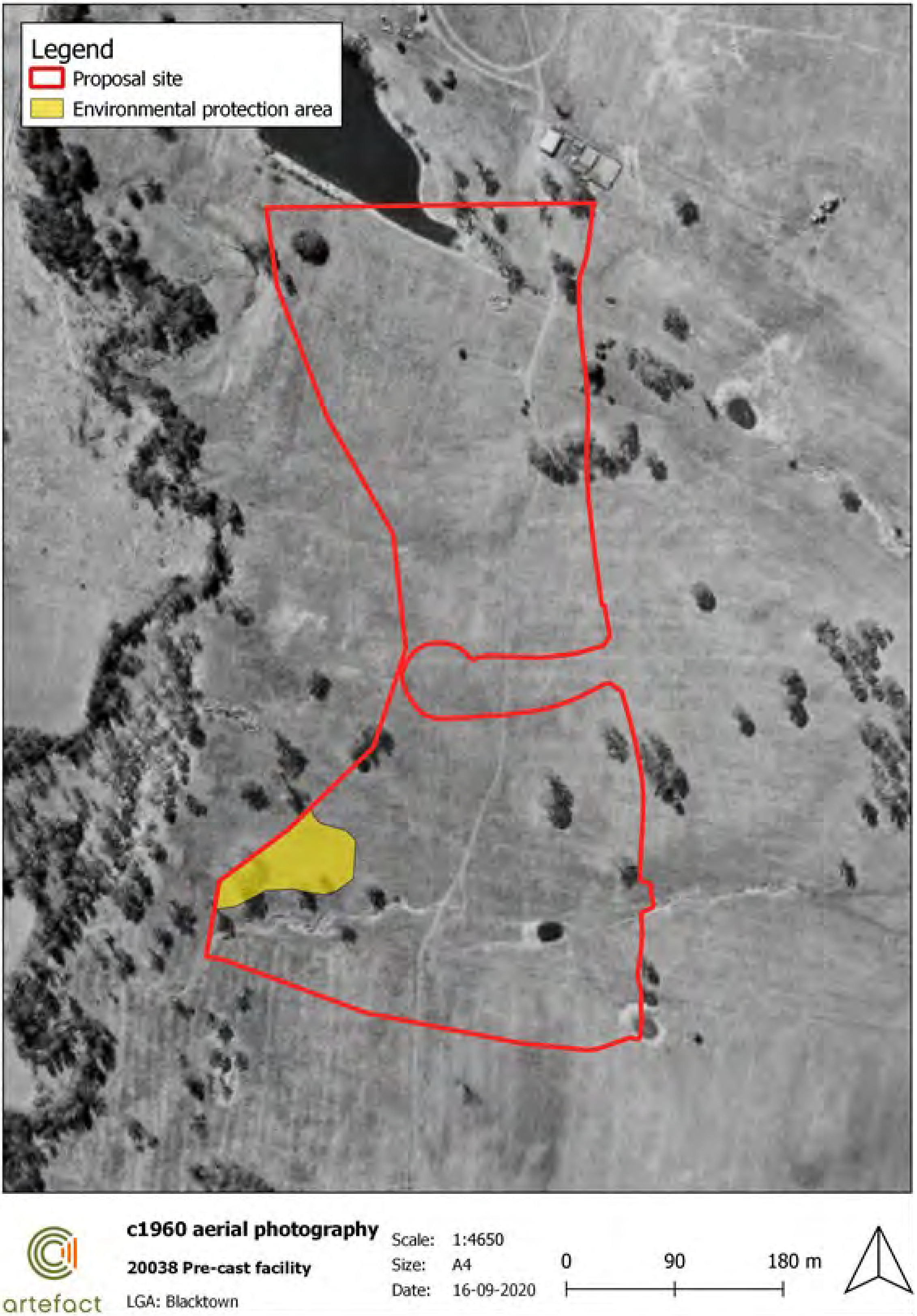

Figure 3: 1960's aerial depicting the proposal site (highlighted in red) and surrounding landscape (Source: NSW Department of Finance, Services and Innovation)

Figure 4: 2004 aerial image (Source: Google Earth)

4.0 ABORIGINAL HISTORICAL AND ARCHAEOLOGICAL CONTEXT

4.1 Aboriginal material culture

The archaeological understanding of the early Aboriginal settlement of the Sydney Basin and surrounds is constantly expanding and developing. The oldest evidence of human occupation in the vicinity of the study area comes from Cranebrook Terrace, located approximately 14 kilometres north west of the study area (Attenbrow, 2010: 18-20). Cranebrook Terrace has been dated to 41,700 years before present. Several other radiocarbon dates across the Sydney region have recovered dates of a similar antiquity including excavation in Parramatta dated to 30,725 years before present (Jo McDonald Cultural Heritage Management, 2005) and Pitt Town dated to 36,000 years before present.

Evidence of Aboriginal occupation has been found dated to 50-60,000 years before present at Lake Mungo in NSW, so it is likely that Aboriginal people have lived in the Sydney region for even longer than indicated by the oldest recorded dates we have at present. The archaeological material record provides evidence of this long occupation, but also provides evidence of a dynamic culture that has changed through time.

The existing archaeological record is limited to certain materials and objects that were able to withstand degradation and decay. As a result, the most common type of Aboriginal objects remaining in the archaeological record are stone artefacts. Archaeological analyses of these artefacts in their contexts have provided the basis for the interpretation of change in material culture over time. Technologies used for making tools changed, along with preference of raw material. Different types of tools appeared at certain times, for example ground stone hatchets are first observed in the archaeological record around 4,000 years before present in the Sydney region (Attenbrow, 2010:102). It is argued that these changes in material culture were an indication of changes in social organisation and behaviour.

The Eastern Regional Sequence was first developed by McCarthy in 1948 to explain the typological differences he was seeing in stone tool technology in different stratigraphic levels during excavations such as Lapstone Creek near the foot of the Blue Mountains (McCarthy et al. 1948). The sequence had three phases that corresponded to different technologies and tool types (the Capertian, Bondaian and Eloueran). The categories have been refined through the interpretation of further excavation data and radiocarbon dates (Hiscock and Attenbrow, 2005; Jo McDonald Cultural Heritage Management, 2006). It is now thought that prior to 8,500 years before present tool technology remained fairly static with a preference for silicified tuff, quartz and some unheated silcrete. Bipolar flaking was rare with unifacial flaking predominant. No backed artefacts have been found of this antiquity.

After 8,500 years before present silcrete was more dominant as a raw material, and bifacial flaking became the most common technique for tool manufacture. From about 4,000 years before present to 1,000 years before present backed artefacts appear more frequently. Tool manufacture techniques become more varied and bipolar flaking increases (Jo McDonald Cultural Heritage Management, 2006). It has been argued that from 1,400 to 1,000 years before contact there is evidence of a decline in tool manufacture. This reduction may be the result of decreased tool making, an increase in the use of organic materials, changes in the way tools were made, or changes in what types of tools were preferred (Attenbrow, 2010:102). The reduction in evidence coincides with the reduction in frequency of backed blades as a percentage of the assemblage.

After European colonisation, Aboriginal people of the Cumberland Plain often continued to manufacture tools, sometimes with new materials such as bottle glass or ceramics. There are several sites in Western Sydney where flaked glass has been recorded including Prospect (Ngara Consulting, 2003) and Oran Park (Jo McDonald Cultural Heritage Management, 2007).

4.2 Aboriginal Ethno-historic Context

Prior to the appropriation of their land by Europeans, Aboriginal people lived in small family groups that were associated with particular territories or places. It seems that territorial boundaries were fairly fluid, although details are not known. The language group spoken on the Cumberland Plain is known as Darug (Dharruk – alternative spelling).

This term was used for the first time in 1900 (Matthews and Everitt) as before the late 1800s language groups or dialects were not discussed in the literature (Attenbrow, 2010:31). The Darug language group is thought to have extended from Appin in the south to the Hawkesbury River, west of the Georges River, Parramatta, the Lane Cove River and to Berowra Creek (Attenbrow, 2010:34). This area was home to a number of different groups throughout the Cumberland Plain.

British colonisation had a profound and devastating effect on the Aboriginal population of the Sydney region, including Darug speakers. In the early days of the colony Aboriginal people were disenfranchised from their land as the British claimed areas for settlement and agriculture. The colonists, often at the expense of the local Aboriginal groups, also claimed resources such as pasture, timber, fishing grounds and water sources. Overall, the devastation of the Aboriginal culture did not come about through war with the British, but instead through disease and forced removal from traditional lands. It is thought that during the 1789 smallpox epidemic over half of the Aboriginal people of the Sydney region died. The disease spread west to the Darug of the Cumberland Plain and north to the Hawkesbury. Some suggest that the disease may have spread much further afield, over the Blue Mountains (Butlin, 1983). This loss of life meant that some of the Aboriginal groups who lived away from the coastal settlement of Sydney may have disappeared entirely before Europeans could observe them or record their group names (Karskens, 2010:425).

The British initially thought that Aboriginal people did not live inland and were confined to the coast taking advantage of the abundant marine resources available. The first major expeditions into the interior did not witness any Aboriginal people, but evidence of their existence was noted. In April 1788 Governor Philip led an expedition west to Prospect Hill. It was noted, '…that these parts are frequented by the natives was undeniably proved by the temporary huts which were seen in several places. Near one of these huts, the bones of kangaroo were found, and several trees where seen on fire' (Phillip, 1789).

In 1789 Captain Watkin Tench led an expedition to the Nepean River. He noted that:

> *Traces of the natives appeared at every step, sometimes in their hunting huts which consist of nothing more than a large piece of bark bent in the middle and opened at both ends, exactly resembling two cards set up to form an acute angle; sometimes in marks on trees which they had climbed; or in squirrel-traps….We also met with two old damaged canoes hauled up on the beach*. (Tench, 1789)

It wasn't until rural settlement began in the western Cumberland Plain, around 1791 that the colonists and Aboriginal peoples came face to face away from the coast. Relations quickly disintegrated, and tensions over land and resources spilled over. Governor King sanctioned the shooting of Aboriginal people in a General Order made in 1801 (Kohen, 1986:24). Intermittent killings on both sides continued for over 15 years, including the Appin massacre and attacks at South Creek in 1816 (Kohen, 1986:23; Karskens, 2010:225).

Although tensions existed between Aboriginal people and Europeans on the Cumberland Plain, a number of Aboriginal families continued to live semi-traditional lives in the area. The first parcels of land granted to an Aboriginal person were to the north of the proposal site between Richmond Road and Plumpton Ridge along Bells Creek. Governor Macquarie granted this land to Colebee and Nurragingy in 1819. Colebee did not stay long but Nurragingy lived on the land and it remained in the family until 1920 when it was resumed by the Aboriginal Protection Board (Kohen, 1986:27). The Colebee and Nurrgingy land grant is located approximately 12 kilometres north of the proposal site.

The government policy to remove Aboriginal children from their parents in order to assimilate them into white society began fairly early on in the colony's history and was epitomized by the development of the Native Institution at Parramatta in 1814.

The Native Institution facility was moved to the Black Town settlement in 1823. It was closed in 1829 and the land was used for farming, but the site remains significant for its historical, archaeological and social values (GML, 2007:36). The Blacktown Native Institute is located approximately 11 kilometres north of the proposal site.

Descendants of Darug language speakers continued to live in Western Sydney into the nineteen and twentieth centuries along with Aboriginal people from other areas of NSW.

4.3 Existing regional predictive models

Over the last 30 years, several regional predictive models related to the presence of Aboriginal archaeological sites have been developed. This includes several of relevance to the Cumberland Plain. These include a predictive model based on the relationship between stream order Aboriginal site distribution (White and McDonald, 2010), as well as further assessment and investigation of this model in other investigations across the Cumberland Plain (Artefact, 2013; ENSR/AECOM, 2009; Owen and Cowie, 2017).

A summary of relevant regional predictive models is included below.

White and McDonald 2010

Beth White and Jo McDonald developed a predictive model based on the relationship between stream order and the nature of Aboriginal site distribution based on the analysis of excavated sites in the Rouse Hill Development Area (White & McDonald, 2010). The paper provides a spatial and distributive analysis of Aboriginal objects in relation to freshwater resources and along varying landform units. The findings of this study highlighted the relationship between proximity to fresh water and landscape with Aboriginal occupation. The following predictive statements were asserted (White & McDonald, 2010: 36):

- Archaeological evidence of past Aboriginal peoples will be limited and be representative of background scatter within proximity to first order creek lines.
- Within the reaches of second order creek lines, archaeological evidence will again be representative of background scatter and will likely consist of one-off camp locations and / or isolated events.
- Within the reaches of third order creeks, archaeological evidence will consist of repeated occupation by small groups of people. Archaeological expressions will likely consist of knapping floors and evidence of repeated use over time.
- Along major fourth order creek lines archaeological expressions will consist of continued and repeated use by past Aboriginal peoples and may include stratified deposits.

This stream order model identifies that the confluences of creek lines across the Cumberland Plain will likely have evidence of a foci of activity with stratified deposits (White & McDonald, 2010: 33). It was found that artefacts were most likely within 50 – 100 metres of higher (fourth) order streams, within 50 metres of second order streams, and that artefact distribution around first order streams was not significantly affected by distance from watercourse (White & McDonald, 2010: 33).

The study also found that artefact densities were most likely to be greatest on terraces and lower slopes within 100 metres of freshwater resources (White & McDonald, 2010). The predictive model identified that ridgelines and crests located between drainage lines will contain archaeological evidence though usually representative of background scatter (White & McDonald, 2010).

Further assessment of the stream order model

The stream order model suggests that artefacts would generally be retrieved in higher densities at sites associated with high order watercourses, with low densities of less than one artefact per square metre at sites associated with first order watercourses, and densities of between two to ten artefacts per square metre associated with second order watercourses (Jo McDonald Cultural Heritage Management, 2010b: 43).

Further exploration and differing perspectives on artefact distribution across Cumberland Plain, particularly the southern portion of the Cumberland Plain, have been discussed in reporting for archaeological investigation by Artefact (2012), ENSR/AECOM (2009), Jo McDonald Cultural Heritage Management (2005) and Owen and Cowie (2017).

Jo McDonald Cultural Heritage Management’s (2005) large archaeological investigation program at Second Ponds Creek in Blacktown is one the most extensive and detailed subsurface investigations undertaken in that area. One of the aims of the investigation was to test the different landform units represented within the Second Ponds Creek valley, including flat, lower slope, mid-slope, upper slope and crest (Jo McDonald Cultural Heritage Management, 2005: 64). A total of 32,987 artefacts were retrieved from 1,130 square metres of excavation, as well as 7,922 artefacts retrieved from a surface collection in an eroded creek channel of Second Ponds Creek (Jo McDonald Cultural Heritage Management, 2005: 64).

The results indicate a clear drop in artefact density with increasing distance from Second Ponds Creek, which also correlates with a change in landform context from flat and lower slope to upper slope and crest (Jo McDonald Cultural Heritage Management, 2005: 64). Excavation bordering Second Ponds Creek yielded a high average density of 59 artefacts per square metre, compared to an average of between 0.5 and one artefact per square metre in crest and upper slope contexts respectively.

Jo McDonald Cultural Heritage Management (2005: 131) suggested that the excavation results reflected some evidence of raw material rationing at the lower density artefact scatters in the upper slope and crest landform contexts. This was evidenced by a higher frequency of modified artefacts and retouch / usewear, discard of smaller cores, low frequency of cortex, and presence of better-quality raw material (Jo McDonald Cultural Heritage Management, 2005: 131).

Several projects in the southern portion of the Cumberland Plain have further investigated both the variation in artefact density with increasing distance from creek line as well as variation in raw material utilisation. These studies are discussed below:

ENSR/AECOM (2009: 65-66) suggest that Aboriginal artefact clusters were likely to occur in a continuous low density scatter up to 300 metres from major watercourses, and 120 metres from second order streams, with landscape characteristics, including reliable water and good outlook over surrounding valleys also determining factors irrespective of distance from major watercourses.

Excavation at Spring Farm (site SFPAD5) at Menangle Park revealed a high artefact density from test excavation (8.5 per square metre) in association with a first order watercourse and swamp (Jo McDonald Cultural Heritage Management, 2010b). The high artefact density in association with a low order stream was suggested as being due to the proximity of the swamp and the relatively close proximity (750 metres) of the Nepean River (Jo McDonald Cultural Heritage Management, 2010b: 46). Jo McDonald Cultural Heritage Management (2010b: 45) also suggest that the relatively fewer archaeological excavations across the southern portion of the Cumberland Plain make it difficult to interpret results in the area in the context of the stream order model.

Like SFPAD5, results of archaeological excavation by Artefact at Menangle Park (Artefact 2013) demonstrate a relatively high mean artefact density (5.9 per square metre) in association with a first order watercourse. The relatively high artefact densities identified at Menangle Park in association with first order watercourses (Artefact, 2013; Jo McDonald Cultural Heritage Management, 2010b) supports ENSR/AECOM's (2009: 65-66) assertion that landscape context and reliable water, regardless of stream order, were important factors in the distribution of archaeological material across the landscape. These findings also support Jo McDonald Cultural Heritage Management's (2010b: 45) statement that further subsurface archaeological investigation in the region would provide a better framework for interpreting the distribution of archaeological material across the southern portion of the Cumberland Plain.

Further north of the Menangle Park and Oran Park areas investigated by Jo McDonald Cultural Heritage Management, ENSR/AECOM and Artefact, Owen and Cowie assessed a variety of more recent predictive models against results of the Cumberland Plain based on works completed at the East Leppington Precinct. The study utilised the Stream Order Model developed by White and McDonald (2010) and three different and complementary models to explain their findings. Owen and Cowie identified limitations in the Stream Order Model, as a broad regional based model with limited ability to consider small-scale intra-landform variations.

Owen and Cowie (2017) describe three other models that can be used to more accurately assess the archaeological potential within the landscape, the Economic Resource Model, the Activity Overprinting Model and the Domiciliary Spacing Model. Post excavation analysis considered that the combination of these models provided a good understanding of the over-arching archaeological potential of the East Leppington landscape.

The Economic Resource Model identifies locations with substantial resources (such as food and knapping sources) as economic zones. The model identifies a correlation between the relative yield of the economic zone and the distance that sites are likely to be away from the economic zone. Site locations are also considered to relate to changes in 'textures' across the landscape which may include changes in landform. Varying landforms within the influence of an economic zone can then be ranked according to their suitability for repeated occupation. Substantial creek lines are considered to be high resource zones due to the richness in flora and fauna. The model suggests that the evidence of Aboriginal activities will decrease with distance from these resource rich nodes.

The Activity Overprinting Model explains the density of sites at increasing distances from the creek. The model requires the examination of local environmental resources to identify zones of 'complexity' which would represent areas where repeated occupation and therefore 'activity overprint' were more likely. Areas of complexity were identified as more likely near an environmental focus, with evidence of activity overprint becoming sparser with increasing distance from environmental resources.

The Domiciliary Spacing Model was used to describe the features and spatial variation of a site by describing the layout of and features of a habitation site. The Domiciliary Spacing model suggests the division of a campsite into several distinct camping locations based on smaller family units or activity requirements. The model suggests the presence of archaeological evidence would be discretely spaced corresponding to the location of each small campsite with areas in between campsites associated with a general scarcity of archaeological material.

4.3.1 Implications of existing predictive models for the proposal site

The above predictive models have identified a number of factors which influence the presence, density and type of Aboriginal objects likely to be present within the proposal site. These factors include:

- Distance to watercourses of varying orders
- Presence of additional resources such as raw material sources and subsistence resources
- Visibility and outlook towards surrounding environments
- Spatial variation associated with habitation.

4.4 Previous archaeological assessments

A number of archaeological investigations have been completed in the vicinity of the proposal site. These have generally been associated with the development of infrastructure and industrial projects. The following discussion presents a review of the most recent and relevant studies and aims to provide contextual information for the current study.

The Archaeological Investigation of Lot 2, DP 120673 the site of a proposed new clay and shale extraction area, Old Wallgrove Road Horsley Park, NSW (John Appleton, 2002)

An archaeological assessment of Lot 2, DP 120673 was undertaken by Appleton as part of the assessment of a proposed clay/shale extraction site. The assessment area is located approximately one kilometre south of the proposal site between Old Wallgrove Road and Ropes Creek. The survey identified an area of PAD associated with an isolated mudstone flake along the banks of Ropes Creek and an isolated mudstone flake within an unmarked vehicle track.

The area of PAD was identified based on the location of the identified artefact eroding out of the creek bank at a depth of 20 centimetres below the surface. Appleton stated that it could then be reasonably assumed that other artefactual material may also be buried at the same or a similar depth.

Appleton also recorded an area of Potential Archaeological Sensitivity (PAS) surrounding the PAD on the basis that any artefactual material recovered would have been associated with camp sites and/or activity areas along the creek bank. A second PAS was identified on a tributary of Ropes Creek within the vicinity of a previously recorded artefact. This area encompassed a slight rise in the landform which was interpreted as an attractive location for use as a camp site. These areas of sensitivity were not recorded as sites with AHIMS but were highlighted within the report to indicate the potential of areas surrounding Ropes Creek and its tributaries for containing Aboriginal objects below the surface.

Proposed 132kV Transmission Line Erskine Park, NSW Cultural Heritage Assessment (Navin Officer Heritage Consultants, 2003)

Navin Officer conducted an Aboriginal cultural heritage assessment for Integral Energy for the proposed 132kV transmission line extending between the Sydney West Substation and Erskine Park. The majority of the assessment was undertaken on land 50 metres south of the proposal site. The assessment identified two Aboriginal sites and an area of archaeological potential.

The Aboriginal sites identified were both artefact scatters. The first, Erskine Park 1 (AHIMS ID 45-5-3235) was located within an eroded area adjacent to a minor drainage line. There were seven artefacts recorded consisting of silcrete and mudstone flakes, broken flakes and a core. The second site, Erskine Park 2 (AHIMS ID 45-5-3311) was located within a backhoe hole and consisted of eight artefacts. The assemblage consisted of silcrete flakes, broken flakes, a core and three blades.

An area of archaeological potential was recorded on both sides of Ropes Creek, near the junction of the creek with an unnamed tributary. EP PAD 1(AHIMS ID 45-5-3062) was identified based on the raised landform surrounding the creek and previous studies within the Cumberland Plain which have demonstrated larger sites with higher artefact densities are more likely to occur near permanent water sources.

Archaeological Investigations at SEPP59 EC3, Wonderland Surplus (Jo McDonald Cultural Heritage Management, 2006)

Jo McDonald Cultural Heritage Management was commissioned to conduct a salvage excavation program within the Wonderland Surplus lands in accordance with AHIP 2470. The salvage area is located approximately 1.6 kilometres north-east of the proposal site.

The salvage area included investigation of two areas of PAD, EC3-PAD1 (AHIMS ID 45-5-3201) and EC3-PAD2 (AHIMS ID 45-5-3202). The salvage program targeted areas identified in earlier works as having good potential to contain intact archaeological deposits. The deposits within the sites were found to be relatively shallow with the A1 horizon largely no longer present across the site and artefacts recovered from the remnant A2 horizon.

The first PAD, EC3-PAD1 sampled a hill slope and drainage gully. The open area within this PAD recovered a low density, sometimes discontinuous scatter. The artefacts were found to have been displaced in a downslope direction and assessed as likely to be subject to colluvial processes.

The second area of salvage sampled an adjacent ridge top. Lithic distribution within the area was continuous but fairly low density. The open area excavation revealed that the assemblage had been dispersed in a generally east to north-east direction. This dispersal was interpreted to have likely occurred due to behavioural or environmental events more so than colluvial processes given the ridgetop location of the artefacts.

A total of 1,550 artefacts were recovered from the PAD sites, equating to densities of 0.8 and 0.9 lithics per square metre. The predominant raw material was silcrete with some silicified tuff, quartz and petrified wood.

Based on the low densities of artefacts across the salvage areas, both sites were interpreted as being used in an intermittent manner. Further, the accumulation of lithics at the site was assessed as likely to have occurred slowly over long time periods rather than as part of an intense period of discard associated with tool production or domestic areas.

Erskine Park Employment Area, Ropes Creek, Western Sydney, NSW, Archaeological Subsurface Testing Program (Navin Officer, 2007)

A subsurface testing program was conducted by Navin Officer within part of the Erskine Park Employment Area, located 750 metres south-west of the proposal site. The test excavations focussed on three previously identified sites, EPRC1 (AHIMS ID 45-5-3234), EPRC2 (AHIMS ID 45-5-3312) and EPRC3 (not registered).

Areas of archaeological potential ranging from low to high were defined in relation to these sites and 112 test pits were excavated to test that potential. A total of 261 artefacts were recovered from test excavation with an average density of 5.7 artefacts per square metre recovered across the test excavation program. The raw material present at the sites included silcrete, tuff, quartzite and chert, with silcrete being the dominant lithology. The artefacts present included flakes, broken flakes, cores, core fragments, and microblades. Bipolar flaking, utilised pieces and backed flakes were also identified within the assemblage.

Out of the four investigation areas, the two areas closest to Ropes Creek returned the highest number of artefacts. One of these areas was located on the basal midslopes and crest of a north-south running spur line above Ropes Creek. Navin Officer proposed these results suggest that the whole broad spur line was the location of repeated and ephemeral habitation involving transitory camp sites.

The areas with the lowest incidence of artefacts were located adjacent to first order drainage lines and were furthest away from Ropes Creek. These results fit within the broader regional model that predicts these areas to have low to moderate potential.

Energy from Waste Facility, Eastern Creek, Aboriginal Heritage Test Excavation (Artefact Heritage, 2014)

Artefact Heritage conducted test excavations within Aboriginal site EFW South (AHIMS ID 45-5-4491), an area located approximately 500 metres east of the northern portion of the proposal site. The site was located on an elevated area at the confluence of three drainage lines.

The subsurface testing involved the excavation of thirty-seven 500x500 millimetre test pits. An assemblage of 14 artefacts from nine of these test pits were retrieved resulting in an artefact density of 0.76 artefacts per square metre. Silcrete was the only raw material represented within the assemblage. Reduction types present included angular fragments, flakes and broken flakes.

The assemblage was interpreted to represent general stone reduction and causal discard. It was considered likely that use of the site was intermittent and opportunistic. The assessment identified that while the area was close to water sources it was also prone to flooding which would have limited use of the site. Following the predictive model established by previous studies, it was assessed that the higher slopes and crests surrounding the area would have been more preferable camp sites.

St Marys Wastewater System Augmentation Salvage Excavation Report (ENSure JV, 2015)

ENSure JV was engaged to undertake salvage excavation of several sites as part of the St Marys Wastewater System Augmentation project located along a four kilometre pipeline route running parallel to Ropes Creek. Works were undertaken as a condition of AHIP C0000501 which authorised impacts to seven Aboriginal sites including two sites within the proposal site. These sites included Southwest 12 (AHIMS ID 45-5-0564), RCAS 8 (AHIMS ID 45-5-3160), Blacktown Southwest 7 (AHIMS ID 45-5-0559), RCIF 2 (AHIMS ID 45-5-3159), RC1 (AHIMS ID 45-5-0206), EP PAD 1 (AHIMS ID 45-5-3062) and Oakdale Campsite 1 (AHIMS ID 45-5-3383).

A total of 2128 artefacts were recovered during the salvage excavation program. The majority of these (1346,) were recovered from Blacktown Southwest 7 (AHIMS ID 45-5-0559) located on the north western border and extending partially within the proposal site.

Blacktown Southwest 7 (AHIMS ID 45-5-0559) is located on a low to mid-level rise which is located approximately six metres above the surrounding floodplain. Prior to surface excavation a total of 27 surface artefacts were identified and collected within the site extent of Blacktown Southwest 7 (AHIMS ID 45-5-0559) in accordance with AHIP C0000501 (Figure 5). Salvage excavation at this location included the excavation of 20 shovel test pits and 20 test pits resulting in a total excavation area of 25 square metres (Figure 6). A total of 1,346 artefacts were excavated from this salvage area.

The relative high density of artefacts from Blacktown Southwest 7 (AHIMS ID 45-5-0559) was considered to support the theory that the site and elevated landform adjacent to Ropes Creek was visited with a higher intensity than other sites investigated as part of the salvage program.

Salvage excavation was also completed across a portion of RCIF2 (AHIMS ID 45-5-3159). RCIF2 (AHIMS ID 45-5-3159) is located on a low rise approximately 100 metres north of Ropes Creek within the south-western corner of the proposal site. Prior to salvage a total of eight surface artefacts were recovered from the portion of RCIF2 (AHIMS ID 45-5-3159) within boundary of AHIP C0000501 (Figure 7). Salvage excavation at this location was comprised of 20 shovel test pits and 20 test pits resulting in the excavation of 25 square metres (Figure 8). A total of 463 artefacts were recovered from salvage excavation in this area with the artefacts identified as containing a low proportion of cortex and low mean size. This in conjunction with the results of Blacktown Southwest 7 (AHIMS ID 45-5-0559) was used as evidence to suggest that the low rises above the floodplain were utilised more intensively for tool curation than the surrounding flood plain landform.

The majority of the sites investigated as part of the salvage excavation program contained stone artefacts, although artefact density varied considerably. Elevated well drained landforms adjacent to the floodplain of Ropes Creek saw the greatest density of artefacts with salvage excavation recovering an average of between 18.52 – 53.84 artefacts per square metre at these locations. The salvage works also included the excavation of five sites within the Ropes Creek flood zone. Artefact concentrations across these areas were substantially lower than the results of Blacktown Southwest 7 (AHIMS ID 45-5-0559) and RCIF 2 (AHIMS ID 45-5-3159) with average artefact densities ranging between 0-8.5 artefacts per square metre.

Following salvage excavation, artefacts salvaged from Blacktown Southwest 7 (AHIMS ID 45-5-0559) and RCIF2 (AHIMS ID 45-5-3159) were reburied within their existing site extents (see Figure 5 and Figure 7).

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Figure 5: Portion of AHIMS ID 45-5-0559 subject to salvage and surface collection as part of AHIP C0000501

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Figure 6: Location of ENSure JV salvage excavation pits AHIMS ID 45-5-0559 with current proposal site overlaid in red (Source: ENSure JV, 2015: 37)

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Figure 7: Portion of AHIMS ID 45-5-3159 subject to surface collection and salvage investigation as part of AHIP C0000501

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Figure 8: Location of ENSure JV salvage excavation pits AHIMS ID 45-5-3159 with current proposal site overlaid in red (Source: ENSure JV, 2015: 37)

Archbold Road, Archaeological survey report (Artefact Heritage, 2015)

Artefact Heritage was engaged by Transport for NSW to conduct an archaeological survey as part of a proposal to upgrade and extend Archbold Road. The survey area extended between the M4 motorway and Old Wallgrove Road, a portion of which includes the eastern portion of the current proposal site.

The study area was divided into four survey units, Survey unit 3 was located partially within the proposal site. The survey unit was comprised of a relatively flat landform with some small hills. The southern area of the survey unit was located adjacent to Lenore Drive and was identified as having a high degree of disturbance due to its use as a compound area and illegal dumping.

A total of six artefact sites were located across survey unit including four sites within the proposal site. RCAS4 (AHIMS ID 45-5-3162) and RCAS5 (AHIMS ID 45-5-3162) were both revisited as part of the assessment for this proposal. RCAS4 was not relocated due to dense grass regrowth at the proposal site. RCAS5 was not relocated due to identified inaccuracies in the site coordinates. AIF-05 (AHIMS ID 45-5-4605) and AIF-06 (AHIMS ID 45-5-4599) were identified during the survey and recorded as isolated finds along vehicle track exposures.

The assessment identified the areas surrounding Ropes Creek and its tributaries as containing potential for intact surface deposits. The assessment did not identify any areas of subsurface potential within the eastern half of the proposal site.

Lot 10 DP 1157491, Eastern Creek, NSW, Aboriginal and historical heritage Study (Ecological, 2016)

Ecological was engaged to prepare a Historical and Aboriginal Heritage Study to inform a Development Control Plan for Lot 10 DP1157491 at Eastern Creek, NSW. The assessment included the entirety of the current proposal site area.

The assessment identified areas of substantial disturbance associated with the proposal site including the southernmost portion of the lot which had been highly disturbed by construction associated with the upgrade of Lenore Drive and the St Marys Wastewater System Augmentation Project.

The assessment identified that the dense ground cover limited the identification of further artefacts during the site survey. The assessment further identified that due to the low levels of disturbance across the assessment area, proximity to water and presence of multiple sites within the assessment area, that it was likely that additional Aboriginal objects would be present within the assessment area.

Ecological assessed the surface artefact sites within the assessment area as common and representative of the region but noted that the potential for subsurface Aboriginal objects was largely unknown. Ecological recommended that further archaeological investigation should be undertaken across all landform units to understand the nature, extent and significance of the archaeological resource.

Archbold Road extension and upgrade, Great Western Highway to Southern Link Road, cultural heritage assessment report (Kelleher Nightingale Consulting, 2017a)

Kelleher Nightingale Consulting was engaged to complete an Aboriginal cultural heritage assessment report as part of the proposed upgrade and extension of Archbold Road. The report follows the survey report completed for the road project completed by Artefact (2015).

Kelleher Nightingale Consulting's assessment identified that much of the road project area had been completely modified through former erosion events with soils considered likely to be less than 150 years old. The assessment suggested that older soils were likely to have been removed due to substantial erosion from flooding, clearing and mining which was present uphill of portions of the site. The assessment identified that remnant archaeological deposit within the project area were limited to narrow strips along creek terraces which were situated high enough to avoid the effects of fluvial energy.

Four sites were located within the assessment area including one site, AIF-06 (AHIMS ID 45-5-4599) within the proposal site. AIF-06 (AHIMS ID 45-5-4599) was identified as an isolated artefact within a bike access track. The site was assessed as heavily disturbed and of low significance. The assessment identified that the road project would result in a direct impact resulting in total loss of value to AIF-06. The assessment recommended that an AHIP be sought to impact AIF-06 (AHIMS ID 45-5-4599) with no further mitigation measures recommended. It is understood that at the time of the preparation of this report, the AHIP application for Archbold Road upgrade had not yet been submitted.

Two sites were recommended for archaeological salvage excavation, RCAS 1 (AHIMS ID 45-5-3165) and Ropes Creek AS3 (AHIMS ID 45-5-3937). Both sites were located within terrace landforms above tributaries to Ropes Creek and considered to contain relatively intact soils. No further archaeological investigation or management was recommended within the proposal site.

Lot 103 DP 1189012, Eastern Creek NSW, Archaeological salvage excavation (Kelleher Nightingale Consulting, 2017b)

Kelleher Nightingale Consulting was engaged to complete salvage excavation and surface collection as part of a proposed commercial development of Lot 103 Eastern Creek. Salvage excavation was undertaken across three sites, Archbold Artefact Scatter 1 (AHIMS ID 45-5-4377), Archbold Artefact Scatter 2 (AHIMS ID 45-5-4378) and Archbold Artefact Scatter 3 (AHIMS ID 45-5-4487), with surface collection undertaken of an additional 14 sites.

Salvage excavations consisted of the excavation of 60 x 1 metre square excavation units within a 20 metre staggered grid. Excavation retrieved a total of 55 artefacts with no localised concentrations identified across the salvage area. The excavation results were interpreted as a low-density archaeological deposit which had been heavily disturbed and contained no evidence of intact deposits. While the assessment was broadly considered to support the concept that the salvage area represented a transitional landscape between Ropes Creek and Eastern Creek, the high level of disturbance was considered to limit the further analytic and comparative potential of the excavation results.

4.4.1 Archaeological Implications

Previous surface and subsurface archaeological investigations in the area have identified some proportionately high concentrations of artefacts in raised areas adjacent to Ropes Creek (in some cases greater than 40 artefacts per square metre) (ENSure JV, 2015). Test excavation completed at greater distances from Ropes Creek by comparison have identified lower artefact concentrations consistent with intermittent background scatter (Jo McDonald Cultural Heritage Management, 2006; Artefact, 2014; Keller Nightingale Consulting, 2017b). Subsurface artefact deposits have also been identified in proximity to first order watercourses. Artefact densities associated with these watercourses have been identified as highest in areas in close proximity to Ropes Creek (Navin Officer, 2007).

The results of previous investigations in the region is generally consistent with existing regional predictive models including the Stream Order Model (White and McDonald, 2010) and the Economic Resource Model (Owen and Cowie, 2016). In addition, the increased concentration of artefacts identified along first order watercourses in close proximity to Ropes Creek is consistent with the findings of test excavation completed by Jo McDonald Cultural Heritage Management (2010b) and Artefact (2013).

The proximity of several silcrete sources to the proposal site including a source in Erskine Park (approximately 3.7 kilometres west of the proposal site) and Plumpton Ridge (8.2 kilometres to the north-east) suggest that stone artefacts within the proposal site would be predominantly comprised of silcrete.

Several areas within the proposal site have been subject to substantial disturbance associated with agricultural use (dam construction) as well as construction programs including the construction of Lenore Drive and the Sydney Water pipeline for the St Mary's Wastewater System Augmentation project. These areas have been subject to high level of disturbance and would contain low archaeological potential (Figure 9).

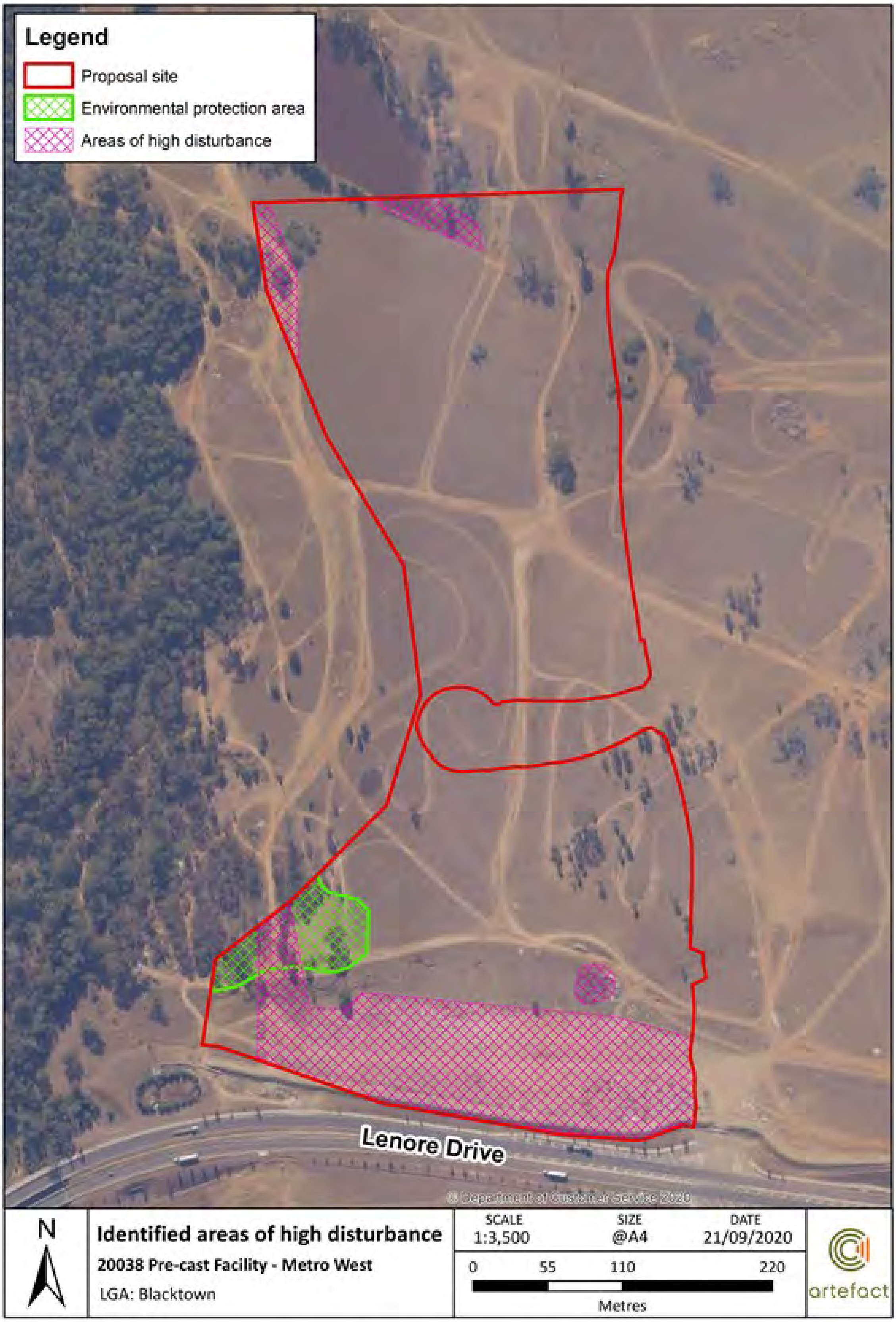

Figure 9: Identified areas of high disturbance

4.5 Aboriginal Heritage Information Management System

The location of Aboriginal sites is considered culturally sensitive information. It is advised that this information, including the AHIMS data appearing on the heritage map for the proposal be removed from this report if it is to enter the public domain.

An extensive search of the AHIMS database was undertaken on the 27 March 2020 (AHIMS search ID 491998). An area of approximately 3.6 kilometres by 3.9 kilometres was included in the search. The AHIMS search provides archaeological context for the area and identifies whether any previously recorded Aboriginal sites are located within or near the proposal site. The parameters of the search were as follows:

GDA 1994 MGA 56	296267 - 299859 metres East 6255686 - 6259638 metres South
Buffer	0 metres
Number of sites	112

A total of 112 Aboriginal sites were identified in the extensive AHIMS search area. The frequency of recorded site features is summarised in Table 1.

A registered Aboriginal site is made up of one or more site features. Heritage NSW lists 20 standard site features that can be used to describe a site registered with AHIMS. For the 112 sites within the search area, three combinations of site features were recorded. The majority of recorded site features are artefacts (n=107).

Table 1: Frequency of site features from AHIMS data (proposal site and surrounds)

Site Feature	Frequency	Percentage (%)
Artefact	107	95.5
Artefact, Potential Archaeological Deposit (PAD)	4	3.6
Potential Archaeological Deposit (PAD)	1	0.9
Total	*112*	*100*

Figure 10 illustrates that a substantial number of sites are located within and in close proximity to the open grassland areas adjacent to Ropes Creek. While many sites have been identified within proximity of Ropes Creek and its tributaries, artefact sites located to the north of the proposal site include a density of artefact sites associated with slope and crest landforms several hundred metres away from the creek line.

Artefact sites within the vicinity of the study area are limited to either artefact sites or areas of PAD, suggesting that environmental conditions and former land clearance and modification make the identification of scarred trees, grinding grooves or artwork unlikely within the proposal site.

Nine sites previously recorded either within or in the immediate vicinity of the proposal site are summarised in Table 2. The distribution of these recorded sites is illustrated in Figure 11.

Table 2: Summary of sites located within or in close proximity to the proposal site

Site name and AHIMS ID	Site type	Proximity to proposal site[1]	Description
Blacktown Southwest 8, AHIMS ID 45-5-0560	Artefact scatter	About 85m west	• Artefact scatter consisting of two large silcrete flakes eroding out of an artificial terrace alongside Ropes Creek
Bankstown Southwest 10, AHIMS ID 45-5-0562	Artefact scatter	About 22m south	• Artefact scatter identified in an exposure located within the mid slope of a ridgeline • Comprised of 4 chert flakes, 2 silcrete flakes and a quartz flake
Blacktown Southwest 11, AHIMS ID 45-5-0563	Open site	Within	• Artefact scatter within an erosion scar associated with a small creek as well as one artefact within adjacent dam feature • Site area was assessed as grossly disturbed by creation of a dam • Site consists of a quartzite pebble and quartz flake as well as a chert flake identified 8m from quartzite artefacts within adjacent dam
Bankstown Southwest 7, AHIMS ID 45-5-0559	Artefact scatter	Partially within	• Artefact scatter eroding out of a raised terrace alongside Ropes Creek • Several artefacts including a basalt pebble with evidence of grinding identified on terrace and surrounding slope landform • Subject to partial salvage under AHIP C0000501 recovering 1346 artefacts • Artefacts reburied within portion of the proposal site subject to AHIP C0000501, with artefact reburial located immediately adjacent to proposal site.
RCIF 2, AHIMS ID 45-5-3159	Artefact scatter	Partially within	• Originally recorded as mudstone flake located on the top of an eroding creek gully • Subject to salvage excavations under AHIP C0000501 which identified a further 463 artefacts from a 25 square metre salvage excavation area • Artefacts reburied within portion of site subject to AHIP C0000501, with artefact reburial located in proposal site

[1] Based on identified site extents identified in AHIMS site cards

Site name and AHIMS ID	Site type	Proximity to proposal site[1]	Description
RCAS 4, AHIMS ID 45-5-3162	Artefact scatter	Within	• Originally recorded as seven artefacts located within an exposure caused by animal and vehicle traffic • Site was recorded as six silcrete flakes and a single quartz flake
RCAS 5, AHIMS ID 45-5-3163	Artefact scatter	Within	• Originally recorded as three silcrete flakes eroding from the edge of a water pool on the original course of a tributary for Ropes Creek • Originally assessed within site card as likely to have been redeposited into their current location through construction of the water pool • Site was considered to indicate the likely presence of additional artefacts within the immediate vicinity of the proposal site
AIF-06, AHIMS ID 45-5-4599	Isolated find	Within	• Single red silcrete flake identified in an exposure caused by a bike track • Artefact located on a gently undulating plain
AIF-05, AHIMS ID 45-5-4605	Isolated find	Within	• Single yellow silcrete distal flake identified within an exposure caused by vehicle access track • Artefact located on a gently undulating plain

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Figure 10: Results of Extensive AHIMS Search

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Figure 11: AHIMS within and in the vicinity of the proposal site

4.6 Predictive model

Based on the background environment, existing predictive models and the results of previous archaeological investigations, the following conclusions can be made regarding the predicted archaeological sensitivity and potential of the proposal site:

- Stone artefact scatters are the most likely Aboriginal site type to be identified within the proposal site. Based on the underlying geology and historical land use, scarred trees, grinding sites and art sites are unlikely to be identified within the study area.
- Silcrete will be the dominant raw material of stone artefact assemblages.
- Artefacts sites are likely to be concentrated along Ropes Creek and its tributaries.
- High density subsurface distributions of artefacts have been identified within elevated landforms adjacent to the Ropes Creek floodplain. For the proposal site this means that areas within the western portion of the project area are more likely to contain higher artefact densities.
- Floodplain landforms are likely to exhibit lower densities of subsurface artefacts as a result of fluvial action.
- Crest and ridgeline landforms are likely to exhibit low artefact densities consistent with ephemeral use.
- Visibility is likely to be low, obstructed by dense grass cover; sites are most likely to be identified in exposed areas including vehicle tracks, recently cleared areas and eroded banks.
- Archaeological deposits within the proposal site are likely to have been impacted by former and current land use including land clearance and agricultural activity, however these impacts are likely to have largely been superficial in nature.
- Small portions of the proposal site have been subject to substantial disturbance associated with the installation of the Sydney Water pipeline for the St Mary's Wastewater System Augmentation project and former use of the southern portion of the proposal site as a construction compound (Figure 9).

This review of the background information suggests that portions of the proposal site are likely to have high archaeological potential.

5.0 ARCHAEOLOGICAL SURVEY

5.1 Aims

The aims of the archaeological survey were to:

- Cover a representative sample of the proposal site that would potentially be impacted by the proposed works
- Reinspect any previously registered sites
- Record any new Aboriginal objects or sites observed during the survey
- Identify areas of PAD that may be present in areas that have had no or minimal disturbance
- Liaise with stakeholders present regarding the archaeological potential of the proposal site
- Collect information to ascertain whether further archaeological investigation is required

5.2 Timing and personnel

Initial archaeological survey was undertaken on the 8 April 2020. The survey was supervised by Alyce Haast (Senior Heritage Consultant, Artefact Heritage) with Jessica Horton (Heritage Consultant, Artefact Heritage) also present. A second archaeological survey was undertaken on 18 June 2020 with Alyce Haast, Josh Symons (Principal, Artefact Heritage) and Steve Randall (Deerubbin LALC) in attendance.

5.3 Methodology and coverage

The proposal site generally consists of an area of open grassland with several unsealed vehicle and bike access tracks across the study area. Given the extremely limited visibility, sample survey of the study area was undertaken on foot by teams of two or three, with survey focused on areas of exposure, sensitive landforms as identified through predictive modelling and the site extents of formerly registered sites.

A handheld non-differential Global Positioning System was used to track the path of the survey team and record the coordinates of survey transects as well as the location of Aboriginal sites.

A photographic record was kept during the survey. Photographs were taken to record aspects of survey units including surface exposures, vegetation, areas of surface disturbance, and any identified Aboriginal sites and areas of archaeological potential. Scales were used for photographs where appropriate as specified in the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment Climate Change and Water, 2010a).

Survey was delineated into three survey units based on landform, breaks in the landscape (such as access tracks) and evidence of former disturbances. The survey units are illustrated in Figure 12.

Previously registered Aboriginal sites in the immediate vicinity of the proposal site were also visited to confirm the nature of these sites and assess whether the extent of those sites includes the proposal site.

Figure 12: Survey units

5.3.1 Survey unit one

Survey unit one was comprised of the western portion of the study area encompassing the gently sloping raised terrace landform located above the Ropes Creek floodplain. The survey unit was heavily vegetated with thick grasses obscuring the majority of the ground surface (Figure 13). Several areas of exposure were noted within the survey unit associated with vehicle tracks and areas of former Sydney Water pipeline works for the St Marys Wastewater System Augmentation Project (Figure 14 – Figure 16, Figure 18). The survey unit included several modified drainage lines, one which of had been modified into a large dam partially located in the north of the survey unit (Figure 17).

Old growth trees within the proposal site were inspected for cultural scarring. One tree within the south-western portion of the survey unit was identified as containing a potential Aboriginal cultural scar. Detailed inspection of the scar and tree surface identified irregularities in the scar shape which was inconsistent with an Aboriginal cultural scar. In addition the presence of several other irregular scars across the tree surface suggested that the scar was created as part of the natural growth of the tree (Figure 19). The scar has been assessed as unlikely to represent an Aboriginal scar tree.

Three previously recorded AHIMS sites were located within survey unit one during the April 2020 survey, Blacktown Southwest 7 (AHIMS ID 45-5-0559), Blacktown Southwest 11 (AHIMS ID 45-5-0563) and RCIF 2 (AHIMS ID 45-5-3159). Both Blacktown Southwest 7 and RCIF 2 were inspected during the survey with additional artefacts recorded at their location. The recorded site location of Blacktown Southwest 11 was also visited but was unable to be relocated.

Two newly identified sites, RCAS 09 (AHIMS ID 45-5-5355) and RCAS 10 (AHIMS ID 45-5-5354) were located within survey unit one during the April 2020 and June 2020 survey. Further detail regarding RCAS 09 (AHIMS ID 45-5-5355) and RCAS 10 (AHIMS ID 45-5-5354) is located in Section 6.2.

Figure 13: Grasslands across raised terrace landform, south-western aspect

Figure 14: Wide vehicle track exposure across south western portion of survey unit one

Figure 15: Large exposure in south-western portion of survey unit one

Figure 16: Sandstone based fill material within former Sydney Water pipeline route immediately west of survey unit one

Figure 17: Large dam in northern portion of survey unit one

Figure 18:Heavily eroded vehicle track within south-western portion of survey unit one

Figure 19: Potential Aboriginal culturally scarred tree

5.3.2 Survey unit two

Survey unit two was comprised of the eastern portion of the proposal site encompassing the transition between a gently sloping terrace landform located across survey unit one and the slightly steeper lower slopes of the foothills located to the east of the proposal site (Figure 20). The survey unit was heavily vegetated with thick grasses obscuring the majority of the ground surface (Figure 21). Small pockets of regrowth eucalypt species were also noted in the south-eastern portion of the survey unit. Visibility was generally very low with small areas of exposure associated with vehicle tracks and erosion scours (Figure 22). Evidence of disturbance was largely limited to tree clearance and isolated areas of dumped rubbish.

Four previously recorded AHIMS sites were located within survey unit two, AIF-05 (AHIMS ID 45-5-4605), RCAS 4 (AHIMS ID 45-5-3162), RCAS 5 (AHIMS ID 45-5-3163) and AIF 06 (AHIMS ID 45-5-4599). None of the previously recorded sites within survey unit two were relocated during April 2020 survey.

One additional Aboriginal site, RCAS 11 (AHIMS ID 45-5-5353) was identified within survey unit two during the June 2020 survey.

Figure 20: Transitional landscape between terrace and adjacent foothills

Figure 21: High grasses associated with survey unit two

Figure 22: Vehicle track exposure within survey unit two

5.3.3 Survey unit three

Survey unit three was comprised of an artificial slope landform located in the southern portion of the proposal site (Figure 23). Based on historical aerials the survey unit was formerly utilised as a construction compound area with substantial earthworks noted between 2013 and 2018. The survey area was heavily obscured by high grasses with exposed areas showing a sandstone based fill located across the surface within this landform (Figure 24 – Figure 26).

No Aboriginal objects or areas of potential were identified within survey unit three.

Figure 23: Artificial slope landform, eastern aspect

Figure 24: Sandstone based fill material across survey unit three, with raised road batter in background

Figure 25: View of artificial slope landform towards Ropes Creek

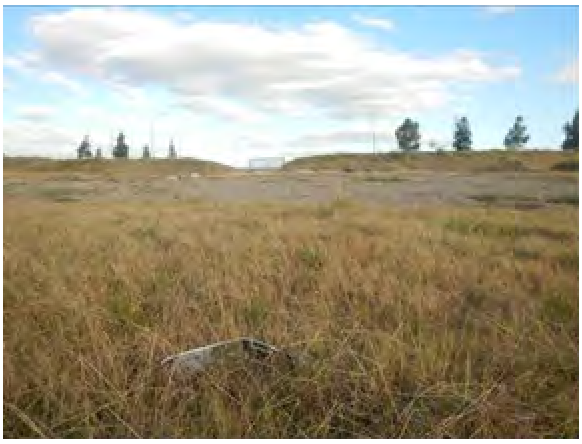

Figure 26: View across artificial slope landform showing access from Lenore Drive

5.3.4 Survey coverage

A summary of survey coverage, in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water 2010a) is outlined in Table 3 and Table 4.

Table 3: Survey coverage summary - survey units

Survey unit	Survey unit area (m^2)	Landform	Visibility (%)	Exposure (%)	Effective coverage (m^2)	Effective coverage (%)
1	82,506	Slope, Drainage line	50	20	8250.6	10
2	48,262	Slope, Drainage line	25	10	1206.5	2.5
3	24,787	Artificial slope	5	5	61.9	0.25

Table 4: Survey coverage summary - landforms

Landform	Landform area (m^2)	Area effectively surveyed (m^2)	Percentage of landform effectively surveyed (%)	Number of sites
Slope	123,941	8675.9	7.0	10
Drainage line	6,827	507.3	7.4	0
Artificial slope	24,787	63.5	0.25	0

6.0 RESULTS

6.1 Registered Aboriginal sites

Summaries of sites identified during the survey and previously recorded sites within the proposal site are outlined below.

6.1.1 Blacktown Southwest 11 (AHIMS ID 45-5-0563)

Site type: Artefact scatter
Centroid: [redacted]

Blacktown Southwest 11 (AHIMS ID 45-5-0563) was originally recorded in an erosion scour associated with a small creek line. The site card notes that a small dam had been built lower down the gully. The site was originally recorded by Kohen in 1986 as including a quartzite pebble and quartz flake which were identified as non-local raw material along with a small chert flake which was identified within the dam wall.

The site coordinates were visited as part of the April 2020 site survey. It was found that the coordinates of the site recorded on AHIMS do not match the description of the landform in the site card. The registered site coordinates were approximately 45 metres north of the drainage line identified within the site card, therefore it is assumed the site coordinates are an error (see Figure 35).

During the April 2020 site survey the registered site location was heavily vegetated by thick grasses (Figure 27 – Figure 28). The site coordinates of the assessed site location were visited during the June 2020 survey. No Aboriginal objects were located within the registered site coordinates or assessed site location.

Figure 27: Location of Blacktown Southwest 11 recorded site coordinates, northern aspect

Figure 28: High grasses obscuring the ground surface across Blacktown Southwest 11, south-western aspect

6.1.2 Blacktown Southwest 7 (AHIMS ID 45-5-0559)

Site type: Artefact scatter
Centroid: [redacted]
Artefact reburial centroid: [redacted]

Blacktown Southwest 7 (AHIMS ID 45-5-0559) was originally recorded by Kohen in 1986 as an artefact scatter eroding out of a slope and top of a raised terrace landform (Figure 29 – Figure 30).

The site has been partially destroyed by Sydney Water pipeline works for the St Marys Wastewater System Augmentation Project associated with AHIP C0000501. Salvage excavation prior to impact resulted in the recovery of 1,346 artefacts from a 25 square metre salvage area. Following salvage excavation, the artefacts were reburied within the wider site extent within the proposal site.

The site extent was inspected as part of the April 2020 survey. Evidence of earthworks associated with impacts under AHIP C0000501 were noted, with a clear exposure identifying the pipeline route (Figure 31 – Figure 32). Additional evidence of disturbance was noted with sandstone based fill material spread across the wider site extent. Survey identified five new artefacts within the former AHIP boundary (Figure 33 – Figure 34). High grasses obscured the remainder of the site extent.

A summary of newly identified artefacts is provided in Table 5.

Table 5: Summary of artefacts identified at AHIMS ID 45-5-0559

Material	Colour	Artefact type	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Pink	Proximal flake fragment	28	14	6
Silcrete	Pink	Proximal flake fragment	18	24	9
Mudstone	Orange	Multi-platform core	61	48	36
Silcrete	Pink	Medial flake fragment	29	33	22
Silcrete	Red	Proximal flake fragment	24	18	5

During the June 2020 site survey, the site extent of AHIMS ID 45-5-0559 was reassessed. Site survey identified that the raised landform which delineated the site extent within the site card extended to the east of the registered site extent as part of a wider low-lying spur crest feature. Examination of exposures confirmed that visible soils within this portion of the project site were relatively intact. The site extent was modified to encompass the entirety of the localised rise associated with this landform (see Figure 35).

Figure 29: Recorded site centroid location of AHIMS ID 45-5-0559, southern aspect

Figure 30: Recorded site centroid location of AHIMS ID 45-5-0559, western aspect


Figure 31: Visible gravel fill associated with Sydney Water pipeline works


Figure 32: Vehicle track exposure in which newly identified artefacts were identified


Figure 33: Silcrete and mudstone artefacts located within site extent of AHIMS ID 45-5-0559


Figure 34: Silcrete artefacts identified within site extent of AHIMS ID 45-5-0559

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Figure 35: Registered and reassessed site extent of AHIMS ID 45-5-0559

6.1.3 RCIF 2 (AHIMS ID 45-5-3159)

Site type: Artefact scatter, PAD
Centroid: [redacted]
Artefact reburial centroid: [redacted]

RCIF 2 (AHIMS ID 45-3-3159) was originally recorded by Environmental Resources Management in 2005 as an isolated mudstone flake located within an eroding creek gully. The original site recording noted the likely presence of additional artefacts including subsurface deposits. Salvage excavation of the site was undertaken as a condition of AHIP C0000501 in 2014 which recovered 463 artefacts from 25 square metres of excavation. Artefacts recovered from the salvage excavation were reburied on site.

The site was revisited during the current survey with multiple large areas of exposure associated with the wider site extent. The site centroid was located directly adjacent to the remains of a tributary of Ropes Creek with a wide vehicle track extending east – west directly adjacent to it (Figure 36 – Figure 37). The area subject to salvage excavation was also surveyed with large exposures extending approximately 80 metres x 50 metres across and surrounding the former salvage area (Figure 38). Portions of the exposure included gravel topsoil which was interpreted as related to a fill event from the St Marys Wastewater System Augmentation Project (Figure 39).

Survey identified nine additional artefacts within the exposures associated with AHIMS ID 45-5-3159 (Figure 40). A summary of the artefacts identified in the clearing is provided in Table 6.

Table 6: Summary of artefacts identified at AHIMS ID 45-5-3159

Material	Colour	Artefact type	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Pink	Right proximal flake fragment	32	28	6
Silcrete	Pink	Angular fragment	38	28	5
Silcrete	Yellow	Distal flake fragment	18	21	2
Silcrete	Yellow	Medial flake fragment	22	9	6
Silcrete	Yellow	Proximal flake fragment	46	35	8
Silcrete	Red	Complete flake	24	12	3
Silcrete	Red	Medial flake fragment	23	7	4
Silcrete	Red	Complete flake	25	22	4
Silcrete	Red	Single platform core	21	11	4

During the April 2020 site survey it was identified that the landscape to the east and west of the originally recorded extent of AHIMS ID 45-5-3159 was relatively intact with limited evidence of disturbance and was associated with the same drainage line as the original site recording. The site area was therefore reassessed and extended with areas of potential identified to the east and west of the original site extent (Figure 41).


Figure 36: Location of recorded site centroid of AHIMS ID 45-5-3159


Figure 37: Exposed vehicle track directly adjacent to site centroid


Figure 38: Open clearing where new artefacts were identified


Figure 39: Sandstone cobbles within backfill layer


Figure 40: Artefacts identified within site extent of AHIMS ID 45-5-3159

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Figure 41: Former and reassessed site extent of AHIMS ID 45-5-3159

6.1.4 RCAS 4 (AHIMS ID 45-5-3162)

Site type: Artefact Scatter
Centroid: [redacted]

RCAS 4 (AHIMS ID 45-5-3162) was previously recorded by Environmental Resources Management in 2005 as an artefact scatter comprised of seven artefacts identified within a vehicle track exposure. The site consisted of four red silcrete flakes, two grey silcrete flakes and one quartz flake.

The site was visited during the current survey and was observed to be heavily overgrown by thick grasses (Figure 42 – Figure 43). Visibility across the site during the survey was nil with no Aboriginal objects located.

Figure 42: View of current site condition of AHIMS ID 45-5-3162, northern aspect

Figure 43:View of heavy grasses over assessed former location of exposure

6.1.5 RCAS 5 (AHIMS ID 45-5-3163)

Site type: Artefact Scatter
Centroid: [redacted]

RCAS 5 (AHIMS ID 45-5-3163) was recorded by Environmental Resources Management in 2005 as an artefact scatter eroding out of the margins of a water pool located along the original course of a tributary of Ropes Creek. The site was recorded as three red silcrete flakes scattered along an eight-metre area.

The site coordinates were visited as part of the April 2020 site survey (Figure 44). The coordinates of the site recorded on AHIMS did not match description of the landform within the site card. Desktop assessment of historical aerials of the study area suggest that the water pool mentioned in the site card is comprised of a dam located approximately 50 metres south of the recorded site coordinates (see Figure 47). It is therefore assumed the registered site coordinates are in error.

The reassessed site location was also visited during the April 2020 and June 2020 survey with the dam noted in aerials re-identified. The dam was heavily overgrown with grasses (Figure 46). No Aboriginal objects were relocated.

Figure 44: Location of AHIMS ID 45-5-3163 based on site card coordinates, northern aspect

Figure 45: View of overgrown water pool and dumped rubbish piles assessed as likely site location, eastern aspect

6.1.6 AIF-06 (AHIMS ID 45-5-4599)

Site type: Isolated Find
Centroid: [redacted]

AIF-06 (AHIMS ID45-5-4599) was originally recorded by Artefact Heritage in 2015 as an isolated find located within an eroded unauthorised bike track. The site was comprised of a red silcrete flake measuring 19 millimetres long x 22 millimetres wide x 4 millimetres thick.

The recorded site location was covered by dense grasses during reinspection of the area (Figure 46). Due to the limited surface visibility, no evidence of the unauthorised bike track or the recorded artefacts were identified. No evidence of surface disturbance since the original site recording was observed, suggesting that the artefacts may remain on the ground surface in this area but were not visible during the survey due to lack of surface visibility.

Figure 46: Location of AHIMS 45-5-4599 based on site card coordinates, north-western aspect

6.1.7 AIF-05 (AHIMS ID 45-5-4605)

Site type: Isolated Find
Centroid: [redacted]

AIF-05 (AHIMS ID 45-5-4605) was originally recorded by Artefact Heritage in 2015 as an isolated find within a vehicle access track. The artefact was assessed as yellow silcrete distal flake which appeared to have been utilised as a core with one complete flake scar visible on the dorsal side.

The recorded site location was covered by dense grasses during reinspection of the area (Figure 47). Due to the limited surface visibility, no evidence of the recorded artefact was identified. No evidence of surface disturbance since the original site recording was observed, suggesting that the artefact may remain on the ground surface in this area but were not visible during the survey due to lack of surface visibility.

Figure 47: Location of AHIMS ID 45-5-4605

6.2 Newly identified sites

6.2.1 RCAS 09 (AHIMS ID 45-5-5355)

Site type: Artefact Scatter, PAD
Centroid: [redacted]
Site length: 120 metres
Site width: 50 metres

RCAS 09 (AHIMS ID 45-5-5355) is comprised of an artefact scatter and area of PAD. The artefact scatter associated with this site was identified within a wide exposure associated with a large vehicle track running parallel to Ropes Creek (Figure 48 – Figure 49). The surface exposure is located within a very gently sloped landform which includes a localised crest area within the southern portion of the artefact scatter. The localised crest landform was identified as an area of PAD due to the high number of surface artefacts identified within the vehicle exposure and the identification of the area as a localised spur crest landform.

The exposure includes substantial ironstone gravels with small amounts of scattered rubbish throughout the site extent likely associated with the unauthorised use of the proposal site for off-roading and as a construction vehicle access track associated with works for the St Marys Wastewater System Augmentation Project. Artefacts observed across the vehicle track are considered likely to have been subject to some level of post depositional movement through vehicle use of the track and surface water erosion across exposed areas of the ground surface. Soils across the remainder of the site extent including the area of PAD appeared to be largely intact.

The site is comprised of eight artefacts and an area of PAD (Figure 50 – Figure 51). Characteristics of the identified artefacts area detailed in Table 7. The location of the area of PAD and the identified artefacts are shown in Figure 52.

Table 7: Summary of artefacts identified at RCAS 09

Material	Colour	Artefact type	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Red	Complete flake	29	25	6
Silcrete	Yellow	Retouched utilised piece	25	32	4
Silcrete	Red	Marginal flake fragment	22	20	6
Silcrete	Red	Marginal flake fragment	12	10	3
Indurated Mudstone /Tuff (IMT)	Cream	Marginal flake fragment	18	15	7
Petrified wood	Grey	Proximal flake fragment	24	20	3
IMT	Cream	Multi platform core	28	28	15
IMT	Cream	Flaked piece	22	10	5

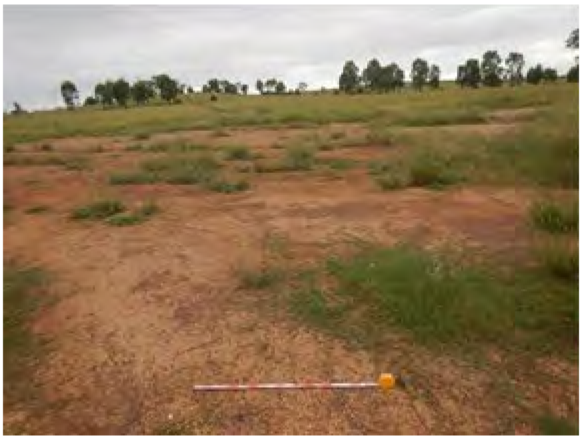

Figure 48: Exposure in which RCAS 09 was identified

Figure 49:Access track exposure in which the majority of surface artefacts were identified

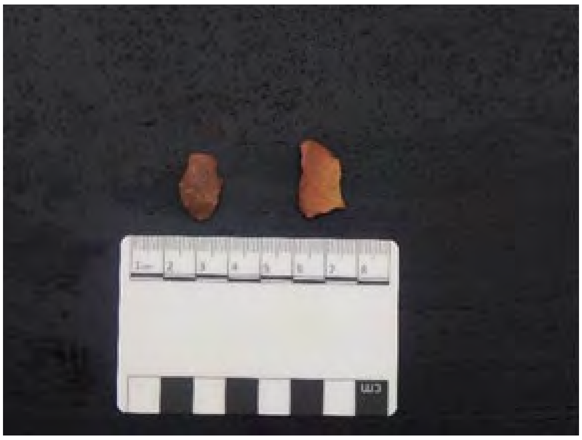

Figure 50: Silcrete artefacts, RCAS 09

Figure 51: Petrified wood artefact, RCAS 09

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Figure 52: Site features associated with RC AS 09

6.2.2 RCAS 10 (AHIMS ID 45-5-5354)

Site type: Artefact Scatter
Centroid: [redacted]
Site length: 15 metres
Site width: 5 metres

RCAS 10 (AHIMS ID 45-5-5354) is comprised of an artefact scatter located within a vehicle track exposure running perpendicular to Ropes Creek (Figure 53 – Figure 54). The site extent is located across a gentle slope landform which includes evidence of erosion associated with water runoff and unauthorised use of the proposal site for off roading.

A total of three silcrete artefacts were located within the site extent over a 15 metre length of the vehicle track (Figure 55 – Figure 56). Artefacts present included a single platform core, a complete flake and a proximal flake fragment. Characteristics for the identified artefacts are recorded in Table 8.

Table 8: Summary of artefacts identified at RCAS 10

Material	Colour	Artefact type	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Red	Single platform core	35	35	20
Silcrete	Red	Complete flake	30	20	5
Silcrete	Red	Proximal flake fragment	35	12	10

Figure 53:View west across RCAS 10 towards Ropes Creek

Figure 54:View east across RCAS 10

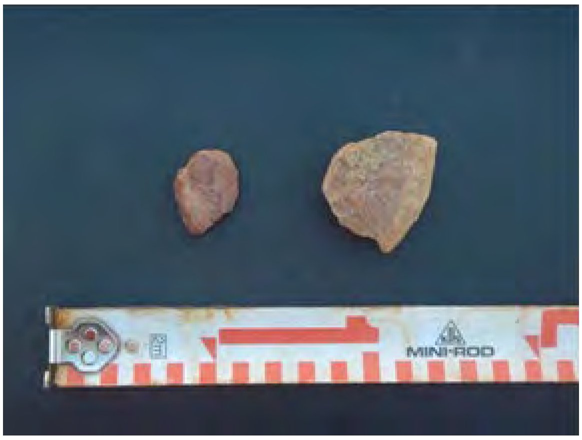

Figure 55: Silcrete artefacts identified within site extent of RCAS 10

Figure 56: Silcrete artefacts identified within site extent of RCAS 10

6.2.3 RCAS 11 (AHIMS ID 45-5-5353)

Site type: Artefact Scatter
Centroid: [redacted]
Site length: 15 metres
Site width: 5 metres

RCAS 11 (AHIMS ID 45-5-5353) is comprised of an artefact scatter within an exposure associated with an unauthorised trail bike track (Figure 57). The artefact site is located within the vicinity of the turn in the trail which is associated with a deeper erosion scour then the surrounding areas of tracks. The exposure includes substantial areas of exposed gravels consistent with the natural B horizon of the underlying soil profile. Some evidence of fill associated with the presence of blue metal gravels were also noted.

A total of three artefacts were located within the site extent over a 10 metre length of the trail bike track. Artefacts present included an IMT proximal flake fragment, a silcrete distal flake fragment and a silcrete proximal flake fragment (Figure 58 – Figure 59). A large silcrete cobble was also identified within the wider site extent although as it was partially buried it could not be fully examined for evidence of knapping during the site inspection (Figure 60). Characteristics of the identified artefacts are located in Table 9.

Table 9: Summary of artefacts identified at RCAS 11

Material	Colour	Artefact type	Length (mm)	Width (mm)	Thickness (mm)
IMT	Red	Proximal flake fragment	16	16	2
Silcrete	Red	Distal flake fragment	9	9	4
Silcrete	Red	Proximal flake fragment	8	4	2

Figure 57: Site location RCAS 11

Figure 58: Silcrete artefact, RCAS 11

Figure 59: Silcrete artefacts, RCAS 11

Figure 60: Silcrete cobble identified within site extent of RCAS 11

7.0 ANALYSIS AND DISCUSSION

7.1 Analysis of archaeological potential

The archaeological potential of an area is determined by its landform, its location and the level of disturbance. Certain landforms, such as gentle slopes are more conducive to the survival of archaeological material while others such as steep slopes are not. Additionally, different landform types are likely to have been utilised differently resulting in a different archaeological signature. The proximity of a landform to natural resources, in particular, permanent water sources is also a determining factor in assessing archaeological potential. Correlations between site location and proximity to a water source have been demonstrated in previous archaeological investigations where the number of sites and their densities is highest in close proximity to a water source.

In areas where there is a high level of disturbance however, the archaeological potential is lowered. It is unlikely that surface finds in these contexts are in their original context, and it is unlikely that subsurface archaeological deposits are intact.

7.2 Identified Aboriginal surface sites

Seven previously recorded sites were visited during the April 2020 site survey conducted for this report. Of the seven, only two were able to be relocated, RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) which were both partially harmed under AHIP C0000501. It is possible that these artefacts have been redeposited in their current locations following partial impact to these sites under AHIP C0000501.

The remaining previously recorded AHIMS surface sites within the proposal site were comprised of isolated artefacts or low density artefact scatters located in areas of exposure which have since been obscured by heavy grasses. These sites were largely located within vehicle tracks or in the banks of modified drainage gullies suggesting that the sites have been subject to some level of movement through surface disturbance. The movement associated with these impacts are considered to be relatively minor in nature and the sites are considered likely to be located generally within the vicinity of their original deposition.

The recorded site coordinates of two previously recorded surface sites (Blacktown Southwest 11 [AHIMS ID 45-5-0563] and RCAS 5 [AHIMS ID 45-5-3163]) were reassessed as part of the current assessment with new site locations identified utilising historical aerials and descriptions provided in each site card. The reassessed site location of these sites is shown in Figure 61.

Three newly identified surface sites were located within the proposal site. These sites were identified within heavily eroded vehicle and trail bike tracks. Of these, one site, RCAS 09 (AHIMS ID 45-5-5355) included the identification of an area of PAD associated with an intact localised crest landform surrounding the vehicle track exposure which included the identified surface artefacts. The remaining two sites were located across gently slope landforms which were not identified as containing subsurface archaeological potential.

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Figure 61: Summary of survey results

7.3 Areas of subsurface archaeological potential

Two previously recorded sites within the proposal site (RCIF 2 [AHIMS ID 45-5-3159] and Blacktown Southwest 7 [AHIMS ID 45-5-0559]) are comprised in part of subsurface archaeological remains. Both of these sites were identified on raised landforms in direct proximity to Ropes Creek which has since been subject to partial salvage under AHIP C0000501.

The proposal site is largely comprised of a broad gently sloping raised terrace landform transitioning to basal slopes in the eastern portion of the proposal site. Two intermittent drainage lines are also present across the proposal site.

Test excavation previously completed for Navin Officer (2007) across similar landforms to the south-west of the proposal site identified high densities of artefacts across two areas of PAD located across the basal mid slope and crest landform associated with a crest of a north-south running spur line in close proximity to Ropes Creek. Areas of PAD were also investigated further from Ropes Creek in proximity to first order drainage lines which recovered comparatively lower artefact densities.

Salvage excavation completed by ENSure JV (2015) across portions of Blacktown Southwest 7 (AHIMS ID 45-5-0559) and RCIF 2 (AHIMS ID 45-5-3159) have also identified high densities of artefacts across raised landforms within 100 metres of Ropes Creek. Both of these sites are also located directly adjacent to first order tributaries.

The northern first order tributary has been modified to form a large dam located on the northern boundary of the proposal site. Blacktown Southwest 7 (AHIMS ID 45-5-0559) has been previously assessed as relating to a distinct crescent shaped landform directly south-west of the dam feature. Reassessment of the site extent during the June 2020 survey identified that land to the east of the recorded site extent included a localised spur crest landform which was an extension of the landform associated with Blacktown Southwest 7 (AHIMS ID 45-5-0559). Inspection of exposed areas within the spur crest landform confirmed that the soil profile within this portion of the proposal site remained relatively intact. Consequently, the current assessment has adjusted the identified site extent of Blacktown Southwest 7 (AHIMS ID 45-5-0559) to include this portion of the landform.

The southern first order tributary has been subject to modification including the creation of two small dams as well as the construction of a raised compound area across the southern boundary of the study area which obscured portions of the former waterway. These impacts are however considered to have largely been limited to the southern side of the tributary with land on the northern side of the tributary considered to be relatively intact. RCIF 2 (AHIMS ID 45-5-3159) is identified along this tributary with the site extent identified as being located on a low rise in close proximity to Ropes Creek.

Reassessment of the area immediately surrounding RCIF 2 (AHIMS ID 45-5-3159) identified minimal landform variation between the registered site extent and the area extending along the bank of the tributary running east/west directly adjacent to the registered site extent. In addition, several previously recorded surface artefact sites have been identified within close proximity to the tributary at substantially further distances from Ropes Creek, including one site in which artefacts were identified within the wall of a water hole (Blacktown Southwest 11 [AHIMS ID 45-5-0563]). The current assessment has consequently adjusted the identified site extent of AHIMS ID 45-5-3159 to include an area of PAD to the east and west of the existing site extent (see Figure 61).

One newly identified area of PAD was identified associated with newly identified site RCAS 09 (AHIMS ID 45-5-5355). Survey of the surface components of this site identified a total of eight artefacts along a heavily eroded access track. Survey identified that the access track crossed a localised spur crest landform feature which with exception of the eroded area of the access track remained relatively intact. Assessment considered it likely that the artefacts associated with the surface scatter was indicative of a wider subsurface artefact scatter within this portion of the proposal site.

Identified areas of PAD have been located across several low lying crest landforms including two located adjacent to tributaries of Ropes Creek and one crest landform which is not located within the vicinity of existing watercourses. Predictive modelling and previous subsurface investigation have identified land adjacent to Ropes Creek and the tributaries of Ropes Creek as well as crest landforms as archaeologically sensitive. Test excavation of these landforms would allow for further investigation into the nature of the archaeological resource across landforms with varying proximity to Ropes Creek and its tributaries across the proposal site. This approach is consistent with the recommendation of Ecological (2016) that further archaeological investigation should be undertaken across all landforms within the proposal site.

8.0 SIGNIFICANCE ASSESSMENT

8.1 Significance assessment criteria

An assessment of the cultural heritage significance of an item or place is required in order to form the basis of its management. *The Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (Office of Environment and Heritage, 2011) provides guidelines for heritage assessment with reference to the Burra Charter (Australia ICOMOS, 2013) and the Heritage Office (2001) guidelines. *The Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (Office of Environment and Heritage, 2011) requires consideration of the following:

- Research potential: does the evidence suggest any potential to contribute to an understanding of the area and/or region and/or state's natural and cultural history?
- Representativeness: how much variability (outside and/or inside the subject area) exists, what is already conserved, how much connectivity is there?
- Rarity: is the subject area important in demonstrating a distinctive way of life, custom, process, land-use, function or design no longer practised? Is it in danger of being lost or of exceptional interest?
- Education potential: does the subject area contain teaching sites or sites that might have teaching potential?

It is important to note that heritage significance is a dynamic value.

8.2 Archaeological significance assessment

A summary of archaeological significance for Aboriginal sites within the proposal site is provided in Table 10.

Assessment of the previously identified sites was based on significance assessments on AHIMS site cards and observations from the April 2020 and June 2020 surveys.

Table 10: Summary of archaeological significance

Site name/ AHIMS ID	Research potential	Representative value	Rarity	Education potential	Overall archaeological significance
Blacktown Southwest 11, (AHIMS ID 45-5-0563)	Moderate	Low	Low	Low	Low
Blacktown Southwest 7, (AHIMS ID 45-5-0559)	Moderate-high	High	High	High	High
RCIF 2, (AHIMS ID 45-5-3159)	Moderate-high	High	High	High	High
RCAS 4, (AHIMS ID 45-5-3162)	Moderate	Low	Low	Low	Low
RCAS 5, (AHIMS ID 45-5-3163)	Moderate	Low	Low	Low	Low

Site name/ AHIMS ID	Research potential	Representative value	Rarity	Education potential	Overall archaeological significance
AIF-06, (AHIMS ID 45-5-4599)	Low	Low	Low	Low	Low
AIF-05, (AHIMS ID 45-5-4605)	Low	Low	Low	Low	Low
RCAS 09 (AHIMS ID 45-5-5355)	Moderate	Moderate	Low	Low	Moderate
RCAS 10 (AHIMS ID 45-5-5354)	Low	Low	Low	Low	Low
RCAS 11 (AHIMS ID 45-5-5353)	Low	Low	Low	Low	Low

8.2.1 Blacktown Southwest 11 (AHIMS ID 45-5-0563)

Blacktown Southwest 11 (AHIMS ID 45-5-0563) is comprised of a quartzite flake, quartzite pebble and a chert flake identified within an erosion scour associated with a dam feature. The site card identifies the site as being located within a grossly disturbed context associated with the construction of the dam. While the site card assesses the area as heavily disturbed, the current assessment identifies the site as being located with a wider area of subsurface archaeological potential which is considered to demonstrate moderate research potential as a wider landscape. The site card identifies quartzite as a relatively common raw material across the Cumberland Plain and subsequently the site is considered to have low rarity values. While limited detail is available in the site card regarding the nature of the flakes and quartzite pebble within the site card, as a low density artefact scatter the site is considered to contain low representativeness and low education potential. The overall archaeological significance of Blacktown Southwest 11 is considered to be low.

8.2.2 Blacktown Southwest 7 (AHIMS ID 45-5-0559)

Blacktown Southwest 7 (AHIMS ID 45-5-0559) is a dense artefact scatter recovered during salvage excavation on spur crest located within a raised terrace landform adjacent to the Ropes Creek flood plain. Assessment during the salvage excavation undertaken as part of the St Marys Wastewater System Augmentation project identified Blacktown Southwest 7 as being of high significance as a large number of uncommon artefacts were recovered during the salvage. The salvage report (ENSure JV 2015) assessed the site as demonstrating a moderate-high level of integrity and subsequently research potential. The salvage report (ENSure JV 2015) assessed the site to have high representative and rarity values associated with the variety of artefacts identified across the salvage excavation including some relatively uncommon artefacts. The site is considered to have high education values associated with the variety of artefacts present. The overall archaeological significance of Blacktown Southwest 7 is considered to be high.

8.2.3 RCIF 2 (AHIMS ID 45-5-3159)

RCIF 2 (AHIMS ID 45-5-3159) is a surface artefact as well as a dense subsurface artefact scatter recovered during salvage excavation. Assessment during the salvage excavation undertaken as part of the St Marys Wastewater System Augmentation project (ENSure JV 2015) identified RCIF 2 as demonstrating high rarity values due to the large variety of tool types identified. The salvage report (ENSure JV 2015) assessed the site as demonstrating moderate-high intactness (research potential), in conjunction with highly representative artefact types, which is considered to represent moderate-high research potential and educational value. Survey undertaken for the current assessment confirmed the relatively intact nature of the site. The overall archaeological significance of RCIF 2 is considered to be high.

8.2.4 RCAS 4 (AHIMS ID 45-5-3162)

RCAS 4 (AHIMS ID 45-5-3162) was originally recorded as a low density artefact scatter located within an eroded vehicle track. The site was not able to be relocated during the April 2020 survey and the significance assessment is based on the original site recording. Artefact scatters dominated by silcrete are considered to be common within the local region and the site exhibits low rarity values. While limited information is available about the artefacts from the site card, they do not appear to be representative of a specific artefact type or use and are considered to have low education values. While disturbed to some extent by vehicle and livestock movements the extent of the disturbance across the site is unclear from the current survey and the site is considered to demonstrate a moderate level of site integrity and research potential. The overall archaeological significance of RCAS 4 is considered to be low.

8.2.5 RCAS 5 (AHIMS ID 45-5-3163)

RCAS 5 (AHIMS ID 45-5-3163) was originally recorded as three silcrete artefacts eroding from the margins of a water pool. The site was not able to be relocated during the April 2020 survey and the significance assessment is based on the original site recording. The site card identifies the site as being located within the bank of a modified water pool which was assessed as a highly disturbed context. Based on this the site is not considered to be representative of former land use by Aboriginal people when compared to areas of the Cumberland Plain with higher preserved integrity including the area immediately west of Ropes Creek (which would not be impacted by the proposal). Silcrete artefact scatters are relatively common in the region and considered to demonstrate low rarity values. While the site card does not provide any information regarding the specific nature of the silcrete artefacts it is considered unlikely that they would provide significant educational values. Despite the level of disturbance associated with the construction of the water pool, the site card identifies that the surrounding area contain subsurface potential. This is supported by the current assessment which identifies the surrounding area as an area of potential. Based on the assessed subsurface potential, the site is considered to have moderate research potential. The overall archaeological significance of RCAS 5 is considered to be low.

8.2.6 AIF-06 (AHIMS ID 45-5-4599)

AIF 06 is an isolated silcrete artefact located on a vehicle access track. Isolated silcrete artefacts are considered to be common both within the proposal site and the wider Cumberland Plain. As the isolated find was identified within a disturbed context it is considered to contain low research potential and is not considered to be representative of a specific example of past land use by Aboriginal people. As an isolated find of a common artefact type in the region, the site is considered to demonstrate low representative and education values. The overall archaeological significance of AIF-06 is considered to be low.

8.2.7 AIF-05 (AHIMS ID 45-5-4605)

AIF 05 is an isolated silcrete artefact located on a vehicle access track. Isolated silcrete artefacts are considered to be common both within the proposal site and the wider Cumberland Plain. As an isolated artefact the site is considered to have limited research potential. As a distal flake fragment the artefact is not considered to be a good representation of artefacts of its type and considered to have low educational value. The overall archaeological significance of AIF-05 is considered to be low.

8.2.8 RCAS 09 (AHIMS ID 45-5-5355)

RCAS 09 is a low density artefact scatter and area of PAD. While the significance of the area of PAD is at present unknown, the identified surface artefacts identified a substantial variation in artefact types with a variety of raw materials types and artefact morphologies represented within the assemblage. Based on the variety of artefacts identified within the surface exposure the site is considered to demonstrate moderate representativeness and when combined with the area of PAD, moderate research potential. The surface artefacts are comprised of a low density artefact scatter located in a disturbed context which are considered to be common within the proposal site and wider Cumberland Plain. In isolation from the area of PAD the artefact scatter is considered to demonstrate low rarity values and low education values. The significance of this site would be updated following the completion of archaeological test excavation across the area of PAD.

8.2.9 RCAS 10 (AHIMS ID 45-5-5354)

RCAS 10 is a low density artefact scatter located in a heavily utilised vehicle track. Low density artefact scatters in disturbed contexts are considered to be common within the proposal site and wider Cumberland Plain. The site is located within a disturbed context associated with high levels of erosion identified across the site, consequently the site is considered to demonstrate low research potential. As the artefacts are located on a vehicle track, they are considered to have been subject to movement from vehicle use and surface water erosion and are therefore not considered to be representative of a specific land use by Aboriginal people. As silcrete flakes, the artefacts are considered to be relatively common artefact types. The artefacts are therefore considered to demonstrate low rarity and educational values. The overall archaeological significance of RCAS 10 is considered to be low.

8.2.10 RCAS 11 (AHIMS ID 45-5-5353)

RCAS 11 is a low density artefact scatter located in a heavily utilised trail bike track. Low density artefact scatters in disturbed contexts are considered to be common within the proposal site and wider Cumberland Plain. The wider site context was identified as heavily eroded based on the presence of substantial gravels consistent with the A2 horizon within the Blacktown soil landscape suggesting low research potential associated with the site. As the artefacts are located on a vehicle track, they are considered to have been subject to movement from vehicle use and surface water erosion and are therefore not considered to be representative of a specific land use by Aboriginal people. As silcrete and IMT flakes, the artefacts are considered to be relatively common artefact types. The artefacts are therefore considered to demonstrate low rarity and educational values. The overall archaeological significance of RCAS 11 is considered to be low.

8.3 Cultural significance

No specific areas of cultural significance were identified during site survey with a representative of Deerubbin LALC. No comments on the archaeological significance of the identified sites were received during the site inspection. In their report (Appendix 2), Deerubbin LALC noted that further investigation through test excavation should be undertaken prior to development.

Further assessment of the cultural significance of proposal site will be undertaken during preparation of the Aboriginal Cultural Heritage Assessment Report (ACHAR) for the proposal.

9.0 IMPACT ASSESSMENT

9.1 Proposed works

Sydney Metro is proposing to construct and operate two adjacent precast facilities (the proposal) to support construction of the proposed tunnelling for Sydney Metro West (Figure 62). The precast facilities which are the subject of this proposal would manufacture precast concrete segments for the purpose of lining the Sydney Metro West tunnels.

The proposal would comprise the following key features:

- Site establishment at the proposal site at Eastern Creek including vegetation clearing, remediation, and earthworks
- The establishment and operation of two separate and adjacent precast facilities on the proposal site, the northern and southern precast facilities. Each precast facility would include:
    - A precast yard including a shed for construction of precast concrete segments and storage laydown areas
    - Boiler, aggregate bins and consumables
    - Office facilities
    - On-site parking for up to 60 light vehicles
- Internal roads with entrances to each facility from the Western Access Road located between the northern and southern precast facilities (external roads would be subject to separate approvals)
- Ancillary supporting infrastructure, including utilities installation (power, water, sewerage, gas and communications), lighting, signage and landscaping.

A portion of the proposal site in the south-west would be conserved as an environmental protection area associated with the presence of Cumberland Plain Woodland. Vegetation within this area would be retained and protected during works.

9.2 Identified impacts

Earthworks across the proposal site would result in total impact to the ground surface with exception of the environmental protection zone associated with the area of Cumberland Plain Woodland located in the south-western portion of the proposal site. The proposal will result in partial to total removal of Aboriginal sites within the proposal site.

As a portion of RCIF 2 (AHIMS ID 45-5-3159) extends across the environmental protection area a portion of the site would be preserved. Further, as the site extent of Blacktown Southwest 7 (AHIMS ID 45-5-0559) extends past the proposal site boundary, a portion of this site would also be preserved.

Aboriginal site AIF-06 (AHIMS ID 45-5-4599) is within the works boundary of the planned Archbold Road upgrade and extension. The Archbold Road Upgrade and Extension ACHAR (KNC, 2017a: 21) identified a total direct impact to AIF-06 as part of the planned Archbold Road upgrade and extension. The site is located within the proposed AHIP application area extent as identified in the Archbold Road Upgrade and Extension ACHAR (KNC 2017: 23). The intention of that AHIP application, as outlined in the Archbold Road Upgrade and Extension ACHAR (KNC 2017: 21), will be to permit direct harm to that site with a consequence of total loss of value.

However, the AHIP application for the planned Archbold Road upgrade and extension had not been submitted to Heritage NSW at the time this report was prepared. As that AHIP application has not yet been submitted, AHIMS ID 45-5-4599 is included in the impact assessment for the proposal. Sydney Metro and other relevant parts of Transport for NSW would coordinate any future Aboriginal Cultural Heritage Assessment Report(s) (ACHAR) and AHIP application(s).

A summary of identified impacts is outlined in Table 11 and shown in Figure 63.

Table 11: Summary of impacts associated with proposed works

Name / AHIMS ID	Type of harm	Degree of harm	Consequence of harm
Blacktown Southwest 11, (AHIMS ID 45-5-0563)	Direct	Total	Total loss of value
Blacktown Southwest 7, (AHIMS ID 45-5-0559)	Direct	Partial	Partial loss of value
RCIF 2, (AHIMS ID 45-5-3159)	Direct	Partial	Partial loss of value
RCAS 4, (AHIMS ID 45-5-3162)	Direct	Total	Total loss of value
RCAS 5, (AHIMS ID 45-5-3163)	Direct	Total	Total loss of value
AIF-06, (AHIMS ID 45-5-4599)	Direct	Total	Total loss of value
AIF-05, (AHIMS ID 45-5-4605)	Direct	Total	Total loss of value
RCAS 09 (AHIMS ID 45-5-5355)	Direct	Total	Total loss of value
RCAS 10 (AHIMS ID 45-5-5354)	Direct	Total	Total loss of value
RCAS 11 (AHIMS ID 45-5-5353)	Direct	Total	Total loss of value

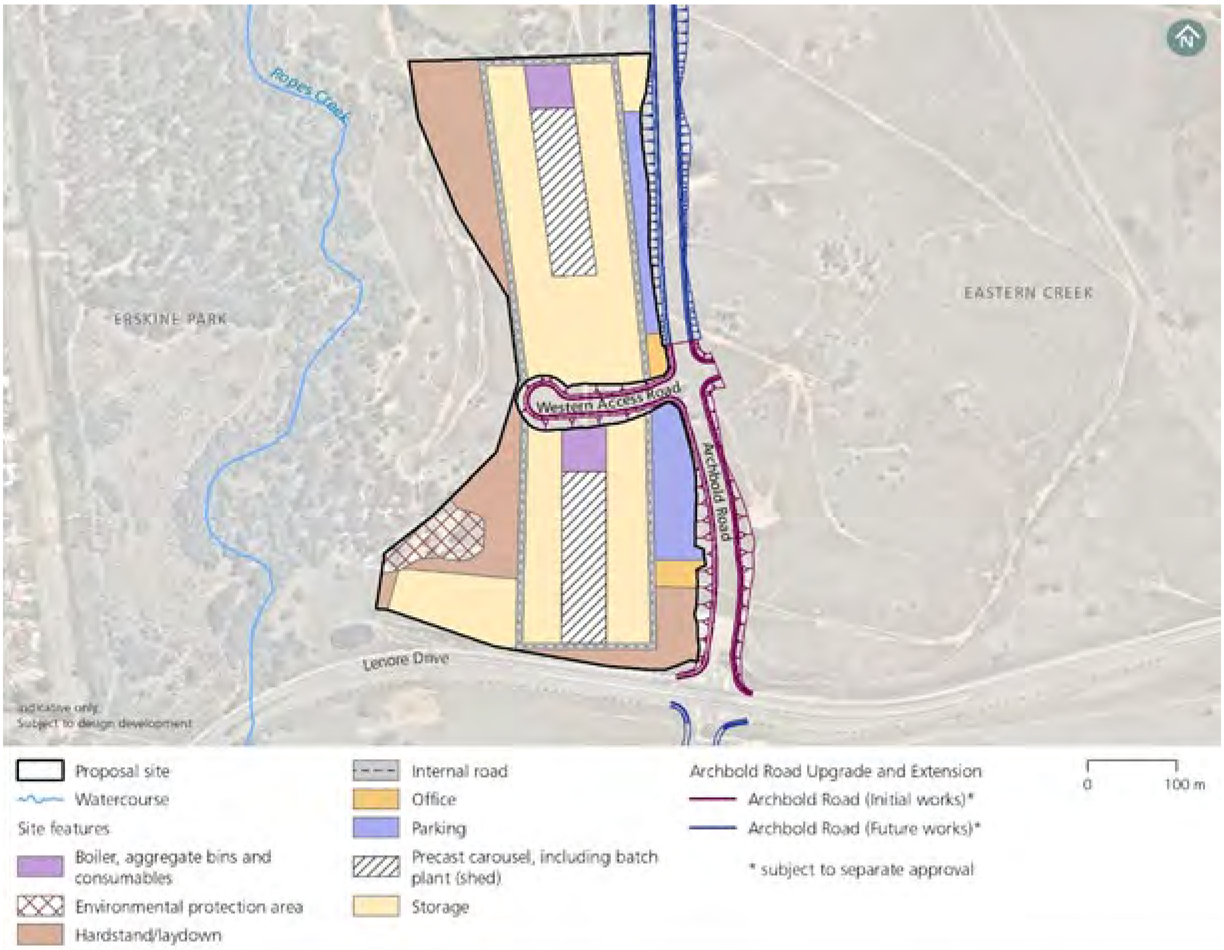

Figure 62: Overview of proposed works

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Figure 63: Sites subject to impact by the proposed works

10.0 MANAGEMENT AND MITIGATION MEASURES

10.1 Guiding principles

The overall guiding principle for cultural heritage management is that Aboriginal sites should be conserved. If conservation is not practicable, measures should be taken to mitigate impacts. The nature of the mitigation measures recommended is based on the assessed significance of the sites and the impact assessment.

10.2 Conservation

Those portions of site RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) outside the proposal site would not be subject to impact. The location of these sites should be marked on construction drawings or Environmental Control Maps to ensure that the portions of each site outside the construction footprint are not impacted. Further heritage assessment would be required prior to any works outside the proposal site.

10.3 Comprehensive consultation

Further heritage investigation must include comprehensive consultation with Aboriginal stakeholders in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents (*Department of Environment, Climate Change and Water, 2010b). This includes ongoing consultation regarding Aboriginal cultural values as well as throughout the archaeological test excavation process, during preparation of an ACHAR and when submitting an AHIP application to the Heritage NSW for the proposed works.

10.4 Test excavation

The archaeological significance of the areas of PAD identified within the extended site extent of RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) as well as its relationship to the formerly investigated portion of these sites is at present unknown. Similarly, the significance of the identified area of PAD associated with RCAS 09 (AHIMS ID 45-5-5355) and the relationship of the area of PAD to the identified surface artefacts within RCAS 09 is unknown. Further investigation of these areas of PAD would be required to confirm the nature of proposed impact to the identified site, as well as identify appropriate mitigation measures for proposed impacts.

Test excavation under the *Code of Practice for Archaeological Investigation of Aboriginal objects in New South Wales* (Department of Environment, Climate Change and Water, 2010a) would be required in order to determine whether subsurface Aboriginal objects are present within the expanded site extent of RCIF 2 (AHIMS ID 45-5-3159). The purpose of the excavations would be to confirm the extent of subsurface artefacts, their association with other sites in the area and their significance. Further information regarding the nature, extent and significance of this site will subsequently assist in the identification of appropriate mitigation measures for proposed impacts to the site. Archaeological test excavation is not conducted to mitigate against impacts.

Prior to the commencement of test excavation, a test excavation methodology must be prepared and circulated to registered Aboriginal parties for a 28 day review and comment period. Test excavation would be limited to relevant areas of the impact footprint of the proposal.

10.5 Artefact reburial location

There is potentially one existing artefact reburial location within the proposal site associated with AHIP C0000501 (see Figure 2). Further clarification of the location of the reburial location in relation to the proposed works would be required to determine appropriate management and mitigation measures.

Potential management of the existing artefact reburial sites would be discussed with registered stakeholders for the project as part of consultation completed for the ACHAR.

10.6 Aboriginal Heritage Impact Permit application

As Aboriginal objects that are not currently subject to an AHIP are present within the proposal site, an AHIP would need to be obtained to allow impacts to the following sites:

- Blacktown Southwest 11 (AHIMS ID 45-5-0563)
- Blacktown Southwest 7 (AHIMS ID 45-5-0559)
- RCIF 2 (AHIMS ID 45-5-3159)
- RCAS 4 (AHIMS ID 45-5-3162)
- RCAS 5 (AHIMS ID 45-5-3163)
- AIF-06 (AHIMS ID 45-5-4599)
- AIF-05 (AHIMS ID 45-5-4605)
- RCAS 09 (AHIMS ID 45-5-5355)
- RCAS 10 (AHIMS ID 45-5-5354)
- RCAS 11 (AHIMS ID 45-5-5353)

The application for an AHIP for the above sites would require the completion of an ACHAR in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (Office of Environment and Heritage, 2011). The preparation of an ACHAR would involve comprehensive Aboriginal stakeholder consultation in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (Department of Environment, Climate Change and Water, 2010b), an assessment of Aboriginal cultural heritage values and an assessment of the potential harm to those values from the proposed works.

Results from this assessment and the results of the test excavation will be used as a basis of the ACHAR. Mitigation measures developed during the ACHAR would address potential impacts caused by the proposal and form the basis of proposed mitigation to be assessed as part of the AHIP application. Conditions of the AHIP (once issued), would be in addition to management measures proposed for the current ASR and the project REF.

10.6.1 AHIMS ID 45-5-4599

AIF-06 (AHIMS ID 45-5-4599) would also be subject to potential impacts from the planned Archbold Road upgrade and extension project. Sydney Metro and other relevant parts of Transport for NSW would coordinate any future Aboriginal Cultural Heritage Assessment Report(s) (ACHAR) and AHIP application(s).

11.0 RECOMMENDATIONS

The following recommendations regarding Aboriginal heritage are based on consideration of:

- Statutory requirements under the *National Parks and Wildlife Act 1974*
- The requirements of the relevant guidelines: *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (Office of Environment and Heritage, 2011), *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (Department of Environment, Climate Change and Water, 2010a) and the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (Department of Environment, Climate Change and Water, 2010b)
- The results of the background research, site surveys and sensitivity assessment
- The likely impacts of the proposed development.

It was found that:

- Ten Aboriginal sites are located within the study area
  - Blacktown Southwest 11 (AHIMS ID 45-5-0563)
  - Blacktown Southwest 7 (AHIMS ID 45-5-0559)
  - RCIF 2 (AHIMS ID 45-5-3159)
  - RCAS 4 (AHIMS ID 45-5-3162)
  - RCAS 5 (AHIMS ID 45-5-3163)
  - AIF-06 (AHIMS ID 45-5-4599)
  - AIF-05 (AHIMS ID 45-5-4605)
  - RCAS 09 (AHIMS ID 45-5-5355)
  - RCAS 10 (AHIMS ID 45-5-5354)
  - RCAS 11 (AHIMS ID 45-5-5353)
- The current assessment has identified an area of potential archaeological deposit (PAD) associated with the wider site extent of Aboriginal sites RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 11 (AHIMS ID 45-5-0559) as well as the area of PAD identified within RCAS 09 (AHIMS ID 45-5-5355)
- RCIF 2 (AHIMS ID 45-5-3159) and Blacktown Southwest 7 (AHIMS ID 45-5-0559) would be subject to partial harm as a portion of their identified site extents are located outside of the current impact area
- All remaining identified surface artefact sites within the proposal site would be subject to total harm resulting in total loss of value to all remaining sites.

The following recommendations are made:

- Archaeological test excavation would be limited to the proposal site and undertaken in accordance with the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW (Department of Environment, Climate Change and Water, 2010a) to confirm the geographic extent of RCIF 2 (AHIMS ID 45-5-3159), Blacktown Southwest 11 (AHIMS ID 45-5-

0559) and the area of PAD identified within Ropes Creek Artefact Scatter 09 (AHIMS ID 45-5-5355)
Test excavation would be limited to areas subject to potential impacts by the proposed works and outside the area already salvaged as part of the St Mary's Wastewater System Augmentation project. Archaeological test excavation would be undertaken in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010a)

- As part of the preparation of the test excavation methodology and ACHAR, comprehensive Aboriginal stakeholder consultation would be carried out in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (Department of Environment, Climate Change and Water, 2010b) and the National Parks and Wildlife Regulation 2019
- An AHIP would be submitted to the Department of Premier and Cabinet NSW (DPC) for those portions of the proposal site subject to impacts once test excavation is completed. The AHIP application would be supported by an ACHAR and test excavation report. An AHIP would be issued for the proposal prior to construction works commencing in areas where known Aboriginal sites and areas of PAD are located
- Sydney Metro would liaise with Transport for NSW regarding overlapping impacts to Aboriginal site AIF-06 (AHIMS ID 45-5-4599) and coordinating further assessment and management
- In the event that suspected Aboriginal ancestral remains are exposed during construction, the requirements of Section 3.6 of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) would be implemented.

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APPENDIX 1 – EXTENSIVE AHIMS SEARCH

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APPENDIX 2 – DEERUBBIN LALC REPORT

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Appendix H

Biodiversity Assessment Report

Jacobs

Sydney Metro Precast Facilities

Biodiversity Assessment Report

v05 | Final

22 October 2020

Sydney Metro Authority

Sydney Metro Precast Facilities

Project No:	IA199800
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02	16/06/20	Second draft report	B. Hays	C. Thomson	C. Thomson
03	31/08/20	Third and final draft report	B. Hays		
04	14/09/20	Fourth and final report	B. Hays		
05	22/10/20	Fifth and final report	B. Hays		

Contents

Glossary of terms

Definitions

Cumulative impact	The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Refer to Clause 228(2) of the EP&A Regulation 2000 for cumulative impact assessment requirements.
Direct impact	Where a primary action is a substantial cause of a secondary event or circumstance which has an impact on a protected matter (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf).
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component (OEH 2014).
Indirect impact	Where an event or circumstance is a direct consequence of the action (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf).
Matters of NES	A matter of national environmental significance (NES) protected by a provision of Part 3 of the EPBC Act
NSW landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000 (OEH 2014).
Mitigation	Action to reduce the severity of an impact (OEH 2014).
Mitigation measure	Any measure that facilitates the safe movement of wildlife and/or prevents wildlife mortality.
Population	All the individuals that interbreed within a given area.
Proposal site	The area of land that is directly impacted on by the proposal.
Ecological study area	The area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly (OEH 2014). This has been defined as the proposal site with an approximate 50 metre buffer.
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure.

Abbreviations

BC Act	*Biodiversity Conservation Act 2016*
CEEC	Critically Endangered Ecological Community
CEMP	Construction Environmental Management Plan
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and the Environment
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Federal).
FM Act	*Fisheries Management Act 1994* (NSW)
GDE	Groundwater dependent ecosystems

IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant Community Type
REF	Review of Environmental Factors
TEC	Threatened Ecological Community
TBDC	Threatened Biodiversity Data Collection

Executive Summary

Sydney Metro propose to establish two precast facilities (the proposal) to support the construction of the proposed Sydney Metro West. The precast facilities which are the subject of this proposal would manufacture precast concrete segments for the purpose of lining the Sydney Metro West tunnels. This report details the methods and results of a biodiversity survey and assessment of the distribution and abundance of threatened species, populations and ecological communities, and the extent and magnitude of ecological impacts associated with the proposal.

An ecological survey was undertaken within the ecological study area on 9 and 16 April 2020. While on site, a habitat assessment was undertaken to assess the likelihood of threatened biodiversity existing in the ecological study area. The field survey aimed to ground-truth the results of the background research and desktop habitat assessment. All threatened species, populations and communities that were considered likely to occur within the ecological study area were targeted during the field surveys and habitat assessment. Vegetation surveys were completed in line with the Biodiversity Assessment Method (BAM). Targeted surveys were completed for threatened plant species and the Cumberland Plain Land Snail. The habitat value of the waterways and dams were characterised in accordance with NSW Department of Primary Industries (Fisheries) document *Policy and Guidelines for fish habitat conservation and management (2013 update).* This assessment also considers the outcomes of the Biodiversity technical paper prepared as part of the Archbold Road upgrade and extension Review of Environmental Factors (REF) (WSP | Parsons Brinckerhoff 2017).

Three Plant Community Types (PCTs) were identified in the ecological study area based on floristic composition, geology, and landscape position with regard to relevant regional vegetation classifications:

- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849).
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 835).
- Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071).

These PCTs are mostly in poor condition, existing as regenerating canopy over exotic dominated grasses. Two patches of grassland with a high abundance of Kangaroo Grass were mapped as a derived grassland condition of PCT 849. The highest quality vegetation is moderate condition PCT 849 in the west of the ecological study area (<0.001 hectares within the proposal site), which is part of the Ropes Creek riparian corridor and mapped as both Priority Investment Land and a biodiversity corridor of regional significance (BIO Map). Areas of planted native / exotic vegetation that cannot be matched to a PCT were also present. The remainder of the vegetated areas are classed as exotic grassland.

Two threatened ecological communities (TECs) listed under the *Biodiversity Conservation Act 2016* (BC Act) were identified in the ecological study area:

- Cumberland Plain Woodland in the Sydney Basin Bioregion (listed as critically endangered).
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (listed as endangered).

One threatened ecological community as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was identified outside the proposal site, though within the ecological study area:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (listed as critically endangered).

One threatened plant species was recorded in the ecological study area during the field survey undertaken for the proposal: *Grevillea juniperina* subsp. *juniperina*. Four plants were identified growing from the southern bank of the large dam in the north of the ecological study area outside of the proposal site. A further 30 plants were identified outside the south west of the ecological study area. These individuals are part of the Ropes Creek population. None of these individuals would be directly impacted by the proposal. No other threatened fauna species are considered likely to occur in the ecological study area based on the results of the targeted survey and lack of suitable habitat.

Live Cumberland Plain Land Snails were found in leaf litter and under rubbish in moderate condition woodland in the west of the ecological study area. This is expected to be the best quality habitat for this species in the ecological study area, which would be avoided by the proposal.

The following fauna species are either known to occur in adjacent habitat and/or are considered at least moderately likely to occur in the proposal site based on the presence of suitable habitat:

- Green and Golden Bell Frog (*Litoria aurea*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Little Bent-winged Bat (*Miniopterus australis*)
- Large Bent-winged Bat (*Miniopterus orianae oceanensis*)
- Southern Myotis (*Myotis macropus*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)
- Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)
- Varied Sittella (*Daphoenositta chrysoptera*)
- Little Lorikeet (*Glossopsitta pusilla*)
- Swift Parrot (*Lathamus discolor*)
- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*).

The key impacts of the proposal include the removal of 1.92 hectares of native vegetation, a subset of which includes the following threatened ecological communities:

- 1.74 ha of Cumberland Plain Woodland in the Sydney Basin Bioregion (BC Act: listed as critically endangered)
- 0.07 ha of River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act: listed as endangered)
- <0.001 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EPBC Act: listed as critically endangered); a subset of the 1.74 ha of the associated BC Act listed Cumberland Plain Woodland community.

The native vegetation to be removed provides habitat (or potential habitat) for the species listed above. No *Grevillea juniperina* subsp. *juniperina* plants would be directly impacted, however 0.06 hectares of potential habitat for this species would be removed.

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing would occur, and the extent of this impact would be proportionate to the extent of vegetation that is cleared. Indirect operational impacts would include a minor increase in habitat isolation. Invasion and spread of weeds, invasion and spread of pests, and invasion and spread of pathogens and disease are a risk with a proposal of this type due to the potential for vehicles and machinery to introduce and spread contaminated soil during clearing. Noise, light and vibration would be increased during construction and operation. Significant impacts to aquatic ecosystems are unlikely to occur as a result of the proposal.

The ecological study area is situated in an over-cleared landscape due to historic activities. In the context of historic vegetation removal, any future vegetation clearing no matter how small would result in incremental cumulative impact that would detrimentally affect biodiversity. In combination with other projects in the area the proposal would contribute to cumulative biodiversity impacts (refer to REF for full cumulative impact assessment).

Although efforts have been made to avoid, minimise and mitigate potential ecological impacts from the proposal, some residual impacts would occur. Management measures would be implemented during the construction and operational phases to mitigate the potential ecological impacts of the proposal. This assessment has identified a range of mitigation techniques to be implemented during construction and operation (see **Section 8.2**). Due to the presence of the critically endangered ecological communities and threatened fauna habitat, exclusion zones would be established to delineate the works limit boundary to ensure no accidental impacts occur.

The overall outcome of the BC Act tests of significance and EPBC Act assessments of significance indicate that there is a high level of certainty that the impacts to threatened biodiversity are unlikely to be significant.

1. Introduction

1.1 The proposal

Sydney Metro propose to establish two precast facilities (the proposal) to support the construction of the proposed Sydney Metro West. The precast facilities which are the subject of this proposal would manufacture precast concrete segments for the purpose of lining the Sydney Metro West tunnels. Key components of the proposal are shown in **Figure 1-2** and would include:

- Site establishment at the proposal site at Eastern Creek including vegetation clearing, remediation, and earthworks
- The establishment and operation of two separate adjacent precast facilities on the proposal site, the northern and southern precast facilities. Each precast facility would include:
  - A precast yard including a shed for construction of precast concrete segments and storage laydown areas
  - Boiler, aggregate bins and consumables
  - Office facilities
  - On-site parking for up to 60 light vehicles
- Internal roads entrances to each facility from the Western Access Road located between the northern and southern precast facilities (external roads would be subject to separate approvals)
- Ancillary supporting infrastructure, including utilities installation (power, water, sewerage, gas and communications), lighting, signage and landscaping.

The northern and southern precast facilities would operate concurrently, 24 hours a day, seven days a week for the majority of the lifespan of the project.

The proposal would be temporary, operating for an approximate timeframe of four to five years, subject to the delivery strategy and construction program for Sydney Metro West.

1.2 Purpose and scope of this report

This report details the methods and results of a biodiversity survey and assessment to identify the distribution and abundance of threatened species, populations and ecological communities in the area of the proposal to assess the extent and magnitude of ecological impacts associated with the proposal. The report addresses the requirements for assessment of significance under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Mitigation measures to ameliorate ecological impacts arising from the proposal are also provided. The aims of the biodiversity assessment are to:

- Describe the characteristics and ecological condition of the vegetation communities and habitats within the ecological study area
- Determine the occurrence, or likelihood of occurrence of threatened species, populations and communities listed under the *Biodiversity Conservation Act 2016* (BC Act) and EPBC Act within the ecological study area
- Describe the potential impacts on biodiversity in the ecological study area because of the proposal
- Undertake a test of significance for threatened species and communities that are confirmed or considered likely to occur within the ecological study area in accordance with section 7.3 of the BC Act to determine whether the proposal is likely to significantly affect threatened species
- Undertake assessments in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999* (Department of

Environment, 2013) to consider impacts to nationally listed threatened species, ecological communities and migratory species

- Propose measures to mitigate impacts on ecological values.

1.3 Ecological study area

The ecological study area for the purposes of this biodiversity assessment (see **Figure 1-2**) includes the proposal site plus a 50-metre buffer to account for the area that would be directly and indirectly impacted by construction and operation of the proposal.

The following areas are discussed throughout the report and are defined as:

- Proposal site: the boundary of the northern and southern precast sites (see **Figure 1-2**)
- Ecological study area: includes the proposal site and surrounding 50-metre buffer (see **Figure 1-2**)
- Locality: defined as the area within a 10-kilometre radius surrounding the proposal site (see **Figure 1-1**)
- Bioregion: The ecological study area is in the Sydney Basin bioregion (Thackway and Cresswell, 1995) and within Cumberland sub-region (see **Figure 1-1**).

Figure 1-1 Proposal context

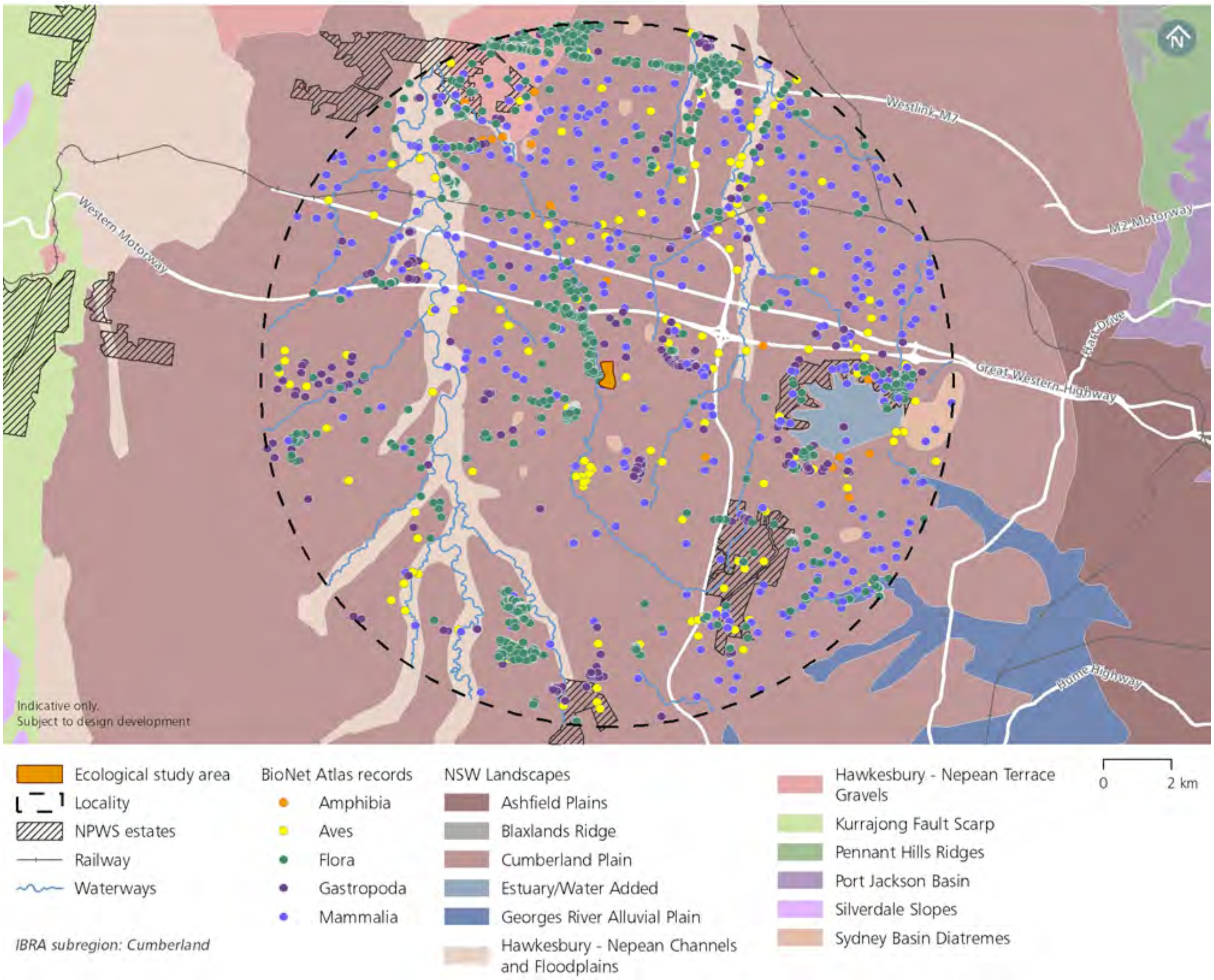
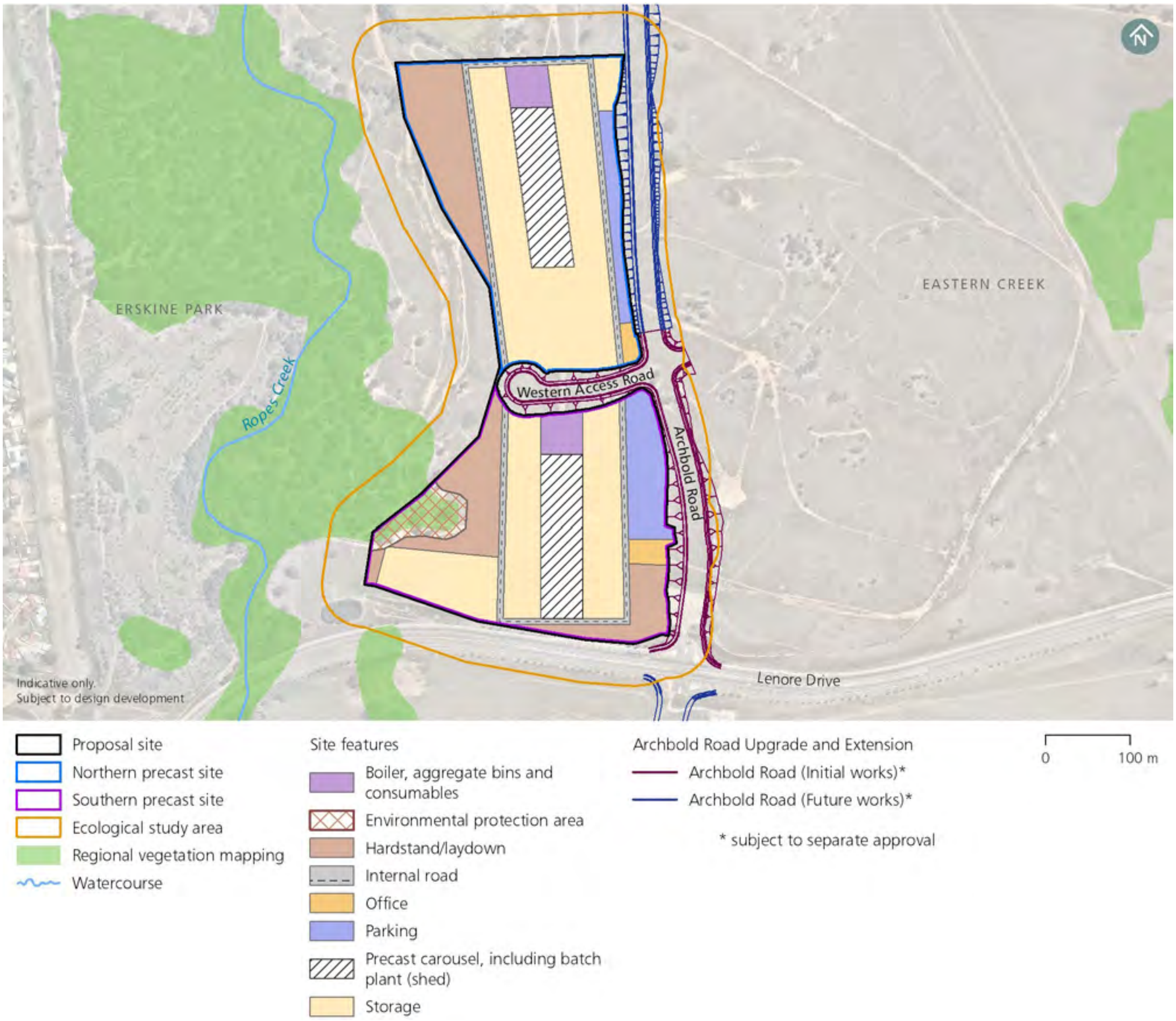


Figure 1-2 The proposal



2. Legislative and policy framework

A Review of Environmental Factors (REF) has been prepared to fulfil Sydney Metro's obligations in accordance with Division 5.1, Section 5.5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to "examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity" and Section 5.7 in making decisions on the likely significance of any environmental impacts. This biodiversity impact assessment forms part of the REF prepared for the Sydney Metro West Precast Facility (incorporating the northern and southern precast facilities) and assesses the biodiversity impacts of the proposal to meet the requirements of the EP&A Act.

The *Biodiversity Conservation Act 2016* (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 Division 5.1 activities (amongst other types of development). The BC Act lists a number of threatened species, populations or ecological communities to be considered in deciding whether a development or activity is "likely to significantly affect threatened species". A development or an activity is likely to significantly affect threatened species if:

(a) it is likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in Section 7.3 (of the BC Act), or

(b) the development exceeds the biodiversity offset scheme (BOS) threshold if the BOS applies to the impacts of the development on biodiversity values, or

(c) it is carried out in a declared Area of Outstanding Biodiversity Value (AOBV).

The BOS does not apply to development that is an activity subject to environmental impact assessment under Division 5.1 of the EP&A Act unless the proponent chooses to opt in to the BOS. The proponent has not opted into the BOS for this proposal. As such, the test of significance detailed in Section 7.3 of the BC Act must be used to determine whether the proposal is likely to significantly affect threatened species.

Sydney Metro must consider impacts to nationally listed threatened species, ecological communities and migratory species as part of the approval process under the strategic assessment. To assist with this, assessments are required in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999* (DoE 2013).

3. Assessment methodology

3.1 Personnel

This biodiversity assessment was undertaken and prepared by appropriately qualified and experienced ecologists (refer to **Table 3-1**).

Table 3-1 Personnel, role and qualifications

Name	Role	Qualifications
Brenton Hays	Ecologist - Technical lead, ecology surveys, reporting, GIS analysis	Bachelor of Environmental Science and Management (Hons) Accredited under section 6.10 of the Biodiversity Conservation Act 2016 as a Biodiversity Assessment Method Assessor (No. BAAS19068)
Tim Maher	Ecologist - Field survey assistant	Bachelor of Advanced Science (Biology) Master of Research (Plant Ecology)
Chris Thomson	Principal Ecologist - Technical review	Graduate Certificate in Natural Resources Bachelor of Applied Science (Environmental Management) Accredited under section 6.10 of the Biodiversity Conservation Act 2016 as a Biodiversity Assessment Method Assessor (No. BAAS18058)

3.2 Background research

A background review of existing information was undertaken to identify the existing environment of the proposal within a search area of 10 kilometres. The review focussed on database searches, relevant ecological reports pertaining to the ecological study area, particularly the Biodiversity technical paper prepared as part of the Archbold Road Upgrade and Extension Review of Environmental Factors (REF) (WSP | Parsons Brinckerhoff 2017), property boundaries, and relevant GIS layers. The review was used to prepare a list of threatened species, populations and communities as well as important habitat for migratory species with a likelihood of occurrence in the ecological study area and locality. The searches were also undertaken to identify if any Areas of Outstanding Biodiversity Value were present.

The following database searches were performed:

- BioNet - the website for the Atlas of NSW Wildlife and Threatened Biodiversity Data Collection – 24 March 2020
- NSW Department of Primary Industries (DPI) Fisheries Spatial Data Portal – 22 April 2020
- The federal Department of Environment’s Protected Matters Search Tool – 23 March 2020
- BioNet Vegetation Classification Database – 15 April 2020
- The federal Bureau of Meteorology’s Atlas of Groundwater Dependent Ecosystems (GDE) – 21 April 2020
- Department of Environment’s Directory of Important Wetlands in Australia – 21 April 2020
- Department of Planning and Environment’s SEPP (Coastal Management) 2018 maps – 21 April 2020

Regional vegetation mapping projects including the Southeast NSW Native Vegetation Classification and Mapping – SCIVI (VIS_ID 2230), (State Government of NSW and Office of Environment and Heritage, 2010) and the Remnant Vegetation of the western Cumberland subregion, 2013 Update (VIS_ID 4207) (State Government of NSW and Office of Environment and Heritage, 2015). Vegetation mapping from the Archbold Road upgrade and extension Archbold Road Upgrade and Extension Biodiversity Assessment Report (WSP | Parsons Brinckerhoff 2017) was also examined.

Preliminary and provisional determinations to list species and ecological communities as threatened under the BC Act was viewed on the OEH NSW Threatened Species Scientific Committee website (Department of Planning, Industry and Environment 2020). There were no preliminary or provisional listings of relevance to the proposal.

The annual Final Priority Assessment List of nominated species and ecological communities that have been approved for assessment by the Minister responsible for the EPBC Act was reviewed (period commencing 1 October 2019) (Threatened Species Scientific Committee, 2019). None of the nominated species and ecological communities are of relevance to the proposal.

3.3 Habitat assessment

A habitat assessment was undertaken within the ecological study area on the identified list of threatened flora and fauna species known or predicted to occur in the Cumberland IBRA subregion that have been recorded within a 10-kilometre radius of the proposal (see **Appendix B** for the habitat assessment results). This list was identified from databases and literature as well as past surveys. The habitat assessment compared the preferred habitat features for these species with the type and quality of the habitats identified in the ecological study area. This habitat assessment was completed to assess the likelihood of the species being present in the ecological study area (i.e. subject species). The habitat assessment formed the basis for targeted surveys within the ecological study area.

The criteria used in the habitat assessment are detailed in **Table 3-2**. The results of the habitat assessment are provided in **Appendix B**.

Table 3-2 Likelihood of occurrence classification and criteria

Likelihood	Criteria
Recorded	The species was observed in the ecological study area during the current survey.
High	It is highly likely that a species inhabits the ecological study area and is dependent on identified suitable habitat (i.e. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10 km) and is known or likely to maintain resident populations in the ecological study area. Also includes species known or likely to visit the ecological study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the ecological study area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the ecological study area opportunistically or during migration. The species is unlikely to be dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on habitat within the ecological study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the ecological study area and has not been recorded recently in the locality (10 km). It may be an occasional visitor, but habitat similar to the ecological study area is widely distributed in the local area, meaning that the species is not dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the ecological study area or the species are non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the ecological study area.

3.4 Field survey

Two separate field surveys were undertaken within the ecological study area on the 9th and 16th of April 2020 to ground-truth the results of the background research and habitat assessment.

3.4.1 Vegetation surveys

The vegetation survey was completed using field survey methods in line with Chapter 5 of the Biodiversity Assessment Method (BAM) (Office of Environment and Heritage, 2017a). A plot-based vegetation survey of the ecological study area was undertaken. The survey was stratified and targeted to assess the expected environmental variation and address any areas with gaps in existing mapping and site information.

The broad scale vegetation mapping and aerial photography reviewed during the desktop assessment was used to initially identify vegetation extent. The initial vegetation mapping was then ground-truthed and where possible assigned to Plant Community Types (PCTs) according to those described in the BioNet Vegetation Classification Database (Department of Planning, Industry and Environment 2020a). Surveys assessed the environmental variation within the ecological study area and any areas with gaps in existing mapping and site information to determine vegetation zones.

A vegetation integrity assessment was then undertaken in each vegetation zone in accordance with Chapter 5 of the BAM. The plot-based floristic survey used a series of 400 square metre plots around a central 50 metre transect to assess vegetation structure and composition attributes (species richness and foliage cover). Function attributes (number of large trees, tree stem size class, tree regeneration and length of fallen logs) were recorded within the larger 1000 square metre plot. Litter cover was assessed as the average percentage ground cover of litter recorded from five 1 metre x 1 metre plots evenly located along the central transect. The number of trees with hollows was determined by counting the number of trees with hollows that are visible from the ground in the 1000 square metre plot. All data was collected according to the methods described in Chapter 5 of the BAM.

Areas of exotic vegetation and landscape plantings were inspected and mapped within the ecological study area. These areas were not surveyed using the above method and not assigned vegetation zones as they are not naturally occurring and cannot be matched to a PCT.

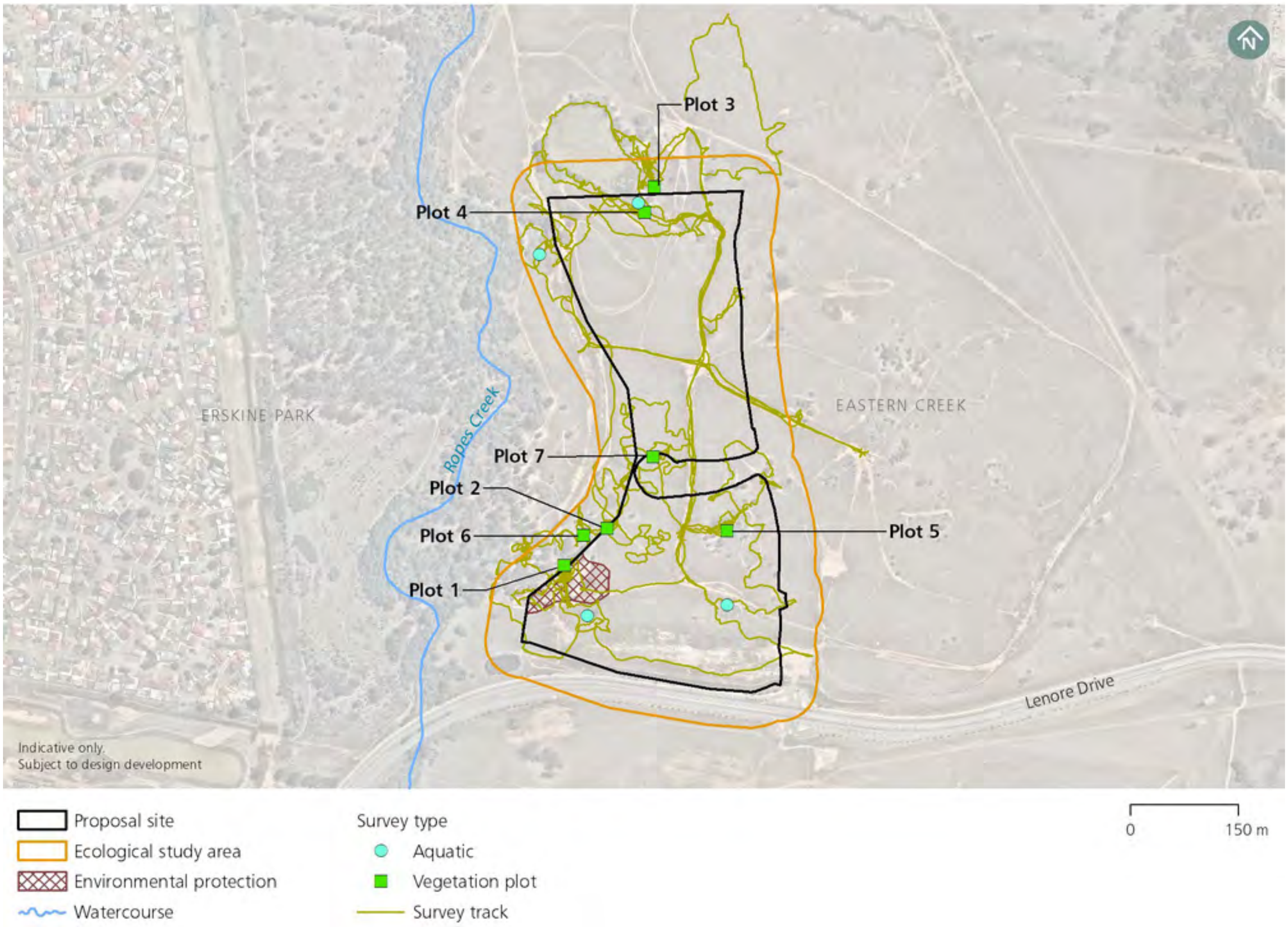
A summary of vegetation survey effort, outlining the number of vegetation zones and respective number of floristic plots / transects sampled in the field is presented in **Table 3-3**. The location of each plot / transect is shown in **Figure 3-1**.

Table 3-3 Summary of PCT / vegetation zones survey effort

Vegetation Zone Number	Plant Community Type (PCT)	Condition	Area in proposal site (ha)	No. plots/transects required	No. plots/transects sampled
1	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849)	Moderate	<0.001	1	1 (Plot 1)
2		Poor	1.13	1	2 (Plot 5 and 6)
3		Derived Grassland	0.61	1	2 (Plot 2 and 7)

Vegetation Zone Number	Plant Community Type (PCT)	Condition	Area in proposal site (ha)	No. plots/transects required	No. plots/transects sampled
4	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 835)	Poor	0.07	1	1 (Plot 3)
5	Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071)	Poor	0.11	1	1 (Plot 4)

Figure 3-1 Vegetation survey locations



3.4.2 Targeted flora surveys

Targeted searches were undertaken for all identified candidate flora species initially considered moderately likely to occur within the ecological study area (see **Table 3-2**). The surveys followed the methods described in the *NSW Guide to Surveying Threatened Plants* (Office of Environment and Heritage, 2016) with random meander surveys through the habitat undertaken using paired parallel transects. The floristic plot surveys also provided opportunity to record threatened species in discreet areas if they were present.

Targeted surveys for threatened flora species have been previously undertaken for the Archbold Road Upgrade and Extension REF Biodiversity Assessment Report (WSP | Parsons Brinckerhoff 2017). The surveys undertaken for this assessment builds on the previous surveys from the Archbold Road Upgrade and Extension REF with a focused effort on the western edge of the ecological study area. The habitats on the western edge are in higher quality vegetation and the most suitable for threatened plant species out of the habitats present within the ecological study area.

The threatened flora species targeted, and details of the surveys undertaken are outlined in **Table 3-4**. The location of transects is shown on **Figure 3-1**.

Table 3-4 Targeted species survey techniques for threatened flora species and survey effort (V = Vulnerable species, E = Endangered species)

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Acacia pubescens	V	V	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a medium shrub the maximum distance between transects in open vegetation such as that in the ecological study area is 20 m. With approximately 3.5 ha of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 1 to 5 km. The recommended survey time is estimated between 0.25 and 1.25 hours. Surveys for *Acacia pubescens* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hour (3-person hour of survey and total around 6 km). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Dillwynia tenuifolia	V	-	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a medium shrub the maximum distance between transects in open vegetation such as that in the ecological study area is 20 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 1 to 5 km. The recommended survey time is estimated between 0.25 and 1.25 hours. Surveys for *Dillwynia tenuifolia* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hour (3-person hour of survey and total around 6 km). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.
Grevillea juniperina subsp. *juniperina*	V	-	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a medium shrub the maximum distance between transects in open vegetation such as that in the ecological study area is 20 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 1 to 5 km. The recommended survey time is estimated between 0.25 and 1.25 hours. Surveys for *Grevillea juniperina* subsp. *juniperina* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hour (3-person hour of survey and total around 6 km). The survey was undertaken in an appropriate season to detect this species. This species was identified at several locations in the ecological study area during surveys undertaken for this proposal. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF.

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Pultenaea parviflora	E	V	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a medium shrub the maximum distance between transects in open vegetation such as that in the ecological study area is 20 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 1 to 5 km. The recommended survey time is estimated between 0.25 and 1.25 hours. Surveys for *Pultenaea parviflora* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.
Persoonia nutans	E	E	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a medium shrub the maximum distance between transects in open vegetation such as that in the ecological study area is 20 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 1 to 5 km. The recommended survey time is estimated between 0.25 and 1.25 hours. Surveys for *Persoonia nutans* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was not identified during the survey undertaken for this proposal. This species was not targeted during surveys for the Archbold Road Upgrade and Extension REF.

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Pilularia novae-hollandiae	E	-	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat, however this was limited to wet areas fringing dams and depressions. As a semi-aquatic fern, the maximum distance between transects in open vegetation such as that in the ecological study area is 10 m. With approximately 0.3 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is less than 1 km. The recommended survey time is about 0.25 hours. Surveys for *Pilularia novae-hollandiae* should be undertaken October to December in drying mud after inundation.	Approximately 0.75 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 0.5 hours (this equates to a total of 1-person hour of survey time and around 1 km of transects). The survey was not undertaken in an appropriate season to detect this species, however previous rain had filled the dams. Fringing areas of dams and wet depressions were surveyed. This species was not identified during the survey undertaken for this proposal. This species was not targeted during surveys for the Archbold Road Upgrade and Extension REF.
Pimelea curviflora var. curviflora	V	V	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As an herb the maximum distance between transects in open vegetation such as that in the ecological study area is 10 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 2 to 10 km. The recommended survey time is estimated between 0.5 and 2.5 hours. Surveys for *Pimelea curviflora var. curviflora* can be undertaken year-round, though easiest when this species is flowering from September to March.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was identified in the work undertaken for the Archbold Road Upgrade and Extension REF north of the ecological study area. This species has not been previously identified in the ecological study area or during the survey undertaken for this proposal.

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Pimelea spicata	E	E	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As an herb the maximum distance between transects in open vegetation such as that in the ecological study area is 10 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 2 to 10 km. The recommended survey time is estimated between 0.5 and 2.5 hours. Surveys for *Pimelea spicata* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.
Marsdenia viridiflora subsp. *viridiflora* endangered population	E	-	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As a climber the maximum distance between transects in open vegetation such as that in the ecological study area is 10 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 2 to 10 km. The recommended survey time is estimated between 0.5 and 2.5 hours. Surveys for *Marsdenia viridiflora* subsp. *viridiflora* can be undertaken year-round.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.

Threatened flora species	Status		Recommended survey technique, effort and timing (OEH 2016)	Survey completed
	BC Act	EPBC Act		
Thesium australe	V	V	A parallel field traverse (i.e. parallel transects) was undertaken in areas of potential habitat. As an herb the maximum distance between transects in open vegetation such as that in the ecological study area is 10 m. With approximately 3.5 hectares of potential habitat in the ecological study area, in open vegetation, the recommended field traverse length is 2 to 10 km. The recommended survey time is estimated between 0.5 and 2.5 hours. Surveys for *Thesium australe* can be undertaken November to February.	Approximately 3 km of transects were walked through areas of potential habitat by two ecologists over a period of approximately 1.5 hours (this equates to a total of 3-person hours of survey time and around 6 km of transects). The survey was undertaken in an appropriate season to detect this species. This species was not identified in the work undertaken for the Archbold Road Upgrade and Extension REF or during the survey undertaken for this proposal.

3.4.3 Targeted fauna surveys

Targeted surveys for the Cumberland Plain Land Snail were undertaken throughout areas of suitable habitat during the survey. The habitats in the west of the ecological study area around Ropes Creek are the most suitable for the Cumberland Plain Land Snail out of the habitats present within the ecological study area. The location of Cumberland Plain Land Snail survey sites is shown by the survey tracks on **Figure 3-1**.

Searches for Cumberland Plain Land Snail involved looking for active specimens on the base of tree trunks, turning over suitable ground shelter including fallen timber, sheets of iron and exposed rocks and rubble, raking back bark, litter and debris from the ground, and searching in dense grass clumps.

Other fauna surveys were not undertaken during the field work for this proposal. Extensive targeted fauna surveys (diurnal and nocturnal surveys for large forest owls, Grey-headed Flying Fox, Green and Golden Bell Frog, woodland birds and Cumberland Plain Land Snail) were previously undertaken in and around the ecological study area for the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017) and this data has been used to inform the assessment for this proposal. Where a species has not been surveyed, the habitat assessment has been used to determine the likelihood of occurrence.

3.4.4 Aquatic surveys

An aquatic habitat assessment was conducted to assess the dams and depressions along the drainage lines against the NSW DPI (Fisheries) document *Policy and Guidelines for fish habitat conservation and management (2013 update)* (NSW Department of Primary Industries, 2013) and *Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003). These guidelines provide information for waterway classification and describe ways to minimise potential impacts of road projects on fish and other aquatic wildlife by protecting aquatic habitat and maintaining fish passage. The habitat assessment was visual only and no fish surveys or macroinvertebrate surveys were conducted; nor was water quality sampling undertaken. The aim of the habitat assessment was to identify the presence of 'key fish habitat'.

Habitat assessment for threatened aquatic species was undertaken for the dams along the two drainage lines and around the Ropes Creek offshoot drain in the west. Aquatic habitats were assessed by examining characteristics such as the structure and floristics of aquatic vegetation, channel width, the presence of surface water, water flow, water depth, turbidity, visible pollutants, erosion, the presence of shelter (rocks, submerged vegetation and woody debris), and channel substrate.

There is no mapped indicative threatened fish habitat in or around the ecological study area. The habitat characteristics observed did not match the habitat characteristics of any threatened aquatic species known or predicted to occur in the locality hence targeted surveys for aquatic species were not undertaken.

3.5 Limitations

The vegetation field survey was able to provide adequate spatial coverage and survey effort for the entire ecological study area. This was achievable in the timeframe given the small size of the ecological study area. Detailed floristic survey was undertaken to provide a list of flora species for that point in time. Additional flora species may appear in other times of the year, particularly cryptic orchids. A period of several seasons or years is often needed to identify all the species present in an area, and specific weather conditions are required for optimum detection (e.g. breeding and flowering periods). The conclusions of this report are therefore based upon available data and limited field survey and are indicative of the environmental condition of the ecological study area at the time of the survey. It should be recognised that site conditions, including the presence of threatened species, can change with time. To address this limitation, the assessment has aimed to identify the presence and suitability of the habitat for threatened species.

Data and results from the ecological surveys undertaken for the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017) have been relied upon and are assumed to be accurate.

The mapping included in this report shows the inferred distribution of plant community types and habitat within the ecological study area. Any vegetation mapping shown outside the ecological study area has been taken from available resources (VIS_ID 4207 and WSP | Parsons Brinckerhoff 2017) and was not verified as part of this assessment. In many cases, the boundaries between plant community types and habitats are not well-defined and the mapping provides an approximation of on-ground conditions. The maps represent a snapshot in time.

4. Existing environment

4.1 Environmental context

The ecological study area is located within the Cumberland sub-region of the Sydney Basin Bioregion as defined by Thackway and Cresswell (1995) and the Cumberland Plain Mitchell Landscape as mapped by the NSW National Parks and Wildlife Service (2002a) and described by the NSW Department of Environment and Climate Change (2008). The Cumberland Plain Mitchell Landscape is an over cleared landscape with 89 per cent of native vegetation having been cleared. Only 11 per cent of the original native vegetation remains.

The landscape is predominantly low rolling hills and wide valleys in a rain shadow area below the Blue Mountains (Morgan, 2001). Geology is dominated by undifferentiated middle Triassic Wianamatta group shales (Bringelly Shale) (Clarke and Jones, 1991). Soils overlying the Wianamatta Shale are of the residual Blacktown soil landscape (Hazelton et al., 1989, Morgan, 2001, Department of Environment and Climate Change, 2008).

The ecological study area is situated in a landscape that has been extensively cleared and modified, where remaining intact vegetation is concentrated along waterways and small fragmented bushland remnants and isolated trees. The riparian vegetation and grassy woodland around Ropes Creek forms one of the largest contiguous areas of native vegetation surrounding the ecological study area. The PCTs within the ecological study area are described in **Section 4.2**.

The proposal site has been historically cleared and modified for agricultural practices and was partly modified by the construction of Lenore Drive in 2012. Historical imagery shows the proposal site being primarily used for agriculture up until around 2006, when vehicle tracks begin to appear. Recently the proposal site has been used by the public for unauthorised recreational off-road driving and motorcycling, as evidenced by the extensive network of tracks and observations of motorcycles on the proposal site during field surveys.

The aquatic environment includes two artificial dams, the largest being located on a mapped unnamed first order stream in the north of the proposal site and the other on an unmapped drainage line in the south of the ecological study area. The proposal site only includes the southern section of the large dam. These drainage lines are likely naturally formed, though have been highly influenced over time by clearing of woodland vegetation and increasing run-off. Both drainage lines are highly ephemeral, only draining water from the immediate surrounds into Ropes Creek to the west of the proposal site. The habitat quality for fish is poor (discussed in **Section 3.4.4**). There are no wetlands of significance (*State Environmental Protection Policy Coastal Management 2018* or wetlands listed in the Directory of Important Wetlands (Department of Agriculture, Water and Environment 2020) in or adjacent to the ecological study area.

Vegetation in the west of the ecological study area around Ropes Creek has been mapped by the Department of Planning, Industry and Environment as Cumberland Plains Priority Conservation Lands (see **Figure 4-2**) and also a biodiversity corridor of regional significance (see **Figure 4-5**) as identified by the Biodiversity Investment Opportunities Map (BIO Map).

4.2 Plant community types

The proposal site is mostly cleared and dominated by exotic grassland, however native vegetation is scattered across the proposal site varying from small intact woodland patches to isolated trees (see **Figure 4-1**). Remnant woodland exists around Ropes Creek to the west, which occurs within the proposal site along the western boundary at two locations. Most of the vegetation on the proposal site is in poor condition, lacking a shrub layer and containing a high prevalence of exotic grasses. Past and present land use activities such as land clearing, weed and pest invasion, rubbish dumping, and human interaction have modified the extent and condition of native vegetation in the ecological study area and locality.

There were three PCTs identified in the ecological study area based on floristic composition, geological substrate, and landscape position with regard to relevant regional vegetation classifications:

- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849).
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 835).
- Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071).

Small areas of exotic vegetation (potential historic planting of shrub species such as *Lagerstroemia indica*, *Cupressus* sp.) and planted native trees along Lenore Drive that cannot be matched to a PCT were also present. The remainder of vegetated areas are classed as exotic grassland.

The PCTs and other vegetation identified within the ecological study area are outlined in **Table 4-1** and illustrated in **Figure 4-1**.

Table 4-1 Plant community types

Plant community type (PCT)	Condition class	Vegetation formation	Percent cleared in major catchment area	Threatened ecological community?	Area (ha) in proposal site*	Area (ha) in ecological study area
Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (849)	Moderate	Grassy Woodlands	93	<u>BC Act:</u> Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC <u>EPBC Act:</u> Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC (in part)	<0.001	0.89
	Poor				1.13	1.7
	Derived grassland				0.61	0.81
Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835)	Moderate	Forested Wetlands	93	<u>BC Act:</u> River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions endangered ecological community (EEC)	0	0.001
	Poor				0.07	0.55
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071)	Poor	Freshwater Wetlands	75	No. This PCT occurs a result of altered drainage caused by agricultural practices and is not a naturally occurring wetland.	0.11	0.44
				Sub-total	1.92	4.39
Exotic vegetation	NA	NA	NA	No	0.07	0.15
Blackberry infestation	NA	NA	NA	No	0	0.03
Planted native vegetation	NA	NA	NA	No	0.002	0.03
				Totals	**1.98**	**4.6**

*Excludes environmental protection zone

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

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

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

Estimate of percent cleared: 93 per cent

Condition: Moderate

Extent in the ecological study area: 0.89 hectares

Plots completed in vegetation zone: 1 (Plot 1)

Structure	Height range (m)	Foliage cover estimate (%)	Typical species
Upper	10 – 20 m	17	*Eucalyptus moluccana, Eucalyptus tereticornis*
Middle	-	-	-
Ground	0 – 1 m	30	*Paspalum dilatatum*, Microlaena stipoides, Eragrostis curvula*, Setaria parviflora*, Cynodon dactylon, Aristida vagans, Fimbristylis dichotoma, Solanum pseudocapsicum*, Themeda triandra, Eragrostis leptostachya, Paspalidium distans, Solanum nigrum*, Bothriochloa macra, Sporobolus creber, Cheilanthes sieberi.*

Description:

The gentle topography associated with the shale plains of Western Sydney carries an open grassy woodland dominated by *Eucalyptus moluccana, Eucalyptus tereticornis* and *Eucalyptus crebra/Eucalyptus fibrosa*. Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) (Office of Environment and Heritage, 2017b). Tozer et al. (2006) define the primary habitat for the community as occurring at elevations less than 150 metres above sea level with some sites occurring at higher elevations where the landscape remains gently inclined (Office of Environment and Heritage, 2017b).

Within the ecological study area, PCT 849 - Moderate is limited to the south-western corner, where a small amount occurs within the proposal site (<0.001 hectares). The vegetation is contiguous with riparian vegetation associated with Ropes Creek. The canopy contains *Eucalyptus moluccana* and *Eucalyptus tereticornis*. No midstorey species were recorded in the plot, however further into this patch *Bursaria spinosa*, *Acacia parramattensis*, *Dillwynia sieberi* and *Grevillea juniperina* subsp. *juniperina* are present. The groundcover is moderately dense, with about 50 per cent of cover being native grasses (notably *Microlaena stipoides*) but there is also high invasion by weeds on the edge where the plot was undertaken. The cover of native grasses is higher further into this patch.

Fauna habitat values are moderate. The vegetation surveyed is the edge of a larger patch that is contiguous with riparian vegetation along Ropes Creek. The vegetation has been historically disturbed and consists of a low number of large remnant trees with dense midstorey of regrowth canopy species. No hollow bearing trees or large trees above 50 centimetres (diameter at breast height) were present in the plot which limits the habitat suitability for nesting and roosting, however these trees were present in the wider patch in low abundance. The canopy provides foraging opportunities for insectivorous and nectarivorous birds and mammals. A low abundance of large woody debris was recorded in the ground layer which limits sheltering and foraging opportunities for some fauna groups. The habitat does still provide some good sheltering and foraging value with leaf litter layer (average cover of 19 per cent) and dumped refuse providing opportunity for ground dwelling species, including the threatened Cumberland Plain Land Snail, to find shelter sites.

The Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) - Moderate as it occurs in the ecological study area is shown in Photograph 1.

Photograph 1: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) – Moderate (photograph is of Plot 1 transect looking south west).

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

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

Conservation status: Critically Endangered Ecological Community (BC Act): Cumberland Plain Woodland in the Sydney Basin Bioregion. This vegetation does not meet the condition threshold for listing under the EPBC Act.

Estimate of percent cleared: 93 per cent

Condition: Poor

Extent in the ecological study area: 1.7 hectares

Plots completed in vegetation zone: 2 (Plots 5 and 6)

Structure	Height range (m)	Foliage cover estimate (%)	Typical species
Upper	10 – 20 m	5	*Eucalyptus moluccana, Eucalyptus tereticornis*
Middle	1 – 10 m	10	*Eucalyptus moluccana, Eucalyptus tereticornis*
Ground	0 – 1 m	30	*Paspalum dilatatum*, Microlaena stipoides, Eragrostis curvula*, Setaria parviflora*, Chloris truncata, Bothriochloa macra, Cynodon dactylon, Aristida vagans, Fimbristylis dichotoma, Themeda triandra, Eragrostis leptostachya, Sporobolus creber, Paspalidium distans, Wahlenbergia gracilis, Cyperus gracilis, Hypoxis hygrometrica*

Description:

Within the ecological study area, PCT 849 - Poor is the most abundant vegetation type, occurring as scattered remnant paddock trees and patches of natural regeneration. The canopy contains *Eucalyptus moluccana* and *Eucalyptus tereticornis*. Both larger patches within the proposal site contain scattered young trees (one to 10 metres) surrounding one mature tree (>80 centimetres). No midstorey species were recorded in the plot, except for canopy regeneration. The groundcover is highly variable in composition. Some areas, particularly underneath a large tree or denser patches of small trees, have a high cover of native species (notably *Microlaena stipoides*). A moderate to high richness of native grasses was recorded (eight species in both plots). There is high invasion by weeds, particularly *Paspalum dilatatum* (up to 50 per cent), *Setaria parviflora* and *Eragrostis curvula*.

Fauna habitat values are low to moderate. The vegetation is mostly regenerating, though some remnant mature trees with hollows are present that provide roosting and nesting opportunities. Rainbow Lorikeets and Red-rumped Parrots were observed using the hollows in several large remnants. Trees also present perching habitat and open areas hunting habitat for predatory birds. A Kestrel and Black-shouldered Kite were observed hunting and perching. The canopy provides foraging opportunities for insectivorous and nectarivorous birds and mammals, however the connectivity is low. A low abundance of large woody debris was recorded in the ground layer which limits sheltering and foraging opportunities for some fauna groups. The leaf litter layer is absent from these areas and the ground layer very dry, limiting opportunity for ground dwelling species, including the threatened Cumberland Plain Land Snail, to find shelter sites.

The Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) - Poor as it occurs in the ecological study area is shown in Photograph 2.

Photograph 2: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) – Poor (photograph is of Plot 5 transect looking north east).

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

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

Conservation status: Critically Endangered Ecological Community (BC Act): Cumberland Plain Woodland in the Sydney Basin Bioregion. This vegetation does not meet the condition threshold for listing under the EPBC Act.

Estimate of percent cleared: 93 per cent

Condition: Derived grasslands

Extent in the ecological study area: 0.81 hectares

Plots completed in vegetation zone: 2 (Plot 2 and 7)

Structure	Height range (m)	Foliage cover estimate (%)	Typical species
Upper	-	-	-
Middle	0.5 – 1.5 m	2	*Eucalyptus tereticornis*
Ground	0 – 1 m	60	*Themeda triandra, Cynodon dactylon, Paspalum dilatatum*, Setaria parviflora*, Microlaena stipoides, Hypochaeris radicata*, Bothriochloa macra, Sporobolus fertilis, Eragrostis curvula*, Eragrostis brownii,*

Description:

Within the ecological study area, PCT 849 – Derived grasslands is limited to three discrete patches mixed within exotic grassland in the central and southern parts of the proposal site. The vegetation adjoins patches of PCT 849 – Poor.

This vegetation does not have an intact canopy, though canopy species *Eucalyptus tereticornis* are present in the midstorey as regenerating seedlings. The groundcover is dense with a variable, though high and often dominating cover of native grasses (notably *Themeda triandra* and *Microlaena stipoides* with approximately 40 per cent cover). Cover of exotic grasses is also high, including *Paspalum dilatatum* and *Setaria parviflora*.

Fauna habitat values are low. These grasslands may provide hunting habitat for predatory birds. Most of the regenerating trees are currently unlikely to be mature enough to produce flowers.

The Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) – Derived grassland as it occurs in the ecological study area is shown in Photograph 3.

Photograph 3: The Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) – Derived grassland (photograph is of Plot 2 transect looking east).

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

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Floodplain Wetlands

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

Estimate of percent cleared: 93 per cent

Condition: Poor

Extent in the ecological study area: 0.55 hectares

Plots completed in vegetation zone: 1 (Plot 3)

Structure	Height range (m)	Foliage cover estimate (%)	Typical species
Upper	10 – 15 m	35	*Eucalyptus tereticornis, Angophora subvelutina*
Middle	2 – 4 m	5	*Eucalyptus tereticornis, Lycium ferocissimum**
Ground	0 – 1.5 m	65	*Paspalum dilatatum*, Microlaena stipoides, Setaria parviflora*, Eragrostis leptostachya, Sida rhombifolia*, Axonopus fissifolius*, Cynodon dactylon, Eragrostis curvula*, Paspalum dilatatum*, Bidens pilosa*, Sporobolus creber, Senecio madagascariensis*, Fimbristylis dichotoma, Solanum pseudocapsicum*, Commelina cyanea, Phyllanthus virgatus*

Description:

PCT 835 is an open eucalypt forest situated on alluvial flats of the Hawkesbury and Nepean river systems which also forms narrow ribbons along streams and creeks that drain the Cumberland Plain (Office of Environment and Heritage, 2017b). The canopy typically includes one of either *Angophora floribunda* or *Angophora subvelutina* and one or both of *Eucalyptus tereticornis* and *Eucalyptus amplifolia* however there are a wide variety of other eucalypts also present (Office of Environment and Heritage, 2017b). In its natural state, the community has an understorey characterised by a generally sparse small tree stratum and sparse lower shrub layer that features *Bursaria spinosa* at most sites (Office of Environment and Heritage, 2017b). The ground layer is characterised by an abundant cover of grasses with small herbs and ferns (Office of Environment and Heritage, 2017b).

Within the ecological study area, PCT 835 – Poor occurs around Ropes Creek and the two drainage lines. Around Ropes Creek, this vegetation borders higher quality patches that have had less clearing, though contain a higher cover of exotic shrubs. The vegetation where Plot 3 was undertaken is located around the larger dam in the north of the proposal site, and is a relatively dry version of this PCT. The canopy contains *Eucalyptus tereticornis* and *Angophora subvelutina.* The midstorey in this location is absent apart from regenerating *Eucalyptus tereticornis* and scattered *Lycium ferocissimum,* a Priority Weed in the Greater Sydney Region and Weed of National Significance (WoNS). However elsewhere this vegetation contains *Casuarina glauca* and *Melaleuca styphelioides*, particularly on the edge of Ropes Creek where the occurrence of this vegetation is only regeneration of midstorey. The groundcover is highly variable in composition. Some areas, particularly underneath a large tree or denser patches of small trees, have a high cover of native species (notably *Microlaena stipoides*). A moderate to high richness of native grasses was recorded (seven species). There is high invasion by weeds, particularly *Paspalum dilatatum* (up to 40 per cent) and *Setaria parviflora*.

Fauna habitat values are low to moderate. The vegetation is mostly regenerating, though some remnant mature trees with hollows are present around the dam that provide roosting and nesting opportunities. The canopy provides foraging opportunities for insectivorous and nectarivorous birds and mammals. The connectivity is low among the scattered patches and single trees along the drainage lines, however beside Ropes Creek this vegetation may provide some resources for dispersing animals. A low abundance of large woody debris was recorded in the ground layer which limits sheltering and foraging opportunities for some fauna groups. The leaf litter layer is mostly absent along the drainage lines and the ground layer very dry, however next to Ropes Creek, vegetation may provide shelter opportunities for ground dwelling species, including the threatened Cumberland Plain Land Snail.

Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835) - Low as it occurs in the ecological study area is shown in Photograph 4.

Photograph 4: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835) - Low (photograph is of Plot 2 transect looking north).

Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071) - Poor

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

Conservation status: Endangered Ecological Community (BC Act): Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (only applies to small naturally occurring patch of PCT 1071 in the north west of the ecological study area, outside of the proposal site)

Estimate of percent cleared: 75 per cent

Condition: Poor

Extent in the ecological study area: 0.44 hectares

Plots completed in vegetation zone: 1 (Plot 4)

Structure	Height range (m)	Foliage cover estimate (%)	Typical species
Upper	NA	0%	None
Middle	2 – 5 m	0.5%	*Casuarina glauca*
Ground	0 – 2 m	25%	*Typha orientalis, Salvinia molesta*, Persicaria lapathifolia, Cladium procerum, Ludwigia peruviana*, Ludwigia peploides, Triglochin spp.*

Description:

The Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071) consists of wetlands located on coastal plains, valleys, lagoons and other sites of poor drainage (Office of Environment and Heritage, 2017b). This PCT also includes man-made water bodies, drainage lines and depressions across a wide variety of environments (Office of Environment and Heritage, 2017b) where wetland vegetation has established. This is the case with much of the occurrence of this PCT in the ecological study area. The vegetation has established in two artificial farm dams and one constructed basin beside Lenore Drive. These areas would not have originally supported a naturally occurring wetland. A small offshoot depression line from Ropes Creek is the only likely natural occurrence of PCT 1071 within the north-west of the ecological study area, however this is outside of the proposal site.

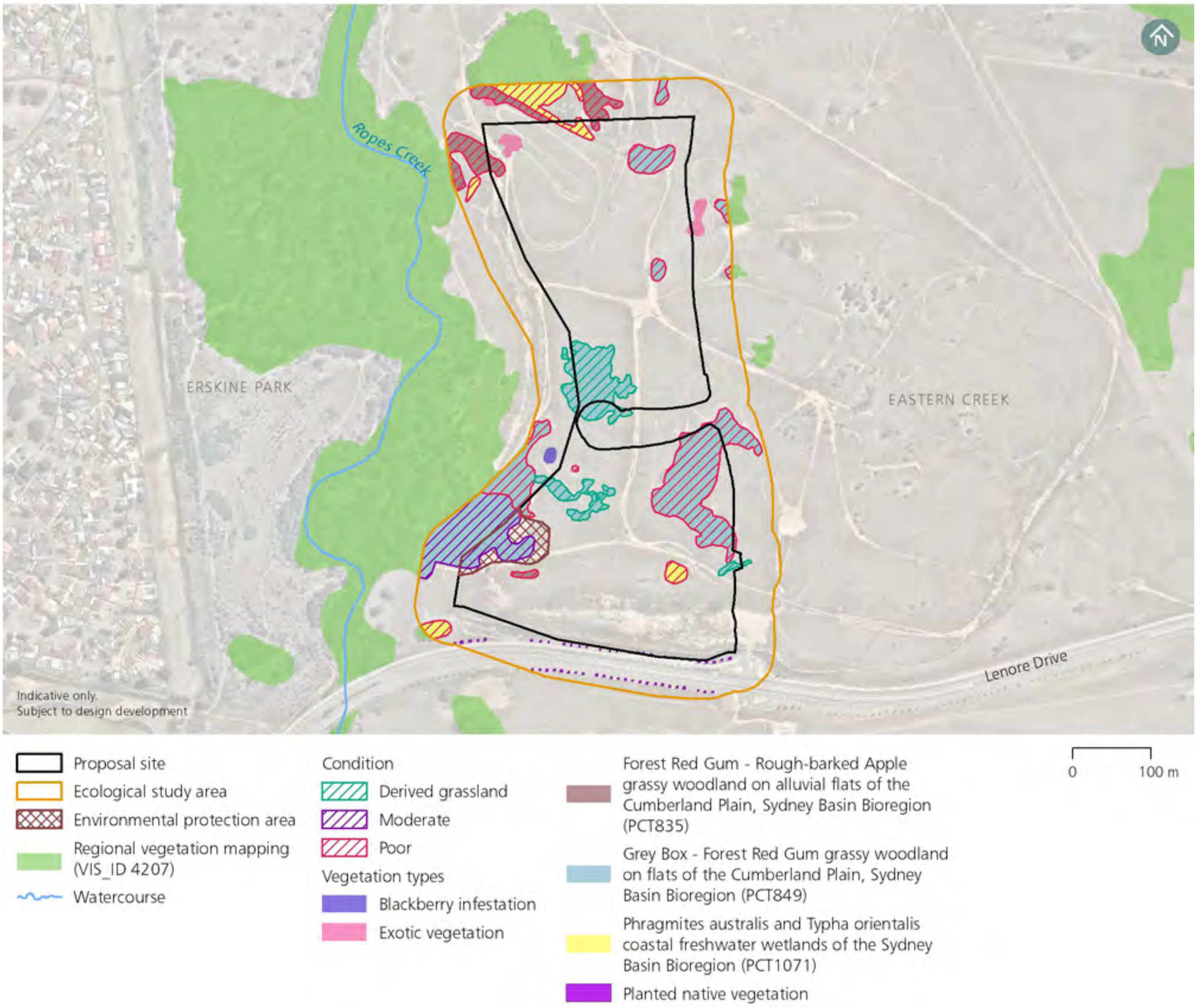
As is commonly found on the Cumberland Plain, this PCT consists of a dense stand of *Typha orientalis* with *Cladium procerum* and *Persicaria lapathifolia* and a range of exotic grass and herbaceous species on the fringes. The dam in the north has a very high abundance of *Salvinia molesta* over areas of open water, a Priority Weed in the Great Sydney Region and Weed of National Significance (WoNS).

Fauna habitats are in moderate condition. There are areas of open water present around this PCT on the larger northern dam and several common waterbird species were observed, however habitat is limited by the high cover of *Salvinia molesta*. The dense *Typha orientalis* stand provides suitable habitat for small birds that frequent thick rush beds, though only the common Superb Fairy Wren was observed. The absence of extensive shallow edges or mudflats limits the habitat suitability for waders or other wetland bird species. The dense cover of *Typha orientalis* is suitable for a range of common frog species, with several heard calling including *Crinia signifera*, *Limnodynastes peronii* and *L. tasmaniensis*. It may also be suitable for the threatened Green and Golden Bell Frog (*Litoria aurea*). However, the habitat is not considered to be optimal and there are only three records of this species from the locality since 2000, all around Ropes Crossing and Tregear. The most recent of these records is from 2012 on Ropes Creek about eight kilometres north of the proposal site. Records have not been made at other former habitats in the locality since the 1970s so it is unlikely that this species remains in the ecological study area.

The Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071) – Poor as it occurs in the ecological study area is shown in Photograph 5.

Photograph 5: Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071) – Low (photograph is of Plot 2 transect looking north west).

Figure 4-1 Plant community types



4.3 Threatened ecological communities

Three TECs listed under the BC Act were identified in the ecological study area:

- Cumberland Plain Woodland in the Sydney Basin Bioregion (listed as critically endangered).
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (listed as endangered).
- Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (listed as endangered).

A brief description of each TEC is provided in **Table 4-2** and the distribution of TECs is mapped in **Figure 4-2**.

The Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071) within the ecological study area mostly occurs because of artificial damming of the two drainage lines on the proposal site and one sediment basin next to Lenore Drive and are not a naturally occurring wetlands, except for a small area next to Ropes Creek. The two dams/wetlands are man-made, and a freshwater wetland may not have naturally occurred in these locations considering the ephemeral nature of the drainage lines. Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production (such as the case with the PCT in the ecological study area), are not regarded as part of the Freshwater Wetlands on Coastal Floodplains TEC (NSW Scientific Committee, 2004). As such, the extent of this PCT in the two dams and sediment basin is not considered to form part of the Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions EEC. However, the small area near Ropes Creek does meet the EEC definition considering the natural waterway likely contributed to its occurrence. This area is outside the proposal site and unlikely to be directly impacted.

Table 4-2 Threatened ecological communities present in the ecological study area

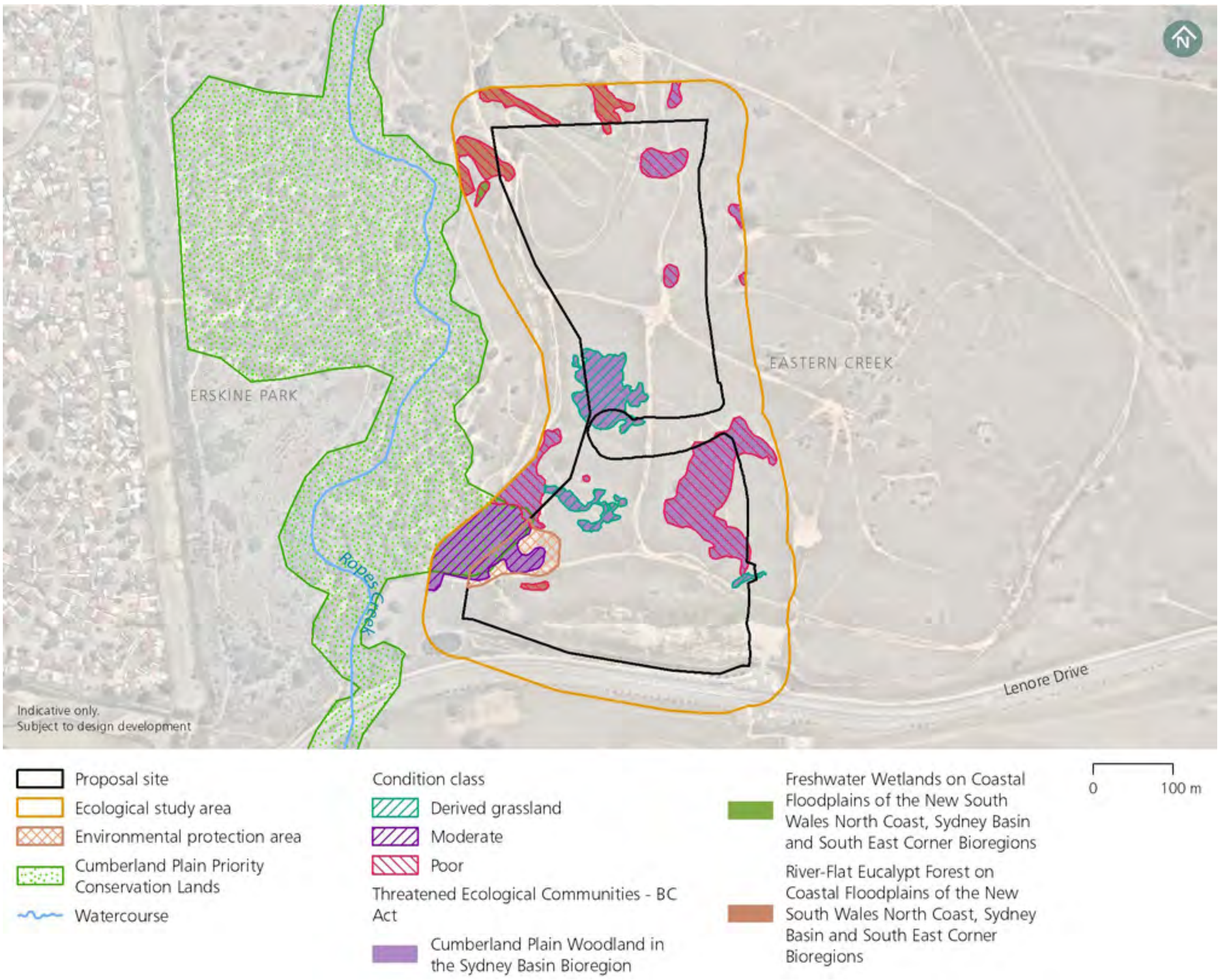
Threatened ecological community	Listing advice description	Description of TEC in the ecological study area	Area in proposal site (ha)*	Area in ecological study area (ha)
Cumberland Plain Woodland in the Sydney Basin Bioregion (Critically Endangered, BC Act)	Cumberland Plain Woodland is the name given to the ecological community in the Sydney Basin bioregion associated with clay soils derived from Wianamatta Group geology, or more rarely alluvial substrates, on the Cumberland Plain. Cumberland Plain Woodland is characterised by an upper-storey that is usually dominated by *Eucalyptus moluccana* and *Eucalyptus tereticornis*, often with *Eucalyptus crebra*, *Eucalyptus eugenioides*, *Corymbia maculata* or other less frequently occurring eucalypts, including *Angophora floribunda*, *Angophora subvelutina*, *Eucalyptus amplifolia* and *Eucalyptus fibrosa*.	Located on the Cumberland Plain in the Sydney Basin Bioregion on clay soils derived from Wianamatta Group geology. Occurs on proposal site as disturbed remnant around Ropes Creek, natural regeneration around isolated remnants and also derived gresslands dominated by Kangaroo Grass. Characterised by an upper-storey that is dominated by *Eucalyptus moluccana* and occasional *Eucalyptus tereticornis*. The Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (849) PCT corresponds directly to this TEC.	1.74	3.46

Threatened ecological community	Listing advice description	Description of TEC in the ecological study area	Area in proposal site (ha)*	Area in ecological study area (ha)
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, BC Act)	River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. The composition of River-Flat Eucalypt Forest on Coastal Floodplains is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil. It has a tall open tree layer of eucalypts and the composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus tereticornis, Eucalyptus amplifolia, Angophora floribunda* and *Angophora subvelutina*. A layer of small trees may be present, including *Melaleuca decora*, *Melaleuca styphelioides*, *Backhousia myrtifolia, Melia azaderach, Casuarina cunninghamiana* subsp. *cunninghamiana* and *Casuarina glauca*.	Located in the Sydney Basin Bioregion on clay-loam soils on a drainage line and dam and around Ropes Creek. It has a tree layer dominated by *Eucalyptus tereticornis* and *Angophora subvelutina,* with *Melaleuca styphelоides* and *Casuarina glauca* in adjacent areas. The Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835) PCT corresponds directly to this TEC.	0.07	0.55
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, BC Act)	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is the name given to the ecological community associated with periodic or semi-permanent inundation by freshwater, although there may be minor saline influence in some wetlands. Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South	Located in the Sydney Basin Bioregion located in a natural drainage offshoot associated with Ropes Creek. Dominant species include *Typha orientalis* and *Carex appressa*. The wetland is outside the proposal site and not expected to be direcly impacted. The Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	0	0.27

Threatened ecological community	Listing advice description	Description of TEC in the ecological study area	Area in proposal site (ha)*	Area in ecological study area (ha)
	East Corner bioregions is dominated by herbaceous plants and have very few woody species. The structure and composition of the community varies both spatially and temporally depending on the water regime. Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of this community, although they may provide habitat for threatened species.	(1071) PCT corresponds to this TEC, except around artifical waterbodies (e.g. dams and basins).		

*Excludes environmental protection area

Figure 4-2 Threatened ecological communities



4.4 Groundwater dependent ecosystems

The level of groundwater dependence of vegetation communities in the ecological study area has been identified using the Atlas of Groundwater Dependent Ecosystems (GDEs) (Bureau of Meteorology, 2017) and the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* released by the NSW DPI (Kuginis et al., 2012). The Atlas of GDEs (Bureau of Meteorology, 2017) identifies Ropes Creek riparian corridor as containing groundwater dependent terrestrial vegetation (phreatophytes) in the form of Cumberland Shale Plains Woodland (PCT 849). The ecological study area contains some of this vegetation in the south of the proposal site. There are no aquatic GDEs in the ecological study area or immediate surrounds and the ecological study area is not located within a floodplain alluvial groundwater source. The Atlas of GDEs dataset uses the same polygons as the *Southeast NSW Native Vegetation Classification and Mapping – SCIVI* (VIS_ID 2230) (State Government of NSW and Office of Environment and Heritage, 2010) and does not provide a fine scale map of GDEs so must be used as a guide only.

While PCT 849 and PCT 835 are considered with a high likelihood to be GDEs (Kuginis et al., 2012), these two PCTs are not obligate GDEs (i.e. they are not entirely dependent on groundwater). These PCTs are not restricted to locations of groundwater discharge and are not located within aquifers. These two PCTs are likely to be opportunistic facultative GDEs that depend on the subsurface presence of groundwater (often accessed via the capillary fringe – subsurface water just above the water table) in some locations but not in others, particularly where an alternative source of water (i.e. rainfall) cannot be accessed to maintain ecological function (Kuginis et al., 2012). The plants within these PCTs would use shallow soil water before seeking deeper soil water or groundwater. The trees may take up groundwater from the capillary fringe when necessary (e.g. during dry seasons or in extended drought). The drainage line within the ecological study area is a losing stream reach and is not a baseflow stream that would have vegetation highly dependent on groundwater.

PCT 1071 mostly occurs in the ecological study area as a consequence of agricultural activities (i.e. dams) and stormwater management works (i.e. sediment basin) and these are not naturally occurring wetlands. These wetlands are man-made and exist due to damming of a small catchment of rain and ponding of stormwater next to Lenore Drive. A freshwater wetland would not have naturally occurred in these locations. These occurrences of PCT 1071 in the ecological study area are rain fed and is not likely to be a GDE. A small area of ponded water in an offshoot of Ropes Creek may qualify as a GDE as discussed above.

4.5 Threatened species and populations

4.5.1 Threatened flora species

Twenty-five threatened flora species and one endangered population have been previously recorded or modelled as having potential to occur in the locality (see **Appendix B**). Many of these species favour habitats that are not represented in the ecological study area or are only known to exist in populations restricted to specific localities or are presumed extinct. Ten threatened flora species were initially considered moderately likely to occur within the ecological study area and targeted during the field survey of the proposal site.

One threatened flora species, *Grevillea juniperina* subsp. *juniperina* (vulnerable species: BC Act) was recorded outside of the proposal site, though in the ecological study area, during the field survey undertaken for the proposal. This species has been previously recorded at numerous locations along Ropes Creek and in the south west of the ecological study area as shown by the presence of BioNet Atlas records, of which there are 1095 records in the locality. *Grevillea juniperina* subsp. *juniperina* plants were identified at this location just outside of the ecological study area and along the southern bank of the larger dam in the north of the proposal site. Four individuals were identified within the ecological study area along the dam bank, outside of the proposal site (see Photo 6 and 7). Over 30 plants were also identified to the west of the ecological study area on the edge of Ropes Creek. Considering these observations, the Ropes Creek population size is likely quite high.

Photo 6. *Grevillea juniperina* subsp. *juniperina* along the northern dam bank. Photo is facing west along the southern bank of the large dam.

Photo 7. *Grevillea juniperina* subsp. *juniperina* (close up of plant shown in Photo 6)

Surveys undertaken for the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017) identified *Pimelea curviflora* var. *curviflora* north of the ecological study area in woodland north and south of the Western Motorway around Archbold Road. This species was not identified during surveys for this assessment. *Pimelea curviflora* var. *curviflora* is known to occur on shale/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Although the vegetation type in the ecological study area is similar to where it has been identified to the north, the soil observed was heavy clay and around Ropes Creek is likely more alluvium influenced. Therefore, *Pimelea curviflora* var. *curviflora* is considered to have a low likelihood of occurring in ecological study area.

The highest quality habitat is in disturbed remnant woodland around Ropes Creek. A small section of moderate quality woodland extends into the south western part of the proposal site, which was targeted during surveys. Most of the ten species originally flagged for survey can be confidently assumed to be absent as they are easily identifiable, and the area of potential habitat is small. The habitats in the ecological study area are either not considered suitable (e.g. vegetation type, soil type, landscape position) or optimal for any of the remaining threatened flora species listed in Table B-1 in **Appendix B** due to the degraded nature of the vegetation, disturbance to the soil and dominance of exotic species. Overall, except for the *Grevillea juniperina* subsp. *juniperina* identified, the remaining locally recorded threatened flora species are considered to have a low likelihood of occurrence or are unlikely to occur on the proposal site (see Table B-1 in **Appendix B**).

4.5.2 Threatened fauna species

Based on regional records and the presence of suitable habitat, 65 threatened fauna species have been identified in the locality (see **Appendix B**) or have modelled habitat. This includes 14 mammals, 44 birds, three frogs, two invertebrates, and two fish. The ecological study area does not contain suitable habitat for some species listed in **Appendix B**. The habitats within the ecological study area are generally poor quality and do not possess the features required for many of the threatened species listed in **Appendix B** to complete their life cycles. No suitable habitat for threatened fish is present in the ecological study area.

Cumberland Plain Land Snail

The Cumberland Plain Land Snail (see Photo 8) was found in the ecological study area in Plot 1 during the surveys undertaken for the proposal (see **Figure 4-3**). This species was also identified at numerous locations to the north of the ecological study area during surveys undertaken for the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017). This species requires a groundcover of thick and moist leaf litter and large woody debris for shelter and foraging. These habitat features are present in moderate quality woodland (PCT 849) in the south west of the ecological study area, however the rest of the vegetation on the proposal site is likely too disturbed and unsuitable for this species. There are numerous piles of dumped building and house-hold rubbish around the ecological study area that may provide sheltering habitat for this species (see Photo 9).

Photo 8. Cumberland Plain Land Snail found in the south west of the ecological study area outside of the proposal site (refer to Figure 4-3 for location).

Photo 9. Dumped rubbish may provide sheltering habitat. Photo taken in the south east of the proposal site (refer to Figure 4-3 for location).

Green and Golden Bell Frog

The dense cover of *Typha orientalis* in the dams and small offshoot drain from Ropes Creek is suitable for a range of common frog species and may also be suitable for the threatened Green and Golden Bell Frog. Four sites were identified within the ecological study area (refer Photos 10 to 13) as containing potential habitat and are discussed in **Table 4-3** in relation to some of the known habitat requirements of the species as reported by Pyke and White (1996):

- Site 1 – Larger northern dam
- Site 2 – Offshoot drain from Ropes Creek
- Site 3 – Smaller southern dam
- Site 4 – Small depression along unmapped drain in the south of the proposal site.

These four sites are shown in **Figure 4-3** and Photos 5-8. As discussed in **Table 4-3**, the four sites meet eight of the ten habitat requirements and are very similar in their habitat characteristics, differing mainly in size. In terms of available habitat, Site 1 is probably the best quality habitat for the Green and Golden Bell Frog in the ecological study area.

The distribution of the Green and Golden Bell Frog has become very disjunct in the Cumberland Plain region. There are just three records of this species from the locality since 2000, all around Ropes Crossing and Tregear. The most recent and viable of these records is from 2012 on Ropes Creek about eight kilometres north of the proposal site, which may be evidence that a low-density population is active in the locality. Targeted surveys were unsuccessful at identifying the Green and Golden Bell Frog for the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017), which may have included the southern dam in the ecological study area (Site 3) though it is not clear what locations were surveyed. The key population at Mount Druitt was reported to have gone extinct in the late 1990s (Pyke and White 2001). The closest key population of Green and Golden Bell Frog is in Parramatta. Although these records and the current known location of populations suggest that the Green and Golden Bell Frog is not likely to occur in the ecological study area, this species is highly mobile and may possibly disperse as far as 10 kilometres (White & Pyke 2008). Therefore, Ropes Creek may provide a movement corridor for this species and hence it is considered moderately likely to occur in the habitats within the ecological study area.

Table 4-3 Habitat requirements of the Green and Golden Bell Frog (green cell = meets requirement)

Habitat requirement (Pyke and White 1996)	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Ephemeral or fluctuating water level, with still or slow-moving water	Large dam that does not flow and will fluctuate with rain and evaporation	Filled during sutiable rainfall when Ropes Creek overflows though mostly pooled	Small dam that does not flow and will fluctuate with rain and evaporation	Would flow during heavy rainfall though typically pooled water
Shallow water depth <50 cm	On edges yes, though likely much deeper in centre	Likely	On edges yes, though likely deeper in centre	Likely
No visible signs/sources of water pollution	None visible	None visible	None visible	None visible
Absence of shaded cover	Small amount of canopy cover from adjacent woodland though mostly unshaded	Small amount of canopy cover from adjacent woodland though mostly unshaded	No shaded cover	Small amount of canopy cover from adjacent woodland though mostly unshaded
Crinia signifera or *Limnodynastes peronii* present	Both present	*Crinia signifera* present	*Crinia signifera* present	*Crinia signifera* present
Absence of predatory fish (in particular *Gambusia* sp.)	*Gambusia holbrooki* observed	*Gambusia holbrooki* observed	*Gambusia holbrooki* observed	*Gambusia holbrooki* observed
Pond substrate is sand or rock	Substrate clay/silt	Substrate clay/silt	Substrate clay/silt	Substrate clay/silt
Presence of emergent aquatic vegetation or rocks for diurnal shelter	Northern end of dam contains *Typha orientalis.* Southern end in theproposal site is less vegetated	Moderate cover of *Typha orientalis*	Dense cover of *Typha orientalis*	Moderate cover of *Typha orientalis*
Adjacent to grassy area	Extensive areas of grass surrounding	Extensive areas of grass surrounding	Extensive areas of grass surrounding	Extensive areas of grass surrounding

Habitat requirement (Pyke and White 1996)	Site 1	Site 2	Site 3	Site 4
Adjacent vegetation is no higher than woodland	Low regenerating woodland surrounds two sides of dam	Ropes Creek vegetation tall woodland	No adjacent vegetation	Only several trees

Photo 10. Site 1 – Northern dam

Photo 11. Site 2 – Ropes Creek offshoot drainage line

Photo 12. Site 3 – Southern dam

Photo 13. Site 4 – Drain depression

Other threatened fauna

The ecological study area also provides suitable habitat features for a range of threatened species that have been previously recorded in the locality (refer to **Figure 4-3**), including insectivorous bats, woodland birds, nectarivorous birds the Grey-headed Flying Fox and large predatory birds. All species considered at least moderately likely to occur in habitats within the proposal site are listed in **Table 4-4**.

Potential habitat is present for species of threatened insectivorous bat: Little Bent-winged Bat, Large Bent-winged Bat, Eastern Coastal Free-tailed Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat, Yellow-bellied Sheathtail-bat and the Southern Myotis (all listed as vulnerable under the BC Act). These species have been recorded widely from the locality and are likely to forage in the habitats. Tree hollows are moderately abundant in the large remnant trees in the ecological study area and may provide roosting opportunities for hollow-dependant species.

The Grey-headed Flying-fox (listed as vulnerable under the BC Act and EPBC Act) is considered moderately likely to forage in the trees within the ecological study area, particularly *Eucalyptus moluccana* and *Eucalyptus tereticornis*. No roost camps are present in the ecological study area but the bats from the Nationally Important Parramatta Park camp and/or the intermittent Ropes Creek camp are likely to forage in the ecological study area.

The Swift Parrot (listed as endangered under the BC Act and critically endangered EPBC Act) has been recorded in the locality (notably three records on Eastern Creek in 2019) and sporadically occurs in the urbanised areas of Western Sydney during winter. This species may pass through the ecological study area during movements between larger foraging habitats (e.g. from Prospect Nature Reserve to Whalan Reserve and Wianamatta Regional Park and Nature Reserve) where it may rest and forage. A range of hollow sizes are present in large remnant trees in the ecological study area and were observed being used by common parrot species. Although no significant areas of foraging habitat are present, the Swift Parrot is considered moderately likely to occur in the ecological study area on occasion. Likewise, the Little Lorikeet is also likely to use the trees in the ecological study area in a similar manner as foraging habitat. The Regent Honeyeater is also a sporadic visitor to the region, however the recorded sightings are very few with the last in 1995, therefore this species is deemed to have a low likelihood of occurring.

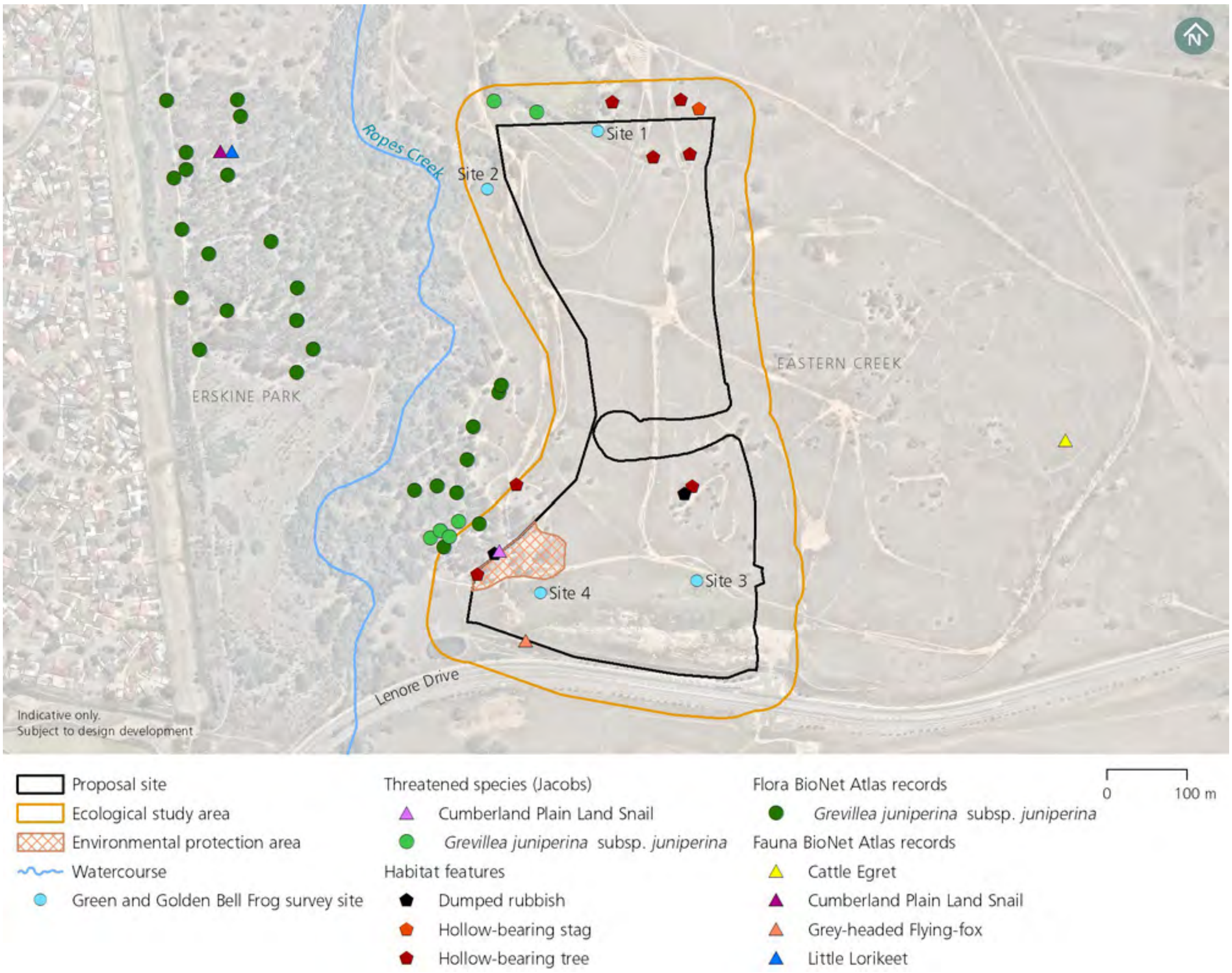
Other threatened birds including the Dusky Woodswallow, Varied Sittella, Little Eagle, Square-tailed Kite and Powerful Owl are known to utilise highly modified and partially-cleared habitats and are likely to pass through the ecological study area on occasion. No stick nests or large hollows were observed. The ecological study area is considered unlikely to form suitable breeding habitat for these species and habitat use would be likely restricted to occasional foraging use.

Table 4-4 Threatened fauna

Species	**BC Act**	**EPBC Act**	**Habitat in ecological study area (ha)**	**Habitat in proposal site (ha)**
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E	-	0.89	<0.001
Green and Golden Bell Frog (*Litoria aurea*)	E	E	0.44 (non-breeding habitat)	0.11 (non-breeding habitat)
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	3.1 (foraging habitat)	1.2 (foraging habitat)
Insectivorous bats (cave-roosting)				
Little Bent-winged Bat (*Miniopterus australis*)	V	-	4.4 (foraging habitat)	1.92 (foraging habitat)
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	V	-		
Southern Myotis (*Myotis macropus*)	V	-		
Insectivorous bats (hollow-roosting)				
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	-	4.4 (foraging habitat) and 8 hollow-bearing trees	1.92 (foraging habitat) and 4 hollow-bearing trees
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	V	-		
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	-		
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-		
Woodland birds				
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	V	-	3.1 (foraging habitat)	1.2 (foraging habitat)
Varied Sittella (*Daphoenositta chrysoptera*)	V	-		

Species	BC Act	EPBC Act	Habitat in ecological study area (ha)	Habitat in proposal site (ha)
Nectarivorous birds				
Little Lorikeet (*Glossopsitta pusilla*)	V	-	3.1 (foraging habitat) and 8 hollow-bearing trees	1.2 (foraging habitat) and 4 hollow-bearing trees
Swift Parrot (*Lathamus discolor*)	E	CE		
Large predatory birds				
Little Eagle (*Hieraaetus morphnoides*)	V	-	3.1 (foraging habitat)	1.2 (foraging habitat)
Square-tailed Kite (*Lophoictinia isura*)	V	-		
Powerful Owl (*Ninox strenua*)	V	-		
Masked Owl (*Tyto novaehollandiae*)	V	-		

Figure 4-3 Recorded threatened species



4.5.3 Aquatic results

The proposal site lies within the Hawkesbury catchment area. The aquatic environment includes two artificial dams, the largest being located on a mapped unnamed first-order stream in the north of the ecological study area and the other on an unmapped drainage line in the south of the ecological study area. These drainage lines are likely naturally formed, though have been highly influenced over time by clearing of woodland vegetation and increasing run-off. Both drainage lines are highly ephemeral, only draining water from the immediate surrounds into Ropes Creek to the west of the proposal site. Ropes Creek is a third-order stream that flows generally north before reaching its confluence with South Creek in Ropes Crossing, which then flows into the Hawkesbury River. Ropes Creek is mapped as 'Key Fish Habitat' by the NSW DPI. A constructed sediment basin is also within the ecological study area in the south west of the proposal site, however it was not included in the aquatic habitat assessment as it is an artificial structure constructed for the purpose of stormwater management.

Two threatened species, the Macquarie Perch and Australian Grayling have been recorded within the Hawkesbury-Nepean Catchment; however, habitat for these species is not present within the ecological study area. The Australian Grayling inhabits clear, flowing waters. The habitat and water quality in the ecological study area is degraded and not suitable for this species. The ecological study area is also to the north of its known distribution. The Macquarie Perch is now considered isolated to the upper reaches of catchments and is not present in the ecological study area. The nearest known population is in Cataract Dam. The degraded waterways in the ecological study area are not suitable for this species.

Habitat quality was assessed at four locations in the ecological study area (see **Figure 4-4**), which includes the two dams along the two drainage lines, a small depression along the southern drainage line and a small offshoot drain beside Ropes Creek. An assessment of the aquatic habitat against the basic 'Class' system (Fairfull and Witheridge et al. 2003) is provided in **Table 4-5**.

Table 4-5 Fish habitat classification

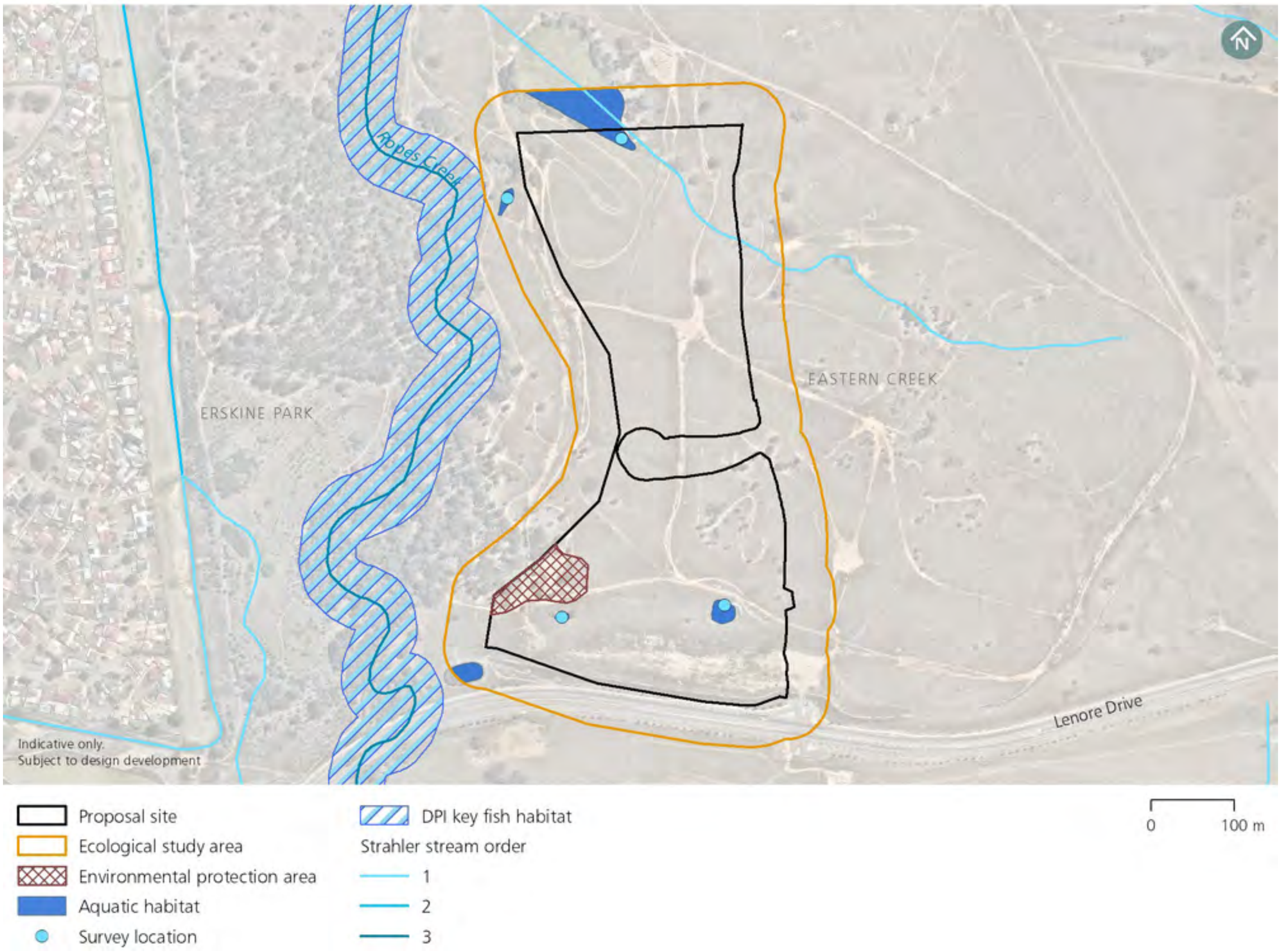
Class	Characteristics	Habitat in the ecological study area
<u>Class 1</u> Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek); habitat of a threatened fish species.	Not present in the proposal site or ecological study area. The closest Class 1 waterway to the ecological study area would be the Nepean River.
<u>Class 2</u> Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.	Not present in the proposal site or ecological study area. Ropes Creek (to the west of the ecological study area) qualifies as a Class 2 waterway.
<u>Class 3</u> Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi- permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Not present in the proposal site. Present at the offshoot drain from Ropes Creek within the ecological study area. This area contains a shallow ponded overflow from the creek with macrophyte and regrowth riparian vegetation.
<u>Class 4</u> Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free-standing water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).	Present in the mapped unnamed first order stream in the north of the proposal site and the unmapped (likely first order stream) in the south of the proposal site.

The ponded overflow from Ropes Creek is the best quality waterway in the ecological study area and likely to provide 'minimal fish habitat' (Class 3). This waterway is likely a result of land modification to build the large dam, however macrophyte and riparian vegetation has regenerated and there is a shallow area of ponded water that likely gets flushed during high flows of Ropes Creek. It may contain area of refuge, feeding and breeding for non-threatened fish species.

The mapped unnamed first order stream in the north of the proposal site and the unmapped (likely first order stream) in the south of the proposal site are considered to be 'unlikely fish habitat' (Class 4) as available habitat is really only represented by the dams. The drainage lines have no defined banks or channel and only flow under high rainfall. The dams may be occupied by common fish and invertebrate species though habitat for threatened species is unlikely.

There is a lack of permanent flow, weed proliferation, and evidence of physical disturbance. As such, the aquatic habitats in the ecological study area are considered to be in moderately to highly degraded condition. The drainage lines and dams do not have characteristics suitable for any of the threatened aquatic species known or predicted to occur in the locality as shown in Table B-2 in **Appendix B**.

Figure 4-4 Aquatic survey results



4.5.4 Areas of Outstanding Biodiversity Value

Areas of Outstanding Biodiversity Value (AOBV) are listed under the BC Act as special areas with irreplaceable biodiversity values that are important to the whole of NSW, Australia or globally. This includes areas formerly declared as critical habitat under the *Threatened Species Conservation Act 1995*. Information about AOBV in New South Wales, including declarations and maps, can be found in the Register of Declared AOBV and Biodiversity Values Map. There are no AOBV within or near the ecological study area.

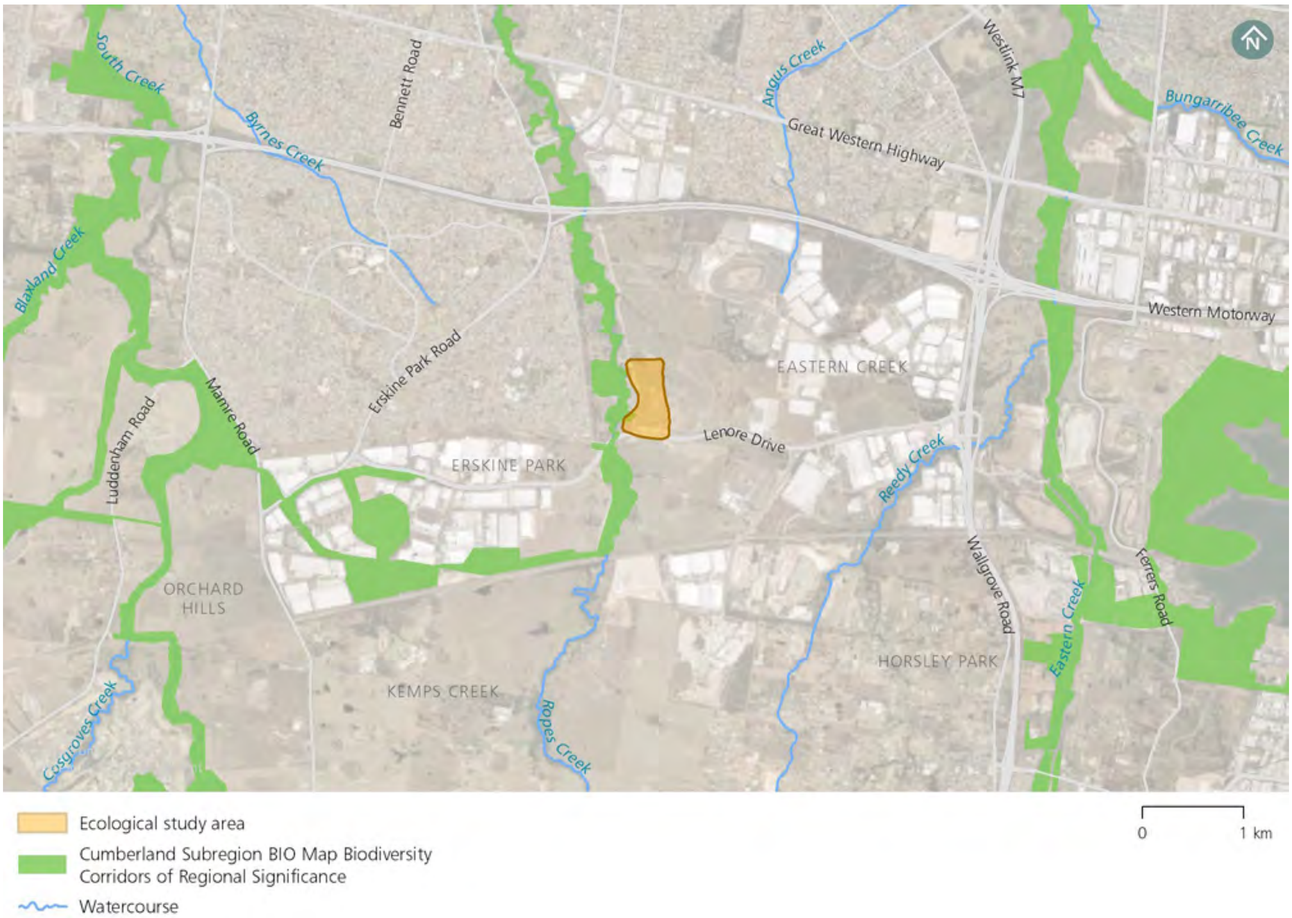
4.6 Wildlife connectivity corridors

Despite the barrier posed by the M4 Motorway, the habitats in the ecological study area retain some form of functional north-south connectivity along the Ropes Creek riparian corridor, which is mapped as a biodiversity corridor of regional significance (see **Figure 4-5**) as identified by the Biodiversity Investment Opportunities Map (BIO Map) (Office of Environment and Heritage 2015). Depending on the mobility of the species, some may be able to maintain connectivity to other riparian corridors to the east (Eastern Creek, Prospect Nature Reserve and Western Sydney Parklands) and to the west (South Creek). There is likely to be some movement of species and genetic material between the ecological study area and these adjacent habitats.

The barriers posed by the M4 Motorway and the generally cleared landscape serve to restrict fauna movements between the habitat patches for most terrestrial and arboreal species. However, the permeability of landscapes for different fauna species varies and habitat connectivity for more mobile species (e.g. birds, flying-foxes, insectivorous bats, insects, plants) remains. The connectivity for sedentary species and smaller species such as the Cumberland Plain Land Snail, frogs and reptiles is likely to be minimal. The Green and Golden Bell Frog is highly mobile and may possibly disperse as far as 10 kilometres (White & Pyke 2008) using the Ropes Creek corridor.

The roadways and urban areas do not totally prevent fauna movement between habitat fragments. Fauna can, and likely do, cross the road and disturbed areas of habitat but would do so less frequently than in natural habitats and would be at greater risk of mortality during movements. It is likely that highly mobile animals move between the ecological study area and habitats to the east and west by the estimated movement corridor shown in **Figure 4-5**. It is also likely that plant pollinators and seed dispersers move pollen and seed (or other vegetative reproductive material) between the ecological study area and adjacent habitats. The M4 Motorway contains vegetated areas along its margins that may allow movement for some highly mobile species. Functional connectivity for many species would exist between the ecological study area and habitats to the east and west despite the level of fragmentation that has occurred across the landscape.

Figure 4-5 Wildlife connectivity corridors



4.7 Matters of National Environmental Significance

4.7.1 Threatened ecological communities

One TEC as listed under the EPBC Act was identified within the ecological study area during the field survey undertaken for the proposal: Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest, listed as a critically endangered ecological community (CEEC).

The critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest community corresponds to the Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion PCT (PCT 849). However, the *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest listing advice* (Threatened Species Scientific Committee, 2009) outlines condition thresholds that vegetation must meet in order to be included in the EPBC Act listed community.

The vegetation within the ecological study area was analysed against this condition criteria, using the diagnostic flowchart provided in *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest: A guide to identifying and protecting the nationally threatened ecological community* (Department of the Environment, Water, Heritage and the Arts 2010) (refer to **Figure 4-6**).

Most of the occurrence of PCT 849 in the ecological study area is isolated small patches in poor condition, which includes some large remnant *Eucalyptus tereticornis* trees with natural canopy regeneration around the base. Most of these patches are less than 0.5 hectares in size and therefore do not qualify as the CEEC listing. However, there are two patches of poor condition 849 in the ecological study area that do meet this size criteria (see Plots 5 and 6 in **Figure 4-7**). These two patches answer yes to some of the criteria questions, though suffer from high cover of exotic grasses (primarily *Paspalum dilatatum*, *Setaria parviflora* and *Eragrostis curvula*) and therefore have less than 30 percent native perennial understorey, which does not meet the CEEC condition criteria for listing. Confidence in the recorded cover of native grasses at each plot is high, as up to eight species were identified in flower due to the suitable climatic conditions preceding the survey. Additionally, a previous assessment of vegetation against the condition criteria in the east of the ecological study area around Plot 5 as part of the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017), found this patch also did not meet the condition threshold.

Areas of grassland dominated by *Themeda triandra* were also assessed against the listing criteria. The listing advice (Threatened Species Scientific Committee, 2009) states that "*Derived grasslands and shrublands are not included in the EPBC-listed ecological community, but if they are contiguous with the ecological community they may be considered under Condition category C in Table 1*". The southern patch of derived grassland (see Plot 2 in **Figure 4-7**) is immediately disqualified from listing as it is less than 0.5 hectares in size. The northern patch (see Plot 7 in **Figure 4-7**) does meet the size (≥0.5 hectares) and native understorey cover (≥30 percent) criteria, however it is separated from the poor condition patch by around 40 metres, which is less than five hectares in size and also does not meet the definition of a native vegetation remnant (i.e. any native vegetation where cover in each layer present is dominated by native species). Therefore, the derived grasslands in the ecological study area do not meet the CEEC condition criteria for listing.

The only area that qualified as the CEEC is the moderate condition vegetation that is contiguous with the Ropes Creek riparian corridor, as the patch size is greater than 5 hectares and greater than 30 percent of the perennial understorey cover is made up of native species (see Table A-1 in **Appendix A** for covers recorded in Plot 1).

There is around 0.89 hectares of the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest community within the ecological study area and <0.001 hectares within the proposal site (refer **Figure 4-7**).

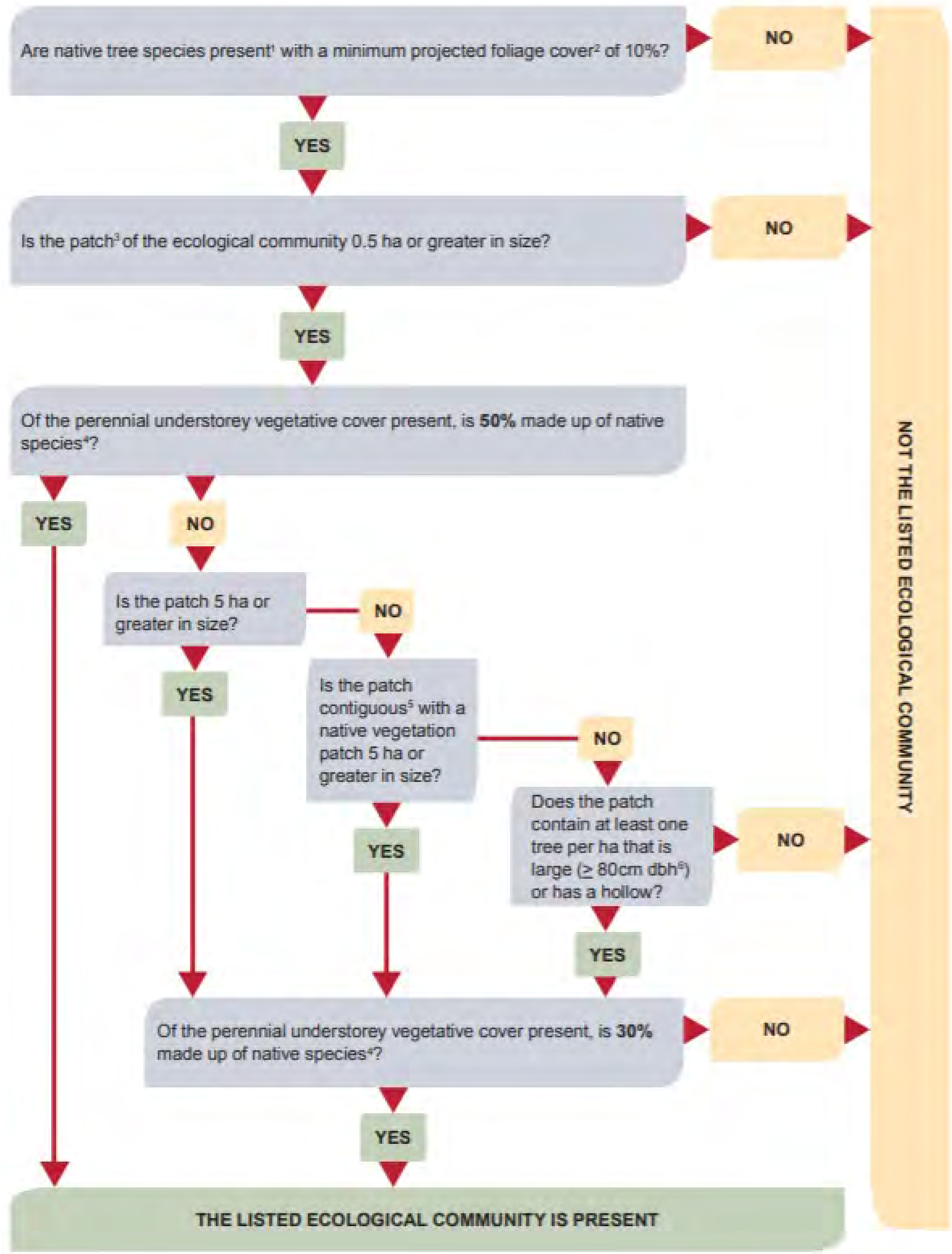


Figure 4-6 Flowchart of key diagnostic features and condition thresholds to identify the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. Figure taken from Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest

4.7.2 Threatened species

Three threatened animal species listed under the EPBC Act are considered moderately likely to use the habitats in the ecological study area for foraging; the Green and Golden Bell Frog (listed as endangered), the Swift Parrot (listed as critically endangered) and the Grey-headed Flying-fox (listed as vulnerable). No threatened plants listed under the EPBC Act are considered to have a moderate or higher likelihood of occurring.

The dense cover of *Typha orientalis* in the dams and small offshoot drain from Ropes Creek may be suitable for the Green and Golden Bell Frog (refer **Section 4.5.2** for discussion). Although there are very few recent records of this species in the locality and no known populations, there is potential for the Green and Golden Bell Frog to disperse along the Ropes Creek riparian corridor close to the proposal site. Therefore, considering the presence of potential habitat and high mobility of this species, the Green and Golden Bell Frog is moderately likely to occur in the habitats in the ecological study area.

The Grey-headed Flying-fox (listed as vulnerable under the BC Act and EPBC Act) is considered moderately likely to forage in the trees within the ecological study area, particularly *Eucalyptus moluccana* and *Eucalyptus tereticornis*. No roost camps are present in the ecological study area but the bats from the Nationally Important Parramatta Park camp and/or the intermittent Ropes Creek camp are likely to forage in the ecological study area.

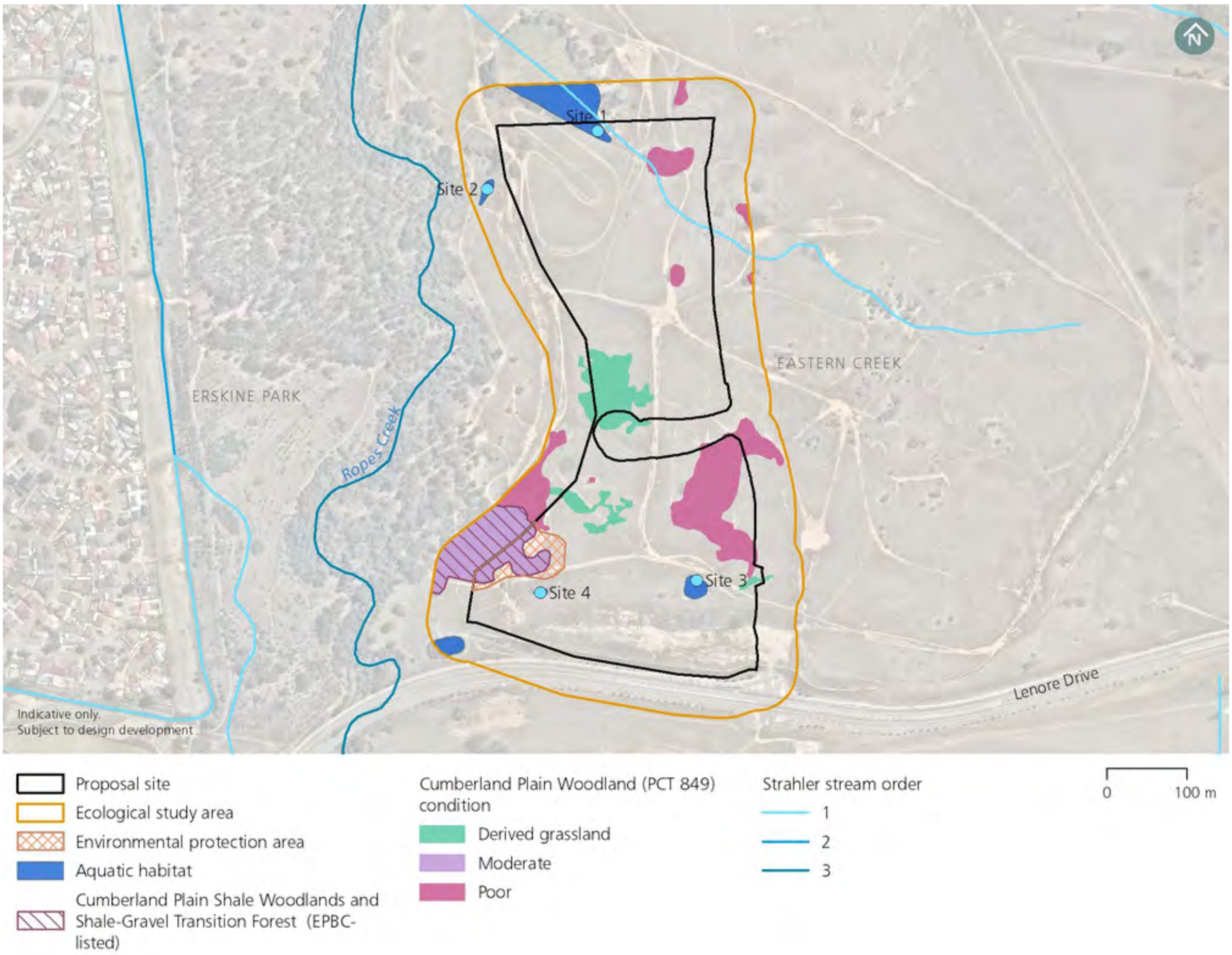
The Swift Parrot (listed as endangered under the BC Act and critically endangered EPBC Act) has been recorded in the locality (notably three records on Eastern Creek in 2019) and sporadically occurs in the urbanised areas of Western Sydney during winter. This species may pass through the ecological study area during movements between larger foraging habitats (e.g. from Prospect Nature Reserve to Whalan Reserve and Wianamatta Regional Park and Nature Reserve) where it may rest and forage. Although no significant areas of foraging habitat are present, the Swift Parrot is considered moderately likely to occur in the ecological study area on occasion.

4.7.3 Migratory species

Seventeen migratory bird species were identified in the EPBC Act Protected Matters Search Tool as potentially occurring in the locality based on the distributional range of the species and modelled habitat. These migratory species, along with their preferred habitat requirements and an assessment of their likely presence in the ecological study area are listed in Table B-2 in **Appendix B**. Only the Fork-tailed Swift and White-throated Needletail are considered moderately likely to fly over the ecological study area but would not use it as habitat.

While some migratory species of bird are likely use the ecological study area and locality, the ecological study area would not be classed as an 'important habitat'. A nationally significant proportion of the population would not be supported by the ecological study area, as the habitats are not large enough or high enough quality. Therefore, the proposal would not substantially modify, destroy or isolate an area of important habitat for the migratory species and it would not seriously disrupt the lifecycle of an ecologically significant proportion of a population of migratory birds and does not require further assessment.

Figure 4-7 Matters of National Environmental Significance



5. Construction assessment

The likely direct and indirect impacts of the construction of the proposal on biodiversity are summarised in this chapter. Direct impacts have been calculated using the boundary of the proposal site as the extent of construction, excluding the environmental protection area in the south west of the proposal site. The potential for indirect impacts on biodiversity values is considered low given that much of the ecological study area is highly fragmented, subject to strong edge effects, and surrounded by existing roads and barriers. However, in accordance with best-practice guidelines for assessing indirect impacts, as outlined in the BAM Operational Manual – Stage 2, a 50-metre buffer around the proposal site has been considered.

5.1 Key assumptions

Key assumptions of the construction assessment include:

- All vegetation within the proposal site boundary would be cleared (with the exception of the environmental protection area in the south west of the proposal site).
- There would be no direct impacts during construction outside of the proposal site boundary.
- An environmental protection area in the south western portion of the proposal site would be established to minimise impact on Cumberland Plain Woodland in the Sydney Basin Bioregion.

5.2 Removal of native vegetation

The proposal would have direct impacts on a range of biodiversity values during construction. Under the current design (the proposal site boundary), the estimated clearing of PCTs is about 1.92 hectares consisting of the PCTs listed in **Table 5-1**.

Table 5-1 Impacts to PCTs

Vegetation Zone Number	Plant Community Type (PCT)	Condition	Area in proposal site (ha)*
1	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849)	Moderate	<0.001
2		Poor	1.13
3		Derived Grassland	0.61
4	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 835)	Poor	0.07
5	Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (PCT 1071)	Poor	0.11
		Total	1.92

*Excludes environmental protection zone

The local occurrence of each PCT is defined as the area of the PCT that occurs within the ecological study area and adjacent areas that form part of a larger contiguous area of the PCT, in which movement of individuals and exchange of genetic material across the boundary of the ecological study area can be clearly demonstrated. Much of the native vegetation within the ecological study area is quite fragmented in nature, though is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence.

Although the PCTs in these areas are separated from the riparian corridor by a distance that does not qualify as a contiguous patch, they are considered to be connected and part of the local occurrence. Movement of individuals and exchange of genetic material from the vegetation in the ecological study area to and from vegetation along the Ropes Creek corridor can be expected.

Some of the PCTs listed in **Table 5-2** correspond to TEC listed under the BC Act and EPBC Act. Specifically, the proposal would result in the removal of around 1.74 hectares of the Cumberland Plain Woodland in the Sydney Basin Bioregion TEC (listed as critically endangered under the BC Act) and 0.07 hectares of the River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC (listed as endangered under the BC Act).

Moderate quality vegetation associated with PCT 849 meets the listing criteria for the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest community, listed under the EPBC Act. An impact of <0.001 hectares has been calculated, however it is likely that this would be avoided, and the actual impact would be limited to potential indirect edge effects on retained vegetation.

The proposal sites also includes approximately 0.002 hectares (20 square metres) of planted native vegetation along Lenore Drive and approximately 0.08 hectares (800 square metres) of exotic vegetation. The remaining impacted areas consist of exotic grassland.

Table 5-2 Impacts on native vegetation

Plant community type (PCT)	Condition class	BC Act	EPBC Act	Direct impact[1] (hectares)	Percent cleared in Catchment Management Authority (CMA)[2]
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (849)	Moderate	CE	CE	<0.001	93
	Poor	CE	-	1.13	
	Derived grassland	CE	-	0.61	
			Sub-total	1.74 ha	
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835)	Poor	E	-	0.07	93
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (1071)	Poor	-	-	0.11	75
			Total	**1.92 ha**	-

1- Area to be cleared based on ground-truthed vegetation mapping. Excludes environmental protection zone
2- Based on the BioNet Vegetation Classification database.

5.3 Removal of threatened species and habitat

The extent of native vegetation clearing estimated to result from the proposal is outlined above in **Section 5.2**. This vegetation, with the addition of planted trees, provides suitable habitat for a range of threatened fauna species listed under the BC Act and EPBC Act. As such, direct impacts through loss of habitat for threatened fauna species (although it is only moderate to poor quality) would occur during construction.

Threatened plant species *Grevillea juniperina* subsp. *juniperina* would not be directly impacted, however 0.06 hectares of potential habitat for this species would be removed.

The direct impacts of the proposal to threatened plant species and habitats for threatened fauna have been estimated based on the current design. A breakdown of the direct impacts to habitat for threatened fauna species is provided in **Table 5-3**.

Table 5-3 Impacts on threatened species and fauna habitat (V = Vulnerable species, E = Endangered species)

Species	BC Act	EPBC Act	Impact
Grevillea juniperina subsp. *juniperina*	V	-	0.06 ha of potential habitat. No direct impact to individual plants
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E	-	<0.001 ha
Green and Golden Bell Frog (Litoria aurea)	E	E	0.11 ha (potential non-breeding habitat)
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	1.2 ha (foraging habitat)
Insectivorous bats (cave-roosting)			
Little Bent-winged Bat (*Miniopterus australis*)	V	-	1.92 ha (foraging habitat)
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	V	-	
Southern Myotis (*Myotis macropus*)	V	-	
Insectivorous bats (hollow-roosting)			
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	-	1.92 ha (foraging habitat) and 4 hollow-bearing trees
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	V	-	
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	-	
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	
Woodland birds			
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	V	-	1.2 ha (foraging habitat)
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	
Nectarivorous birds			
Little Lorikeet (*Glossopsitta pusilla*)	V	-	1.2 ha (foraging habitat) and 4 hollow-bearing trees
Swift Parrot (*Lathamus discolor*)	E	CE	
Large predatory birds			
Little Eagle (*Hieraaetus morphnoides*)	V	-	1.2 ha (foraging habitat)
Square-tailed Kite (*Lophoictinia isura*)	V	-	
Powerful Owl (*Ninox strenua*)	V	-	
Masked Owl (*Tyto novaehollandiae*)	V	-	

5.4 Aquatic impacts

The aquatic habitat to be affected by the proposal is in poor condition due to previous development and agricultural activity within the catchment which has resulted in changes to hydrological conditions, increased input of nutrients, sedimentation and weed invasion. As shown in **Appendix B**, no threatened species listed under the FM Act are likely to occur in these streams due to their poor condition and lack of characteristic habitat features associated with threatened species.

As discussed in **Section 4.5.3** the aquatic environment includes two artificial dams, the largest being located on a mapped unnamed first-order stream in the north of the ecological study area and the other on an unmapped drainage line in the south of the ecological study area. These drainage lines are likely naturally formed, though have been highly influenced over time by clearing of woodland vegetation and increasing run-off. Both drainage lines are highly ephemeral, only draining water from the immediate surrounds into Ropes Creek to the west of the proposal site. They meet the description for Class 4 (unlikely fish habitat), with a small overflow from Ropes Creek meeting the description for Class 3 (minimal key fish habitat). Ropes Creek is mapped as 'Key Fish Habitat' by the NSW Department of Primary Industries, which is outside of the proposal site. As such, there would be no impacts to sensitive or key fish habitats.

Impacts to aquatic habitat would be of low magnitude and standard mitigation measures would be implemented to limit impacts to surrounding habitats (see **Section 8.2**).

5.5 Injury and mortality

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing would occur. The extent of this impact would be proportionate to the extent of vegetation that is cleared. Less mobile species (e.g. ground dwelling reptiles), or those that are nocturnal and nest or roost in trees during the day (e.g. arboreal mammals and microchiropteran bat species), may find it difficult to rapidly move away from the clearing when disturbed. The ecological study area is only likely to contain a limited number of arboreal species (e.g. possums) and nesting birds that may be injured or killed during vegetation removal. Reptiles, frogs and invertebrates may also be injured or killed during construction as habitat is cleared.

Entrapment of wildlife in any trenches or pits that are dug is a possibility if the trenches are deep and steep sided. Wildlife may also become trapped in or may choose to shelter in machinery that is stored in the ecological study area overnight. If these animals were to remain inside the machinery, or under the wheels or tracks, they may be injured or may die once the machinery is in use.

There is a chance of fauna mortality occurring during the construction phase of the proposal through vehicle collision (i.e. roadkill). Vehicle collision is a direct impact that reduces local population numbers. Mammals, reptiles, amphibians and birds are all at risk of vehicle strike. As there are no definitive data on current rates of roadkill or fauna population densities in the ecological study area, the consequences of vehicle strike on local populations is unknown. Considering the nature of the proposal, there is not expected to be a large increase in vehicle traffic, however there would be some increase in vehicle traffic going in and out of the proposal site. A temporary haul road would be established for proposal site access prior to completion of Archbold Road works. Construction traffic would utilise the temporary haul road until the permanent road is constructed. The proposal would therefore contribute traffic on land that does not currently have any traffic. The significance of such an impact on fauna cannot be predicted. The impact on threatened species however is expected to be minimal. Based on evidence from other roadways in the locality most vehicle strike impacts can be expected to occur to common mammals such as birds and possums and exotic animals including foxes.

Security fencing would be erected around the perimeter of the proposal site during construction. Barbed wire (if used) can entangle nocturnal flying species, however considering the fencing would not be located close to foraging habitats then the potential of this impact is considered to be low.

Mitigation measures designed to reduce any injury and mortality of fauna are provided in **Section 8.2**.

5.6 Indirect impacts

5.6.1 Wildlife connectivity and habitat fragmentation

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller 'fragments' (Fahrig, 2002). The habitats within the ecological study area are fragments that have formed since the initial habitat clearing that has occurred, regenerating into patches around large remnant trees. The current alignment of the Great Western Highway and M4 Motorway fragments connectivity to the north, and the ecological study area was further isolated around 2012 when Lenore Drive was built. Additionally, the upgrade and extension to Archbold Road east of the ecological study area will eventually create another road barrier to east-west movement. It is assumed that the first stage of the Archbold Road extension (i.e. connection from Lenore Drive to the proposal site) would be constructed concurrently with this proposal, with the rest of the extension to be completed in the future.

The barriers posed by the Great Western Highway and Lenore Drive serve to restrict most wildlife movements between the habitat patches. However, functional habitat connectivity for more mobile species (e.g. birds, flying-foxes, insectivorous bats, insects, plants) is still present via vegetated riparian corridors and roadside vegetation (refer **Figure 4-5**). The current roadways do not totally prevent fauna movement between habitat fragments (fauna can and likely do cross the road) but the roads do create a considerable hazard.

The proposal would not break apart continuous habitats into separate smaller 'fragments'. The proposal would however result in an increase in isolation of habitats as all the vegetation on the proposal site would be removed (with the exception of moderate quality woodland located in the environmental protection area in the south-west of the site that would be retained), which would increase the physical distance between habitat fragments. The isolation that may be caused by the proposal is not likely to have an appreciable impact on nomadic or migratory species such as birds and bats. The proposal is likely to be detrimental to the dispersal of arboreal mammals and other species including frogs and reptiles, but the effects would only be marginally greater than that which is already experienced due to the current cleared nature of the ecological study area. Additionally, planned perimeter fencing around the construction site is unlikely to impact movement of ground animals as the proposal site does not currently provide a high level of connectivity.

The predicted level of isolation from the proposal is not likely to be enough to prevent the breeding and dispersal of plant pollinators or the dispersal of plant propagules (i.e. seed or other vegetative reproductive material) between habitat patches. Functional connectivity for many species would remain in the ecological study area. However, local division of some wildlife populations, isolation of key habitat resources, loss of genetic interchange, and loss of population viability for some species may result.

This impact would be of low magnitude and mitigation measures are not deemed necessary.

5.6.2 Edge effects on adjacent native vegetation and habitat

The proposal would be built in an area that is currently subject to a high level of edge effects (changes to ecosystem functioning that occur as a result of sudden and artificial edges, e.g. increased light) from the existing roadways, previous agricultural land use practices and urban development. The vegetation patches are suffering from intense weed invasion and the habitats that would be impacted by the proposal are edge habitats without any undisturbed core. The highest quality vegetation in the ecological study area is on the very edge of a large contiguous riparian corridor around Ropes Creek, which is affected by weed invasion and rubbish throughout. Illegal public access to the proposal site has resulted in recreational motorbike and four-wheel-drive activity and significant rubbish dumping in this vegetation. There is unlikely to be any further impacts from edge effects resulting from the proposal as all vegetation is suffering from edge effects in the form of weed invasion, increased light levels, increased wind speeds, and greater temperature fluctuations. No new edge habitats would be created as the ecological study area does not possess large core areas of undisturbed habitat.

This impact would be of low magnitude and mitigation measures are not deemed necessary.

5.6.3 Invasion and spread of weeds

Native vegetation in the ecological study area is currently subject to invasion by exotic perennial grasses (notably *Eragrostis curvula*, *Paspalum dilatatum* and *Setaria parviflora*), which is recognised as a Key Threatening Process by the BC Act. Proliferation of weed and pest species is an indirect impact (i.e. not a direct result of proposal activities). Without mitigation, proliferation of weeds is likely to occur during construction, although impacts would be greatest due to vegetation clearing during the construction phase. Clearing activities may also exacerbate the key threatening process in less disturbed vegetation to the west of the proposal site. The most likely causes of weed dispersal and importation associated with the proposal include earthworks, movement of soil, and attachment of seed (and other propagules) to vehicles and machinery during all phases. Disturbance of native vegetation patch edges may also influence weed proliferation (see **Section 5.6.2**). The ecological study area contains significant weed growth and no undisturbed weed free habitat exists. As such, weeds must be managed during construction.

Mitigation measures to limit the spread and germination of weeds are provided in **Section 8.2**.

5.6.4 Invasion and spread of pests

The ecological study area and locality are likely occupied by a range of pest species including the European Red Fox, Rabbit and Black Rat. The Eastern Gambusia was observed in the waterbodies in the ecological study area. Proposal activities have the potential to disperse pest species out of the proposal site across the surrounding landscape (particularly dewatering the dams) but the magnitude of this impact would be low (i.e. the Eastern Gambusia was identified across the entire ecological study area, including in Ropes Creek) and mitigation measures are not deemed necessary.

5.6.5 Invasion and spread of pathogens and disease

Several pathogens known from NSW have potential to impact on biodiversity as a result of their movement and infection during construction. Of these, three are listed as a key threatening process under either the EPBC Act and/or BC Act including:

- Dieback caused by Phytophthora (Root Rot; EPBC Act and BC Act)
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (EPBC Act and BC Act)
- Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae (BC Act).

While these pathogens were not observed or tested for in the ecological study area the potential for pathogens to occur should be treated as a risk during construction. The most likely causes of pathogen dispersal and importation associated with the proposal include earthworks, movement of soil, and attachment of plant matter to vehicles and machinery during all proposal phases (construction and operation). Pathogens would be managed within the proposal site in accordance with the *Biosecurity Act 2015*.

5.6.6 Noise and vibration, dust and contaminated pollution

Noise, vibration, dust, light and contaminant pollution are temporary impacts that are likely to result from proposal activities. These impacts are likely to have cumulative effects. Noise, vibration, dust, light and contaminant pollution are likely to occur during the construction of the proposal from all proposal activities, although impacts to biodiversity would be greatest where activities take place near vegetated areas (i.e. along Ropes Creek).

Edge effects can create changes in a population or a community structure that occur at the boundary of differing habitats. Using a 50-metre edge effect buffer around the proposal site, these impacts of noise, vibration, dust and contaminated pollution may result in the modification of about 2.22 hectares of native vegetation that would remain at the edge of the proposal once construction is complete (refer **Figure 4-1**). However much of this vegetation is already disturbed and modified, and the impacts of increased noise, vibration, dust and contaminated pollution is likely to be negligible.

Noise and vibration pollution

Anthropogenic noise can alter the behaviour of animals or interfere with their normal functioning (Bowles 1997). During the construction of the proposal there would be increased noise and vibration levels in the ecological study area and immediate surrounds due to vegetation clearing, ground disturbance, machinery and vehicle movements, and general human presence. The predicted noise and vibration created by project is outlined in Chapter 8.1 of the REF.

Construction of the proposal would be scheduled to the following standard working hours, namely:

- Monday to Friday, 7am to 6pm
- Saturday, 8am to 1pm
- Sunday and Public Holidays, no work.

Out of Hours Works may be required for the following:

- Installation of utilities
- Work determined to comply with the relevant noise management level at the nearest sensitive receiver
- The delivery of materials outside approved hours as required by the NSW Police or other authorities for safety reasons
- Emergency situations where it is required to avoid the loss of lives and properties and/or to prevent environmental harm
- Situations where agreement is reached with affected receivers.

No other out-of-hours works are anticipated as part of the proposal. The noise and vibration from activities associated with the proposal would potentially disturb fauna and may disrupt foraging, reproductive, or movement behaviours in proximity to the proposal site. The impacts from noise emissions are likely to be localised to the construction areas and are not considered likely to have a significant, long-term, impact on wildlife populations outside the area of impact. Within the area of impact, some sensitive species (e.g. woodland birds) may avoid the noise and some more tolerant species, including small mammals, would habituate over the longer-term (Byrnes *et al.* 2012).

Dust pollution

Elevated levels of dust may be deposited onto the foliage of vegetation adjacent to the proposal activities. This has the potential to reduce photosynthesis and transpiration and cause abrasion and radioactive heating resulting in reduced growth rates and decreases in overall health of the vegetation. Consequently, changes in the structure and composition of plant communities and consequently the grazing patterns of fauna may occur (Auerbach *et al.* 1997; Walker & Everett 1987).

An air quality assessment has been undertaken and is provided in Chapter 8 of the REF. Without mitigation, dust is likely to be generated during the construction of the proposal, although dust pollution is likely to be greatest during periods of substantial earthworks, vegetation clearing, vehicle movements for construction and during adverse weather conditions. However, deposition of dust on foliage is likely to be highly localised, intermittent, and temporary and is therefore not considered likely to be a major impact of the proposal.

Contaminant pollution

During the construction phase localised release of contaminants (i.e. hydraulic fluids, oils, drilling fluids, etc.) into the surrounding environment (including drainage lines) may accidentally occur. The most likely result of contaminant discharge would be the localised contamination of soil and potential direct physical trauma to flora and fauna that come into contact with contaminants. Accidental release of contaminants is likely to be localised. An assessment of soil contamination has been undertaken and is provided in Chapter 8 of the REF.

5.6.7 Groundwater dependent ecosystems

The PCTs within the ecological study area are likely to be opportunistic facultative GDEs that depend on the subsurface presence of groundwater (often accessed via the capillary fringe – subsurface water just above the water table) when an alternative source of water (i.e. rainfall) cannot be accessed to maintain ecological function. The proposal would impact on the occurrence of these PCTs within the proposal site (see **Section 4.2**).

5.7 Cumulative construction impacts

The potential biodiversity impacts must be considered as a consequence of the construction and operation of the proposal within the existing environment. The proposal would not act alone in causing impacts to biodiversity. The incremental effects of multiple sources of impact (past, present and future) are referred to as cumulative impacts and provide an opportunity to consider the proposal within a strategic context.

The accumulating impacts of historic vegetation clearing for agriculture, urban development, and development and maintenance of infrastructure would likely include continued loss of biodiversity on the Cumberland Plain. The Cumberland Plain NSW Landscape is an over cleared landscape with 89 per cent of native vegetation having been cleared. Only 11 per cent of the original native vegetation remains. Due to the likely expansion of Western Sydney and creation of housing and associated infrastructure, further impacts to biodiversity are likely to result in this region.

An assessment of the likely cumulative biodiversity impacts from recent projects using publicly available information is provided in Chapter 8 of the REF.

5.8 Construction impacts summary

A summary of the predicted ecological impacts from the construction of the proposal is provided in **Table 5-4**.

Table 5-4 Summary of impacts

Impact	Biodiversity values	Nature of impact	Extent of impact*	Duration	Does the proposal constitute or exacerbate a key threatening process?
Removal of native vegetation	Native vegetation	Direct	1.92 ha	Permanent	Clearing of native vegetation
	Cumberland Plain Woodland in the Sydney Basin Bioregion	Direct	1.74 ha	Permanent	Clearing of native vegetation
	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Direct	0.07 ha	Permanent	Clearing of native vegetation
	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Direct	<0.001 ha	Permanent	Clearing of native vegetation
Removal of threatened fauna habitat	Cumberland Plain Land Snail	Direct	<0.001 ha	Permanent	Clearing of native vegetation Loss of hollow-bearing trees Removal of dead wood and dead trees
	Green and Golden Bell Frog	Direct	0.11 ha (potential non-breeding habitat)	Permanent	Clearing of native vegetation
	Grey-headed Flying-fox	Direct	1.2 ha (foraging habitat)	Permanent	Clearing of native vegetation
	Little Bent-wing Bat, Large Bentwing-bat, Eastern False Pipistrelle, Eastern Freetail-bat, Southern Myotis, Greater Broad-nosed Bat, Yellow-bellied Sheathtail-bat	Direct	1.92 ha (foraging habitat) and 4 hollow-bearing trees	Permanent	Clearing of native vegetation Loss of hollow-bearing trees
	Dusky Woodswallow, Varied Sittella	Direct	1.2 ha (foraging habitat)	Permanent	Clearing of native vegetation Loss of hollow-bearing trees Removal of dead wood and dead trees

Impact	Biodiversity values	Nature of impact	Extent of impact*	Duration	Does the proposal constitute or exacerbate a key threatening process?
	Little Lorikeet, Swift Parrot,	Direct	1.2 ha (foraging habitat) and 4 hollow-bearing trees	Permanent	Clearing of native vegetation Loss of hollow-bearing trees
	Little Eagle, Square-tailed Kite, Powerful Owl, Masked Owl	Direct	1.2 ha (foraging habitat)	Permanent	Clearing of native vegetation Loss of hollow-bearing trees Removal of dead wood and dead trees
Removal of threatened flora	*Grevillea juniperina* subsp. *juniperina*	Direct	0.06 ha of potential habitat. No individuals would be directly impacted.	Permanent	Clearing of native vegetation
Aquatic impacts	Aquatic fauna	Direct	Only minor habitat to be affected.	Short term	No
Injury and mortality of fauna	All fauna species present in the habitat	Direct	Unknown. Impact cannot be quantified.	Long term	No
Fragmentation of identified biodiversity links and habitat corridors	All PCTs and flora and fauna species present in the habitat	Direct/ indirect	Minimal, but local habitat isolation would be increased.	Long term	No
Edge effects on adjacent native vegetation and habitat	All PCTs and flora and fauna species present in the habitat	Indirect	Minimal as no core habitat is present.	Long term	No

Impact	Biodiversity values	Nature of impact	Extent of impact*	Duration	Does the proposal constitute or exacerbate a key threatening process?
Invasion and spread of weeds	All PCTs and flora and fauna species present in the habitat	Indirect	Without appropriate management strategies, proposal activities have the potential to disperse weeds.	Long term	Invasion and establishment of exotic vines and scramblers Invasion of native plant communities by African Olive (*Olea europaea* L. subsp. *cuspidata)* Invasion, establishment and spread of *Lantana camara* Invasion of native plant communities by exotic perennial grasses
Invasion and spread of pests	All PCTs and flora and fauna species present in the habitat	Indirect	The ecological study area is currently likely habitat for a range of pest species.	Long term	Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*) Predation by the European red fox (*Vulpes vulpes*)
Invasion and spread of pathogens and disease	All PCTs and flora and fauna species present in the habitat	Indirect	While pathogens were not observed or tested for in the ecological study area the potential for pathogens to occur should be treated as a risk during construction.	Long term	Infection of native plants by *Phytophthora cinnamomi* Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae Infection of frogs by amphibian chytrid causing the disease chytridiomycosis

Impact	Biodiversity values	Nature of impact	Extent of impact*	Duration	Does the proposal constitute or exacerbate a key threatening process?
Noise, light and vibration	All PCTs and flora and fauna species present in the habitat	Direct/ indirect	There would be an impact from noise, light and vibration but the level of noise, vibration and light spill into adjacent habitats cannot be quantified.	Short term	No

*Excludes environmental protection zone

6. Operational assessment

6.1 Aquatic impacts

Impacts to aquatic habitats are discussed in **Section 5.4**. Additionally, Ropes Creek is mapped as 'Key Fish Habitat' by the NSW DPI, which is outside of both the proposal site and the ecological study area. During the operation phase localised release of contaminants (i.e. hydraulic fluids, oils, drilling fluids, etc.) into the surrounding environment (including drainage lines) may accidentally occur. The most likely result of contaminant discharge would be the localised contamination of soil and potential direct physical trauma to flora and fauna that come into contact with contaminants. Accidental release of contaminants is likely to be localised. The potential for impact to surrounding aquatic habitats can reduced by implementing standard mitigation measures (see **Section 8.2**).

6.2 Injury and mortality

Impacts from fauna injury or death are discussed in **Section 5.5**. The potential for impact may be slightly elevated during the operational phase as there would be more traffic going in and out of the proposal site.

Mitigation measures to reduce an injury and mortality of fauna are provided in **Section 8.2**.

6.3 Edge effects on adjacent native vegetation and habitat

As discussed in **Section 5.6.2**, the proposal would be built in an area that is currently subject to a high level of edge effects from the existing roadways, agricultural land use practices and urban development. No new edge habitats would be created as the ecological study area does not possess large core areas of undisturbed habitat.

This impact would be of low magnitude and mitigation measures are not deemed necessary.

6.4 Noise and vibration, light, dust and contaminated pollution

The potential impacts of noise and vibration, dust and contaminated pollution during construction are discussed in **Section 5.6.6**. Potential impacts are expected to be similar during the operation of the proposal and therefore considered unlikely to be a major impact. This impact would be of low magnitude and mitigation measures are not deemed necessary.

Light pollution

Ecological light pollution is the descriptive term for light pollution that includes direct glare, chronic or periodic increased illumination, and temporary unexpected fluctuations in lighting (including lights from a passing vehicles), that can have potentially adverse effects on wildlife (Longcore & Rich 2004).

The proposal would have 24 hours per day, seven days per week operations. As such, the immediate area surrounding the proposal site, and the roadside during operation, would be subject to artificial lighting, essentially creating permanent 'daylight' conditions. Ecological light pollution may potentially affect nocturnal fauna by interrupting their life cycle. Some species (i.e. light tolerant microchiropteran bats) may benefit from the lighting due to increased food availability (insects attracted to lights) around these areas. Due to the frequency and sustained nature of the lighting, it is unlikely that animals would habituate to the light disturbance and a long-term impact in the area of lighting is likely. This impact would be of low magnitude and mitigation measures are not deemed necessary.

6.5 Operational impacts summary

The proposal is not expected to result in any different impacts (from construction) during operation. The key impacts of the proposal would occur during the construction phase and have been assessed in **Section 5**.

7. Assessment of impact significance

An Assessment of Significance has been conducted for threatened species that have been positively identified within the ecological study area or that are considered to have a moderate or high likelihood of occurring in the ecological study area due to the presence of suitable habitat.

The proposed works would be assessed under Part 5 of the EP&A Act. Section 7.3 of the BC Act outlines the 'test of significance' that is to be undertaken to assess the likelihood of significant impact upon threatened species or ecological communities listed under the BC Act. These tests of significance have been undertaken in accordance with the *Threatened Species Test of Significance Guidelines* (Office of Environment and Heritage 2018), which outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of the assessment process. The guidance provided by the former Office of Environment and Heritage has been used here in preparing these tests of significance and in determining whether there is likely to be a significant impact to a threatened species, population or ecological community listed under the BC Act.

Full details of assessment of significance under the BC Act are presented in **Appendix C**. Species with similar broad habitat requirements have been grouped together for assessment. The conclusions of the assessments are provided in **Table 7-1**, which indicates that a significant impact is considered unlikely on any threatened species or threatened ecological communities listed under the BC Act.

For threatened biodiversity listed under the EPBC Act, significance assessments have been completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013). Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment that is affected, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of Environment, 2013). Importantly, for a 'significant impact' to be 'likely', it is not necessary for a significant impact to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility (Department of Environment, 2013). This advice has been considered while undertaking the assessments.

A significant impact is considered unlikely for any Matter of NES and a referral of the proposal would not be required (see **Table 7-1**). Full details of the assessment of significance for threatened species under the EPBC Act are presented in **Appendix C**.

Table 7-1 Summary findings of the BC Act test of significance

Threatened species, or communities	**Significance assessment question[1]**					**Likely significant impact?**
	a	**b**	**c**	**d**	**e**	
Cumberland Plain Woodland in the Sydney Basin Bioregion	X	N	N	N	Y	No
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	X	N	N	N	Y	No
Grevillea juniperina subsp. *juniperina*	N	X	N	N	Y	No
Cumberland Plain Land Snail (*Meridolum corneovirens*)	N	X	N	N	Y	No
Green and Golden Bell Frog (*Litoria aurea*)	N	X	N	N	Y	No
Grey-headed Flying-fox (*Pteropus poliocephalus*)	N	X	N	N	Y	No
Insectivorous bats (cave-roosting)						
Little Bent-winged Bat (*Miniopterus australis*)	N	X	N	N	Y	No
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	N	X	N	N	Y	No
Southern Myotis (*Myotis macropus*)	N	X	N	N	Y	No
Insectivorous bats (hollow-roosting)						
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	N	X	N	N	Y	No
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	N	X	N	N	Y	No
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	N	X	N	N	Y	No

Threatened species, or communities	Significance assessment question[1]					Likely significant impact?
	a	b	c	d	e	
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	N	X	N	N	Y	No
Woodland birds						
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	N	X	N	N	Y	No
Varied Sittella (*Daphoenositta chrysoptera*)	N	X	N	N	Y	No
Nectarivorous birds						
Little Lorikeet (*Glossopsitta pusilla*)	N	X	N	N	Y	No
Swift Parrot (*Lathamus discolor*)	N	X	N	N	Y	No
Large predatory birds						
Little Eagle (*Hieraaetus morphnoides*)	N	X	N	N	Y	No
Square-tailed Kite (*Lophoictinia isura*)	N	X	N	N	Y	No
Powerful Owl (*Ninox strenua*)	N	X	N	N	Y	No
Masked Owl (*Tyto novaehollandiae*)	N	X	N	N	Y	No

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

1. Significance Assessment Questions as set out in the *Biodiversity Conservation Act 2016:*
   a in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
   b in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:
      (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
      (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
   c in relation to the habitat of a threatened species or ecological community:
      (i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and
      (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and
      (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.
   d whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),
   e whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

Table 7-2 Summary findings of the EPBC Act significance assessments

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Important Population+	Likely Significant Impact
	1	2	3	4	5	6	7	8	9		
Ecological communities											
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Y	N	N	Y	N	N	Y	X	X	NA	No
Vulnerable species+											
Grey-headed Flying-fox (*Pteropus poliocephalus*)	N	N	N	N	N	N	N	N	N	Yes	No

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Important Population+	Likely Significant Impact
	1	2	3	4	5	6	7	8	9		
Endangered species											
Green and Golden Bell Frog (*Litoria aurea*)	N	N	N	N	N	N	N	N	N	Yes	No
Critically Endangered species											
Swift Parrot (*Lathamus discolour*)	N	N	N	N	N	N	N	N	N	NA	No

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

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

1) reduce the extent of an ecological community
2) fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
3) adversely affect habitat critical to the survival of an ecological community
4) modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns
5) cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting
6) cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:
   - assisting invasive species, that are harmful to the listed ecological community, to become established, or
   - causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or
7) interfere with the recovery of an ecological community.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

1) Lead to a long-term decrease in the size of a population
2) Reduce the area of occupancy of the species
3) Fragment an existing population into two or more populations
4) Adversely affect habitat critical to the survival of a species
5) Disrupt the breeding cycle of a population
6) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7) Result in invasive species that are harmful to a species becoming established in the species' habitat
8) Introduce disease that may cause the species to decline
9) Interfere with the recovery of the species.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1) lead to a long-term decrease in the size of an important population of a species
2) reduce the area of occupancy of an important population
3) fragment an existing important population into two or more populations
4) adversely affect habitat critical to the survival of a species
5) disrupt the breeding cycle of an important population
6) modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7) result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
8) introduce disease that may cause the species to decline, or
9) interfere substantially with the recovery of the species.

An important population as determined by the EPBC Act is a population of a vulnerable species that is likely to be key source populations either for breeding or dispersal, is likely to be necessary for maintaining genetic diversity, or is at or near the limit of the species range. The Grey-headed Flying-fox exists as one interconnected population along the east coast of Australia. Therefore, it is considered an important population for the purposes of this assessment.

8. Mitigation and management measures

This chapter outlines the steps that have been taken to avoid and minimise impacts to biodiversity and the measures recommended to manage residual impacts.

In general, biodiversity impacts would be managed in accordance with Sydney Metro's Construction Environmental Management Framework. Of relevance, the Construction Environmental Framework includes biodiversity management objectives to maximise workers' awareness of biodiversity values and avoid or minimise potential impacts to biodiversity.

8.1 Avoidance and minimisation

Avoiding environmental impacts as the first step is consistent with the application of the precautionary principle. This section demonstrates the efforts taken to avoid and minimise impacts on biodiversity values in accordance with section 8 of the BAM.

Avoidance can be achieved by early consideration of environmental issues from identification of constraints at proposal inception through to options analysis and selection of a preferred option, design investigation and assessment of the preferred option, detailed design, and implementation of on-ground safeguards during construction and operation and maintenance of the activity.

The primary method to avoid impacts is to locate activities away from areas of known or potential high biodiversity value. In identifying suitable work sites, the first preference is to locate existing cleared and disturbed areas that have good access, are not within immediate proximity to waterways, and that support good site management practices (for example, management of material stockpiles). The proposal has been proposed in a highly disturbed area to avoid impacts to biodiversity.

During the early stages of planning, the riparian vegetation around Ropes Creek was identified as Cumberland Plains Priority Conservation Lands mapped by the Department of Planning, Industry and Environment (see **Figure 4-2** and also a biodiversity corridor of regional significance (see **Figure 4-5**) as identified by the Biodiversity Investment Opportunities Map (BIO Map). The design of the proposal was able to avoid this area of high-value biodiversity through the establishment of an environmental protection area in the south west of the proposal site, greatly reducing the impact on threatened species, habitat and threatened ecological communities.

8.2 Mitigation measures

The proposed measures to mitigate and minimise ecological impacts are outlined in **Table 8-1** and should be considered in the development of the Construction Environmental Management Plan (CEMP) for the proposal. The impacts associated with the proposal will be managed in accordance with Sydney Metro's Construction Environmental Management Framework (CEMF). **Table 8-1** does not include measures already outlined in Chapter 10 of the CEMF, which includes requirements for measures such as pre-clearing surveys prior to native vegetation clearing.

Table 8-1 Recommended mitigation measures during pre-construction and construction

No.	Potential impacts	Mitigation measure
B1	Potential impact to surrounding vegetation and threatened	Prior to construction, the limits of the work zone, areas for parking and turning of vehicles and plant equipment would be accurately and clearly marked out. These areas would be located so that vegetation disturbance is minimised as much as possible and the drip-line of trees avoided.
B2		Prior to construction, exclusion zones would be established around all vegetation to be retained, such as the environmental protection area in the west of the proposal

No.	Potential impacts	Mitigation measure
	ecological communities	site. Periodic monitoring would be undertaken to ensure all controls are in place and no inadvertent impacts are occurring.
B3		Materials, plant, equipment, work vehicles and stockpiles would be placed to avoid damage to surrounding vegetation and would be outside tree drip-lines.
B4		Prior to construction, personnel would be informed of the environmentally sensitive aspects of the proposal site, including plans for impacted and adjoining areas showing vegetation communities; important flora and fauna habitat areas; and locations where threatened species, populations or ecological communities have been recorded. Construction personnel would be made aware that any native fauna species encountered must be allowed to safely leave the proposal site where possible and a local wildlife rescue organisation or appropriately experienced ecologist must be called for assistance where necessary.
B5	Potential impact to native plants and animals including threatened species	Where possible, hollows would be cut out of hollow-bearing trees and re-established in large trees to the west of the proposal site to mitigate the loss of hollow habitat on fauna.
B6	Potential impacts to the Cumberland Plain Land Snail	Pre-clearing surveys for the Cumberland Plan Land Snail would be undertaken by a suitably qualified ecologist within 48 hours prior to the commencement of clearing to translocate any individuals that may be inhabiting areas that would be cleared or disturbed. This includes all areas of dumped rubbish across the proposal site.
B7		Prior to construction, exclusion zones would be established around Cumberland Plain Land Snails habitat in the environmental protection area. All personnel would be inducted to understand the exclusion zone to limit the potential of trampling snails.
B8		Large woody debris cleared within the proposal site would be relocated into habitat to the west of the proposal site.
B9	Potential impacts to the Green and Golden Bell Frog	Pre-clearing surveys for the Green and Golden Bell Frog would be undertaken by a suitably qualified ecologist within 48 hours prior to the commencement of clearing and dewatering of potential habitat to ensure that individuals have not inhabited the site. A suitably qualified ecologist would also be present during the dewatering of the habitat. A stop work in the immediate vicinity would be implemented if this species is identified on the proposal site, and then further consideration of approach to management of individuals on proposal site, through consultation with a Green and Golden Bell Frog expert.
B10		Any work in and around the suitable Green and Golden Bell Frog habitat during clearing would follow the Hygiene Protocol for the Control of Disease in Frogs (Department of Environment and Climate Change 2008b) to reduce the potential for introduction and spread of Chytrid fungus.
B11	Potential impacts from introduction and spread of weeds	Weed control would be undertaken by suitably qualified and/or experienced personnel. This may include: ▪ Manual weed removal in preference to herbicides ▪ Replacing non-target species removed/killed as a result of weed control activities

No.	Potential impacts	Mitigation measure
		▪ Protecting non-target species from spray drift ▪ Using only herbicides registered for use within or near waterways for the specific target weed ▪ Applying herbicides during drier times when the waterway level is below the high-water mark ▪ Not applying herbicide if it is raining or if rain is expected ▪ Mixing and loading herbicides, and cleaning equipment away from waterways and drains
B12		During construction, weed management would be undertaken in areas affected by construction prior to any clearing works in accordance with the *Biosecurity Act 2015* to ensure they are not spread to the surrounding environment; including during transport disposal off-site to a licenced waste disposal facility.
B13		All weeds, propagules, other plant parts and/or excavated topsoil material that is likely to be infested with weed propagules that are likely to regenerate would be treated on site or bagged, removed from site and disposed of at a licensed waste disposal facility.
B14	Potential impacts from introduction and spread of plant pathogens	During construction, all vehicles driving to and from site would follow a protocol to prevent the spread or introduction of phytophthora, namely vehicles would be clean, including the tyres and any equipment.

9. Conclusion

The key impacts of the proposal include the removal of 1.92 hectares of native vegetation belonging to three Plant Community Types (PCTs) and three Threatened Ecological Communities (TECs) including:

- 1.74 hectares of Cumberland Plain Woodland in the Sydney Basin Bioregion (BC Act: listed as critically endangered)
- 0.07 hectares of River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act: listed as endangered)
- <0.001 hectares of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EPBC Act: listed as critically endangered); a subset of the 1.74 hectares of the associated BC Act listed Cumberland Plain Woodland community.

Over 30 *Grevillea juniperina subsp. juniperina* plants, listed as vulnerable under the BC Act, were identified in the ecological study area (but outside of the proposal site) and around 0.06 hectares of potential habitat would be impacted. The native vegetation to be removed provides habitat (or potential habitat) for 18 threatened animal species that were either identified in the ecological study area (i.e. Cumberland Plain Land Snail) or are considered at least moderately likely to occur based on the presence of suitable habitat (e.g. Green and Golden Bell Frog, Grey-headed Flying Fox).

Fauna injury or death has the greatest potential to occur during construction when vegetation clearing would occur, and the extent of this impact would be proportionate to the extent of vegetation that is cleared. Indirect / operational impacts would include a minor increase in habitat isolation. Invasion and spread of weeds, invasion and spread of pests, and invasion and spread of pathogens and disease are a risk with a proposal of this type. Noise, light and vibration would be increased during construction and operation. Significant impacts to aquatic ecosystems are unlikely to occur as a result of the proposal.

The ecological study area is situated in an over-cleared landscape due to historic activities. In the context of historic vegetation removal, any future vegetation clearing no matter how small would result in incremental cumulative impact that would detrimentally affect biodiversity. In combination with other projects in the area, the proposal would contribute to cumulative biodiversity impacts and may result in detrimental impacts to biodiversity (refer to Chapter 8 of the REF for full assessment).

Although efforts have been made to avoid, minimise and mitigate potential ecological impacts from the proposal, some residual impacts would occur. Management measures would be implemented during the construction and operational phases to mitigate the potential ecological impacts of the proposal. This assessment has identified a range of mitigation techniques to be implemented during construction and operation (see **Section 8.2**). Due to the presence of the critically endangered ecological communities and threatened fauna habitat, exclusion zones would be established to delineate the works limit boundary to ensure no accidental impacts occur.

The overall outcome of the BC Act tests of significance and EPBC Act assessments of significance (see **Appendix C**) indicate that there is a high level of certainty that the impacts to threatened biodiversity are unlikely to be significant.

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Appendix A. Plant species recorded

Table A-1 Recorded plants

Scientific Name	Growth form code*	Cover estimate (%)						
		849 - Mod	849 – Derived Grassland		835 – Poor	1071 - Poor	849 - Poor	
		Plot 1	Plot 2	Plot 7	Plot 3	Plot 4	Plot 5	Plot 6
Angophora subvelutina	TG				5			
Aristida vagans	GG	1		0.5				0.5
Aster subulatus	EX	0.1	0.1					
Axonopus fissifolius	HT		3	5	1			
Bidens pilosa	EX	0.2			0.5			
Bothriochloa macra	GG	0.2	0.5		0.5		2	
Brassica fruticulosa	EX	0.1						
Casuarina glauca	TG					0.3		
Cheilanthes sieberi	EG							0.2
Chloris truncata	GG						5	
Cladium procerum	GG					3		
Commelina cyanea	FG				0.1			
Conyza bonariensis	EX	0.1					0.1	
Cynodon dactylon	GG	4	5	3	1			1
Cyperus brevifolius	EX	0.1	0.1	0.2	0.1		0.1	0.1
Cyperus gracilis	GG						0.1	
Cyperus spp.	GG				0.1			
Dichondra repens	FG	0.1						
Einadia trigonos	FG				0.1			
Eragrostis brownii	GG	0.1	0.5					
Eragrostis curvula	HT	5	0.5		1		0.2	5
Eragrostis leptostachya	GG	0.5			2		0.5	1
Eucalyptus moluccana	TG	2					5	2
Eucalyptus tereticornis	TG	15	2	0.1	35		15	10
Fimbristylis dichotoma	GG	1	0.1					
Fimbristylis ferruginea	GG			0.1				0.2
Gamochaeta americana	EX		0.1				0.1	
Glycine tabacina	OG				0.3			

Scientific Name	Growth form code*	Cover estimate (%)						
		849 - Mod	849 – Derived Grassland		835 – Poor	1071 - Poor	849 - Poor	
		Plot 1	Plot 2	Plot 7	Plot 3	Plot 4	Plot 5	Plot 6
Hypochaeris radicata	EX		0.5	0.3	0.2			0.2
Hypoxis hygrometrica	FG		0.1	0.1			0.1	0.1
Lomandra longifolia	GG							0.1
Ludwigia peploides	FG					0.5		
Ludwigia peruviana	HT					1		
Lycium ferocissimum	HT				0.5			
Microlaena stipoides	GG	5	2		5		5	15
Oxalis perennans	FG			0.1	0.1		0.1	0.1
Oxalis spp.	FG		0.1					
Paspalidium distans	GG	0.3			0.1		0.5	
Paspalum dilatatum	HT	10	5	20	40		50	4
Persicaria lapathifolia	FG					2		
Phyllanthus virgatus	FG				0.1			
Plantago lanceolata	EX				0.1		0.1	
Rumex spp.	FG						0.1	
Salvinia molesta	HT					1		
Senecio madagascariensis	HT	0.1	0.1	0.1	0.5		0.2	0.2
Setaria parviflora	EX	4	5	0.5	10		15	5
Sida rhombifolia	EX	0.3			2			
Solanum nigrum	EX	0.2						
Solanum pseudocapsicum	EX	0.5			0.2		0.2	
Solanum linnaeanum	EX	0.1					0.1	
Sonchus oleraceus	EX	0.2					0.1	
Sporobolus creber	GG	0.2	0.5		0.5		0.1	0.5
Sporobolus fertilis	HT				0.5			
Taraxacum officinale	EX							0.1
Themeda triandra	GG	0.5	35	30			0.5	5
Trifolium arvense	EX	0.1						
Triglochin spp.	FG					0.2		
Typha orientalis	GG					5		
Wahlenbergia gracilis	FG	0.1			0.1		0.1	0.1
**GF code: TG = Tree, SG = Shrub, GG = Grass and grass-like, FG = Forb, EG = Fern, OG = Other, HT = High Threat weed, EX = Exotic*								

Appendix B. Habitat assessment table

Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the ecological study area during the current survey
High	It is highly likely that a species inhabits the ecological study area and is dependent on identified suitable habitat (i.e. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10km) and is known or likely to maintain resident populations in the ecological study area. Also includes species known or likely to visit the ecological study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the ecological study area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the ecological study area opportunistically or during migration. The species is unlikely to be dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on habitat within the ecological study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the ecological study area and has not been recorded recently in the locality (10km). It may be an occasional visitor, but habitat similar to the ecological study area is widely distributed in the local area, meaning that the species is not dependent (i.e. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the ecological study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the ecological study area.

Table B-1 Habitat assessment table – Threatened Flora

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Bynoe's Wattle	*Acacia bynoeana*	E	V	Occurs south of Dora Creek-Morisset area to Berrima and the Illawarra region and west to the Blue Mountains. It grows mainly in heath and dry sclerophyll forest on sandy soils (Harden, 2002). Seems to prefer open, sometimes disturbed sites such as trail margins and recently burnt areas. Typically occurs in association with Corymbia gummifera, Eucalyptus haemastoma, E. gummifera, E. parramattensis, E. sclerophylla, Banksia serrata and Angophora bakeri (NSW National Parks and Wildlife Service, 1999a).	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Downy Wattle	*Acacia pubescens*	V	V	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs 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. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone.	PMST, 136 – BioNet	Low – widely recorded in the area. Some areas of suitable habitat around the ecological study area (Cumberland Shale Plains Woodland), however much of the habitat is too disturbed for this species. Surveys did not identify this species.
Allocasuarina glareicola	*Allocasuarina glareicola*	E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil.	PMST, 1 – BioNet	Low – single record in St Mary's. No suitable habitat and no records found nearby.
Netted Bottlebrush	*Callistemon linearifolius*	V	-	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Was more widespread across its distribution in the past. Some populations are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve, and Spectacle Island Nature Reserve. Further north it has been recorded from Yengo National Park and Werakata National Park. Grows in dry sclerophyll forest on the coast and adjacent ranges.	1 – BioNet	Low – single record in McMahon. Suitable habitat may be presented by Cumberland River Flat Forest adjacent to the ecological study area. Surveys did not identify this species.
White-flowered Wax Plant	*Cynanchum elegans*	E	E	Occurs from the Gloucester district to the Wollongong area and inland to Mt Dangar where it grows in rainforest gullies, scrub and scree slopes (Harden, 1992). This species typically occurs at the ecotone between dry subtropical forest/woodland communities.	PMST, 1 – BioNet	Low – single record near Abbotsbury. No suitable habitat in ecological study area and no records found nearby.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Dillwynia tenuifolia, Kemps Creek	*Dillwynia tenuifolia* - endangered population	E2	-	In western Sydney, Dillwynia tenuifolia is generally found on alluvial soils or on residual soil landscapes near the alluvial boundary. In this region this species is strongly associated with the alluvial Hawkesbury – Nepean Terrace Gravels (ferruginised clay and consolidated sand of the Londonderry Clay, the conglomerate of the Rickabys Creek Gravels, laterised sand and clay of the St Mary's Formation). Dillwynia tenuifolia also occurs to a lesser extent on the residual Cumberland Plain landscape on the Bringelly Shale and Ashfield Shale where there is influence from the quaternary alluvium of the Hawkesbury – Nepean Channels and Floodplains (eg South Creek, Kemps Creek, Ropes Creek, and Eastern Creek) and where the gravelly Berkshire Park soil landscape is present (i.e. Kemps Creek, Scheyville). This species is strongly associated with vegetation types including Castlereagh Scribbly Gum Woodland, Cooks River Castlereagh Ironbark Forest, and Shale/Gravel Transition Forest. Some outlier occurrences of Dillwynia tenuifolia occur in patches of Shale Plains Woodland or Alluvial Woodland where these communities intergrade with the aforementioned vegetation types.	873 – BioNet	Low – many records found north of Erskine Park. Found in Cumberland River Flat Forest, which is found adjacent to the ecological study area. Surveys were undertaken for this species and it was not identified in the ecological study area or immediate surrounds.
Yellow Gnat-orchid	*Genoplesium baueri*	E	E	The species has been recorded from locations between Ulladulla and Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga. No collections have been made from those sites in recent years. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded at locations now likely to be within the following conservation reserves: Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. May occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments. Grows in dry sclerophyll forest and moss gardens over sandstone.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Juniper-leaved Grevillea	*Grevillea juniperina* subsp. *juniperina*	V	-	In the locality, Grevillea juniperina subsp. juniperina is highly associated with the Quaternary alluvium of South Creek and the Londonderry Clay and areas of adjacent Bringelly Shale.	1095 – BioNet	Recorded – this species was recorded in several locations in the ecological study area.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Small-flower Grevillea	*Grevillea parviflora* subsp. *parviflora*	V	V	Grevillea parviflora subsp. parviflora occurs sporadically throughout the Sydney Basin. It occurs on ridge crests, upper slopes or flat plains in both low-lying areas between 30–65 m above sea level and on higher topography between 200–300 m above sea level south of Sydney. It occurs in sandy or light clay soils, usually over thin shales often with lateritic ironstone gravels which are often infertile and poorly drained. Soils are mostly derived from Tertiary sands or alluvium and from the Mittagong Formation with alternating bands of shale and fine-grained sandstones. This species is known from Kemps Creek on the sandy lateritic soils and a recent record from Ropes Creek at Mt Druitt on the alluvial South Creek formation soils.	PMST, 18 – BioNet	Low – nearest records at Ropes Creek at Mt Druitt near Cumberland River Flat Forest. Suitable habitat may be present adjacent the ecological study area.
Wingless Raspwort	*Haloragis exalata* subsp. *exalata*	V	V	Square Raspwort occurs in 4 widely scattered localities in eastern NSW. It has a disjunct distributed in the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW. Square Raspwort appears to require protected and shaded damp situations in riparian habitats. Flowering specimens in NSW are recorded from November to January.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Hibbertia puberula	*Hibbertia puberula*	E	-	Recent work on this species and its relatives has shown it to be widespread, but never common. It extends from Wollemi National Park south to Morton National Park and the south coast near Nowra. It favours low heath on sandy soils or rarely in clay, with or without rocks underneath.	3 – BioNet	Low – nearest records found near Willmot. No suitable habitat in the ecological study area and no records found nearby.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	*Marsdenia viridiflora* subsp. *viridiflora* - endangered population	E2	-	Endangered population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas. Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Grows in vine thickets and open shale woodland.	80 – BioNet	Low – numerous records scattered around Erskine Park. Found in in Cumberland Shale Plains Woodland, which is present on site. Surveys were undertaken for this species and it was not identified in the ecological study area or immediate surrounds.
Micromyrtus minutiflora	*Micromyrtus minutiflora*	E	V	The occurrences of Micromyrtus minutiflora to the north west of the ecological study area (Londonderry, Llandilo, Agnes Banks, Berkshire Park) are strongly associated with the Hawkesbury – Nepean Terrace Gravels and the presence of the Londonderry Clay geological formation (clay with sand – top layer hard, semi-indurated zone of cemented ironstone pisolites) with the Berkshire Park and Agnes Banks soil landscapes (laterite and sand).	PMST, 6 – BioNet	Low – nearest records found in Ropes Crossing. No suitable habitat in the ecological study area.
Tall Knotweed	*Persicaria elatior*	V	V	Tall Knotweed has been recorded in south-eastern NSW (Mt Dromedary (an old record), Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Hairy Geebung	*Persoonia hirsuta*	E	E	Persoonia hirsuta is patchily distributed on the Central Coast and Tablelands of NSW, in an area bounded by Putty, Glen Davis and Gosford in the north, and Royal National Park (NP) and Hill Top in the south. It occurs in the Sydney coastal area (Gosford, Berowra, Manly and Royal NP), the Blue Mountains area (Springwood, Lithgow and Putty) and the Southern Highlands (Balmoral, Buxton, Yanderra and Hill Top). It is frequently found on ridge tops and the mid slopes of hills and rises in dry sclerophyll forest and woodland with a shrubby understorey, heath, shrubby thickets and sandstone scrubs from near sea level to 600 m altitude. Associated canopy species include Eucalyptus sclerophylla, Corymbia gummifera, Leptospermum trinervium, Eucalyptus sieberi, Eucalyptus punctata, Eucalyptus sparsifolia, Corymbia eximia and Banksia ericifolia. It grows on sandy to stony soils derived from sandstone or very rarely on shale and is often found in disturbed areas, like along track edges.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Nodding Geebung	*Persoonia nutans*	E	E	Persoonia nutans is restricted to the Cumberland Plain. It is known from an area between Richmond and Macquarie Fields, particularly near the Nepean and Georges Rivers. The range of the species is fragmented, with about 99 per cent of the known populations occurring in the north of the distribution at Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs. This species is also known from Kemps Creek on the sandy lateritic soils. Persoonia nutans is strongly associated with the Hawkesbury – Nepean Terrace Gravels and the presence of the Londonderry Clay geological formation (clay with sand – top layer hard, semi-indurated zone of cemented ironstone pisolites) with the Berkshire Park and Agnes Banks soil landscapes (laterite and sand).	PMST, 32 – BioNet	Low – nearest records found north of Erskine Park near Colyton. Suitable habitat may be present adjacent the ecological study area in riparian vegetation.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Austral Pillwort	*Pilularia novae-hollandiae*	E	-	In NSW, Austral Pilwort has been recorded from suburban Sydney, Khancoban, the Riverina between Albury and Urana (including Henty, Walbundrie, Balldale and Howlong) and at Lake Cowal near West Wyalong. The population at Lake Cowal is the only known extant population in NSW. The species has also been recorded in the Australian Capital Territory, Victoria, Tasmania, South Australia and Western Australia. 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. Most of the records in the Albury-Urana area were from table drains on the sides of roads.	1 – BioNet	Low – single record from 1966 from Doonside. No suitable habitat and no records found nearby.
Pimelea curviflora var. *curviflora*	*Pimelea curviflora* var. *curviflora*	V	V	Pimelea curviflora var. curviflora occurs on ridge tops and upper slopes in open forest and woodland on sandy soil derived from sandstone, on shaley/lateritic soils and shale/sandstone transition soils. The population at Albion Park on the Illawara coastal plain occurs in Lowland Grassy Woodland habitat. It often grows among dense grasses and sedges making it difficult to detect.	PMST, 3 – BioNet	Low – nearest records at Arndell Park from 2018 in disturbed vegetation similar to ecological study area. However preferred soil type and habitat for this species not present in ecological study area. Ecological study area does not contain ridge tops or upper slopes.
Spiked Rice-flower	*Pimelea spicata*	E	E	The Spiked Rice-flower occurs in two disjunct areas; the Cumberland Plain (Marayong and Prospect Reservoir south to Narellan and Douglas Park) and the Illawarra (Landsdowne to Shellharbour to northern Kiama). The western Sydney/Cumberland Plain populations occur on undulating to hilly country in remnant bushland on Wiannamatta shales. Habitats include open woodlands and grasslands of Grey Box (Eucalyptus moluccana), Narrow-leaved Ironbark (E. crebra), Forest Redgum (E. tereticornis), Blackthorn (Bursaria spinosa) and Kangaroo Grass (Themeda triandra).	PMST, 198 – BioNet	Low – nearest records east of the ecological study area closer to Eastern Creek. Suitable habitat around Ropes Creek in west of the ecological study area. Surveys were undertaken for this species. The highest quality area of habitat would be avoided.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Brown Pomaderris	*Pomaderris brunnea*	E	V	Within the Hawkesbury–Nepean region, Pomaderris brunnea is known from a small area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden. It is largely restricted to the Picton – Razorback Hills and Nattai Plateau. It is also found near Camden on the Cumberland Plain, Hawkesbury – Nepean Channels and Floodplains, and Hawkesbury – Nepean Terrace Gravels. This species shows a strong preference for alluvial soils and the shale/sandstone transitional zone of the residual Lucas Heights soil landscape around Bargo. Suitable habitat is the Sydney Hinterland Transitional Woodland around Bargo and the Alluvial Woodland and Riparian Forest along the Nepean River at Camden.	PMST	Low – no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat. However, preferred soils and vegetation found bordering ecological study area. Surveys were undertaken for this species and it was not identified in the ecological study area or immediate surrounds.
Illawarra Greenhood	*Pterostylis gibbosa*	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage. In the Illawarra region, the species grows in woodland dominated by Forest Red Gum Eucalyptus tereticornis, Woollybutt E. longifolia and White Feather Honey-myrtle Melaleuca decora.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Sydney Plains Greenhood	*Pterostylis saxicola*	E	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated. Only one population occurs within a conservation reserve (Georges River National Park). Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where Pterostylis saxicola occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils.	PMST, 1 – BioNet	Low – record found near Arndell Park. No sandstone rock shelves above cliff lines present in the ecological study area.

Common Name	Scientific Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Sydney Bush Pea	*Pultenaea parviflora*	E	V	Pultenaea parviflora is confined to the Cumberland Plain and is mainly found between Penrith and Windsor. Pultenaea parviflora is generally found in scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on Wianamatta shale, tertiary alluvium or laterised clays, and in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland.	PMST, 394 – BioNet	Low - records scattered throughout the locality. Nearest records in Erskine park 1.6km NE of the ecological study area. Vegetation in the ecological study area does not meet the description for preferred habitat of this species. Surveys were undertaken for this species and it was not identified in the ecological study area or immediate surrounds.
Magenta Lilly Pilly	*Syzygium paniculatum*	E	V	Occurs between Bulahdelah and St Georges Basin where it grows in subtropical and littoral rainforest on sandy soils or stabilized dunes near the sea (Harden, 2002). On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Austral Toadflax	*Thesium australe*	V	V	Austral Toad-flax is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia. Although originally described from material collected in the SW Sydney area, populations have not been seen in a long time. It may persist in some areas in the broader region. Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast.	PMST	Low – this species has not been recorded in the locality, Cumberland Shale Plains Woodland occurs in the ecological study area which meets the grassy woodland habitat requirement for this species.

*PMST – Protected Matters Search Tool, BioNet – BioNet Atlas of NSW

Table B-2 Habitat assessment table – Threatened Fauna

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Frogs						
Heleioporus australiacus	Giant Burrowing Frog	V	V	In the northern population there is a marked preference for sandstone ridgetop habitat and broader upland valleys. In these locations, the frog is associated with small headwater creek lines and along slow flowing to intermittent creek lines. The vegetation is typically woodland, open woodland and heath and may be associated with 'hanging swamp' seepage lines and where small pools form from the collected water. They have also been observed occupying artificial ponded structures such as fire dams, gravel 'borrows', detention basins and box drains that have naturalised over time and are still surrounded by other undisturbed habitat. Do not appear to inhabit areas that have been cleared for agriculture or for urban development. Breed in summer and autumn in burrows in the banks of small creeks (Cogger, 2000, NSW National Parks and Wildlife Service, 2001a).	PMST	Low – the habitats in the ecological study area are not considered suitable for this species.
Litoria aurea	Green and Golden Bell Frog	E	V	Various types of habitat have been documented. For breeding utilises a wide range of waterbodies, including both natural and man-made structures, such as marshes, dams and stream sides, and ephemeral locations that are more often dry than wet. Is found in various small pockets of habitat in otherwise developed areas and has the tendency of often turning up in highly disturbed sites. Lotic situations such as fast flowing streams appear to be one of the few water bodies not utilised, at least for breeding purposes (Department of Environment and Conservation, 2004a, Department of Environment and Conservation, 2005).	PMST ,19 – BioNet	Moderate – the dams offer suitable habitat for this species. Considering the location of a record on Ropes Creek from 2012, this species may disperse to and occur in the habitats in the ecological study area. No targeted surveys were undertaken as part of this assessment, however recent surveys for the Archbold Road upgrade (WSP | Parsons Brinckerhoff 2017) did not detect this species.
Litoria raniformis	Growling Grass Frog	E	V	The species is currently widespread throughout the Murray River valley and has been recorded from six Catchment Management Areas in NSW: Lower Murray Darling, Murrumbidgee, Murray, Lachlan, Central West and South East. Found mostly amongst emergent vegetation, including Typha sp. (bullrush), Phragmites sp. (reeds) and Eleocharis sp.(sedges), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Birds						
Actitis hypoleucos	Common Sandpiper	-	M	Found along all coastlines of Australia and in many areas inland, the Common Sandpiper is widespread in small numbers. The species utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Anthochaera phrygia	Regent Honeyeater	CE	CE	Occurs mostly in box-ironbark forests and woodland and prefers the wet, fertile sites such as along creek flats, broad river valleys and foothills. Riparian forests with Casuarina cunninghamiana and Amyema cambagei are important for feeding and breeding. Important food trees include Eucalyptus sideroxylon (Mugga Ironbark), E. albens (White Box), E. melliodora (Yellow Box) and E. leucoxylon (Yellow Gum) (Garnett and Crowley, 2000) with Eucalyptus robusta (Swamp Mahogany) and Corymbia maculata (Spotted Gum) used in coastal habitats.	PMST, 9 – BioNet	Low – the Regent Honeyeater is a rare visitor to the locality and has not been recorded since 1995 when it was found in a residential garden in the Blacktown LGA. This species is a sporadic visitor to the area and would focus habitat use on larger areas of flowering eucalypts in winter.
Apus pacificus	Fork-tailed Swift	-	M	Recorded in all regions of NSW. The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher.	PMST, 5 – BioNet	Moderate – likely to fly over the ecological study area.
Ardea alba	Great Egret	-	M	Widespread in Australia. Reported in a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial).	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Artamus cyanopterus	Dusky Woodswallow	V	-	The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests (Higgins and Peter, 2002).	27 – BioNet	Moderate - likely to fly over the ecological study area. May use vegetation in the ecological study area on occasion though this species was not recorded during surveys.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Botaurus poiciloptilus	Australasian Bittern	V	E	Occurs in shallow, vegetated freshwater or brackish swamps. Requires permanent wetlands with tall dense vegetation, particularly bulrushes and spike rushes. When breeding, pairs are found in areas with a mixture of tall and short sedges but will also feed in territory that is more open. (Garnett and Crowley, 2000, NSW National Parks and Wildlife Service, 2002b).	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Burhinus grallarius	Bush Stone-curlew	E	-	Open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights. Feed on insects and small vertebrates, such as frogs, lizards and snakes. Nest on the ground in a scrape or small bare patch.	2 – BioNet	Low – conspicuous species that is no longer known from the region. Last records of this species in the locality are from 1996 from near Penrith.
Calidris acuminata	Sharp-tailed Sandpiper	-	M	The Sharp-tailed Sandpiper spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand. Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations and in both freshwater and saline habitats. Many inland records are of birds on passage. Prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation; this includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland. They also occur in saltworks and sewage farms. They use flooded paddocks, sedgelands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets, estuaries or seashores, and also swamps and creeks lined with mangroves. They tend to occupy coastal mudflats mainly after ephemeral terrestrial wetlands have dried out, moving back during the wet season. Sometimes they occur on rocky shores and rarely on exposed reefs.	1 – BioNet	Low – record from 2018 near Badgerys Creek, however record cannot be verified. No suitable habitat in the ecological study area.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Calidris ferruginea	Curlew Sandpiper	E	CE	In Australia, Curlew Sandpipers occur around the coasts of all states and are also quite widespread inland, though in smaller numbers. They occur in Australia mainly during the non-breeding period but also during the breeding season when many non-breeding one-year old birds remain. Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They generally roost on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands, occasionally roosting in dunes during very high tides and sometimes in saltmarsh and in mangroves.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Calidris melanotos	Pectoral Sandpiper	-	M	In New South Wales (NSW), the Pectoral Sandpiper is widespread, but scattered. Records exist east of the Great Divide, from Casino and Ballina, south to Ulladulla. West of the Great Divide, the species is widespread in the Riverina and Lower Western regions. Prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	Occurs in wetter forests and woodland from sea level to an altitude over 2000 metres, timbered foothills and valleys, coastal scrubs, farmlands and suburban gardens (Pizzey and Knight, 1997).	1 – BioNet	Low – record in suburban area near Abbotsbury. There is a low possibility that this species may visit the ecological study area as a vagrant.
Calyptorhynchus lathami	Glossy-black Cockatoo	V	-	The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. An isolated population exists on Kangaroo Island, South Australia. Inhabits open forest and woodlands of the coast and the Great Dividing Range where stands of Sheoak occur. Black Sheoak (Allocasuarina littoralis) and Forest Sheoak (A. torulosa) are	1 – BioNet	Low – record in suburban area near Kingswood. No suitable feed trees in or around the ecological study area. There is a low possibility that this species may visit the ecological study area as a vagrant.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
				important foods. Inland populations feed on a wide range of Sheoaks, including Drooping Sheoak, Allocasuarina diminuta, and A. gymnanthera. Belah is also utilised and may be a critical food source for some populations. In the Riverina, birds are associated with hills and rocky rises supporting Drooping Sheoak, but also recorded in open woodlands dominated by Belah (Casuarina cristata).		
Chthonicola sagittata	Speckled Warbler	V	-	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt re-growth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area. Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding. The rounded, domed, roughly built nest of dry grass and strips of bark is located in a slight hollow in the ground or the base of a low dense plant, often among fallen branches and other litter.	12 – BioNet	Low – all records from a reserve near Penrith and generally old. Native vegetation present in the ecological study area may provide habitat for this species however considered to be an uncommon visitor.
Cuculus optatus	Oriental Cuckoo	-	M	Migrates from Eurasia as far south as Indonesia, New Guinea and North Australia. Some remain through Australia in the winter. Inhabits rainforest margins, monsoon forest, vine scrub and mangroves.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Daphoenositta chrysoptera	Varied Sittella	V	-	The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. The Varied Sittella feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees, and from small branches and twigs in the tree canopy. It builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.	32 – BioNet	Moderate – records scattered throughout locality. One record located 500m north of the ecological study area from 1996. Native vegetation present in the ecological study area may provide habitat for this species.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Dasyornis brachypterus	Eastern Bristlebird	E	E	The distribution of the Eastern Bristlebird has contracted to three disjunct areas of south-eastern Australia. There are three main populations: Northern - southern Queensland/northern NSW, Central - Barren Ground NR, Budderoo NR, Woronora Plateau, Jervis Bay NP, Booderee NP and Beecroft Peninsula and Southern - Nadgee NR and Croajingalong NP in the vicinity of the NSW/Victorian border. Habitat for central and southern populations is characterised by dense, low vegetation including heath and open woodland with a heathy understorey. In northern NSW the habitat occurs in open forest with dense tussocky grass understorey and sparse mid-storey near rainforest ecotone; all of these vegetation types are fire prone.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	In Australia, Black-necked Storks are widespread in coastal and subcoastal northern and eastern Australia, as far south as central NSW (although vagrants may occur further south or inland, well away from breeding areas). In NSW, the species becomes increasingly uncommon south of the Clarence Valley, and rarely occurs south of Sydney. Since 1995, breeding has been recorded as far south as Bulahdelah. Floodplain wetlands (swamps, billabongs, watercourses and dams) of the major coastal rivers are the key habitat in NSW for the Black-necked Stork. Secondary habitat includes minor floodplains, coastal sandplain wetlands and estuaries. Storks usually forage in water 5-30cm deep for vertebrate and invertebrate prey. Eels regularly contribute the greatest biomass to their diet, but they feed on a wide variety of animals, including other fish, frogs and invertebrates (such as beetles, grasshoppers, crickets and crayfish). Black-necked Storks build large nests high in tall trees close to water. Trees usually provide clear observation of the surroundings and are at low elevation (reflecting the floodplain habitat).	1 – BioNet	Low – some marginal habitat is present on the site however this species is very uncommon in the region.
Gallinago hardwickii	Latham's Snipe	-	M	Occurs in freshwater or brackish wetlands generally near protective vegetation cover. This species feeds on small invertebrates, seeds and vegetation. It migrates to the northern hemisphere to breed (Garnett and Crowley, 2000).	10 – BioNet	Low – no suitable habitat in the ecological study area.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Glossopsitta pusilla	Little Lorikeet	V	-	The distribution of the Little Lorikeet extends from just north of Cairns, around the east coast of Australia, to Adelaide. In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri (Royal Australian Ornithologists Union, 2003). Little Lorikeets are generally considered to be nomadic (Higgins, 1999) and forage mainly on flowers, nectar and fruit. The breeding biology of Little Lorikeets is little known however studies indicate that nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts, and hollow openings are approximately 3 cm in diameter (Courtney and Debus, 2006).	7 – BioNet	High – recorded in 2019 300m from ecological study area in Shale Plains Woodland, which also occurs in the ecological study area. Commonly recorded species in the region.
Grantiella picta	Painted Honeyeater	V	V	Lives in dry forests and woodlands. Primary food is the mistletoes in the genus Amyema, though it will take some nectar and insects. Its breeding distribution is dictated by presence of mistletoes which are largely restricted to older trees. Less likely to be found in in strips of remnant box-ironbark woodlands, such as occur along roadsides and in windbreaks, than in wider blocks (Garnett and Crowley, 2000).	PMST	Low – there is a low possibility that this species may visit the ecological study area as a vagrant and it is unlikely to breed in the locality. Has not been previously recorded in the locality.
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	M	Distributed along the coastline (including offshore islands) of mainland Australia and Tasmania. Found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. The habitats occupied by the sea-eagle are characterised by the presence of large areas of open water (larger rivers, swamps, lakes, and the sea).	9 – BioNet	Low – there is a low possibility that this species may visit the ecological study area as a vagrant, but no high-quality habitat is present. No large stick nests were observed during surveys.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Hieraaetus morphnoides	Little Eagle	V	-	The Little Eagle is distributed throughout the Australian mainland occupying habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring. Prey includes birds, reptiles and mammals, with the occasional large insect and carrion. Most of its former native mammalian prey species in inland NSW are extinct and rabbits now form a major part of the diet (Marchant and Higgins, 1993).	20 – BioNet	Moderate – this species may visit the ecological study area on occasion to hunt, but no high-quality habitat is present. No large stick nests were observed during surveys.
Hirundapus caudacutus	White-throated Needletail	-	M	Occurs in airspace over forests, woodlands, farmlands, plains, lakes, coasts and towns. Breeds in the northern hemisphere and migrates to Australia in October-April (Pizzey and Knight, 1997).	PMST, 1 – BioNet	Low – a migrant that does not breed in the locality. Only likely to forage in the aerial spaces above the site.
Ixobrychus flavicollis	Black Bittern	V	-	The Black Bittern is found along the coastal plains within NSW, although individuals have rarely been recorded south of Sydney or inland. It inhabits terrestrial and estuarine wetlands such as flooded grasslands, forests, woodlands, rainforests and mangroves with permanent water and dense waterside vegetation. The Black Bittern typically roosts on the ground or in trees during the day and forages at night on frogs, reptiles, fish and invertebrates. The breeding season extends from December to March. Nests are constructed of reeds and sticks in branches overhanging the water.	1 – BioNet	Low – there is a low possibility that this species may occur along Ropes Creek as a vagrant, but no high-quality habitat is present in the ecological study area.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Lathamus discolor	Swift Parrot	E	CE	Breeding occurs in Tasmania, majority migrates to mainland Australia in autumn, over-wintering, particularly in Victoria and central and eastern NSW, but also south-eastern Queensland as far north as Duaringa. Until recently it was believed that in New South Wales, swift parrots forage mostly in the western slopes region along the inland slopes of the Great Dividing Range but are patchily distributed along the north and south coasts including the Sydney region, but new evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important. In mainland Australia is semi-nomadic, foraging in flowering eucalypts in eucalypt associations, particularly box-ironbark forests and woodlands (Garnett and Crowley, 2000),(Swift Parrot Recovery Team, 2001).	PMST, 35 – BioNet	Moderate – records scattered throughout the locality. Nearest record is from St Clair in 2014. This species is a migrant that does not breed in the locality. The Swift Parrot is considered moderately likely to occur within the ecological study area on an infrequent basis during winter migration.
Lophoictinia isura	Square-tailed Kite	V	-	This species hunts primarily over open forest, woodland and mallee communities as well as over adjacent heaths and other low scrubby habitats in wooded towns. It feeds on small birds, their eggs and nestlings as well as insects. Seems to prefer structurally diverse landscapes (Garnett and Crowley, 2000).	2 – BioNet	Low – this species may visit the ecological study area on occasion to hunt, but no high-quality habitat is present. No large stick nests were observed during surveys.
Melithreptus gularis gularis	Black-chinned Honeyeater	V	-	Extends south from central Queensland, through NSW, Victoria into south eastern South Australia, though it is very rare in the last state. In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. Occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially Mugga Ironbark (Eucalyptus sideroxylon), White Box (E. albens), Inland Grey Box (E. microcarpa), Yellow Box (E. melliodora), Blakely's Red Gum (E. blakelyi) and Forest Red Gum (E. tereticornis). Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks, river sheoaks (nesting habitat) and tea-trees.	1 – BioNet	Low – there is a low possibility that this species may visit the ecological study area as a vagrant, but no high-quality habitat is present in the ecological study area.
Merops ornatus	Rainbow Bee-eater	-	M	Distributed across much of mainland Australia, and occurs on several near-shore islands. Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation	2 - BioNet	Low – records from suburban area near Abbotsbury. There is a low possibility that this species may visit the ecological study area as a vagrant.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Monarcha melanopsis	Black-faced Monarch	-	M	Widespread in eastern Australia. Mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical (mesophyll) rainforest, subtropical (notophyll) rainforest, mesophyll (broadleaf) thicket/shrubland, warm temperate rainforest, dry (monsoon) rainforest and (occasionally) cool temperate rainforest.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Motacilla flava	Yellow Wagtail	-	M	Rare but regular visitor around Australian coast, especially in the NW coast Broome to Darwin. Found in open country near swamps, salt marshes, sewage ponds, grassed surrounds to airfields, bare ground; occasionally on drier inland plains.	PMST	Low – this species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat. There is a low possibility that this species may visit the ecological study area as a vagrant.
Myiagra cyanoleuca	Satin Flycatcher	-	M	Widespread in eastern Australia and vagrant to New Zealand. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests.	PMST	Low – this species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat. There is a low possibility that this species may visit the ecological study area as a migrant.
Neophema pulchella	Turquoise Parrot	V	-	Range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	1 – BioNet	Low – record from Prospect Reservoir. There is a low possibility that this species may visit the ecological study area as a vagrant but no high–quality habitat is present in the ecological study area.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Ninox strenua	Powerful Owl	V	-	A sedentary species with a home range of approximately 1000 hectares it occurs within open eucalypt, casuarina or Callitris pine forest and woodland. It often roosts in denser vegetation including rainforest of exotic pine plantations. Generally, feeds on medium-sized mammals such as possums and gliders but will also eat birds, flying-foxes, rats and insects. Prey are generally hollow dwelling and require a shrub layer and owls are more often found in areas with more old trees and hollows than average stands (Garnett and Crowley, 2000).	14 – BioNet	Moderate – nearest record between Erskine Park and Eastern Creek from 2015. Found in Shale Plains Woodland, which is also present in the ecological study area. Marginal foraging habitat present on site. No large tree hollows suitable for breeding were observed. This species may hunt in the ecological study area on occasion.
Numenius madagascariensis	Eastern Curlew	-	CE, M	Within Australia, the Eastern Curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sand flats, often with beds of seagrass.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Pandion haliaetus	Eastern Osprey	V	M	Generally, a coastal species, occurring in estuaries, bays, inlets, islands and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Sometimes ascends larger rivers to far inland. Builds nests high in tree, on pylon or on ground on islands. Feeds on fish (Pizzey and Knight, 1997).	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Petroica boodang	Scarlet Robin	V	-	In NSW, the Scarlet Robin occupies open forests and woodlands from the coast to the inland slopes. Some dispersing birds may appear in autumn or winter on the eastern fringe of the inland plains. It prefers an open understorey of shrubs and grasses and sometimes in open areas. Abundant logs and coarse woody debris are important structural components of its habitat. In autumn and winter, it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. It forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris (Higgins and Peter, 2002).	3 – BioNet	Low – marginal habitat in the ecological study area however this species is very uncommon in the locality and all recorded sighting are old.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Petroica phoenicea	Flame Robin	V	-	In NSW the Flame Robin breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. It migrates in winter to more open lowland habitats (Higgins and Peter, 2002). The Flame Robin forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other woody debris. The robin builds an open cup nest of plant fibres and cobweb, which is often near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank.	2 – BioNet	Low – marginal habitat in the ecological study area however this species is very uncommon in the locality and all recorded sighting are old.
Rhipidura rufifrons	Rufous Fantail	-	M	Occurs in coastal and near coastal districts of northern and eastern Australia. In east and south-east Australia, the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies usually with a dense shrubby understorey often including ferns.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Rostratula australis	Australian Painted snipe	E	E	The Australian Painted Snipe is restricted to Australia. Most records are from the south east, particularly the Murray Darling Basin, with scattered records across northern Australia and historical records from around the Perth region in Western Australia. In NSW many records are from the Murray-Darling Basin including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	1 – BioNet	Low – no suitable habitat in the ecological study area.
Stagonopleura guttata	Diamond Firetail	V	-	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum (Eucalyptus pauciflora) Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland. Nests are globular structures built either in the shrubby understorey, or higher up, especially under hawk's or raven's nests. Birds roost in dense shrubs or in smaller nests built especially for roosting.	2 – BioNet	Low – native vegetation present in the ecological study area may provide habitat however this species is very uncommon in the locality and all recorded sighting are old.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Stictonetta naevosa	Freckled Duck	V	-	Prefer permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds.	1 – BioNet	Low – no suitable habitat in the ecological study area for this species. The dams in the ecological study area are highly disturbed.
Tringa nebularia	Common Greenshank	-	M	The Common Greenshank does not breed in Australia, however, the species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia.	1 – BioNet	Low – no suitable habitat in the ecological study area for this species.
Tyto novaehollandiae	Masked Owl	V	-	Occurs within a diverse range of wooded habitats including forests, remnants and almost treeless inland plains. This species requires large-hollow bearing trees for roosting and nesting and nearby open areas for foraging. They typically prey on terrestrial mammals including rodents and marsupials but will also take other species opportunistically. Also known to occasionally roost and nest in caves (Garnett and Crowley, 2000).	6 – BioNet	Moderate – most suitable habitat is along Ropes Creek. This species may forage in the ecological study area on occasion though no breeding habitat is present.
Mammals						
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (Petrochelidon ariel), frequenting low to mid-elevation dry open forest and woodland close to these features. Found in well-timbered areas containing gullies.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Occurs from the Bundaberg area in south-east Queensland, south through NSW to western Victoria and Tasmania. In NSW, it occurs on both sides of the Great Dividing Range and north-east NSW represents a national stronghold (NSW National Parks and Wildlife Service, 1999d). Occurs in wide range of forest types, although appears to prefer moist sclerophyll and rainforest forest types, and riparian habitat. Most common in large unfragmented patches of forest. It has also been recorded from dry sclerophyll forest, open woodland and coastal heathland, and despite its occurrence in riparian areas, it also ranges over dry ridges. Nests in rock caves and hollow logs or trees. Feeds on a variety of prey including birds, terrestrial and arboreal mammals, small macropods, reptiles and arthropods (NSW National Parks and Wildlife Service, 1999c, NSW National Parks and Wildlife Service, 1999d).	PMST, 7 – BioNet	Low – the patches of habitat in the ecological study area are small and isolated from larger areas of potential habitat. Only possible on site as an extremely rare vagrant.
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	Usually roosts in tree hollows in higher rainfall forests. Sometimes found in caves (Jenolan area) and abandoned buildings. Forages within the canopy of dry sclerophyll forest. It prefers wet habitats where trees are more than 20 metres high (Churchill, 2008)	17 – BioNet	Moderate – native vegetation present in the ecological study area may provide habitat for this species.
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V	-	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in human-made structures.	54 – BioNet	Moderate – native vegetation present in the ecological study area may provide habitat for this species.
Miniopterus australis	Little Bent-winged Bat	V	-	Feeds on small insects beneath the canopy of well-timbered habitats including rainforest, Melaleuca swamps and dry sclerophyll forests. Roosts in caves and tunnels and has specific requirements for nursery sites. Distribution becomes coastal towards the southern limit of its range in NSW. Nesting sites are in areas where limestone mining is preferred (Strahan, 1995).	8 – BioNet	Moderate – native vegetation present in the ecological study area may provide habitat for this species.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	-	Usually found in well-timbered valleys where it forages on small insects above the canopy. Roosts in caves, old mines, stormwater channels and sometimes buildings and often return to a particular nursery cave each year (Churchill, 2008)	76 – BioNet	Moderate – native vegetation present in the ecological study area may provide habitat for this species.
Myotis macropus	Southern Myotis	V	-	Generally, roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December.	43 – BioNet	Moderate – there are many records from the locality and the habitat is suitable for foraging.
Petauroides volans	Greater Glider	-	V	The Greater Glider inhabits eucalyptus forests and woodlands as this species feeds exclusively on Eucalyptus buds and leaves. They occupy tree hollows in the day and tree canopies at night (Department of Environment and Climate Change 2007).	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Petaurus australis	Yellow-bellied Glider	V	-	Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria. Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Feed primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein. Extract sap by incising (or biting into) the trunks and branches of favoured food trees, often leaving a distinctive 'V'-shaped scar.	1 – BioNet	Low – no suitable habitat in the ecological study area for this species.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	The range of the Brush-tailed Rock-wallaby extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However, the distribution of the species across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.
Phascolarctos cinereus	Koala	V	V	Found in sclerophyll forest. Throughout New South Wales, Koalas have been observed to feed on the leaves of approximately 70 species of eucalypt and 30 non-eucalypt species. However, in any one area, Koalas will feed almost exclusively on a small number of preferred species. The preferred tree species vary widely on a regional and local basis. Some preferred species in NSW include Forest Red Gum Eucalyptus tereticornis, Grey Gum E. punctata, Monkey Gum E. cypellocarpa and Ribbon Gum E. viminalis. In coastal areas, Tallowwood E. microcorys and Swamp Mahogany E. robusta are important food species (NSW National Parks and Wildlife Service, 1999b, NSW National Parks and Wildlife Service, 2003).	PMST, 4 – BioNet	Low – associated habitat types present on site however patches of habitat are small and isolated from larger areas of potential habitat.
Pseudomys novaehollandiae	New Holland Mouse	-	V	The New Holland Mouse has a fragmented distribution across Tasmania, Victoria, NSW and Queensland. The species is now largely restricted to the coast of central and northern NSW, with one inland occurrence near Parkes. In NSW, the New Holland Mouse is known from: Royal National Park (NP) and the Kangaroo Valley; Kuringgai Chase NP; and Port Stephens to Evans Head near the Queensland border. Across the species' range, the New Holland Mouse is known to inhabit open heathland, open woodland with heathy understorey, and vegetated sand dunes.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Urban gardens and cultivated fruit crops also provide habitat for this species. Feeds on the flowers and nectar of eucalypts and native fruits including lilly pillies. It roosts in the branches of large trees in forests or mangroves (NSW National Parks and Wildlife Service, 2001b, Churchill, 2008)	422 – BioNet	Moderate – this species is likely to forage in the ecological study area on occasion.
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	V	-	Occurs in eucalypt forest where it feeds above the canopy and in mallee or open country where it feeds closer to the ground. Generally, a solitary species but sometimes found in colonies of up to 10. It roosts in tree hollows. Thought to be a migratory species (Churchill, 2008).	4 – BioNet	Moderate – this species is likely to forage in the ecological study area on occasion.
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	The preferred hunting areas of this species include tree-lined creeks and the ecotone of woodlands and cleared paddocks, but it may also forage in rainforest. Typically, it forages at a height of 3-6 metres but may fly as low as one metre above the surface of a creek. It feeds on beetles, other large, slow-flying insects and small vertebrates. It generally roosts in tree hollows but has also been found in the roof spaces of old buildings (Churchill, 2008)	22 – BioNet	Moderate – this species is likely to forage in the ecological study area on occasion.
Fish						
Macquaria australasica	Macquarie Perch	-	E	The Macquarie Perch is a riverine species that prefers clear water and deep, rocky holes with abundant cover such as aquatic vegetation, large boulders, debris and overhanging banks. In Victorian parts of the Murray-Darling, only small natural populations remain in the upper reaches of the Mitta Mitta, Ovens, Broken, Campaspe and Goulburn Rivers; translocated populations occur in the Yarra River and Lake Eildon. In NSW, natural inland populations are isolated to the upper reaches of the Lachlan and Murrumbidgee Rivers. Populations of the eastern form are confined to the Hawkesbury-Nepean and Shoalhaven river systems. Translocated populations in NSW are found in the Mongarlowe River, Queanbeyan River upstream of the Googong Reservoir and in Cataract Dam. In the ACT, it is restricted to the Murrumbidgee, Paddys and Cotter River.	PMST	None – ecological study area not suitable as habitat.

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence
Prototroctes maraena	Australian Grayling	E	V	The Australian Grayling is diadromous, spending part of its lifecycle in freshwater and at least part of the larval and/or juvenile stages in coastal seas. Adults (including pre spawning and spawning adults) inhabit cool, clear, freshwater streams with gravel substrate and areas alternating between pools and riffle zones. The species has also recorded in a muddy-bottomed, heavily silted habitat in the Tarwin River (Victoria). The species has been found over 100 km upstream from the sea. It has been recorded from many rivers across its range, particularly in Tasmania and Victoria. In NSW it is found from the Shoalhaven River south, with important river systems for the species including the Shoalhaven River, Bega River and Clyde River systems.	PMST	None – ecological study area not suitable as habitat.
Invertebrates						
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	449 – BioNet	Moderate – this species is likely to use habitats within the ecological study area.
Synemon plana	Golden Sun Moth	E	CE	The Golden Sun Moth's NSW populations are found in the area between Queanbeyan, Gunning, Young and Tumut. The species' historical distribution extended from Bathurst (central NSW) through the NSW Southern Tablelands, through to central and western Victoria, to Bordertown in eastern South Australia. Occurs in Natural Temperate Grasslands and grassy Box-Gum Woodlands in which groundlayer is dominated by wallaby grasses Austrodanthonia spp. Grasslands dominated by wallaby grasses are typically low and open - the bare ground between the tussocks is thought to be an important microhabitat feature for the Golden Sun Moth, as it is typically these areas on which the females are observed displaying to attract males. Habitat may contain several wallaby grass species, which are typically associated with other grasses particularly spear-grasses Austrostipa spp. or Kangaroo Grass Themeda australis.	PMST	Low – no suitable habitat and no records found nearby. This species has not been recorded in the locality in the past and predicted presence in the PMST is based on modelled habitat

Scientific Name	Common Name	BC Act	EPBC Act	Habitat requirements	Number of records (source)*	Likelihood of occurrence

Distribution and habitat requirement information adapted from:

- Australian Government Department of the Environment http://www.environment.gov.au/biodiversity/threatened/index.html
- NSW Department of Planning, Industry and Environment http://www.environment.nsw.gov.au/threatenedspecies/
- Department of Primary Industries – Threatened Fish and Marine Vegetation http://pas.dpi.nsw.gov.au/Species/All_Species.aspx
- Data source includes
- Number of records from the NSW Department of Planning, Industry and Environment Wildlife Atlas record data (Accessed March 2020); and
- Identified from the Protected Matters Search Tool (PMST) Australian Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/epbc/pmst/index.html

Key:

E = endangered species

E2 = endangered population

V = vulnerable species

M = migratory species

*PMST – Protected Matters Search Tool, BioNet – BioNet Atlas of NSW

Appendix C. Tests of significance

Tests of significance have been conducted for threatened species, populations and communities that were recorded in the ecological study area during field surveys or were identified as having a moderate or high potential to occur in the ecological study area based on the presence of suitable habitat (see Appendix B).

The proposal would be assessed under Part 5 of the EP&A Act. Section 7.3 of the BC Act outlines the ‘test of significance’ that is to be undertaken to assess the likelihood of significant impact upon threatened species or ecological communities listed under the BC Act. These tests of significance have been undertaken in accordance with the *Threatened Species Test of Significance Guidelines* (Office of Environment and Heritage 2018), which outlines a set of guidelines to help applicants/proponents of a development or activity with interpreting and applying the factors of the assessment process. The guidance provided by the former Office of Environment and Heritage has been used here in preparing these tests of significance and in determining whether there is likely to be a significant impact to a threatened species, population or ecological community listed under the BC Act.

For threatened biodiversity listed under the EPBC Act, significance assessments have been completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013). Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment that is affected, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of Environment, 2013). Importantly, for a ‘significant impact’ to be ‘likely’, it is not necessary for a significant impact to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility (Department of Environment, 2013). This advice has been considered while undertaking the assessments.

The ecological communities and species subject to this assessment are outlined in **Table C.1** along with the predicted impact from the proposal.

Table C.1 Threatened biodiversity subject to this assessment

Species / community	BC Act	EPBC Act	Predicted impact (habitat in ha)
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EPBC Act)	-	CE	<0.001 ha
Cumberland Plain Woodland in the Sydney Basin Bioregion (BC Act)	CE	-	1.74 ha
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act)	E	-	0.07 ha
Grevillea juniperina subsp. *juniperina*	V	-	0.06 ha of potential habitat. No direct impact to individual plants
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E	-	<0.001 ha (<10 m^2)
Green and Golden Bell Frog (*Litoria aurea*)	E	E	0.11 ha (potential non-breeding habitat)
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	1.2 ha (foraging habitat)

Species / community	BC Act	EPBC Act	Predicted impact (habitat in ha)
Insectivorous bats (cave-roosting)			
Little Bent-winged Bat (*Miniopterus australis*)	V	-	1.92 ha (foraging habitat)
Large Bent-winged Bat (*Miniopterus orianae oceanensis*)	V	-	
Southern Myotis (*Myotis macropus*)	V	-	
Insectivorous bats (hollow-roosting)			
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	-	1.92 ha (foraging habitat) and 4 hollow-bearing trees
Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)	V	-	
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	-	
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	
Woodland birds			
Dusky Woodswallow (*Artamus cyanopterus cyanopterus*)	V	-	1.2 ha (foraging habitat)
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	
Nectarivorous birds			
Little Lorikeet (*Glossopsitta pusilla*)	V	-	1.2 ha (foraging habitat) and 4 hollow-bearing trees
Swift Parrot (*Lathamus discolor*)	E	CE	
Large predatory birds			
Little Eagle (*Hieraaetus morphnoides*)	V	-	1.2 ha (foraging habitat)
Square-tailed Kite (*Lophoictinia isura*)	V	-	
Powerful Owl (*Ninox strenua*)	V	-	
Masked Owl (*Tyto novaehollandiae*)	V	-	

Biodiversity Conservation Act 2016 assessment

Threatened ecological communities

The threatened ecological communities that are present in the proposal site and are subject to this assessment include:

- Cumberland Plain Woodland in the Sydney basin Bioregion
- River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats*:*

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

Not applicable

b. **in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
   i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
   ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

In addressing this question, the local occurrence of these threatened ecological communities is taken to be the community that occurs within the ecological study area and all contiguous vegetation. Risk of extinction is used here as the likelihood that the local occurrence of the ecological community would become extinct either in the short-term or in the long-term as a result of direct or indirect impacts on the threatened ecological community from the proposal. Composition refers to the assemblage of species and the physical structure of the community.

Cumberland Plain Woodland in the Sydney basin Bioregion is listed as a critically endangered ecological community and is considered to be facing an extremely high risk of extinction in New South Wales in the immediate future. The River-Flat Eucalypt Forest TEC is considered likely to become extinct in nature in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate.

The threatened ecological communities subject to this assessment are already at risk of extinction and the proposal would exacerbate this risk. However, the proposal is considered unlikely to result in the extinction of the local occurrence of any TECs. The proposal is predicted to remove around 1.74 hectares of the Cumberland Plain Woodland TEC and a smaller extent of the River-Flat Eucalypt Forest TEC (0.07 hectares). The greatest impact to Cumberland Plain Woodland TEC is to poor quality regenerating woodland and derived grasslands. Higher quality remnants would be retained. When the impacts are considered in the local context (i.e. the ecological study area, a 50-metre buffer around the proposal site), this includes 58 percent of the Cumberland Plain Woodland TEC and 48 percent of the River-Flat Eucalypt Forest TEC present in the ecological study area. This proportion is only accounting for a narrow band around the proposal site. A more valuable calculation would be the proportional impact of the occurrence of these TECs in the locality (the area within a 10-kilometre radius surrounding the proposal site). When this is considered, the proportional impact to Cumberland Plain Woodland TEC (0.09 percent) and River-Flat Eucalypt Forest TEC (0.02 percent) are very low.

Plant community type (PCT)	% cleared in CMA	Condition class	BC Act	Direct impact[1] (ha)	Area in ecological study area[2] (ha)	Area in locality (ha)[3]
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (849)	93	Moderate	CE	<0.001	0.89	2088
		Poor	CE	1.13	1.7	
		Derived grassland	CE	0.61	0.81	
			Sub-total	**1.74**	**3.46**	

Plant community type (PCT)	% cleared in CMA	Condition class	BC Act	Direct impact[1] (ha)	Area in ecological study area[2] (ha)	Area in locality (ha)[3]
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (835)	93	Poor	E	0.07	0.55	1560

[1] Area to be cleared based on ground-truthed vegetation mapping within the proposal site boundary.
[2] Based on a 50-metre buffer around the proposal site.
[3] Based on regional mapping within a 10km radius of the ecological study area.

The proposal is considered unlikely to substantially and adversely modify the composition of the two TECs so that their local occurrences are placed at risk of extinction. The local occurrences of these TECs have already been substantially and adversely modified by past land use practices. All TECs subject to this assessment are currently suffering from altered composition caused by a very large reduction in ecological function, as indicated by:

- altered community structure (i.e. missing structural layers)
- altered species composition (i.e. lack of native species)
- disruption of ecological processes (i.e. altered drainage)
- invasion and establishment of exotic species resulting in weed dominance
- degradation of habitat
- fragmentation.

The highest quality vegetation within the ecological study area would mostly be avoided through design, including through the establishment of an environmental protection area in the south west of the proposal site. Impacts would be primarily to poor quality regenerating woodland and derived grasslands. The proposal is not considered likely to further modify the composition of any of the TECs within the ecological study area such that the local occurrence of either TEC is placed at risk of extinction. The composition of the threatened ecological communities within the ecological study area is predicted to remain intact after the implementation of the proposal. However, the remaining patches would be smaller.

c. in relation to the habitat of a threatened species or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

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

The proposal is predicted to remove around 1.74 hectares of the Cumberland Plain Woodland TEC and a smaller extent of the River-Flat Eucalypt Forest TEC (0.07 hectares). More than 99 percent of this impact would be to poor quality woodland and derived grasslands.

Fragmentation is unlikely to occur from the proposal as the work would largely involve removing vegetation from patch edges rather than breaking apart of large blocks of vegetation into many smaller patches. Importantly, the proposal would not result in the breaking apart of large blocks of high-quality examples of threatened ecological communities. No further habitat fragmentation on a landscape scale would occur because of the proposal. Isolation of habitats is likely to increase by a small extent as the distance between patches on either side of the proposal site would be increased.

Due to the conservation significance of these TECs (particularly the critically endangered Cumberland Plain Woodland in the Sydney basin Bioregion), the remaining patches of these TECs within NSW are likely to be important for their survival. However, the patches within the proposal site are small and are largely degraded and higher-quality remnants adjacent to the ecological study area would be retained. Furthermore, there would be no impact to priority conservation land core habitats or regional corridors (mapped to the west of the proposal site and avoided through design). As such, the TEC patches within the ecological study area can be considered less important than larger high-quality examples of these TECs in the locality that retain high levels of ecological integrity and function.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

A Key Threatening Process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, population or ecological community. Key threatening processes are listed under the BC Act and at the present there are currently 38 listed KTPs. Of the 38 listed KTPs under the BC Act, nine are applicable to the TECs subject to this assessment (see **Table C.2**). However, hygiene and weed control measures would reduce or avoid the impact of most KTPs with the exception of clearing of native vegetation and removal of dead wood and dead trees.

Table C.2 Key threatening processes that may result from the proposal that may affect threatened ecological communities

Clear threatening process	Relevance to the proposal
Clearing of native vegetation	Yes. The proposal would result in clearing of native vegetation.
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Yes. The proposal may result in the introduction or spread of amphibian chytrid. However, hygiene measures would be followed to prevent spread of this fungus.
Infection of native plants by *Phytophthora cinnamomi*	Yes. The proposal may result in the introduction or spread of *Phytophthora cinnamomi*. However, hygiene measures would be followed to prevent spread of *Phytophthora cinnamomi*.
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Yes. The proposal may result in the introduction or spread of Exotic Rust Fungi. However, hygiene measures would be followed to prevent spread of Exotic Rust Fungi.
Invasion and establishment of exotic vines and scramblers	Yes. The proposal may result in the invasion and establishment of exotic vines and scramblers. However, weed control measures would be followed to prevent invasion and establishment of exotic vines and scramblers.
Invasion of native plant communities by African Olive *Olea europaea* L. subsp. *cuspidata*	Yes. The proposal may result in the invasion and establishment of African Olive *Olea europaea* L. subsp. *cuspidata*. However, weed control measures would be followed to prevent invasion and establishment of African Olive *Olea europaea* L. subsp. *Cuspidata.*
Invasion, establishment and spread of *Lantana camara*	Yes. The proposal may result in the invasion and establishment of *Lantana camara*. However, weed control measures would be followed to prevent invasion and establishment of *Lantana camara.*
Invasion of native plant communities by exotic perennial grasses	Yes. This key threatening process is already affecting the site. The proposal may result in further invasion and establishment of exotic perennial grasses in native vegetation that would be retained. However, weed control measures would be followed to prevent this potential impact.
Removal of dead wood and dead trees	Yes. Some dead wood and dead trees would be removed as part of the proposal.

Conclusion

In summary, the proposal is considered unlikely to have an adverse effect on the extent of the two TECs such that the local occurrence of each is likely to be placed at further risk of extinction. The impacts to these PCTs is primarily (>99 percent) to poor-quality woodland and derived grasslands. The impact is small when considered in the context the extent of the TECs within the broader locality. The highest quality vegetation in the ecological study area would largely be avoided through design. The proposal is considered unlikely to substantially and adversely modify the composition of any of the TECs as the current composition of the TECs is highly modified.

There is unlikely to be any further increase in fragmentation from the proposal. The TECs within the ecological study area are not recognised as important to the long-term survival of the TECs in the locality as the patches are small and in poor to moderate condition. Furthermore, only a slither (and possibly realistically avoidable) of moderate quality woodland identified as important under the Cumberland Plain Recovery Plan (i.e. priority conservation land) would be impacted. The proposal would contribute to some KTPs that cannot be mitigated against including clearing of native vegetation and removal of dead wood and dead trees.

Considering the context of the TECs and intensity of the potential impacts to these TECs from the proposal, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these TECs.

***Grevillea juniperina* subsp. *juniperina* (Juniper-leaf Grevillea)**

Grevillea juniperina subsp. *juniperina* plants were identified along the southern bank of the large man-made dam in the north of the ecological study area during surveys. These plants may have grown from the transportation of seeds in alluvium soil around Ropes Creek when the dam was built, based on the regrowth of riparian vegetation along the bank. Potential habitat for this species is typically woodland areas on Wianamatta Shale and Tertiary alluvium. Around 30 plants were also identified just outside of the ecological study area in the south west near Ropes Creek. This species appears to be somewhat common along the Ropes Creek corridor based on the prevalence of recorded sightings.

The proposal would result in the removal of around 0.06 hectares of potential habitat. No individual plants would be directly impacted by the proposal.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats*:*

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

According to the Environmental Impact Assessment Guidelines for *Grevillea juniperina* subsp. *juniperina* (NSW National Park and Wildlife Service 2002), all populations should be assumed to be viable. Therefore, the four plants along the southern bank of the large man-made dam in the north of in the ecological study area are part of a local viable population around Ropes Creek.

Based on publicly available data, there are 1,092 recorded sightings of *Grevillea juniperina* subsp. *juniperina* in the locality. Considering single records investigated near the ecological study area contained numerous plants, the number of individuals in the locality is likely to be much higher. Over 30 plants were also identified to the west of the ecological study area on the edge of Ropes Creek. Considering this, the population size in the locality is likely quite high.

No individual plants would be impacted by the proposal. The proposal would remove a small area of potential habitat, however the majority of potential alluvial habitat would remain around Ropes Creek. The proposal is unlikely to place *Grevillea juniperina* subsp. *juniperina* at risk of extinction.

b. **in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
    i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

c. **in relation to the habitat of a threatened species or ecological community:**
   i. **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
   ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
   iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The proposal would directly impact (remove) 0.06 hectares of potential habitat. There may also be a small some indirect impacts on the moderate quality woodland to be retained through edge effects, however considering this species is able to grow in open and disturbed sites these edge effects are unlikely to make the habitat unsuitable.

Fragmentation is unlikely to occur from the proposal as the work would largely involve removing vegetation from patch edges rather than breaking apart of large blocks of vegetation into many smaller patches. Importantly, the proposal would not result in the breaking apart of large blocks of high-quality habitats. No further habitat fragmentation on a landscape scale would occur because of the proposal.

Importantly, the proposal would mostly avoid the highest quality alluvium habitat for *Grevillea juniperina* subsp. *juniperina* through design. The work would be undertaken at the edge of the habitat and avoids impacts to the core habitats of the viable population on the edge of Ropes Creek.

d. **whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),**

The proposal would not impact on any declared area of outstanding biodiversity value.

e. **whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.**

With respect to *Grevillea juniperina* subsp. *juniperina*, the proposal would directly contribute to one key threatening process (KTPs) listed under the BC Act; Clearing of native vegetation. The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds, particularly exotic grasses that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for the *Grevillea juniperina* subsp. *juniperina* adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

The proposal would directly impact (remove) 0.06 hectares of potential habitat. None of the plants identified in and around the ecological study area would be directly impacted by the proposal. These plants are considered part of the Ropes Creek population, which would not be directly impacted by the proposal. The 0.06 hectares of potential habitat removal is a very small proportion of the area of available alluvial habitat around Ropes Creek Therefore an overall conclusion has been made that the proposal is unlikely to result in a significant impact to *Grevillea juniperina* subsp. *juniperina*.

Cumberland Plain Land Snail (*Meridolum corneovirens*)

Live Cumberland Plain Land Snails were found in leaf litter and dumped rubbish in moderate quality woodland vegetation (PCT 849) in the ecological study area during the surveys undertaken for the proposal. This vegetation is the highest quality habitat for the Cumberland Plain Land Snail in the ecological study area due to the presence of a thick leaf litter layer, some large wood debris and piles of dumped rubbish that likely provide sheltering opportunities. Poor quality vegetation across the rest of the ecological study area is likely too disturbed and isolated for the Cumberland Plain Land Snail, however piles of dumped rubbish should be considered during the clearing process.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats*:*

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Cumberland Plain Land Snail primarily inhabits Cumberland Plain Woodland. It lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps and occasionally shelters under rubbish where it is available. It feeds on fungus.

The moderate quality woodland (PCT 849) in the west of the ecological study area that is contiguous with the Ropes Creek riparian corridor presents suitable habitat for the Cumberland Plain Land Snail. The snails were identified in the environmental protection area right on the edge of the proposal site, so this species may spread into the surrounding open and regenerating vegetation, however much of the poor-quality woodland in the study area is unsuitable for this species.

The proposal has been designed to avoid this moderate quality woodland, however considering the proximity of the proposal site boundary some impacts to the ground layer are anticipated. The proposal would remove <0.001 hectares (<10 m^2) of suitable habitat for the Cumberland Plain Land Snail, including a small area of surrounding poor-quality regenerating woodland. Although the proposal would result in a direct impact to habitat of the Cumberland Plain Land Snail, the highest quality habitat is to the west of the development proposal site around the Ropes Creek riparian corridor. Pre-clearing surveys and translocation efforts would reduce the potential for direct mortality of individuals during clearing.

This small amount of habitat removal is not considered likely to have an adverse effect on the life cycle of the species such that a viable local population is likely to be placed at risk of extinction.

b. **in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
   ii. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
   iii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

c. **in relation to the habitat of a threatened species or ecological community:**
   i. **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
   ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
   iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The proposal would remove around <0.001 hectares (<10 m^2) of potential habitat for the Cumberland Plain Land Snail.

Fragmentation is unlikely to occur from the proposal as the work would largely involve removing vegetation from patch edges rather than breaking apart of large blocks of vegetation into many smaller patches. Importantly, the proposal would not result in the breaking apart of large blocks of high-quality habitats. No further habitat fragmentation on a landscape scale would occur because of the proposal. The proposal would increase the isolation between the high-quality habitat in the west of the ecological study area and poor-quality habitats in the east. Although these poor-quality areas would become suitable habitat in the future, they currently are likely too disturbed and not inhabited by this species.

Importantly, the proposal would mostly avoid the highest quality patch of habitat for the Cumberland Plain Land Snail through design. The work would be undertaken at the edge of the habitat and avoids impacts to the core habitats on the edge of Ropes Creek.

d. **whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),**

The proposal would not impact on any declared area of outstanding biodiversity value.

e. **whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.**

With respect to the Cumberland Plain Land Snail, the proposal would directly contribute to two key threatening processes (KTPs) listed under the BC Act:

- Clearing of native vegetation
- Removal of dead wood and dead trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for the Cumberland Plain Land Snail adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

The Cumberland Plain Land Snails identified in the ecological study area were inhabiting vegetation that would largely remain unimpacted by the proposal. The largest area of high-quality habitat would remain to the west of the ecological study area. Pre-clearing surveys of vegetation and rubbish piles, and translocation of individuals prior to clearing would reduce the potential for direct mortality of animals. The impact to habitat would be the edge of a large high-quality habitat and the proposal would not result in fragmentation or isolation of high-quality habitat. Overall, the proposal is unlikely to reduce the population size of the Cumberland Plain Land Snail or decrease the reproductive success of this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Cumberland Plain Land Snail.

Green and Golden Bell Frog (*Litoria aurea*)

The Green and Golden Bell Frog was not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment. Targeted surveys for the Green and Golden Bell Frog were undertaken in proximity to the ecological study area as part of the Archbold Road Upgrade and Extension REF (WSP | Parsons Brinckerhoff 2017), which was unsuccessful at locating this species.

Although records of this species in the locality are rare, the Green and Golden Bell Frog has a moderate likelihood of occurring in habitats in the ecological study area based on the presence of suitable habitat. The proposal would directly impact (remove) up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071 and surrounding exotic grasslands that may be suitable foraging and dispersing habitat.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Green and Golden Bell Frog is found in a wide variety of water bodies, commonly in disturbed habitats, but not in fast flowing streams. Breeding habitat in NSW includes water bodies that are still, shallow, ephemeral, unpolluted (but the frog can be found in polluted habitats), unshaded, with aquatic plants and free of Mosquito Fish (*Gambusia holbrooki*) and other predatory fish, with terrestrial habitats that consisted of grassy areas and vegetation no higher than woodlands, and a range of diurnal shelter sites (Pyke & White 1996).

The proposal would remove up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071 and surrounding exotic grasslands that may be suitable foraging and dispersing habitat. The Green and Golden Bell Frog has not been identified in the ecological study area though may occur based on the presence of suitable habitat and connectivity that the Ropes Creek riparian corridor provides between the ecological study area and the most recent record (2012) in the locality. The proposal would not directly impact on a known breeding site or key population. The loss of habitat would be to foraging and sheltering habitat only. This impact is unlikely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

b. **in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
   i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
   ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

c. **in relation to the habitat of a threatened species or ecological community:**
   i. **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
   ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
   iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The proposal would remove up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071 and surrounding exotic grasslands that may be suitable foraging and dispersing habitat.

Fragmentation is unlikely to occur from the proposal as the work would largely involve removing farm dams along two first order drainage lines that do not provide any east-west connectivity. The habitat removed would likely represent sheltering and foraging habitats for any individuals moving along the Ropes Creek corridor. The Ropes Creek corridor and north-south connectivity would remain after the completion of the proposal.

The habitat that would be removed meets the description of suitable habitat for the Green and Golden Bell Frog (Pyke & White 1996), however this species has not been recorded in the ecological study area. The habitat is likely to represent sheltering and foraging habitat for individuals dispersing across the landscape and is a small proportion of a very large number of similar quality farm dams in the locality. The main connectivity corridor near the ecological study area would be represented by Ropes Creek, which would not be impacted by the proposal. Therefore, the habitats that would be removed are unlikely to be highly important to the long-term survival of the Green and Golden Bell Frog in the locality.

d. **whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),**

The proposal would not impact on any declared area of outstanding biodiversity value.

e. **whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.**

With respect to the Green and Golden Bell Frog, the proposal is consistent with three key threatening processes listed under the BC Act:

- Clearing of native vegetation
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- Chytridiomycosis due to amphibian Chytrid Fungus.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for the Green and Golden Bell Frog in the surrounding landscape.

The proposal would only impact flow regimes on the two first order streams that cross the ecological study area, however these are very ephemeral and only drain run-off from the immediate surroundings into Ropes Creek, which is normally trapped by the two dams anyway. Therefore, the proposal is unlikely to significantly contribute to this Key Threatening Process.

The disease Chytridiomycosis already exists in the Cumberland Plain and as such it is unlikely that the proposal would further exacerbate this Key Threatening Process. Construction activities would follow frog hygiene practices to limit the spread of this disease.

Conclusion

This species has not been identified in the ecological study area and no individuals are expected to be directly impacted. The proposal would remove up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071 and surrounding exotic grasslands that may be suitable foraging and dispersing habitat. The proposal would not directly impact on a known breeding site. The habitats are likely to represent foraging and shelter for individuals dispersing across the landscape and are a small proportion of the availability of similar quality habitat in the locality. Surveys for this species would be undertaken as part of the pre-clearing process prior to the commencement of clearing and de-watering of ponds. Overall, the proposal is considered unlikely to result in a significant impact to the Green and Golden Bell Frog.

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox is considered moderately likely to forage in the trees within the ecological study area, particularly *Eucalyptus moluccana* and *Eucalyptus tereticornis*. No roost camps are present in the ecological study area, however the bats from the Parramatta Park camp and/or the intermittent Ropes camp are likely to forage in the ecological study area.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Grey-headed Flying-fox occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Annual mating commences in January and conception occurs in April or May; a single young is born in October or November.

There are no roost camps located in the ecological study area and at the time of this assessment the proposal would not directly impact on any known breeding / maternity site. As such, the impacts of the proposal to the

Grey-headed Flying-fox would be limited to loss of feeding habitat caused by direct clearing or damage to native vegetation during the construction phase.

The proposal would remove around 1.2 hectares of potential foraging habitat (although it is not likely that the entirety of this habitat is used), however, removal of vegetation would be avoided where possible. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within the locality. Given the relatively widespread nature of similar poor-quality vegetation in the locality and abundance of higher-quality foraging habitat within the feeding range of the camps located near the ecological study area, the proposal is not expected to significantly affect the life cycle of the species.

The proposal is unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species.

b. in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:
   i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
   ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

c. in relation to the habitat of a threatened species or ecological community:
   i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and
   ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and
   iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.

The potential habitat of the Grey-headed Flying-fox within the ecological study area is limited to foraging habitat and includes all vegetation where fruiting and flowering trees and shrubs are present. The extent of potential foraging habitat for the Grey-headed Flying-fox would be reduced by around 1.2 hectares. This amount of habitat removal is small when the amount of available foraging habitat in the locality is considered.

Importantly, the proposal would not result in fragmentation of habitat for the Grey-headed Flying-fox. This species is highly mobile and would freely fly long distances (up to 50 km) over open areas including urbanised city centres to move between roost camps and foraging sites. The proposal would not affect the movement of the Grey-headed Flying-fox between habitat patches.

Importantly, the proposal would not affect the most important habitats for Grey-headed Flying-fox within the locality. The most important habitats for the local Grey-headed Flying-fox sub-populations are the roosting camps at Parramatta Park (Nationally Important) and Ropes Creek (intermittent). These camps would not be affected by the proposal. Foraging habitat within the ecological study area is likely to form part of an overall foraging range of these sub-populations and would only form a small proportion of available habitat for this species. As such, the foraging habitat within the ecological study area is unlikely to be of critical importance for the survival of the Grey-headed Flying-fox within the locality.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

With respect to Grey-headed Flying-fox, the proposal would directly contribute to one key threatening process (KTPs) listed under the BC Act; Clearing of native vegetation. The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for the Grey-headed Flying-fox adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

The Grey-headed Flying-fox would be impacted by a small reduction in extent of suitable foraging habitat from the proposal of around 1.2 hectares. No roosting camps or other important habitat would be impacted. As such, the proposal is considered unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to the Grey-headed Flying-fox.

Insectivorous bats (cave-roosting)

The species subject to this assessment include:

- Little Bent-winged Bat (*Miniopterus australis*)
- Large Bent-winged Bat (*Miniopterus orianae oceanensis*)
- Southern Myotis (*Myotis macropus*)

The Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis were not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment.

The Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis are moderately likely to occur within the ecological study area based on the presence of native vegetation providing habitat for these species. These species have been recorded widely in the locality and are likely to use the ecological study area as foraging habitat. No roosting habitat would be impacted by the proposal.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Little Bent-winged Bat is generally found in well-timbered areas where they roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and occasionally buildings. They often share roosting sites with the Large Bent-winged Bat. In NSW the largest maternity colony is in close association with a large maternity colony of Large Bent-winged Bat. Maternity colonies form in spring and birthing occurs in early summer. Males and juveniles disperse in summer. Only five nursery sites / maternity colonies are known in Australia.

The Large Bent-winged Bat primarily roosts in caves, but will also use derelict mines, storm-water tunnels, buildings and other man-made structures. The Large Bent-winged Bat forms populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. At other times of the year, populations disperse within about 300 kilometres range of maternity caves. The Large Bent-winged Bat hunts in forested areas.

The Southern Myotis generally roosts in groups of 10 – 15 close to water in caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage. The Southern Myotis forages over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW, females have one young each year usually in November or December.

All vegetation within the ecological study area is likely to provide foraging habitat for these three species. The Southern Myotis will preferentially forage in the riparian zones and open water surface of Ropes Creek and potentially the dams within the ecological study area. Riparian zones are also likely to be a focal point for foraging of the Little Bent-winged Bat and Large Bent winged Bat. Only a minor area of riparian habitat would be impacted by the proposal, and the design of the proposal has minimised impacts to riparian vegetation.

The proposal would impact up to 1.92 hectares of suitable foraging habitat for these species, primarily poor condition woodland. Much of this area is not considered high-quality habitat. The current potential for these species to occur, based on the presence of potential foraging habitat around the proposal site, is unlikely to be affected by the proposal.

This amount of habitat removal is not considered likely to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction.

b. in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:
   i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
   ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

c. in relation to the habitat of a threatened species or ecological community:
   i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and
   ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and
   iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.

The proposal would remove around 1.92 hectares of potential foraging habitat for the Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis. However, much of the vegetation that would be impacted is considered poor quality habitat. The amount of habitat removal is small when the amount of available higher-quality habitat in the locality is considered.

Much of the native vegetation within the ecological study area is quite fragmented in nature and is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence. Importantly, the proposal would not result in fragmentation of habitat for these species. These species are highly mobile and will freely fly long distances over open areas to move between habitats. The proposal would not affect the movement of the Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis between habitat patches.

The vegetation in the ecological study area would form a small component of a larger foraging range for these species. Riparian vegetation is likely to be a focal point of foraging activity, as are the edges of vegetation patches. The loss of native vegetation from the ecological study area would reduce the amount of foraging habitat available for these species by a small amount. However, when compared to the larger and higher quality vegetation remnants in the locality, the vegetation within the ecological study area is not considered as important for the long-term survival of these species.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

With respect to the Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis, the proposal is consistent with two Key Threatening Process (KTP) listed under the BC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for these species adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

The Little Bent-winged Bat, Large Bent-winged Bat and Southern Myotis would potentially be impacted by a small reduction in extent of foraging habitat from the proposal. It is unlikely that roosting habitat would be affected. The proposal is unlikely to reduce the population size of these species or decrease the reproductive success of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these threatened insectivorous bats.

Insectivorous bats (hollow-roosting)

The species subject to this assessment include:

- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Eastern Coastal Free-tailed Bat (*Micronomus norfolkensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)

The Eastern False Pipistrelle, Eastern Coastal Free-tailed Bat, Greater Broad-nosed Bat and Yellow-bellied Sheathtail-bat were not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment.

The Eastern False Pipistrelle, Eastern Coastal Free-tailed Bat, Greater Broad-nosed Bat and Yellow-bellied Sheathtail-bat are moderately likely to occur within the ecological study area based on the presence of suitable habitat (particularly vegetated riparian zones) and nearby records. These species have been recorded widely in the locality and are likely to use the ecological study area as foraging habitat on occasion. These species are widespread on the Cumberland Plain and are powerful flyers capable of fast long-distance travel for foraging.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Eastern False Pipistrelle prefers to inhabit moist habitats with mature trees taller than 20 metres. This species generally roosts in eucalypt hollows, though has also been found under loose bark on trees or in buildings. The Eastern False Pipistrelle hibernates in winter and females are pregnant in late spring to early summer.

The Eastern Coastal Free-tailed Bat occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in human-made structures.

The Greater Broad-nosed Bat utilises a variety of habitats from woodland through to moist and dry open eucalypt forest and rainforest. This species usually roosts in tree hollows but has also been found in buildings. Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of young.

The Yellow-bellied Sheathtail-bat roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. The Yellow-bellied Sheathtail-bat forages in most habitats including forested areas and open paddocks. Breeding has been recorded from December to mid-March, when a single young is born. The seasonal movements of this species are unknown but there is speculation about a migration to southern Australia in late summer and autumn.

The ecological study area is likely to provide suitable habitat for these four species. In particular, the riparian zones are likely to be a focal point for foraging due to the higher productivity of these areas (i.e. more insect prey available around creek lines). Tree hollows were also present in some remnant mature trees around the dam in the north of the proposal site, providing potential roosting opportunities. Tree hollows were recorded as moderately abundant in the large remnant trees in the ecological study area.

These species, particularly the Yellow-bellied Sheathtail-bat are large and fast flyers and will exploit the edges of vegetation and open treeless areas for foraging. As such, foraging habitat for these species is widespread in the locality. It is unknown whether the ecological study area contains a roost site for any of these species. However, the eight hollow bearing trees that were recorded in the ecological study area may provide some suitable roosting habitat for these species. Breeding may potentially occur in these trees or these trees may form part of the range of breeding bats and may be used intermittently as shelters. Other trees and vegetation in the ecological study area may also be suitable for roosting under loose bark or in foliage.

The proposal would impact up to 1.92 hectares of suitable foraging habitat and four hollow-bearing trees would be removed. However, much of this area is not considered high quality habitat. The current potential for these species to occur based on the presence of potential foraging habitat in the ecological study area and wider locality is expected to remain after completion of the project.

This amount of habitat removal is not considered likely to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction.

- **b. in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
  - **i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
  - **ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

- **c. in relation to the habitat of a threatened species or ecological community:**
  - **i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
  - **ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
  - **iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The proposal would remove around 1.92 hectares of suitable foraging habitat and four hollow-bearing trees would be removed. However, much of this area is considered poor quality habitat. The amount of habitat removal is small when the amount of available habitat in the locality is considered. Tree hollows were present in some remnant mature trees around the dam providing potential roosting opportunities. Tree hollows were recorded as moderately abundant in the large remnant trees in the ecological study area.

Much of the native vegetation within the ecological study area is quite fragmented in nature and is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence.

Importantly, the proposal would not result in fragmentation of habitat for these species. These species are highly mobile and will freely fly long distances over open areas to move between habitats. The proposal would not affect the movement of the Eastern False Pipistrelle, Eastern Coastal Free-tailed Bat, Greater Broad-nosed Bat and Yellow-bellied Sheathtail-bat between habitat patches.

The vegetation in the ecological study area would form a small component of a larger foraging range for these species. Riparian vegetation is likely to be a focal point of foraging activity, as are the edges of vegetation patches. The loss of native vegetation and hollow-bearing trees from the ecological study area would reduce the amount of habitat available for these species by a small amount. However, when compared to the larger and higher quality vegetation remnants and abundance of tree hollows in the locality, the vegetation within the ecological study area is not considered as important for the long-term survival of these species.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

With respect to the Eastern False Pipistrelle, Eastern Coastal Free-tailed Bat, Greater Broad-nosed Bat and Yellow-bellied Sheathtail-bat, the proposal is consistent with two Key Threatening Process (KTP) listed under the BC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for these species adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

The four insectivorous bat species subject to this assessment would potentially be impacted by a small reduction in extent of foraging habitat from the proposal. Up to four hollow-bearing trees that may be utilised as roosts would be impacted. The proposal is unlikely to reduce the population size or decrease the reproductive success of this species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these threatened insectivorous bats.

Woodland birds

The two woodland bird species concerning this assessment are known to utilise highly modified and partially-cleared habitats and are likely to pass through the ecological study area periodically. The ecological study area is considered unlikely to form suitable breeding habitat for these species and habitat use would be likely restricted to foraging. The species subject to this assessment include:

- Dusky Woodswallow (*Artamus cyanopterus*)
- Varied Sittella (*Daphoenositta chrysoptera*)

The Dusky Woodswallow and Varied Sittella were not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Dusky Woodswallow primarily inhabits dry, open eucalypt forests and woodlands, including mallee associations, with an open or sparse understorey of eucalypt saplings, acacias and other shrubs, and ground-cover of grasses or sedges and fallen woody debris. It has also been recorded in shrublands, heathlands and very occasionally in moist forest or rainforest. It feeds on invertebrates, mainly insects, which are captured whilst hovering or sallying above the canopy or over water. It also frequently hovers, sallies and pounces under the canopy, primarily over leaf litter and dead timber. Nests are an open, cup-shape, made of twigs, grass, fibrous rootlets and occasionally casuarina needles, and generally occur in shrubs or low trees, living or dead, horizontal or upright forks in branches, spouts, hollow stumps or logs, behind loose bark or in a hollow in the top of a wooden fence post.

The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. The Varied Sittella feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees, and from small branches and twigs in the tree canopy. It builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.

Suitable foraging habitat for the Dusky Woodswallow and Varied Sittella is present within the ecological study area where there are rough-barked tree species and mature smooth-barked gums with dead branches. Breeding habitat is considered unlikely to be present, due to the poor quality of vegetation in the proposal site. However, potential breeding habitat is more likely to occur in the larger less disturbed vegetation remnants in the locality.

The loss of vegetation within the ecological study area would directly affect the opportunity for these woodland birds to feed in the area. The proposal would impact up to 1.2 hectares of potential suitable habitat for the Dusky Woodswallow and Varied Sittella. However, much of this potential suitable habitat is not considered critical habitat. The current potential for these species to occur, based on the presence of potential foraging habitat, is unlikely to be affected by the proposal.

This amount of habitat removal is not considered likely to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction.

b. **in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:**
   i. **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
   ii. **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

c. **in relation to the habitat of a threatened species or ecological community:**
   i. **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
   ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
   iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The extent of habitat for the Dusky Woodswallow and Varied Sittella would be impacted by 1.2 hectares. However, much of this area is considered poor quality habitat. The amount of habitat removal is relatively small when the amount of available habitat in the locality is considered.

Much of the native vegetation within the ecological study area is quite fragmented in nature and is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence.

Movement of individuals and exchange of genetic material from the vegetation in the ecological study area to and from vegetation along the Ropes Creek corridor can be expected. Importantly, the proposal would not result in fragmentation of habitat for these species. These species are known to utilise highly modified and partially-cleared habitats and are likely to pass through the ecological study area on occasion. The ecological study area is considered unlikely to form suitable breeding habitat for these species and habitat use would be likely restricted to foraging. The proposal would not affect the movement of the Dusky Woodswallow and Varied Sittella between habitat patches.

The vegetation in the ecological study area would form a small component of a larger foraging range for these species. Riparian vegetation is likely to be a focal point of foraging activity, as are the edges of vegetation patches. The loss of native vegetation from the ecological study area would reduce the amount of foraging habitat available for these species by a small amount. However, when compared to the larger and higher quality vegetation remnants in the locality, the vegetation within the ecological study area is not considered as important for the long-term survival of these species.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

With respect to the Dusky Woodswallow and Varied Sittella, the proposal is consistent with three Key Threatening Processes (KTP's) listed under the BC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees
- Removal of dead wood and dead trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for these species adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

These two woodland bird species would potentially be impacted by a small reduction in extent of foraging habitat from the proposal. The proposal is unlikely to reduce the population size of these species or decrease the reproductive success of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these species.

Nectarivorous birds

The species subject to this assessment include:

- Little Lorikeet (*Glossopsitta pusilla*)
- Swift Parrot (*Lathamus discolor*)

The Little Lorikeet and Swift Parrot were not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment.

The Little Lorikeet is highly likely to occur within the ecological study area and was recorded in 2019 occurring 300 metres from the ecological study area in Shale Plains Woodland.

Additionally, the Swift Parrot is moderately likely to occur within the ecological study area and records indicate a scattered distribution throughout the locality. The nearest record is from St Clair in 2014, 3.5 kilometres north west of the ecological study area. However, the Swift Parrot is a migrant species that does not breed in the locality and is considered to occur within the ecological study area on an infrequent basis during winter migration.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Little Lorikeet occurs just north of Cairns, around the east coast of Australia, to Adelaide. In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Little Lorikeets are generally considered to be nomadic and forage mainly on flowers, nectar and fruit. The breeding biology of Little Lorikeets is partially known however studies indicate that nest hollows are located at heights of between 2 metres and 15 metres, mostly in living, smooth-barked eucalypts, and hollow openings are approximately 3 centimetres in diameter.

The Swift Parrot breeds only in Tasmania and breeding success is strongly correlated with the intensity and extent of flowering of Tasmanian Blue Gums. The majority of the species migrates to mainland Australia in autumn, over-wintering, particularly in Victoria and central and eastern NSW, but also south-eastern Queensland as far north as Duaringa. Until recently it was believed that in New South Wales, swift parrots forage mostly in the western slopes region along the inland slopes of the Great Dividing Range but are patchily distributed along the north and south coasts including the Sydney region, but new evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important. In mainland Australia is semi-nomadic, foraging in flowering eucalypts in eucalypt associations, particularly box-ironbark forests and woodlands.

No significant areas of potential foraging habitat for these species was identified during the field survey. *Eucalyptus tereticornis* is a winter flowering species and may provide a foraging resource for migrating Swift Parrots. A range of hollow sizes are present in large remnant trees in the ecological study area, which may provide roosting opportunities for both species and potentially nesting habitat for the Little Lorikeet. The proposal would impact up to 1.2 hectares of vegetation that would provide potential foraging habitat and four hollow-bearing trees would be removed. However, much of this area is not considered critical habitat for these species. Shelter and food resources in the ecological study area are likely to be important for the life cycle of these species, however there is a low potential that the proposal would adversely affect the life-cycle of the species to be impacted given the widespread occurrence of suitable foraging habitat and nearby records.

This amount of habitat removal is not considered likely to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction.

b. in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:
   i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
   ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

c. in relation to the habitat of a threatened species or ecological community:

i. **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
ii. **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
iii. **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The proposal would remove around 1.2 hectares of potential foraging habitat and four hollow-bearing trees would be removed. However, much of this area is considered poor quality habitat. The amount of habitat removal is relatively small when the amount of available habitat in the locality is considered. A range of hollow sizes are present in large remnant trees in the ecological study area, which may provide roosting opportunities for both species and potentially nesting habitat for the Little Lorikeet.

Much of the native vegetation within the ecological study area is quite fragmented in nature and is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence. Movement of individuals and exchange of genetic material from the vegetation in the ecological study area to and from vegetation along the Ropes Creek corridor can be expected. Importantly, the proposal would not result in fragmentation of habitat for these species. These species are highly mobile and will freely fly long distances over open areas to move between habitats. The proposal would not affect the movement of the Little Lorikeet and Swift Parrot between habitat patches.

The vegetation in the ecological study area would form a small component of a larger foraging range for these species. The Swift Parrot has been recorded in the locality (notably three records on Eastern Creek in 2019) and sporadically occurs in the urbanised areas of western Sydney during winter. *Eucalyptus tereticornis* is a winter flowering species and the trees in the ecological study area may provide a foraging resource for migrating Swift Parrots. Additionally, the Little Lorikeet has been recorded in 2019 occurring 300 metres from the ecological study area in Shale Plains Woodland, which also occurs in the ecological study area. A range of hollow sizes are present in large remnant trees in the ecological study area, which may provide roosting opportunities for both species and potentially nesting habitat for the Little Lorikeet. The Swift Parrot and Little Lorikeet may pass through the ecological study area during movements between larger foraging habitats (e.g. from Prospect Nature Reserve to Whalan Reserve and Wianamatta Regional Park and Nature Reserve), though the habitat that would be impacted is not considered to be important to the long-term survival of the species.

d. **whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),**

The proposal would not impact on any declared area of outstanding biodiversity value.

e. **whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.**

With respect to the Little Lorikeet and Swift Parrot, the proposal is consistent with two Key Threatening Processes (KTP's) listed under the BC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for these species adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

These two nectarivorous birds would potentially be impacted by a small reduction in extent of foraging habitat from the proposal. The loss of four large hollow-bearing tress may also reduce roosting and nesting (Little Lorikeet) opportunities in the locality. However, considering the small proportion of habitat to be lost, the proposal is unlikely to reduce the population size of these species or decrease the reproductive success of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these species.

Large predatory birds

The four large predatory bird species concerning this assessment are known to utilise highly modified and partially-cleared habitats and are likely to pass through the ecological study area periodically. The ecological study area is considered unlikely to form suitable breeding habitat for these species and habitat use would be likely restricted to foraging.

The species subject to this assessment include:

- Little Eagle (*Hieraaetus morphnoides*)
- Square-tailed Kite (*Lophoictinia isura*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)

The Little Eagle, Square-tailed Kite, Powerful Owl and Masked Owl were not identified in the ecological study area during field surveys for this assessment. No targeted surveys have been undertaken as part of this assessment.

The following is to be taken into account for the purposes of determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats:

a. **in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.**

The Little Eagle is distributed throughout the Australian mainland occupying habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring. Prey includes birds, reptiles and mammals, with the occasional large insect and carrion. Most of its former native mammalian prey species in inland NSW are extinct and rabbits now form a major part of the diet.

The Square-tailed Kite hunts primarily over open forest, woodland and mallee communities as well as over adjacent heaths and other low scrubby habitats in wooded towns. It feeds on small birds, their eggs and nestlings as well as insects. Seems to prefer structurally diverse landscapes.

The Powerful Owl is a sedentary species with a home range of approximately 1,000 hectares it occurs within open eucalypt, *Casuarina* or *Callitris* pine forest and woodland. It often roosts in denser vegetation including rainforest of exotic pine plantations. Generally, feeds on medium-sized mammals such as possums and gliders but will also eat birds, flying-foxes, rats and insects. Prey are generally hollow dwelling and require a shrub layer and owls are more often found in areas with more old trees and hollows than average stands.

The Masked Owl occurs within a diverse range of wooded habitats including forests, remnants and almost treeless inland plains. This species requires large-hollow bearing trees for roosting and nesting and nearby open areas for foraging. They typically prey on terrestrial mammals including rodents and marsupials but will also take other species opportunistically. They are also known to occasionally roost and nest in caves.

These large predatory bird species may visit the ecological study area on occasion to hunt, however no high-quality habitat is present within the ecological study area for these species. No large stick nests for the Little

Eagle and Square-tailed Kite were observed during the field surveys. The nearest record in 2015 of the Powerful Owl is located between Erskine Park and Eastern Creek (2km east of the ecological study area). This record is located in Shale Plains Woodland, vegetation which is also present in the ecological study area. Suitable marginal foraging habitat is present on the proposal site for the Powerful Owl. However, no large tree hollows suitable for breeding were observed during the field survey. Alternatively, the most suitable habitat for the Masked Owl exists along Ropes Creek. The Masked Owl exhibits no breeding habitat within the ecological study area.

The proposal would impact up to 1.2 hectares of potential foraging habitat for these species. However, much of this area is not considered critical habitat for these species. No nesting habitat for these species would be impacted by the proposal. Shelter and food resources in the ecological study area are likely to be important for the life cycle of these species, however there is a low potential that the proposal would adversely affect the life-cycle of the species to be impacted given the widespread occurrence of suitable foraging habitat and nearby records in the locality.

This amount of habitat removal is not considered likely to have an adverse effect on the life cycle of these species such that a viable local population is likely to be placed at risk of extinction.

b. in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:
   - **ii. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
   - **iii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

Not applicable.

c. in relation to the habitat of a threatened species or ecological community:
   - **i. the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and**
   - **ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
   - **iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

The extent of potential foraging habitat for the Little Eagle, Square-tailed Kite, Powerful Owl and Masked Owl would be reduced by 1.2 hectares. However, no high-quality habitat is present within the ecological study area for these species and these species may only visit the ecological study area on occasion to hunt. The amount of habitat removal is small when the amount of available habitat in the locality is considered. No stick nests or large hollows were observed during the field surveys.

Much of the native vegetation within the ecological study area is quite fragmented in nature and is in proximity to Ropes Creek, which exhibits a relatively intact riparian corridor and fringing woodland along most of its occurrence. Importantly, the proposal would not result in fragmentation of habitat for these species. These species are known to utilise highly modified and partially-cleared habitats and are likely to pass through the ecological study area on occasion to hunt. The ecological study area is considered unlikely to form suitable breeding habitat for these species and habitat use would be likely restricted to foraging. The proposal would not affect the movement of these four large predatory bird species between habitat patches.

The vegetation in the ecological study area would form a small component of a larger foraging range for these species. The loss of native vegetation from the ecological study area would reduce the amount of foraging habitat available for these species by a small amount. However, when compared to the larger and higher quality vegetation remnants in the locality, the vegetation within the ecological study area is not considered as important for the long-term survival of these species.

d. whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly)

The proposal would not impact on any declared area of outstanding biodiversity value.

e. whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

With respect to the Little Eagle, Square-tailed Kite, Powerful Owl and Masked Owl, the proposal is consistent with three Key Threatening Processes (KTP's) listed under the BC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees
- Removal of dead wood and dead trees

The proposal may also indirectly contribute to several other KTPs including:

- Pest animals that can compete with or prey upon native animals. They can also damage native plants and degrade natural habitats.
- Weeds that compete with native plants for resources such as light and nutrients. They can aggressively invade areas, displacing native plants and animals.
- Diseases, those exotic fungal infections, viruses and other pathogens can weaken and kill native species.

The extent of native vegetation clearing and habitat removal associated with the proposal is considered unlikely to be significant in terms of available habitat for these species adjacent to the ecological study area. Hygiene and weed control measures would reduce or avoid the impact of most other KTPs.

Conclusion

These four large predatory birds would potentially be impacted by a small reduction in extent of potential foraging habitat from the proposal. No breeding habitat is likely to be impacted. The proposal is unlikely to reduce the population size of these species or decrease the reproductive success of these species. After consideration of the factors above, an overall conclusion has been made that the proposal is unlikely to result in a significant impact to these species.

Environment Protection and Biodiversity Conservation Act 1999 assessment

Cumberland Plain Woodland in the Sydney Basin Bioregion

An action is likely to have a significant impact on a Critically Endangered or Endangered ecological community if there is a real chance or possibility that it will:

1. reduce the extent of an ecological community

Based on the estimated construction proposal site, the project may result in the direct clearing of about <0.001 hectares of the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. Therefore, the actual impact is likely to be limited to potential indirect edge effects on retained vegetation.

2. fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines

The proposal would not break apart continuous areas of the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community into separate smaller 'fragments'. Impacts would be limited to the edge of a large contiguous patch. Habitat connectivity is expected to remain in a similar state after completion of the proposal and there is unlikely to be an alteration to community composition, altered species interactions, or altered ecosystem functioning in the locality due to the action. Habitat fragmentation is not considered an important impact of the action with regard to its context and intensity.

3. **adversely affect habitat critical to the survival of an ecological community**

Due to the conservation significance of this TEC, all remaining patches and associated habitat within NSW are likely to be important for its survival. An impact of <0.001 hectares has been calculated, however it is likely that this would be avoided, and the actual impact would be limited to potential indirect edge effects on retained vegetation. Therefore, it is unlikely that the proposal would adversely affect habitat critical to the survival of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.

4. **modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns**

Where the TEC would be removed by the action, all abiotic factors (i.e. water, nutrients and soil) would be permanently modified and/or destroyed through vegetation removal and construction of infrastructure. The proposal may also modify abiotic factors of retained vegetation based on the proximity of its operations, though these modifications are likely to be very minor.

5. **cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting**

The composition of the TEC is likely to be modified as a result of the action through potential weed invasion and removal of vegetation. The patch of the TEC to be impacted is in moderate condition, though is already on the edge of a very disturbed area and suffering from edge effects. Some reduction in ecological function can be expected from indirect edge effects. Species composition in the patch is considered unlikely to occur as it is already highly altered by weed invasion from past disturbance. Functionally important species have already been lost from the patch and the proposal is not considered likely to cause any further substantial change in species composition.

6. **cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:**
   a. **assisting invasive species, that are harmful to the listed ecological community, to become established**
   b. **causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community**

Weed introduction and spread and the infection of native plants by *Phytophthora cinnamomi* have been identified as being spread by construction machinery. The proposal site currently contains a high abundance of exotic perennial grasses throughout areas historically cleared for agriculture. Moderate condition woodland surrounding the Ropes Creek riparian corridor contains a lower abundance of exotic grasses, mostly due to shaded cover, though a moderate abundance of exotic shrubs is present (e.g. African Boxthorn). The proposal has the potential to result in the spread of existing exotic species and potential introduction of new species into these areas by ground disturbance and movement of plant propagules.

Phytophthora infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to introduce and transmit weed propagules and *Phytophthora*. This is a potential indirect impact through the spread and transmission of weeds and pathogens into retained habitat.

These impacts can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene but an impact, particularly from weeds, is likely. The project mitigation strategy and environmental management procedures should include guidance for preventing the introduction and/or spread of weeds and disease-causing agents such as bacteria and fungi. Considering the current disturbance of vegetation adjacent to the ecological study area, the proposal is unlikely to cause a substantial reduction in the quality or integrity of the occurrence of this TEC.

7. **interfere with the recovery of an ecological community.**

A national recovery plan for the TEC has not been prepared. However, the Cumberland Plain Recovery Plan (Department of Environment, Climate Change and Water 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. As this TEC is restricted to NSW, this recovery plan should be considered.

The Cumberland subregion Biodiversity Investment Opportunities Map (BIO Map) (Office of Environment and Heritage, 2015) aims to achieve better biodiversity outcomes in Western Sydney by directing biodiversity investment funding to the strategic locations of greatest benefit. The areas identified for investment, termed priority investment areas, include core areas and biodiversity corridors of state and regional significance. The action would impact a very small edge of a vegetation patch that is connected to an area of mapped Priority Conservation Land or regional corridor. However, the proposal has been designed to avoid this vegetation so the actual impact is likely to be limited to potential indirect edge effects.

Conclusion

After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. The predicted impacts are minor.

Green and Golden Bell Frog (*Litoria aurea*)

The ecological study area contains suitable habitat for the Green and Golden Bell Frog. Although there are very few recent records of this species in the locality and no known populations, there is potential for the Green and Golden Bell Frog to disperse along the Ropes Creek riparian corridor. Therefore, the Green and Golden Bell Frog is moderately likely to occur in the habitats in the ecological study area.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population

The ecological study area contains some areas of habitat (PCT 1071) that meet characteristics that have been described for the Green and Golden Bell Frog. This species has not been confirmed in the ecological study area. A single record on Ropes Creek eight kilometres north of the ecological study area from 2012 may be evidence that a low-density population is active in the locality. This species may possibly disperse as far as 10 kilometres (White & Pyke 2008) and therefore has the potential to occur based on the presence of this suitable habitat and the connectivity corridor provided by Ropes Creek.

The proposal would impact up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071, as well as surrounding exotic grasslands that may be suitable foraging and dispersing habitat. The proposal would not directly impact on a known breeding site or key population. The loss of habitat would be to potential foraging and sheltering habitat only. The habitat lost is a very small proportion of the availability of similar-quality farm dam habitats in the locality. Therefore, the proposal is unlikely to lead to a long-term decrease in the size of a population.

2. reduce the area of occupancy of the species

The Green and Golden Bell is found in a wide range of water bodies across the Cumberland Plain, except fast flowing streams. This species is highly mobile and may disperse up to 10km. The Green and Golden Bell Frog has not been identified on the proposal site, therefore the proposal is unlikely to directly impact a population. The proposal would reduce the area of available foraging and sheltering habitat in the locality by 0.11 hectares. However, considering the availability of similar-quality farm dam habitats in the locality, the proposal is unlikely to reduce the area of occupancy of the Green and Golden Bell Frog in the Cumberland Plain.

3. fragment an existing population into two or more populations

Fragmentation is unlikely to occur from the proposal, as the farm dams along two first order drainage lines which would be removed do not provide any east-west connectivity. The habitat removed would likely represent potential sheltering and foraging habitats for any individuals moving along the Ropes Creek corridor. The Ropes Creek corridor and north-south connectivity would not be impacted by the proposal.

4. adversely affect habitat critical to the survival of a species

No critical habitat has been listed for the Green and Golden Bell Frog on the EPBC Act Register of Critical Habitat.

Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- For activities such as foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species or ecological community.

The most important habitat for the Green and Golden Bell Frog located in the ecological study area is occurrence of PCT 1071. A moderate to high abundance of the predatory Eastern Gambusia was identified in these areas and so are somewhat reduced in their capacity to be used as successful breeding habitat. The habitats on site may be used as foraging and sheltering habitat by dispersing individuals and are unlikely to be critical to the species' survival.

5. disrupt the breeding cycle of a population

This species has not been recorded at the proposal site. No breeding is reasonably expected to occur. The impact would be limited to a reduction in potential sheltering and foraging habitat for dispersing individuals. The breeding cycle of a population is unlikely to be disrupted by the proposal.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposal would reduce the area of available foraging and sheltering habitat in the locality by 0.11 hectares. However, considering the availability of similar-quality farm dam habitats in the locality, the action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat

Introduced Eastern Gambusia, which are known to prey on the tadpoles of the Green and Golden Bell Frog, are already established in the habitats in the ecological study area. Therefore, the proposal is unlikely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat.

8. introduce disease that may cause the species to decline, or

The presence and spread of the Chytrid Fungus is recognised as a Key Threatening Process in Australia and is widely regarded as playing an important role in the decline of the Green and Golden Bell Frog. Chytrid Fungus is already widespread in NSW; however, some populations of this species are free from or resistant to it. It has been suggested that such populations are in areas inhospitable to the growth of the disease, such as fluctuating levels of salinity.

The disease has been recorded in the Parramatta key population. Any work in and around the suitable habitat during clearing would follow the Hygiene Protocol for the Control of Disease in Frogs (Department of Environment and Climate Change 2008b) to reduce the spread of Chytrid fungus. Therefore, the proposal is unlikely to introduce disease that may cause the species to decline.

9. interfere with the recovery of the species.

There is no recovery plan for the Green and Golden Bell Frog. The Management Plan for the Green and Golden Bell Frog Parramatta Key Population (Department of Environment and Climate Change, 2007b) provides a list of six strategies.

The proposal would reduce the area of available foraging and sheltering habitat in the locality by 0.11 hectares, which does not align with recovery of this species. However, given this is a very minor loss of habitat in proportion to the amount of similar-quality habitat available in the locality, the proposal is unlikely to interfere with the recovery of the Green and Golden Bell Frog.

Conclusion

This species has not been identified in the ecological study area and no individuals are expected to be directly impacted. The proposal would remove up to 0.11 hectares of suitable aquatic habitat in the form of PCT 1071 and surrounding exotic grasslands that may be suitable foraging and dispersing habitat. The proposal would not directly impact on a known breeding site or any habitat critical to the survival of this species. The habitats are likely to represent foraging and shelter for individuals dispersing across the landscape and are a small proportion of the availability of similar quality habitat in the locality. Surveys for this species would be undertaken as part of the pre-clearing process prior to the commencement of clearing and de-watering of ponds. Overall, the proposal is considered unlikely to result in a significant impact to the Green and Golden Bell Frog.

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox is considered moderately likely to utilise the PCTs within the ecological study area as foraging habitat.

The Grey-headed Flying-fox exists as one interconnected population along the eastern Australian coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. As a result, for this assessment, the impact has been considered in terms of 'important habitat' as opposed the presence of an 'important population'.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

There are no roost camps in the ecological study area and the action would not affect any known permanent roosting, breeding / maternity site. Therefore, it is likely that the impacts of construction and operation of the action would be confined to minor loss of foraging habitat caused by direct clearing or damage to native vegetation during the construction phase. There is also a low risk of vehicle strike during operation.

The proposal would remove around 1.2 hectares of potential foraging habitat. Given the relatively widespread nature of similar poor condition vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of local individuals, the proposal is not expected to significantly affect important habitat or lead to a long-term decrease in the size of an important population.

2. reduce the area of occupancy of an important population

The area of occupancy of the Grey-headed Flying-fox is not known but the species exists as one interconnected population along the eastern Australian coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. The area occupied by this species would remain the same after the action. No decrease in the area of occupancy for this species expected as a result of the proposal.

3. fragment an existing important population into two or more populations

Highly mobile species such as bats are expected to be less impacted by fragmentation. The Grey-headed Flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom in differing parts of the landscape. The proposal would not fragment an important population of the Grey-headed Flying-fox. Individuals would still be able to disperse between roosts along the east Australian coast. Genetic exchange within the population and dispersal would not be disrupted by the proposal.

4. adversely affect habitat critical to the survival of a species

This species typically exhibits very large home range and Grey-headed Flying-fox is known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources. There are no known roost camps within the ecological study area and the proposal site does not provide critical roosting habitat. However, there are a number of known roost camps with a 50-kilometre radius of the proposal, the closest being the Nationally Important Parramatta Park camp and/or the intermittent Ropes Creek camp. The draft recovery plan for the Grey-headed Flying-fox identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50-kilometre radius of a camp site
- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

Native vegetation within the ecological study area may constitute critical foraging habitat however the affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50-kilometre radius of the Parramatta Park camp and/or the intermittent Ropes Creek camp. Given the extensive nature of high-quality foraging habitats along the escarpment, the proposal is not expected to adversely affect foraging habitat critical to the survival of this species in this region.

5. disrupt the breeding cycle of an important population

As stated above there would be a minor impact on foraging habitat during the breeding cycle of the species. The proposal would not directly impact on a known roost camp / breeding or maternity site. Extensive foraging resources are available in the locality that would provide suitable resources during the maternity season. The habitats in the ecological study area are not limiting for this species.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The impacts to foraging habitat are minimal and no evidence of a roost camp has been identified from the ecological study area. This impact is not expected to lead to a decline in the species in this region considering the magnitude of this impact and the expanse of high-quality foraging habitat available to local animals along the escarpment.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The action is unlikely to result in an invasive species harmful to the Grey-headed Flying-fox becoming established in the habitat. The potential for weed invasion is considered possible with a proposal of this nature and appropriate management and mitigation measures would be implemented during construction and operation of the proposal to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the facility using best practice methods.

8. introduce disease that may cause the species to decline, or

There are no known disease issues affecting this species in relation to the action. The action would be unlikely to increase the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the facility. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease-causing agents such as bacteria and fungi.

9. interfere substantially with the recovery of the species.

The *Draft National Recovery Plan for the Grey-headed Flying-fox* (*Pteropus poliocephalus*) (Department of Environment Climate Change and Water, 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes
- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture
- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps
- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

The recovery actions listed above are largely not applicable to the action and the action is not expected to interfere substantially with the recovery of the species.

Conclusion

The Grey-headed Flying-fox would suffer a small reduction in extent of suitable foraging habitat from the action. No breeding camps or other important habitat would be impacted. The action is unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. The action would not interfere with the recovery of the Grey-headed Flying-fox and would not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Grey-headed Flying-fox.

Swift Parrot (*Lathamus discolor*)

The Swift Parrot (*Lathamus discolor*) is considered moderately likely to occur based on the presence of suitable winter foraging habitat and potential roosting habitat in four large hollow-bearing *Eucalyptus tereticornis* trees.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population

The ecological study area contains some potential foraging and roosting (hollow-bearing trees) habitat for the Swift Parrot. While the habitat in the ecological study area is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the ecological study area is not considered a critical area for the Swift Parrot. The Swift Parrot may utilise trees in the ecological study area for foraging intermittently when no other suitable inland (i.e. box ironbark woodlands) or coastal resources (i.e. Spotted Gum or Swamp Mahogany forests) are available. The potential foraging habitat for this species would be reduced by about 1.2 hectares, as well as a loss of up to four large hollow-bearing trees. Within the Cumberland subregion, this potential habitat removal represents less than 0.01 percent of the currently available habitat for this species.

The Swift Parrot does not breed in the ecological study area and the extent of habitat remaining in the locality area would provide sufficient resources to sustain future visitation, such that the action itself is unlikely to lead to a long-term decrease in the size of the Australian population.

2. reduce the area of occupancy of the species

Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the ecological study area for foraging intermittently when no other suitable resources are available.

The project would contribute to the loss of potential foraging habitat which would reduce the area of habitat available. However, the action would not reduce the area of occupancy of this species which is estimated at 4,000 square kilometres.

3. fragment an existing population into two or more populations

Importantly, the action would not result in fragmentation of habitat for the Swift Parrot. This species is highly mobile and as a regular behaviour flies long distances over open areas to move between suitable foraging habitats. The action would not affect the movement of the Swift Parrot between habitat patches or fragment the population.

4. adversely affect habitat critical to the survival of a species

Key habitats for this species on the coast and coastal plains of New South Wales include large stands of Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*Eucalyptus robusta*), Red Bloodwood (*Corymbia gummifera*) and Forest Red Gum (*Eucalyptus tereticornis*) forests. The ecological study area supports some Forest Red Gum and therefore suitable habitat for this species is considered to be present. The hollow-bearing trees in the ecological study area may also be used by migrating birds to rest.

The habitat within the ecological study area is considered to be secondary habitat for the Swift Parrot as this species is not regularly recorded from the area and it is not known as critical habitat.

5. disrupt the breeding cycle of a population

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania, and migrates to mainland Australia in autumn. As such, the action would not impact on breeding habitat for this species. Important winter foraging grounds would not be impacted.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Potential foraging habitat for this species would be reduced by about 1.2 hectares. Four hollow-bearing trees that may provide roosting habitat for migrating birds would also be removed. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the ecological study area for foraging intermittently when no other suitable resources are available. The action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat

The main invasive species harmful to the habitat for the Swift Parrot is weeds. Noisy Miners are abundant in and around the habitats in the ecological study area which may make the habitat less suitable for the Swift Parrot due to competitive exclusion. The action may result in weed invasion and the removal of habitat may concentrate local miner populations increasing competition. The management of invasive species would be managed under in accordance with mitigation measures listed in **Table 8-1**.

8. introduce disease that may cause the species to decline, or

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the facility. This would be adequately mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease-causing agents such as bacteria and fungi.

9. interfere with the recovery of the species.

The *National Recovery Plan for the Swift Parrot* (Commonwealth of Australia 2019) aims to achieve and sustain a positive population trend for the Swift Parrot over the life of the Recovery Plan. This will be achieved by implementing the actions set out in this Recovery Plan that minimise threats while protecting and enhancing the species' habitat throughout its range. These objectives would be achieved by implementing recovery actions for each of the following specific recovery objectives:

- Strategy 1: Develop and apply techniques to measure changes in population trajectory in order to measure the success of recovery actions.
- Strategy 2: Manage and protect known Swift Parrot breeding and foraging habitat at the landscape scale.
- Strategy 3: Reduce impacts from Sugar Gliders at breeding sites.
- Strategy 4: Improve understanding of foraging and breeding habitat use at a landscape scale in order to better target protection and restoration measures.

These objectives, and the associated recovery actions outlined in the *National Recovery Plan for the Swift Parrot* (Commonwealth of Australia 2019) are not applicable to the ecological study area or proposal. The identified recovery actions mostly relate to identifying the extent and quality of habitat, monitoring, raising community awareness, and coordinating and reviewing the recovery process. There is an action relating to manage and protect Swift Parrot habitat at the landscape scale. However, this action applies to fencing off habitat on private land to encourage regeneration of habitat, revising forestry practices, developing a strategic management plan for Swift Parrot breeding habitat in Tasmania, and providing Swift Parrot conservation information for consideration during the New South Wales Local Government Local Environmental Planning review process. The recovery actions identified in the *National Recovery Plan for the Swift Parrot* (Commonwealth of Australia 2019) would not be interfered with by the proposal.

Conclusion

The Swift Parrot would suffer a small reduction in extent of foraging habitat and loss of potential roosting habitat (four hollow-bearing trees) from the action. The action is unlikely to reduce the population size of the Swift Parrot or decrease the reproductive success of this species. The action would not interfere with the recovery of the Swift Parrot. For the Swift Parrot, impacts are most likely to be significant where a proposal or activity may result in loss of habitat in, or adjacent to priority foraging, nesting and roosting sites (Saunders and Tzaros, 2011). The proposal would not impact on any priority foraging habitat. As such, after consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Swift Parrot.

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Appendix I

Hydrology and Flooding

Sydney Metro Precast Facilityies

Technical Paper - Hydrology and Flooding

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27 October 2020

Sydney Metro Authority

Sydney Metro Precast Facilityies

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B	29/06/2020	Updated proposal site	L Chong	A Hossain	D Haynes W Owers	D Haynes W Owers
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E	27/10/2020	Final	L Chong	A Hossain	D Haynes W Owers	D Haynes W Owers

Contents

Executive Summary

A Review of Environmental Factors (REF) has been prepared for the proposed Sydney Metro West precast facilities (the proposal) seeking approval under Part 5 of the *Environmental Planning and Assessment 1979* (EP&A Act) for the construction and operation of two precast facilities and associated ancillary infrastructure. The proposal site is located on the eastern side of Ropes Creek, in the suburb of Eastern Creek in the Blacktown local government area. Two (2) separate precast facilities, the northern precast facility and the southern precast facility comprise the overall proposal.

A hydrology and flooding assessment has been conducted to support the REF for the proposal. The assessment has considered the available flooding studies, policies and guidelines to define existing case flooding conditions and development controls for the proposal site. Additional hydrologic and hydraulic modelling was undertaken where there were data gaps, that is, for overland flooding around and through the proposal site, for the catchment development conditions relevant to the nature and timing of proposed development on and around the proposal site during its construction and operation.

Review of existing flooding conditions in Ropes Creek indicate that the proposal site is entirely above the 1% AEP flood extent. The proposal site is also mostly above the probable maximum flood, with exception of a small encroachment into the flood extent at the south-western corner of the southern precast site, outside the environmental protection area.

There are two main overland flow paths which pass through each of the northern and southern precast sites. These overland flow paths drain currently undeveloped upstream catchments located to the east of the proposal site. Management of these external flows through/around the site would be required.

An assessment of impacts of the proposal on flooding was undertaken based on qualitative assessment and updated hydrologic modelling. Potential impacts include partial impediment of Ropes Creek flows caused by filling in the south-western corner of the site resulting in negligible flood impacts in the probable maximum flood only, increases in peak flows being discharged to Ropes Creek due to development of the proposal site, impacts on creek geomorphology due to altered flow regime and impacts on overland flooding behaviour and drainage. The final-state construction phase and the operational phase of the proposal were considered to have similar potential impacts to flooding and hydrology. The potential change in impacts during a future climate change scenario were also considered. The cumulative impacts of the proposal in combination with other development in the area are addressed in the Review of Environmental Factors.

A range of mitigation and management measures have been identified to manage the potential impacts to flooding, and are summarised in Table 1. Indicative sizing has been provided for structural measures, which include stormwater/flood detention facilities and external flow diversion channels for the northern and southern precast sites.

Table 1: Construction and operational environmental management measures

No.	Impact	Mitigation measure
F1	Increase in mainstream peak flood flows	Detailed design of the proposal site would include provision of appropriate on-site stormwater detention/flood detention facilities to cater for up to and including the 1% AEP event.

No.	Impact	Mitigation measure
F2	Geomorphic impacts due to changed flow regime in low flows and frequent flood events	Detailed design of the proposal site would include the provision of appropriate on-site stormwater detention/ flood detention facilities. Outlet sizing would be designed to satisfactorily mitigate potential increases in peak flows in frequent events.
F3	Impacts on overland flooding and drainage conditions	Detailed design of the proposal site would include the provision of appropriate flow diversion channels or culverts for management of external flows.
F4		Detailed design would integrate with proposed Archbold Road cross drainage and road drainage outlets.
F5		Detailed design would provide appropriate scour protection works at channel/culvert discharge points to Ropes Creek.
F6	Impacts on the proposal resulting from flooding	Detailed design would provide filling to a height of at least 0.5m above Ropes Creek 1% AEP flood level.

Key Terms

Term	Meaning
AEIs	Areas of environmental interest
afflux	Increase in flood level as a result of obstruction to flow
AHD	Australian Height Datum. A common national surface level datum approximately corresponding to mean sea level.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. The following relationships between AEP and ARI applies to this study (ARR, 2019).

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	**12**			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
Frequent	**1**	**63.2**	1.58	1.00
	0.69	**50.00**	2	1.44
	0.5	39.35	2.54	2.00
	0.22	**20.00**	5	4.48
	0.2	18.13	5.52	5.00
Infrequent	0.11	**10.00**	10.00	9.49
	0.05	**5.00**	20	20.0
	0.02	**2.00**	50	50.0
	0.01	**1.00**	**100**	100
Rare	0.005	0.50	**200**	200
	0.002	0.20	**500**	500
	0.001	0.10	**1000**	1000
	0.0005	0.05	**2000**	2000
Extremely Rare	0.0002	0.02	5000	5000
			↓	
Extreme			PMP	

Term	Meaning
ARR	Australian Rainfall and Runoff. Guidelines prepared by the Institute of Engineers Australia for the estimation of design floods. Reference is made to the 1987 or the 2019 versions of ARR, as specified.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. Also refer to Average Exceedance Probability (AEP), which is the industry standard terminology for definition of design flood events.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
conveyance	The transport of flood water downstream.
development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use (e.g. The urban subdivision of an area previously used for rural purposes). New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area (e.g. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale). Redevelopment generally does not require either re-zoning or major extensions to urban services.
DIPNR	Former NSW Government Department of Infrastructure, Planning and Natural Resources. Now the Department of Planning Industry and Environment (DPIE).
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being

Term	Meaning
	undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
exceedances per year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land /flood prone land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the probable maximum flood event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
flood readiness	Readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances

Term	Meaning
	across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
hazard	A source of potential harm or situation with a potential to cause loss. In relation to this technical paper the hazard is flooding which has the potential to cause damage to the community.
hydraulics	The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at a particular location varies with time during a flood.
hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
IFD	Intensity Frequency Duration. Describes rainfall in terms of intensity (typically mm/hr), frequency (e.g. ARI) and duration of the storm.
LEP	Local Environmental Plan

Term	Meaning
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
LPI	Land and Property Information
m AHD	metres Australian Height Datum (AHD)
m/s	metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
modification measures	Measures that modify either the flood, the property or the response to flooding.
Northern precast facility	Proposed precast facility at the north of the proposal site
overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land, that is, the floodplain.
probable maximum precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to probable maximum flood estimation.
proposal (the)	Construction of two separate precast facilities, including boiler, aggregate bins and consumables, hardstand/laydown areas, offices, parking, precast carousel including batch plant, and warehouses.
proposal site (the)	Site located at Lenore Drive, Eastern Creek
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this technical paper it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Term	Meaning
runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
scour	Erosion by mechanical action of water, typically of soil.
Southern precast facility	Proposed precast facility at the south of the proposal site
stage	Equivalent to water level (both measured with reference to a specified datum)
study area	Area encompassing the proposal site and surrounds. For the precast facility flooding assessment this was taken to be within 500m of the site.
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation (hydraulics). It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.
XP-RAFTS	XP-RAFTS is a computer program which is used to simulate storm rainfall-runoff processes (hydrology) and estimate flood peak flows and temporal variation of flows.

1. Introduction

1.1 Sydney Metro West Eastern Creek Precast Facilities

Sydney Metro propose to establish two precast facilities (the proposal) to support the construction of the proposed Sydney Metro West. The precast facilities which are the subject of this proposal would manufacture precast concrete segments for the purpose of lining the Sydney Metro West tunnels. A Review of Environmental Factors (REF) has been prepared for the proposal seeking approval under Part 5 of the *Environmental Planning and Assessment 1979* (EP&A Act).

The proposal would comprise the following key features:

- Site establishment at the proposal site at Eastern Creek including vegetation clearing, remediation, and earthworks
- The establishment and operation of two separate adjacent and precast facilities on the proposal site, the northern and southern precast facilities. Each precast facility would include:
  - A precast yard including a shed for construction of precast concrete segments and storage laydown areas
  - Boiler, aggregate bins and consumables
  - Office facilities
  - On-site parking for up to 60 light vehicles
- Internal roads with entrances to each facility from the Western Access Road located between the northern and southern precast facilities (external roads would be subject to separate approvals)
- Ancillary supporting infrastructure, including utilities installation (power, water, sewerage, gas and communications), lighting, signage and landscaping.

The northern and southern precast facilities would operate concurrently, 24 hours a day, seven days a week for the majority of the lifespan of the project.

A small portion of the south-western portion of the proposal site would be conserved as an environmental protection area associated with the presence of Cumberland Plain Woodland. Vegetation within this area would be retained and protected during works.

The footprint and operational layout of the proposal is shown in Figure 1-1.

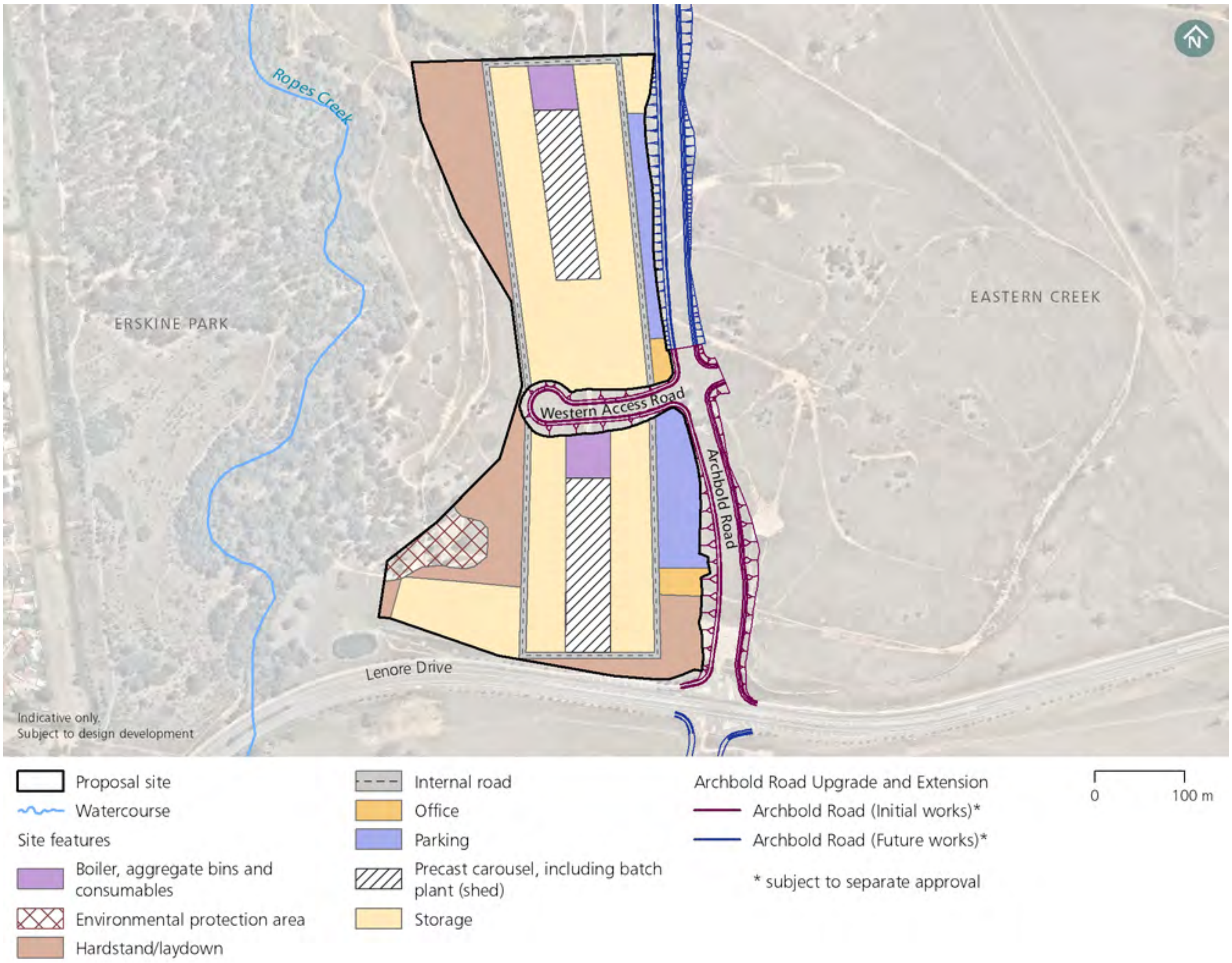

Figure 1-1: Overview of the proposal

1.2 Purpose and scope of this report

This technical paper, Technical Paper: Hydrology and Flooding, is one of a number of technical papers that form part of the REF. The purpose of this technical paper is to identify and assess the potential impacts of the proposal in relation to catchment hydrology, and mainstream and overland flooding.

1.3 Structure of this report

The remainder of this report is structured as follows:

- Chapter 2 outlines the relevant legislative and policy framework
- Chapter 3 documents the assessment methodology including a description of the overall approach and the review of existing information
- Chapter 4 details the existing hydrologic environment
- Chapter 5 provides an assessment of the potential impacts of the proposal to flooding during construction, including cumulative impacts
- Chapter 6 provides an assessment of the potential impacts to flooding during the operation of the proposal. Discussion of potential impacts during future climate change scenario and cumulative impacts are also provided
- Chapter 7 identifies mitigation and management measures
- Chapter 8 provides conclusions and recommendations forthcoming from this study.

2. Legislative and policy framework

The assessment has been undertaken generally in accordance with the following key guidelines and design references as applicable:

- *Australian Rainfall and Runoff (*ARR) 2019
- *NSW Floodplain Development Manual* (NSW Government, 2005)
- Blacktown City Council policies planning instruments.

2.1 Australian Rainfall and Runoff 2019

Australian Rainfall and Runoff 2019 ("ARR 2019"; reference: Ball et al, 2019) provides industry guidance on technical analysis and specifies design rainfall parameters for flooding and hydrologic studies in Australia. These guidelines have been adopted for new hydrologic assessment undertaken in this study.

The existing flood studies reviewed in this assessment are based on the design rainfall data provided in *Australian Rainfall and Runoff 1987* ("ARR 1987"; reference: Institute of Engineers Australia, 1987). The ARR 2019 design rainfall data provides design rainfall depths which vary from ARR 1987, due to analysis of an additional 30 years of data. For the 1% AEP event the difference is +/- 5% compared to ARR 1987, for storm durations between one hour and six hours, which are relevant to the proposal site.

Consideration of flood affectation and flood impacts during detailed construction planning should adopt ARR 2019 in line with the current industry guidance.

2.2 Floodplain Development Manual

The assessment of potential flooding impacts of the proposal on existing flood regimes has been conducted in accordance with the requirements of the *Floodplain Development Manual* (NSW Government, 2005), which incorporates the NSW Government's *Flood Prone Land Policy*. The key objectives of this policy are to identify potential hazards and risks, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

2.3 Blacktown City Council Policies

2.3.1 Blacktown Local Environment Plan 2015

The Blacktown Local Environment Plan 2015 (Blacktown LEP 2015) adopts the Department of Planning and Environment's model flood planning clause as clause 7.1. The objectives of clause 7.1 Flood Planning are to:

- Minimise the flood risk to life and property associated with the use of land;
- Allow development on land that is compatible with the land's flood hazard, considering projected changes as a result of climate change; and
- Avoid significant adverse impacts of flood behaviour on the community.

This clause applies to land at or below the flood planning level or the highest historical flood level.

Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

In this clause—

- highest historical flood event means the highest recorded flood in the Blacktown local government area, which occurred in 1867.
- land at or below the flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.

It should be noted that, although the provisions of the Blacktown LEP 2015 are taken into consideration, Sydney Metro is the determining authority for the proposal and the provisions of the LEP 2015 do not apply.

2.3.2 Blacktown Development Control Plan 2015

Section 9 in *Blacktown Development Control Plan 2015 – Part A Introduction and General Guidelines* (Blacktown DCP 2015) outlines the development controls related to development on flood prone land. In determining any application for development on land designated as being within the floodway or flood fringe, Council will take into consideration those matters listed under Section 79C of the *Environmental Planning and Assessment Act 1979* as appropriate. Council shall also take into consideration the following:

(a) Whether the proposed building materials are suitable

(b) Whether the buildings are to be sited in the optimum position to avoid flood waters and allow evacuation

(c) Whether proposed structures or the filling of land are likely to affect flood flows

(d) Whether consultation with other authorities is considered necessary (e.g. NSW Office of Water)

(e) The NSW Government Floodplain Development Manual 2005.

In general, Council is generally unlikely to support development which includes the filling of land within the floodway. Council would generally support development within the flood fringe subject to a range of development controls.

Relevant to the development of the proposal site (zoned Industrial), the floor level should be at least 300 millimetres above the designated flood level. Where subdivision is approved in industrial and commercial zones, the land must be filled to 300 millimetres above the designated flood level.

Section 10 in *Blacktown Development Control Plan 2015 – Part A Introduction and General Guidelines* includes provisions for development on addressing the risks posed from overland flooding. Review of the document indicates that it is geared towards in-fill development and redevelopment in urban areas, for example ensuring that individual building footprints and fencelines on properties are designed to ensure adequate provision for movement of overland flow and site drainage and to ensure unobstructed overland flows. The guidelines for developing around overland flow areas are not directly relevant to the proposal site, which is a greenfield site in an area which is zoned for industrial use.

Note that Blacktown DCP 2015 provides development controls for Blacktown LGA in general. The *Ropes Creek Precinct Draft Development Control Plan 2016* provides development controls specific to the Ropes Creek Precinct, which includes the proposal site. Refer to Section 2.4.

It should also be noted that, although the provisions of the Blacktown DCP 2015 are taken into consideration, Sydney Metro is the determining authority for the proposal and the provisions of the DCP 2015 do not apply.

2.3.3 Blacktown City Council Engineering Guide for Development 2005

The *Blacktown City Council Engineering Guideline for Development 2005* (amended 2018) specifies design requirements for trunk drainage and on-site stormwater detention. Trunk drainage is to be designed to the 1% AEP event and open channels require a 0.5m freeboard from the design flood level to top of bank.

Sizing and permissible discharge rates for on-site stormwater detention systems are generally based on pro-rata values depending on the site area, for most catchment areas where in-fill development is occurring. The proposal site is a greenfield site and is denoted being within "Exempt OSD Catchment Areas – Regional Basins or Trunk Drainage Augmentation", hence the pro-rata sizing approach does not apply. There is no specific guidance on design storm events to be accommodated or sizing requirements contained in the *Engineering Guide,* although local councils generally require that the developed case peak site discharge rates are not to exceed the existing case for storm events between the 1 in 2 exceedances per year (EY) event up to the 1% AEP event. Sizing of on-site stormwater or flood detention system should be undertaken to achieve this.

Note that the *Engineering Guide* specifies the use of ARR 1987 design rainfall data for design and assessment. The *Engineering Guide* has not yet been updated to adopt the current ARR 2019 design rainfall and procedures. For the design and assessment for the greenfield proposal site it is considered appropriate to adopt ARR 2019.

It should be noted that, although the provisions of the *Engineering Guide* are taken into consideration, Sydney Metro is the determining authority for the proposal and the provisions of the *Engineering Guide* do not apply.

2.4 Ropes Creek Precinct Draft Development Control Plan 2016

The *Ropes Creek Precinct Draft Development Control Plan 2016* has been prepared in response to rezoning of the land in the Ropes Creek Precinct (Lot 10 DP1157491), including the proposal site, to 'IN2 General Industrial' under the State Environmental Planning Policy Western Sydney Employment Area 2009 (WSEA SEPP) and in accordance with section 74(C) of the *Environmental Planning and Assessment Act 1979*. The DCP is listed as "Under Consideration" as of May 2020.

The *Ropes Creek Precinct Draft Development Control Plan 2016* includes provisions for management of flooding on the site. Excerpts of the DCP are provided below.

Objectives

- To ensure that development does not increase the flood hazard or extents.
- To ensure that development within flood affected land is appropriately designed to minimise damage to property or risks to loss of life.

Controls

Council may require a flood assessment to be undertaken for allotments that are flood affected, within an overland flow path or in proximity to such land. The assessment would need to demonstrate that the development will not increase flood impacts, hazard or damage to other properties. Specifically, in accordance with the WSEA SEPP 2009, the assessment may need to address the following (subject to advice from Council):

- the impact of flooding on proposed development, including an estimation of the extent of flood prone land, high hazard areas and floodways, the implications of the full range of floods and the safety of people using or within the site;
- the impact of proposed development on flood behaviour on and off the site (including existing and planned development in the wider area);
- the flood hazard in the area (including hydraulic hazard, flood warning time, rate of rise of floodwater and duration of floods) and access and evacuation issues; and
- viable strategies to manage any adverse impact of proposed development on flood behaviour.

In general, Council would not support development, including the filling of land, within the floodway due to its function as the main flowpath for flood waters once the main channel has overflowed and the possibility of a significant threat to life and property occurring in a major flood.

For industrial and commercial buildings, the floor level is to incorporate a minimum 500mm freeboard above the designated flood level.

Buildings within a flood prone area are to be constructed with materials approved by Council's Building Services Team, resistant to damage by immersion by flood waters for prolonged periods, to the satisfaction of Council.

The *Ropes Creek Precinct Draft Development Control Plan 2016* is to be read in conjunction with Blacktown Council Engineering Guidelines. It does not provide specific requirements for sizing of on-site stormwater or flood detention facilities. The guidance as discussed in Section 2.3.3 is referred to.

It should be noted that, although the provisions of the Ropes Creek Precinct Draft DCP 2016 are taken into consideration, Sydney Metro is the determining authority for the proposal and the provisions of the Draft DCP 2016 do not apply.

3. Assessment methodology

3.1 Overall assessment approach

The objective of this hydrology and flooding assessment is to address flood immunity and flood impacts for the proposed precast facilities. The methodology for this hydrology and flooding assessment is summarised below:

- Desktop review of available flood study reports from Blacktown City Council and other sources to characterise existing flooding conditions at the proposal site and the surrounding area. Parameters considered include:
  - The topography in the vicinity of the sites and presence of flow paths and watercourses, using aerial laser survey data
  - Flood depths and levels
  - Flood hazard
  - Flood hydraulic categories including floodway and flood storage
- Where there is no adequate existing flood information (i.e. for overland flooding), flood modelling has been undertaken to determine flooding conditions
- Review of Blacktown City Council planning and policy documents to identify flood-related development controls including impact mitigation requirements
- Assessment of potential impacts to flooding as a result of the proposal for construction and operational phases
- Identification of the potential impacts to the proposal caused by flooding
- Identification of mitigation and management measures.

3.2 Review of Existing Studies

3.2.1 South Creek Flood Study (Worley Parsons, 2015)

Worley Parsons conducted a flood study for South Creek and its tributaries, including Ropes Creek in the section adjacent to the proposal site. The study focussed on mainstream flooding within the main creeks and did not include minor overland flow paths. Flood modelling was undertaken using RMA-2 software to define the existing flooding conditions for the 20, 50, 100, 200 and 500 year ARI events (i.e. 5%, 2%, 1%, 0.2% and 0.5% AEP events, respectively) and probable maximum flood event. The study was based on ARR 1987 design rainfall data and procedures. Flood mapping including depths, levels, flood hazard and hydraulic categories is presented.

The flood study is referenced in this flooding assessment to define mainstream flood behaviour in Ropes Creek. The study is adopted by Blacktown City Council.

3.2.2 Master Planning reporting for Ropes Creek Precinct

The NSW Office of Strategic Lands (part of the NSW Department of Planning, Industry and Environment Cluster) commissioned assessments to guide future development and formulation of development controls for the Ropes Creek Precinct. The proposal site comprises one sub-portion of the overall Ropes Creek Precinct. A watercycle management strategy was undertaken including assessment of hydrology, flood hydraulics and water quality management. Hydrologic and flood modelling was undertaken in accordance with ARR 1987 design rainfall and procedures.

3.2.3 Archbold Road Upgrade and Extension – Review of Environmental Factors (Transport for NSW, 2017)

A concept design and REF was prepared for the upgrade and extension of Archbold Road in Minchinbury south through the Western Sydney Employment Area (WSEA) to Old Wallgrove Road in Horsley Park. The project would form a new road immediately to the east of the proposal site and linking to Lenore Drive and Old Wallgrove Road in the south.

The *Archbold Road Flooding and Drainage* (Lyall & Associates, 2016) was undertaken to support the REF. Hydrologic and flood modelling was undertaken as a part of the study to determine existing flooding conditions, inform the road drainage design and demonstrate the satisfactory mitigation of flooding and hydrologic impacts. A concept design drainage layout including water quality devices was prepared as shown on Figure 3-1. It indicates that the major cross drainage structures in the vicinity of the proposal site are aligned with the major overland flow paths, while pavement drainage outlets are located adjacent to the cross drainage. Flows discharged from the Archbold Road drainage structures (without the proposal site) were anticipated to be conveyed in the natural overland flow paths through the existing proposal site. There does not appear to be provision of formalised channels to convey flows from the drainage structures to Ropes Creek.

No water quality basins are proposed adjoining the proposal site in the Archbold Road Upgrade and Extension REF (2017). The Archbold Road Upgrade and Extension Addendum REF includes the provision of a basin to the west of the site, adjacent to the Western Access Road.

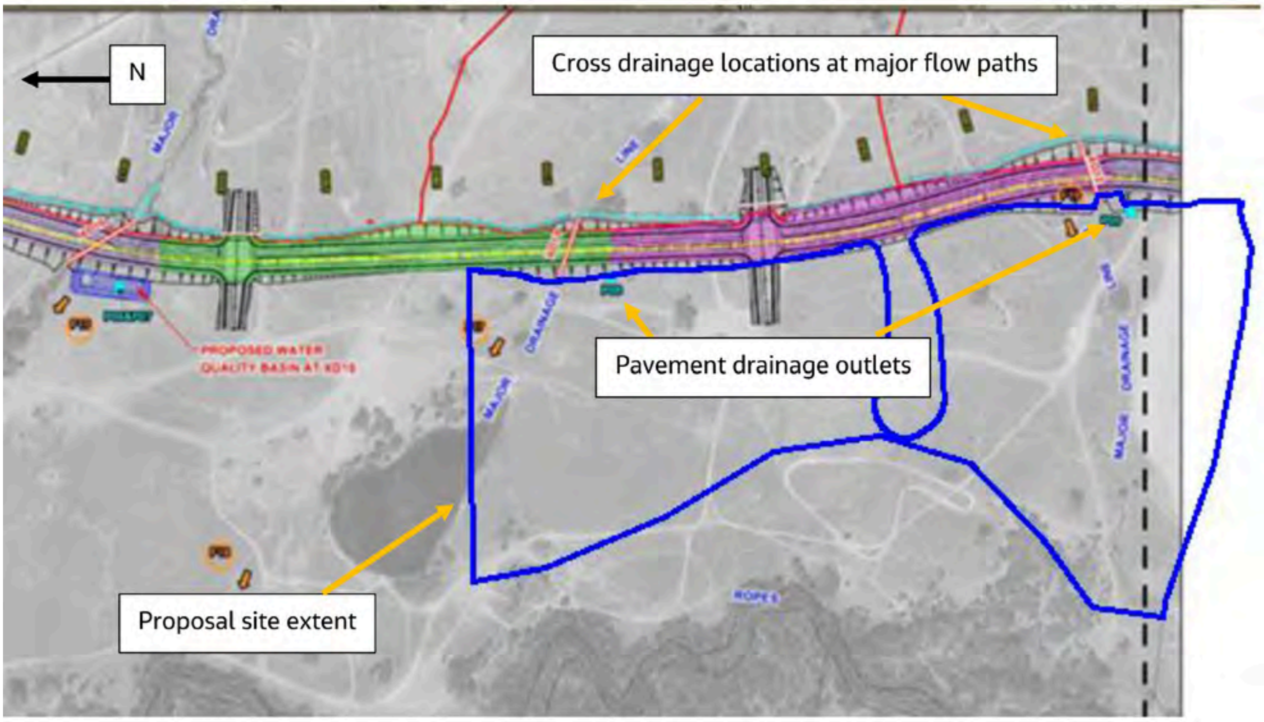

Figure 3-1: Excerpt of concept drainage strategy from *Archbold Road Flooding and Drainage* (Lyall & Associates, 2016)

Drainage structures were sized for a 1% AEP design flow based on ARR 1987, which is expected to result in larger sizes than if based on the current ARR 2019 guidelines. Sizing and design flows for two cross drainage structures are indicated in Table 3-1. For the purpose of the investigation, sizing of the cross drainage was based on peak flow estimates for a level of development consistent with present day conditions. However, consideration has also been given to the potential for uncontrolled development within the catchments which drain to the cross drainage structures.

Pavement drainage outlet locations were indicated but sizing and design flows not provided.

Table 3-1: Archbold Road upgrade concept design sizing for cross drainage structures near proposal site

Structure	**Dimensions**	**1% AEP Flow (m^3/s)**
XD11 (northern proposal site)	3 x 1200mm x 600mm box culvert	4.93* see Note 1
XD12 (southern proposal site)	1 x 1350mm diameter pipe	3.49* see Note 1

* Note 1: Cross drainage design flows extracted from Table 7.1 in Lyall & Associates (2016) for "post road upgrade". Assumes no development to currently greenfield catchment area upstream of the road.

As a part of the assessment for the proposal, sizing of drainage structures on the proposal site need to be cognisant of the proposed hydraulic structures for the Archbold Road upgrade.

4. Existing hydrologic environment

4.1 Proposal site

The proposal is located at Eastern Creek within the Blacktown City Council local government area. The proposal would be located at Lenore Drive, Eastern Creek (the proposal site).

The 'proposal site' refers to the area that would be directly impacted (except for the environmental protection area) by the proposal as shown in Figure 1-1. The environmental protection area would be conserved, with vegetation retained and protected during works.

The proposal site is an undeveloped greenfield site within the broader context of surrounding established and future industrial areas at Eastern Creek.

4.2 Study area hydrologic context

The proposal site is located on the eastern side of Ropes Creek, in the suburb of Eastern Creek in the Blacktown local government area. The existing topography on the site consists of gently undulating land which generally grades to the west towards Ropes Creek.

Ropes Creek flows from south to north to the west of the proposal site. Two main overland flow paths (northern and southern flow paths) originate from the area to the east of the proposal site on land which is gently to moderately sloping, refer to Figure 4-1. A minor, shallow flow path is also present in the middle section of the proposal site.

The northern flow path drains in a north-westerly direction, intersecting the north-eastern corner of the proposal site and drains to a large existing farm dam which straddles the northern boundary of the proposal site, which then discharges to Ropes Creek to the north of the proposal site. There is a second, small existing farm dam on the northern flow path, located about 300 metres upstream of the large farm dam and situated outside of the proposal site boundary.

The southern flow path drains in a westerly direction through the southern portion of the proposal site, approximately 100 metres north of Lenore Drive, and discharges to Ropes Creek adjacent to the south-western corner of the proposal site. There is an existing farm dam on the southern flow path, located within the footprint of the proposal site.

The proposal site and surrounding area was historically agricultural and grazing land, and to date has largely retained its rural appearance. The land includes coverage by grassland with scattered stands of trees. The riparian corridor along Ropes Creek, immediately to the west of the proposal site is moderately to densely vegetated with trees. There is little to no riparian vegetation along the two flow paths.

There is currently no existing development within or in the immediate vicinity of the proposal site. There are existing industrial properties located approximately 1 kilometre to the west of the site, on the catchment boundary or outside the catchment areas draining to the two overland flow paths. Existing residential development is present in the suburb of Erskine Park on the western side of Ropes Creek. Lenore Drive is an existing main road running east-west to the south of the proposal site but is outside of the overland flow paths catchment areas.

4.3 Assessment of Existing Case Flooding

4.3.1 Ropes Creek Mainstream Flooding

The *South Creek Flood Study* (Worley Parsons, 2015), adopted by Blacktown City Council, is referenced for the design flooding conditions in Ropes Creek at the proposal site. The 1% AEP flood mapping from the study has been extracted and mapped with the proposal site layout on Figure 4-2 to Figure 4-5. The flood levels, flood depths, flood hazard and hydraulic categories are presented. The probable maximum flood levels and depths are shown on Figure 4-6 and Figure 4-7, respectively.

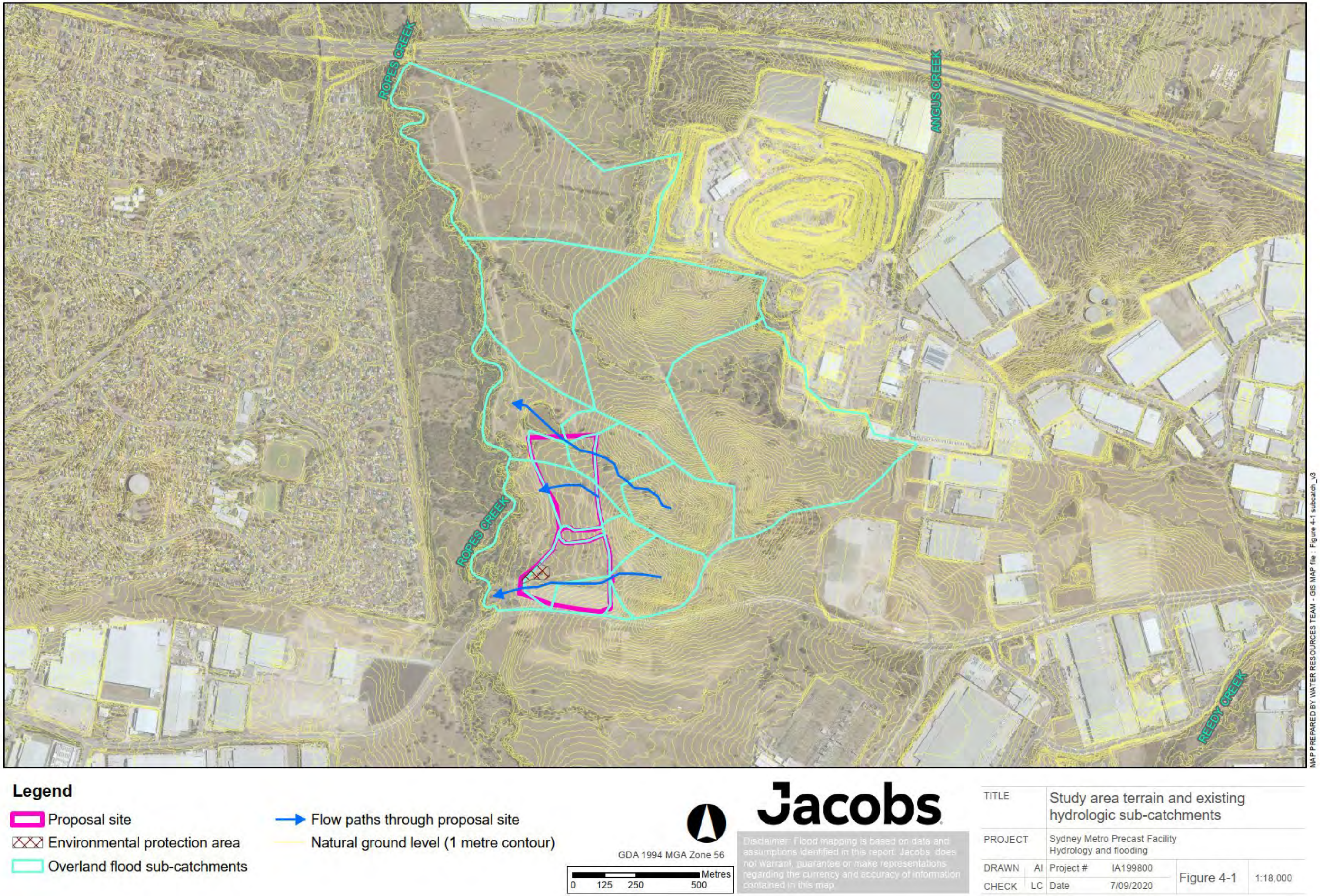

Figure 4-1: Study area terrain and existing hydrologic sub-catchments

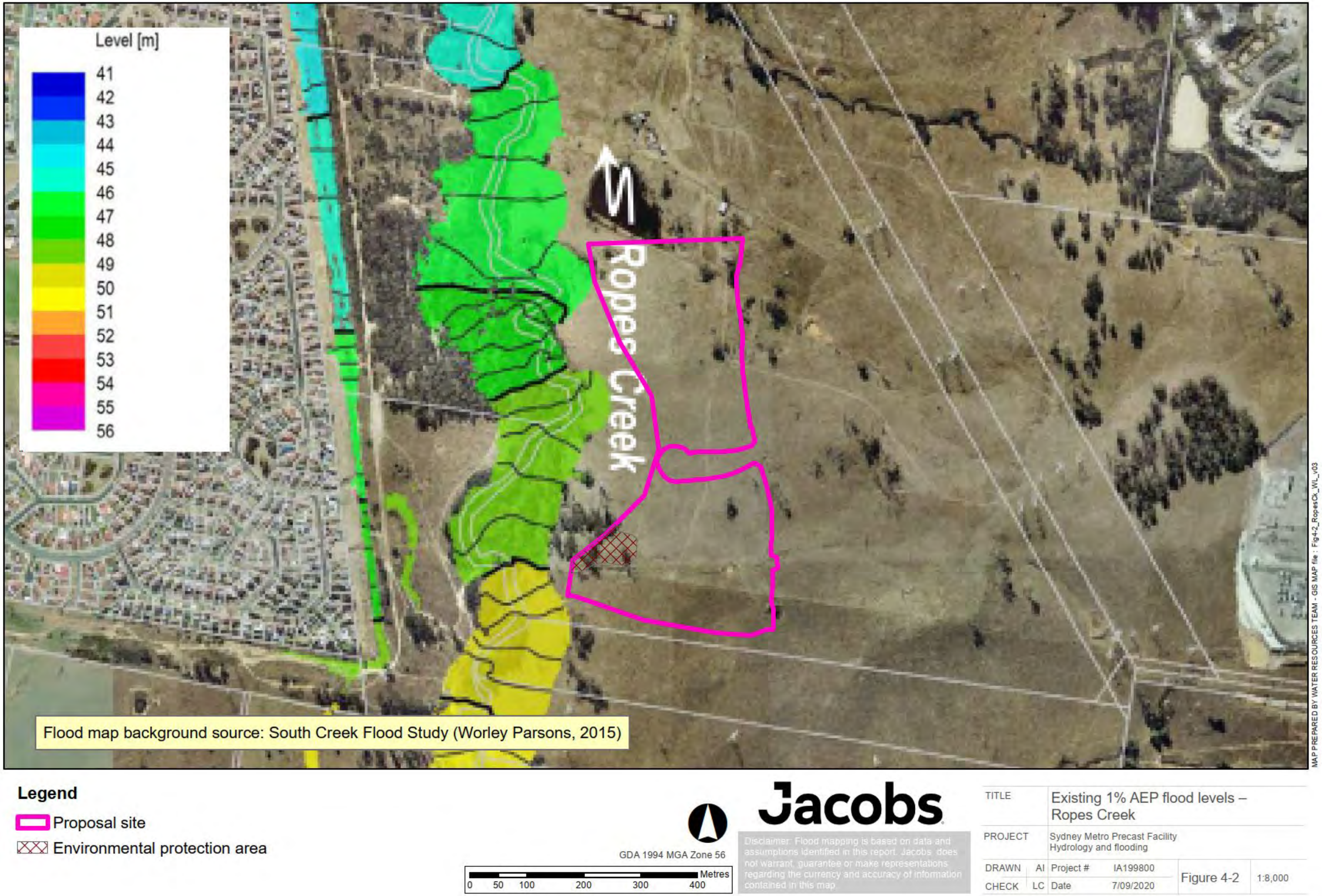

Figure 4-2 Existing 1% AEP flood levels – Ropes Creek

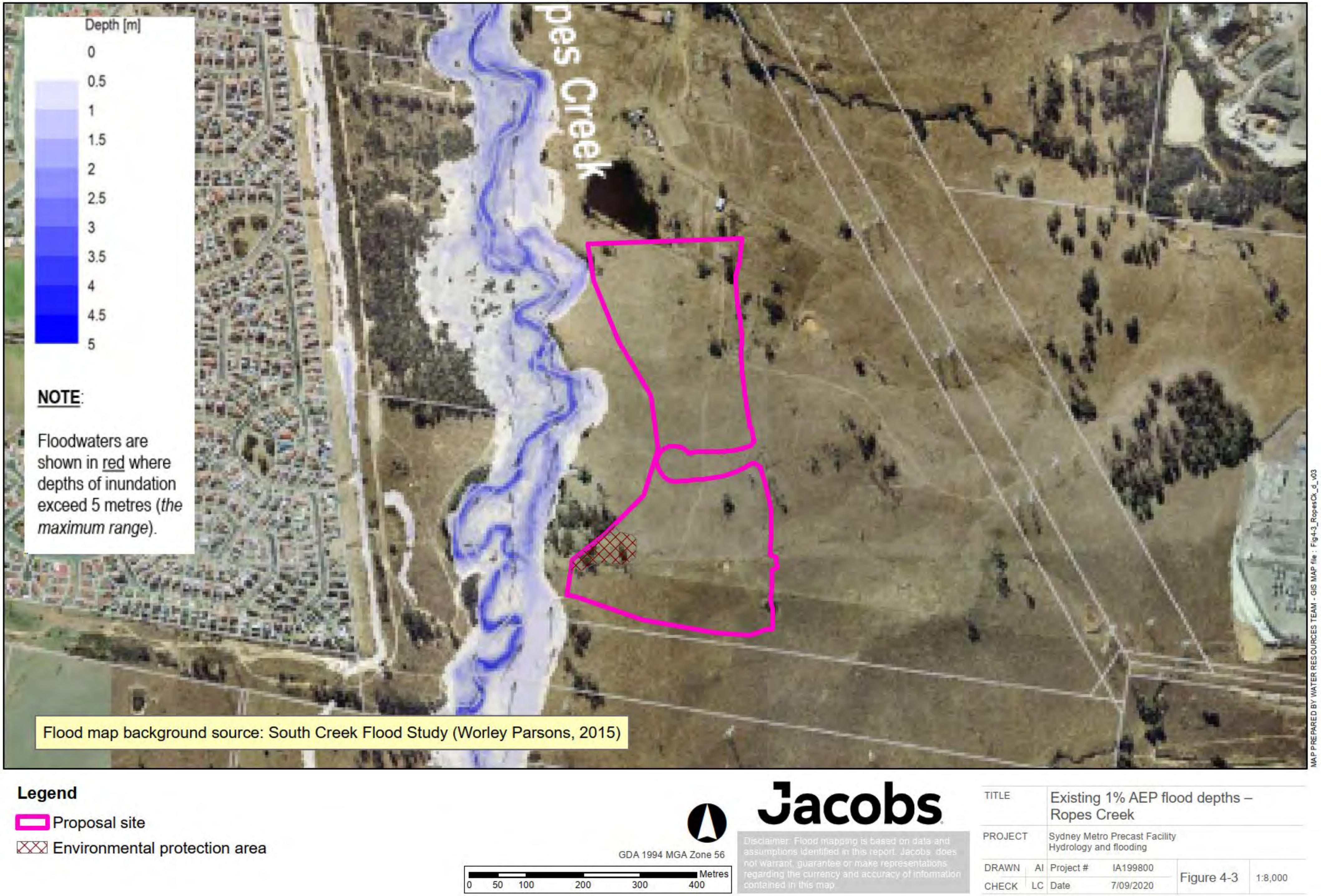

Figure 4-3 Existing 1% AEP flood depths – Ropes Creek

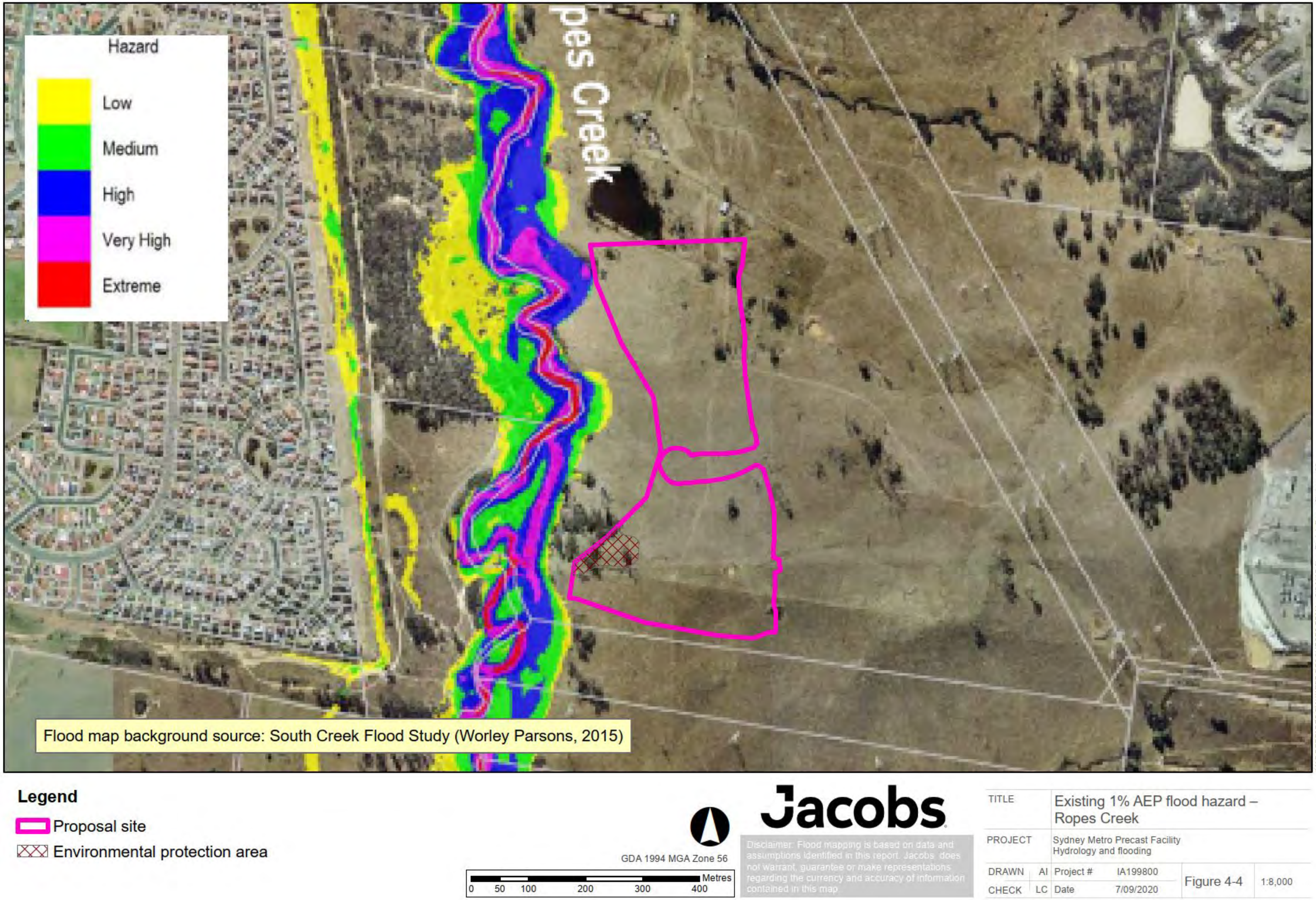

Figure 4-4 Existing 1% AEP flood hazard – Ropes Creek

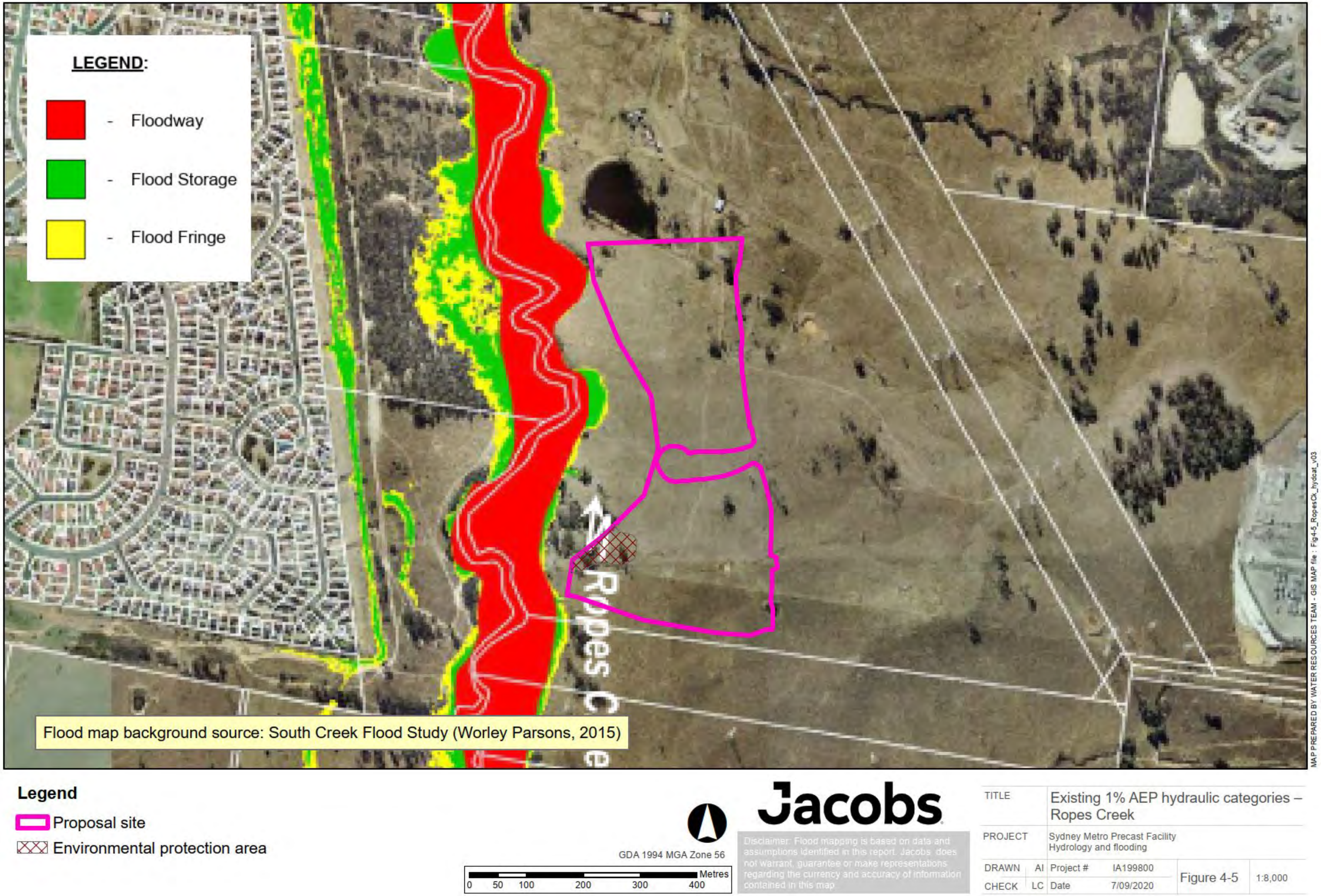

Figure 4-5 Existing 1% AEP hydraulic categories – Ropes Creek

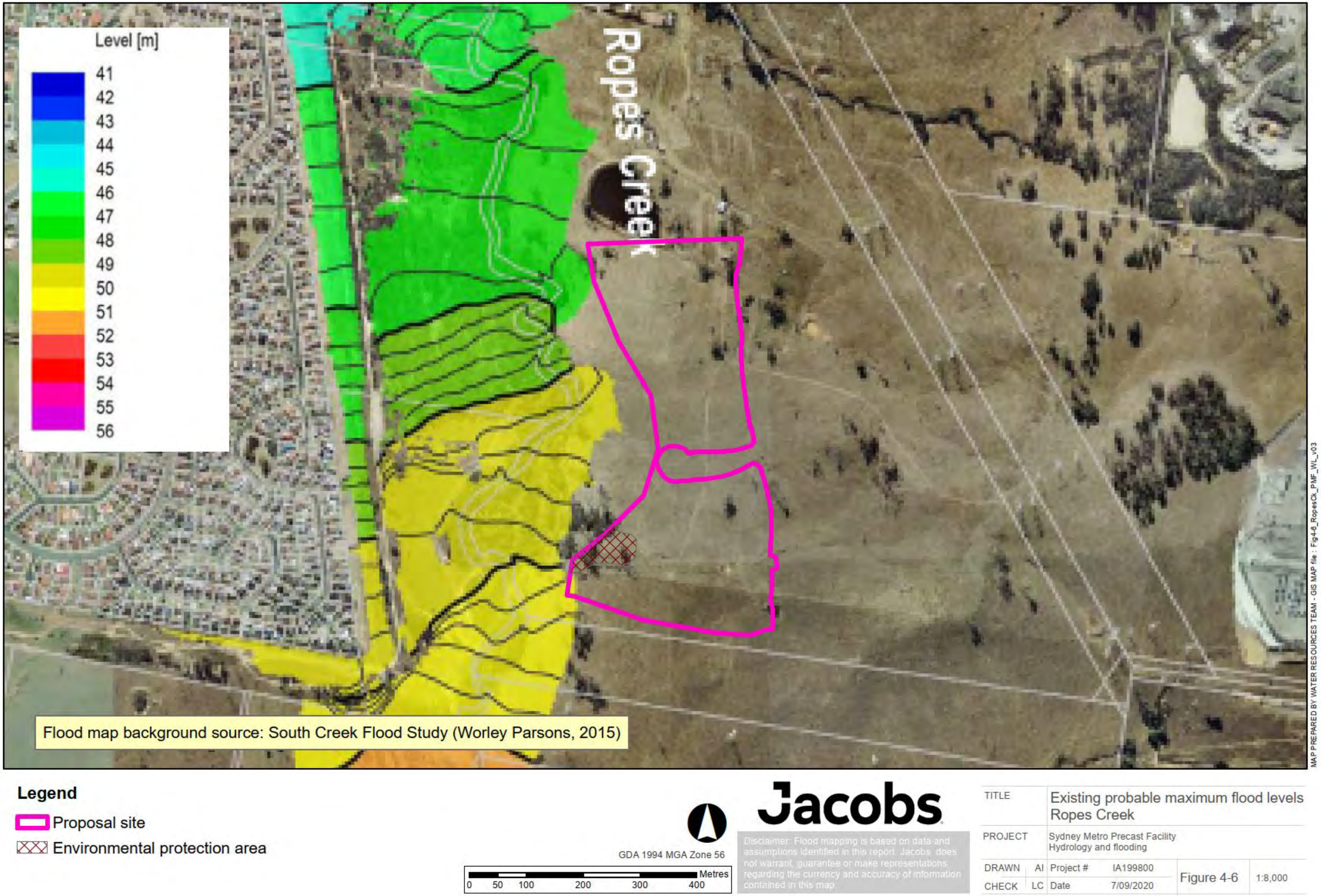

Figure 4-6 Existing probable maximum flood levels – Ropes Creek

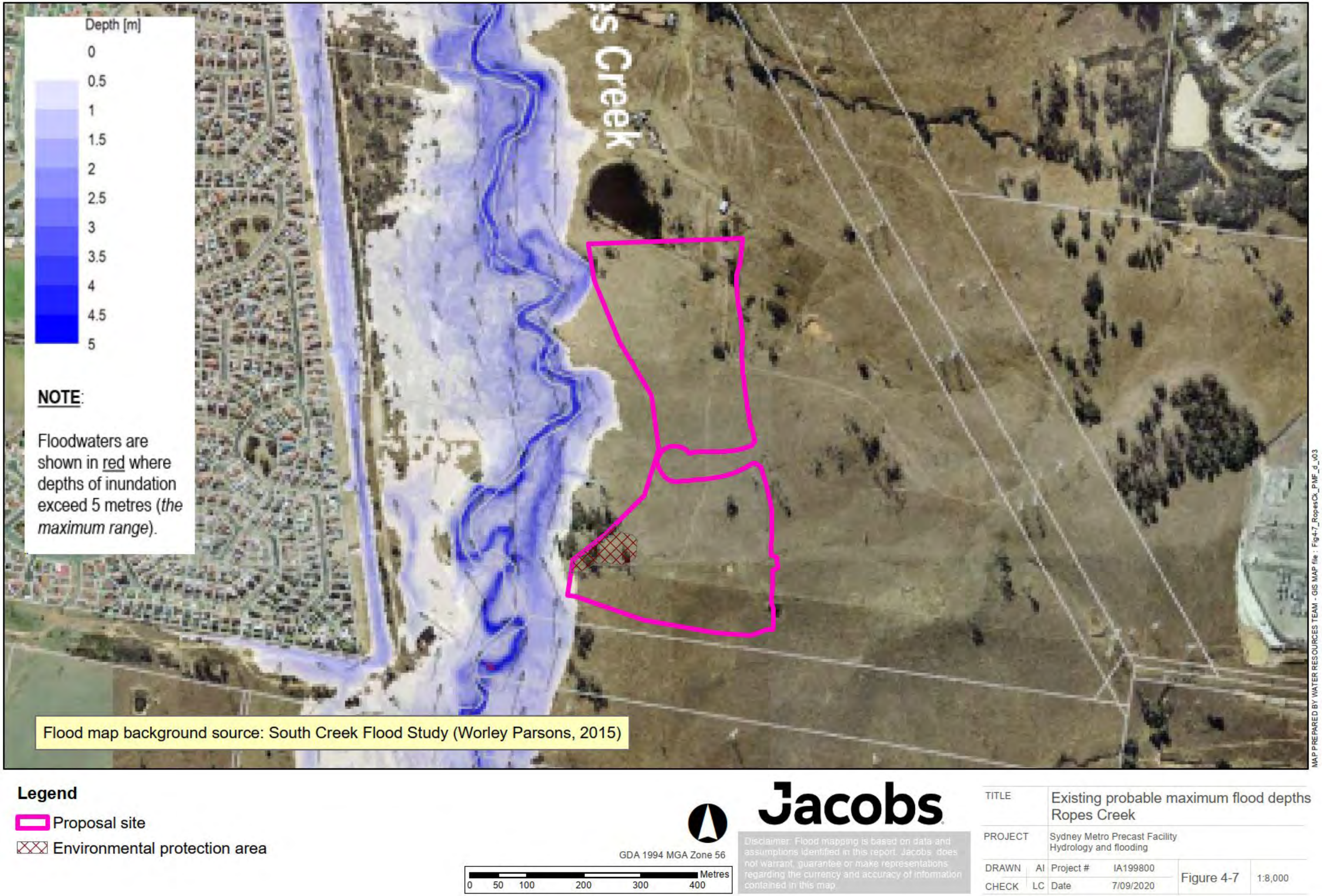

Figure 4-7 Existing probable maximum flood depths – Ropes Creek

The majority of the proposal site is not flood affected by Ropes Creek flooding in the probable maximum flood, with the exception of the south-western corner (outside of the environmental protection area, refer to Figure 4-7). The entire proposal site is not affected by events up to and including the 1% AEP. Details of the existing case mainstream flooding conditions at the proposal site are summarised below:

- The 1% AEP flood levels in Ropes Creek range from 49.4 metres AHD at the south-western corner of the proposal site to 46.7 metres AHD at the north-western corner of the proposal site.
- The probable maximum flood levels in Ropes Creek range from 50.5 metres AHD at the south-western corner of the proposal site to 47.8 metres AHD at the north-western corner of the proposal site.
- The proposal site is entirely above the Ropes Creek 1% AEP flood extent. At the north-western section of the proposal site, the site boundary approaches the fringe of the 1% AEP flood extent. The minimum ground elevation is 48.2 metres AHD, which is above the 1% AEP flood level at that location of 46.9 metres AHD.
- The proposal site is also largely above the Ropes Creek probable maximum flood level except for an encroachment of 15 metres in horizontal extent into the south-western corner of the proposal site. The maximum depth is about 0.1 metres at the south-western corner of the proposal site. At the north-western section of the proposal site where the site boundary approaches the fringe of the probable maximum flood extent, the minimum ground elevation is 48.2 metres AHD, which is above the probable maximum flood level at that location of 47.9 metres AHD.
- Since the proposal site is above the 1% AEP flood level, it does not encroach on the Ropes Creek floodway area.

4.3.2 Overland flow flooding

Overland flows in the two main flow paths through the proposal site were estimated using hydrologic modelling in XP-RAFTS and hydraulic modelling in TUFLOW software. The overland flow assessment was undertaken based on the hydrologic analysis procedures outlined in ARR 2019 and is described in detail in Appendix A. Existing farm dams including the farm dam on the northern boundary of the proposal site were assumed full in the hydrologic modelling. The peak flows at key locations are summarised in Table 4-1. Refer to Figure A-2 for the locations and existing case model node layout.

Table 4-1: Existing peak flows and critical storm duration at selected locations

Location	Total Catchment area	0.5EY	1% AEP
Upstream of southern precast site (Model nodes CA-3 + CA-7)	10.8 ha	0.52 m^3/s 6 hrs critical duration	3.7 m^3/s 15 minutes critical duration
Discharge point of southern precast site (Model node CA-6)	31.9 ha	1.21 m^3/s 6 hrs critical duration	8.25 m^3/s 45 minutes critical duration
Main flow path upstream of northern precast site (Model node CA-10)	16.9 ha	0.72 m^3/s 6 hrs critical duration	4.44 m^3/s 45 minutes critical duration
Discharge point of northern precast site (Model node ReprtDummy)	37.5 ha	1.37 m^3/s 6 hrs critical duration	7.95 m^3/s 45 minutes critical duration

Flood events analysed

The 1% AEP flood event was analysed to define the overland flooding conditions around the proposal site. The coincident flood event in Ropes Creek was assumed to be the 5% AEP event, in line with ARR 2019 guidelines. The modelled flooding in Ropes Creek needs to be considered in conjunction with the mainstream flood conditions for the 1% AEP event as described in Section 4.3.1.

Description of existing overland flood conditions

Mapping of the overland flood depths is shown on Figure 4-8. The Ropes Creek 1% AEP flood extent (as defined in the South Creek Flood Study, Worley Parsons, 2015) is also shown. Both the main northern and southern overland flow paths are mapped. A minor overland flow path which flows through the middle of the proposal site is also indicated.

Overland flow depths in the northern flow path are typically around 0.4 – 0.6 metres in the existing case. Depths of water in the existing farm dam is shown to be over 0.6 metres, however, are expected to be deeper than indicated due to the model topography showing the dam water surface and not reflecting the actual bed level of the dam.

Flow depths in the southern flow path are typically 0.4 – 0.7 metres deep in the main flow path. There are some shallow overflows from the main flow path up to 0.1 metres deep.

The minor middle flow path exhibits shallow (less than 0.05 metres depth) dispersed flow with some deeper ponding within an access track which is in cut below the surrounding ground level.

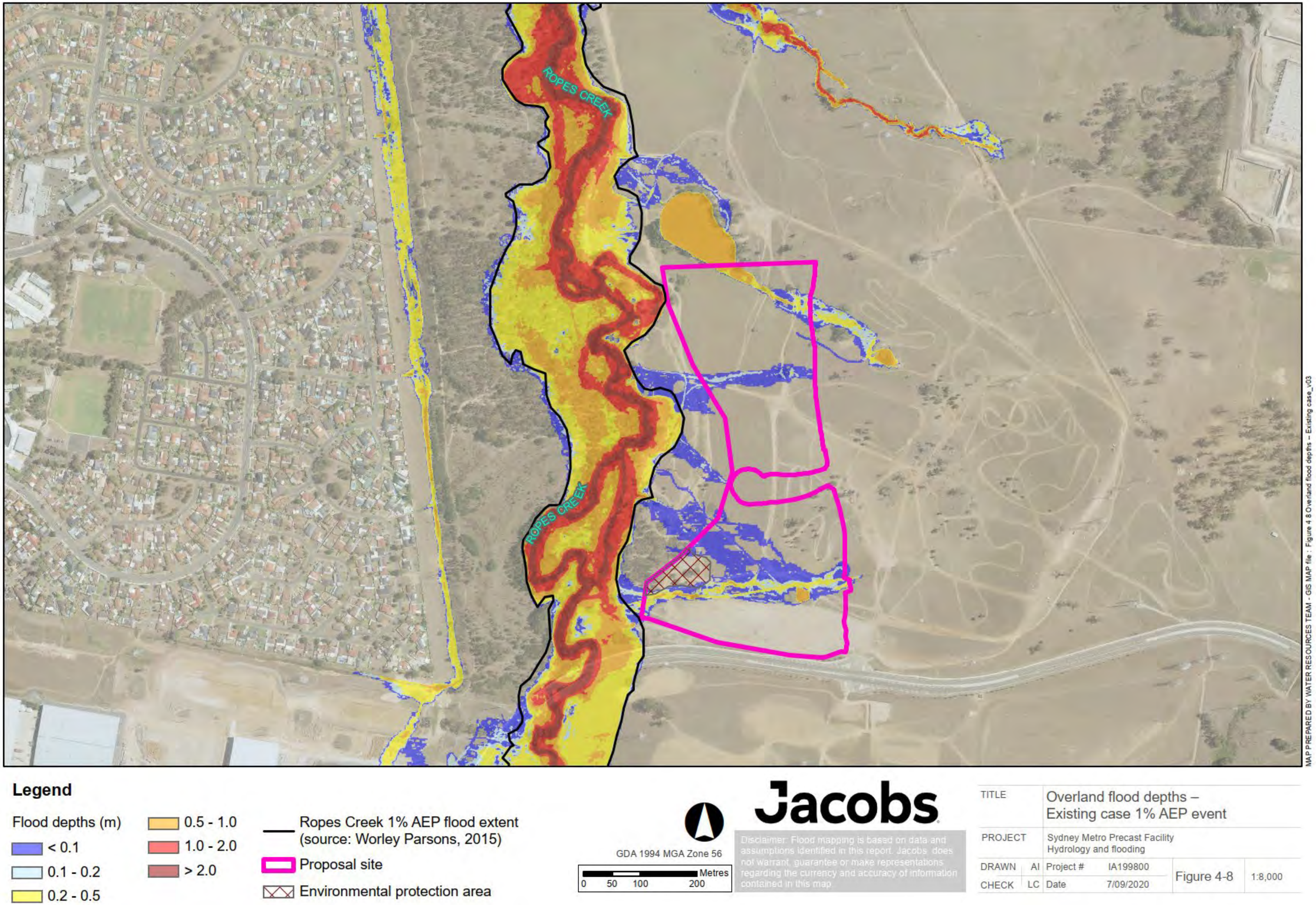

Figure 4-8: Overland flood depths – Existing case

5. Construction impact assessment

5.1 Overview

The construction phase consists of the following stages for each precast facility:

- Site establishment
- Civil and building work
- Commissioning.

Key activities in the construction phase which have the potential to impact on flooding behaviour include:

- Earthworks and site filling (during the site establishment, civil and building works stages)
- Changed drainage conditions (primarily during the civil and building work stage)
- Paving and construction of buildings (during the civil and building work stage).

The potential impacts to flooding behaviour from these construction activities are discussed in this section.

5.2 Key assumptions

The key assumptions in the construction impact assessment are summarised below:

- Based on the description of construction activities the worst-case stage for the construction phase would be upon completion of the civil and building work stage. This would be when earthworks and filling are complete in addition to installation of impervious paved and roof surfaces, and have the maximum potential impact on flood flow obstruction and increased site runoff rates. The worst-case stage for the construction phase would be similar to the operational phase from a hydrologic perspective.
- Filling would be required to raise flood-affected parts of the proposal site above the 1% AEP flood level plus 0.5 metres freeboard.
- The proposal site in its worst-case final state is assumed to be 90% impervious, reflecting the industrial land use zoning. Hardstand areas are assumed to be effectively impervious for the flooding assessment.
- All site internal drainage including mitigation works is assumed to be installed during the construction phase and contributing to the worst-case hydrologic condition.
- A temporary haul road would be established for site access prior to completion of the proposed Archbold Road upgrade and extension works. Drainage structure outlets are assumed to be located as per the concept design in Section 3.2.3. If Archbold Road is constructed concurrent to or following the proposal site, it is assumed the road drainage will be coordinated with the precast site drainage.
- For the purposes of sizing the flood detention for the proposal site, the effects of the completed Archbold Road upgrade and extension on increased flood flows have not been taken into account. Sizing of the proposal site flood detention facilities has been undertaken to mitigate the impacts of development of the proposal site only. Overland flows and road drainage from upstream of the proposal site are assumed to be diverted through or around the site, separating them from the site runoff flows.
- Given the construction stage would occur in the short term, the upstream catchments to the east of the proposal site are assumed to remain undeveloped.

5.3 Impacts on mainstream flooding hydraulics and flood levels

The proposal site is entirely above the 1% AEP flood. It is also almost entirely above the probable maximum flood, except for a small section in the south-western corner of the site where probable maximum flood depths are about 0.1 metres. Potential impacts would be negligible in the probable maximum flood event from filling of the south-western corner of the proposal site obstructing the shallow 0.1 metres flow depths. There would be no flooding impacts in other portions of the proposal site as these are above the probable maximum flood level and any filled embankments would be outside of the flood extent.

Similarly, there would not be any flood impacts in the 1% AEP event as the entire proposal site is above the 1% AEP flood level and any filled embankments would be outside of the flood extent.

5.4 Impacts on mainstream peak flows

The proposal may potentially impact on the peak flows in Ropes Creek as a result of increased impervious areas on the proposal site from its currently undeveloped state. The impervious areas are expected to include building roof areas, road paving and hardstand areas. Increased site imperviousness has the potential to increase peak runoff rates and volumes, which may result in increased peak flow rates in Ropes Creek during flood events which could impact on downstream properties due to associated increased flood levels.

The potential increase in peak flows has been quantified in the XP-RAFTS model. The model sub-catchments covering the proposal site were updated to reflect the increased imperviousness of the developed site. The model link network was also modified to reflect diversion of external upstream flows and the drainage on the northern and southern sites being directed to a centralised discharge point on each site. The developed case (construction and operational) XP-RAFTS model layout is presented in in Appendix B. A comparison of the existing case and developed case (construction and operational) peak flows is presented in Table 5-1.

Table 5-1: Comparison of existing and developed (no mitigation) case peak flows and critical storm duration at selected locations*

Location	Scenario	0.5EY	1% AEP
Discharge point of southern precast site (including diverted external flows)	Existing	1.21 m^3/s 6 hrs critical duration	8.25 m^3/s 45 minutes critical duration
	Developed	1.64 m^3/s 15 minutes critical duration	8.75 m^3/s 45 minutes critical duration
Discharge point of northern precast site (including diverted external flows)	Existing	1.37 m^3/s 6 hrs critical duration	7.95 m^3/s 45 minutes critical duration
	Developed	1.44 m^3/s 20 minutes critical duration	7.57 m^3/s 45 minutes critical duration

* The flows at the selected locations includes the proposal site runoff combined with diverted external flows. Flow reporting locations upstream of the proposal site have been omitted due to additional catchment areas diverted to the reporting locations by Archbold Road drainage.

It is observed that the peak flows generally increase from the existing to the developed case as a result of the increase in imperviousness of the proposal site, which reduces the infiltration capacity and increases the ground surface smoothness, both producing increased runoff from the proposal site. The exception is at the discharge point of the northern precast site in the 1% AEP event, where a minor reduction in peak flow is experienced. This is due to the northern precast site, which is located at the downstream end of the northern overland flow path, producing runoff which discharges from the site at a higher peak flow rate but quicker than the upstream external catchment. By the time the peak in flow from the external catchment reaches the discharge point, the northern precast site flows have receded, therefore resulting in the reduction of the combined peak flow. This may suggest that mitigation would not be required for the 1% AEP event, however, mitigation would be required in any case for the 0.5EY event and potentially other flood events.

5.5 Impacts on creek geomorphology

Without mitigation, increased site runoff peak rates, volumes and durations of flow may result in changes to flow regimes in Ropes Creek in low flows and frequent flood events. This can lead to geomorphic changes in the creek channel as the creek system adjusts to the new flow regime, which may include increased channel erosion, bank slumping and other effects which may cause further impacts on creek habitat and ecology. Further geomorphologic assessment is recommended relating to the potential change in flow regime.

The proposal site is entirely outside of the 1% AEP flood extent. The filled sections of the proposal site would not interact with the 1% AEP flow in Ropes Creek and hence are not expected to result in changes to creek geomorphology due to obstruction of creek flows.

5.6 Impacts on overland flooding and drainage

Development of the proposal site would involve filling and levelling of the proposal site, which would fill in existing overland flow paths and farm dams. The proposal site would abut the Archbold Road upgrade and extension. Design coordination of drainage arrangements for Archbold Road and the detailed design of the proposal site would be undertaken. Without such coordination and implementation of other management measures, the proposal has the potential to impact on the drainage of the overland flows and road drainage discharge points. The potential impacts include obstruction of flows and drainage, causing uncontrolled flooding upstream of the road cross-drainage points and overtopping of the road by floodwaters and poor drainage of the proposed road corridor. There would also be impacts on the construction site resulting from uncontrolled overland flows discharging through the site if no mitigation measures are implemented.

5.7 Construction impacts summary

Without mitigation, the construction phase has the potential to result in the following impacts:

- Increases in site runoff peak flow rates and volumes into Ropes Creek. While the increment in flow compared to existing Ropes Creek flows is small, the potential impacts of the proposal combined with other external developments, without mitigation, may increase downstream flooding.
- Geomorphic changes may result due to changes in flow regimes in the creek in low flow conditions and frequent flood events without mitigation.
- Without design coordination with Archbold Road and implementation of other mitigation measures, construction of the proposal site would change drainage patterns and obstruct overland flow paths, resulting in flooding and drainage impacts to the proposed Archbold Road upgrade and extension. In the absence of mitigation measures there would also be impacts on the construction site due to uncontrolled overland flows.

6. Operational impact assessment

6.1 Key assumptions

In terms of hydrology and flooding, the operational phase of the proposal is expected to be similar to the worst-case condition in the construction phase, which would be the same as the operational layout of the proposal site.

6.2 Flood impacts under climate change scenario

The proposal is anticipated to commence construction in early 2021 and be completed by the end of 2022, and would operate for a period of four – five years (up to about 2027), subject to the delivery strategy for Sydney Metro West. Interim climate change factors for the year 2030 for an upper range projection scenario of anthropogenic greenhouse gas emissions are available from ARR Data Hub, which suggests a 4.9% increase in storm rainfall intensities which would result in increase in flood flows and flood levels. The majority of this increment in rainfall intensity may be expected to occur during the operational phase.

It is expected that there would be a minor increase in flood depths and negligible increase in flow velocities in Ropes Creek at the proposal site. This would not materially affect the flood immunity of the proposal site, as finished site levels are expected to be well above the prescribed 0.5 metre freeboard above the 1% AEP flood level.

Runoff rates from the developed proposal site and from external catchments would increase by a minor increment as a result of climate change. It is expected that any small factor of safety which is provided by the proposed mitigation and management measures would be able to accommodate theses minor increases in flows, so that there is no net impact downstream of the proposal site.

6.3 Operational impacts summary

The potential hydrologic and flooding impacts of the proposal in the operational phase are expected to be similar to the potential construction phase impacts. Refer to Section 5 for discussion.

7. Mitigation and management measures

7.1 Construction and operational management

Environmental management measures for the mitigation of impacts to flooding which are to be implemented during the construction and operational phases of the proposal are listed in Table 7-1. Construction and operational impacts are expected to be similar, hence the same set of mitigation and management measures are proposed for each phase.

Table 7-1: Construction and operational environmental management measures – hydrology and flooding

No.	Impact	Mitigation measure
F1	Increase in mainstream peak flood flows	Detailed design of the proposal site would include provision of appropriate on-site stormwater detention/flood detention facilities to cater for events up to and including the 1% AEP event.
F2	Geomorphic impacts due to changed flow regime in low flows and frequent flood events	Detailed design of the proposal site would include the provision of appropriate on-site stormwater detention/ flood detention facilities. Outlet sizing would be designed to satisfactorily mitigate potential increases in peak flows in frequent events.
F3	Impacts on overland flooding and drainage conditions	Detailed design of the proposal site would include the provision of appropriate flow diversion channels or culverts for management of external flows.
F4		Detailed design would integrate with proposed Archbold Road cross drainage and road drainage outlets.
F5		Detailed design would provide appropriate scour protection works at channel/culvert discharge points to Ropes Creek.
F6	Impacts on the proposal resulting from flooding	Detailed design would provide filling to a height of at least 0.5m above Ropes Creek 1% AEP flood level.

8. Conclusion

A hydrology and flooding assessment has been conducted to support the REF for the proposed precast facilities (the proposal). The assessment has considered the available flooding studies, policies and guidelines to define existing case flooding conditions and development controls for the proposal site. Additional hydrologic and hydraulic modelling was undertaken where there were data gaps, that is, for overland flooding around and through the proposal site, for the catchment development conditions relevant to the nature and timing of proposed development on and around the proposal site during its construction and operation.

Review of existing flooding conditions in Ropes Creek indicate that the proposal site is entirely above the 1% AEP flood extent. The proposal site is also mostly above the probable maximum flood, with exception of a small encroachment into the flood extent at the south-western corner of the southern precast site.

There are two main overland flow paths which pass through each of the northern and southern precast sites. These overland flow paths drain currently undeveloped upstream catchments located to the east of the proposal site. Management of these external flows through/around the site would be required.

An assessment of impacts of the proposal on flooding was undertaken based on qualitative assessment and updated hydrologic modelling. Potential impacts include partial impediment of Ropes Creek flows caused by filling in the south-western corner of the site resulting in negligible flood impacts in the probable maximum flood only, increases in peak flows being discharged to Ropes Creek due to development of the proposal site, impacts on creek geomorphology due to altered flow regime and impacts on overland flooding behaviour and drainage. The final-state construction phase and the operational phase of the proposal were considered to have similar potential impacts to flooding and hydrology. The potential change in impacts during a future climate change scenario was also considered.

A range of mitigation and management measures have been identified to manage the potential impacts to flooding. Indicative sizing has been provided for structural measures, which include stormwater/flood detention facilities and external flow diversion channels for the northern and southern precast sites.

9. References

AECOM (2016), *Ropes Creek Precinct Draft Development Control Plan*. Prepared for Department of Planning and Environment.

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Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.

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Lyall & Associates (2016), *Archbold Road Flooding and Drainage Investigation*. Prepared for RMS.

NSW Government (2005), Floodplain Development Manual, the management of flood liable land.

Worley Parsons (2015), *South Creek Flood Study*. Prepared for Penrith City Council in association with Liverpool City Council, Blacktown City Council and Fairfield City Council.

Transport for NSW (2017), *Archbold Road Upgrade and Extension Review of Environmental Factors*.

Appendix A. Site flooding, drainage and detention assessment

A.1 Introduction

The proposal site is situated on the eastern side of Ropes Creek, with the previous *South Creek Flood Study* (Worley Parsons, 2015) providing information on the existing mainstream flooding at the proposal site. The proposal site is largely unaffected by mainstream flooding with the exception of a small section in the south-western corner of the proposal site in the PMF. The mainstream flooding conditions are discussed in Section 4.3.1 in the main body of this report.

Two overland flow paths flow through the proposal site, and a flood modelling assessment is required to define the flooding conditions in these flow paths in accordance with the current ARR 2019 guidelines.

The proposal site would be developed from a currently greenfield site to an industrial facility and hence assessment is also required to define the hydrology of the site and potential impacts to hydrology and peak runoff rates from the site. Mitigation in terms of on-site stormwater detention or flood detention are identified as a part of this assessment.

Overland flow management through the site is also determined. An assessment of drainage requirements has been undertaken in this regard, including consideration of the proposed Archbold Road upgrade and extension and its associated drainage infrastructure.

A.2 Assessment approach

This flooding, drainage and detention assessment involves numerical modelling of hydrology and hydraulics, and its details are provided in this appendix. In summary, the approach includes the following, with discussion on each aspect provided:

- Definition of existing case overland flooding and drainage conditions, including hydrologic and hydraulic model development and simulation
- Assessment of developed case (no mitigation) conditions, with update of modelling to reflect development of the proposal site
- Identification of mitigation requirements, including representation and confirming details of flood detention facilities
- Confirmation of drainage requirements for management of external flood flows, including update of modelling to reflect the completed Archbold Road project.

A.3 Assessment of existing case flooding conditions

A.3.1 Hydrologic modelling

An XP-RAFTS model was developed to estimate flood flows in the overland flow paths through the proposal site. The model also defines the runoff characteristics from the proposal site itself which will assist with subsequent mitigation assessment.

Sub-catchments

The overall catchment areas of the flow paths were delineated and subdivided into sub-catchments based on a LiDAR ground elevation terrain model. Refer to Figure A-1. The sub-catchment data is presented in Appendix B. The existing case XP-RAFTS model layout is shown on Figure A-2.

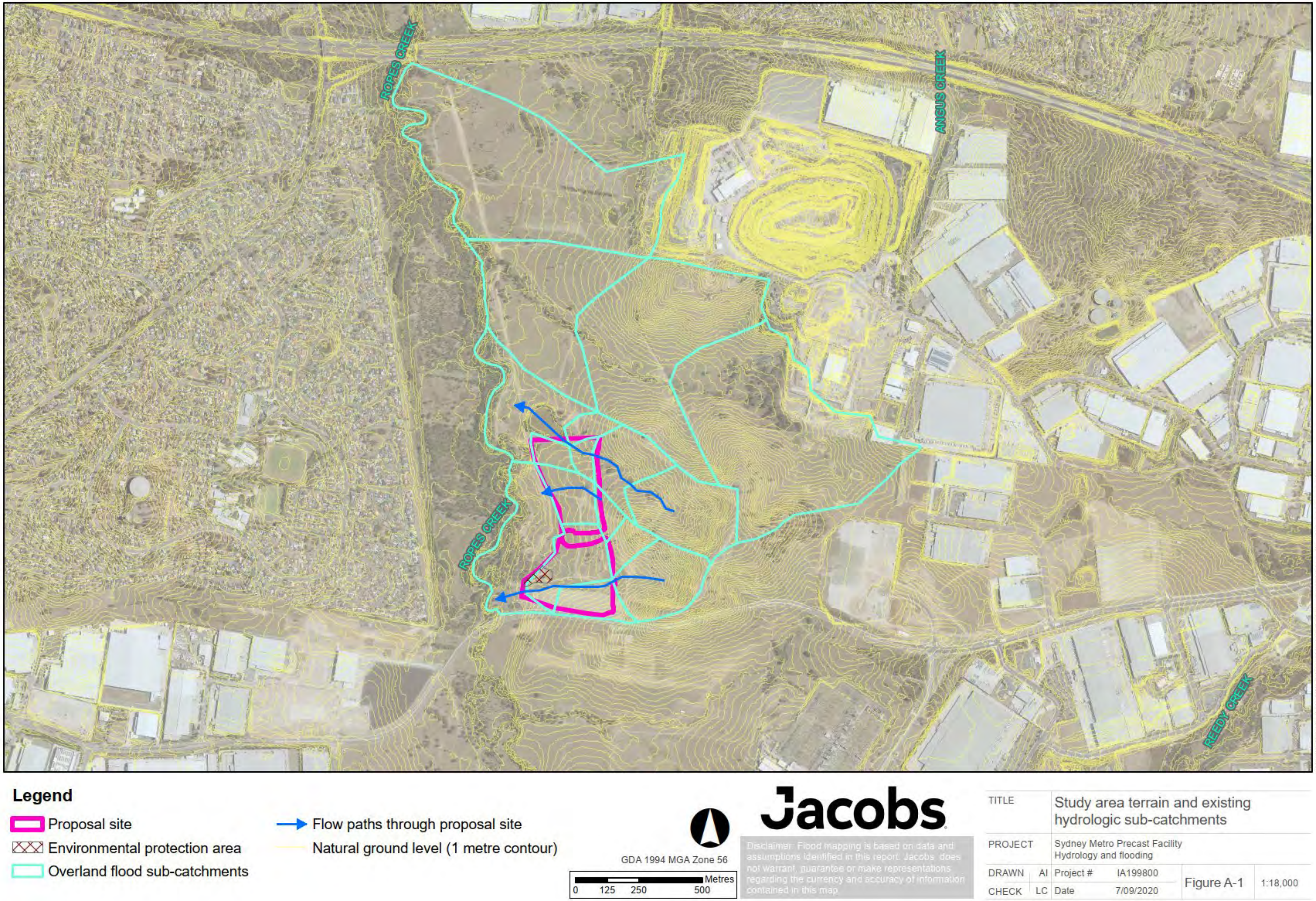


Figure A-1: XP-RAFTS sub-catchments for overland flow paths

Figure A-2: XP-RAFTS layout – Existing case

Hydrologic parameters

The ARR 2019 design rainfall and rainfall losses were extracted from ARR Data Hub. The design rainfall adopted for the hydrologic modelling is presented in Appendix B. The rainfall losses are summarised in Table A-1 along with adopted catchment roughness parameter value. For conciseness, the parameter values for developed and mitigated case models are also shown.

Table A-1: Rainfall losses and catchment roughness

Parameter	Pervious	Impervious*
Rainfall burst initial losses	Varies depending on AEP and duration. ▪ 0.5EY event 26.1 – 31.1 mm. ▪ 1% AEP event 6.9 – 11.6 mm.	1 mm
Continuing losses	0.92 mm/hour (i.e. ARR Data Hub value of 2.3 mm/hour multiplied by correction factor of 0.4 for NSW).	0 mm/hour
Catchment roughness parameter value	0.05. Rural catchment. 0.025 for pervious areas in developed catchments.	0.015

* Impervious area parameters apply to developed and mitigated case only.

Farm dams

There are several existing farm dams, located on the overland flow paths, in the vicinity of the proposal. These are assumed to be full, and hence do not contribute to flood storage and detention of overland flows.

Analysis results

The ARR 2019 storms include ensembles of ten storms for each event AEP and duration. Each ensemble member represents an alternative storm rainfall temporal pattern which affects the runoff characteristics of the storm event. The ensemble rainfall data and hydrologic parameters were input into the XP-RAFTS model and the ensemble results analysed using the Storm Injector software module. The median value peak flow at each key location is selected from each AEP/duration ensemble as the representative flow for that AEP/duration.

For the purposes of this flooding and hydrology assessment the design event flows for the 0.5EY and 1% AEP events were analysed. A range of storm durations from 10 minutes to 9 hours were analysed to select the critical duration.

The peak flows at key locations are summarised in Table A-2.

Table A-2: Existing peak flows and critical storm duration at selected locations

Location	Total Catchment area	0.5EY	1% AEP
CA-3 + CA-7 Upstream of southern precast site	10.8 ha	0.52 m^3/s 6 hrs critical duration	3.7 m^3/s 15 minutes critical duration
CA-6 Discharge point of southern precast site	31.9 ha	1.21 m^3/s 6 hrs critical duration	8.25 m^3/s 45 minutes critical duration

Location	Total Catchment area	0.5EY	1% AEP
CA-10 Main flow path upstream of northern precast site	16.9 ha	0.72 m^3/s 6 hrs critical duration	4.44 m^3/s 45 minutes critical duration
Node "ReprtDummy" Discharge point of northern precast site	37.5 ha	1.37 m^3/s 6 hrs critical duration	7.95 m^3/s 45 minutes critical duration

A.3.2 Hydraulic modelling

Hydraulic modelling was undertaken based on the hydrologic model results to define overland flood behaviour for the existing case, including flood depths and extents. New modelling was conducted as the previous studies did not assess overland flooding based on the current ARR 2019 guidelines and results were not available for detailed analysis.

Model configuration

A TUFLOW two-dimensional hydraulic model was developed to include the overland flow path areas. The Ropes Creek channel and floodplain were also included to represent the tailwater conditions during flood events. Topography in the TUFLOW model was defined with a 2 metre grid and was based on LiDAR data dated February 2011 and sourced from NSW LPI. The overland flow paths and Ropes Creek were represented as two-dimensional features.

The overall model configuration is shown on Figure A-3.

Inflow boundaries

Inflows from the local overland flow catchments were input at the locations indicated on Figure A-3.

Flow in Ropes Creek was extracted from the *South Creek Flood Study* (Worley Parsons, 2015) report. Flooding in Ropes Creek was modelled as a steady peak flow for the purposes of this study.

Downstream boundary

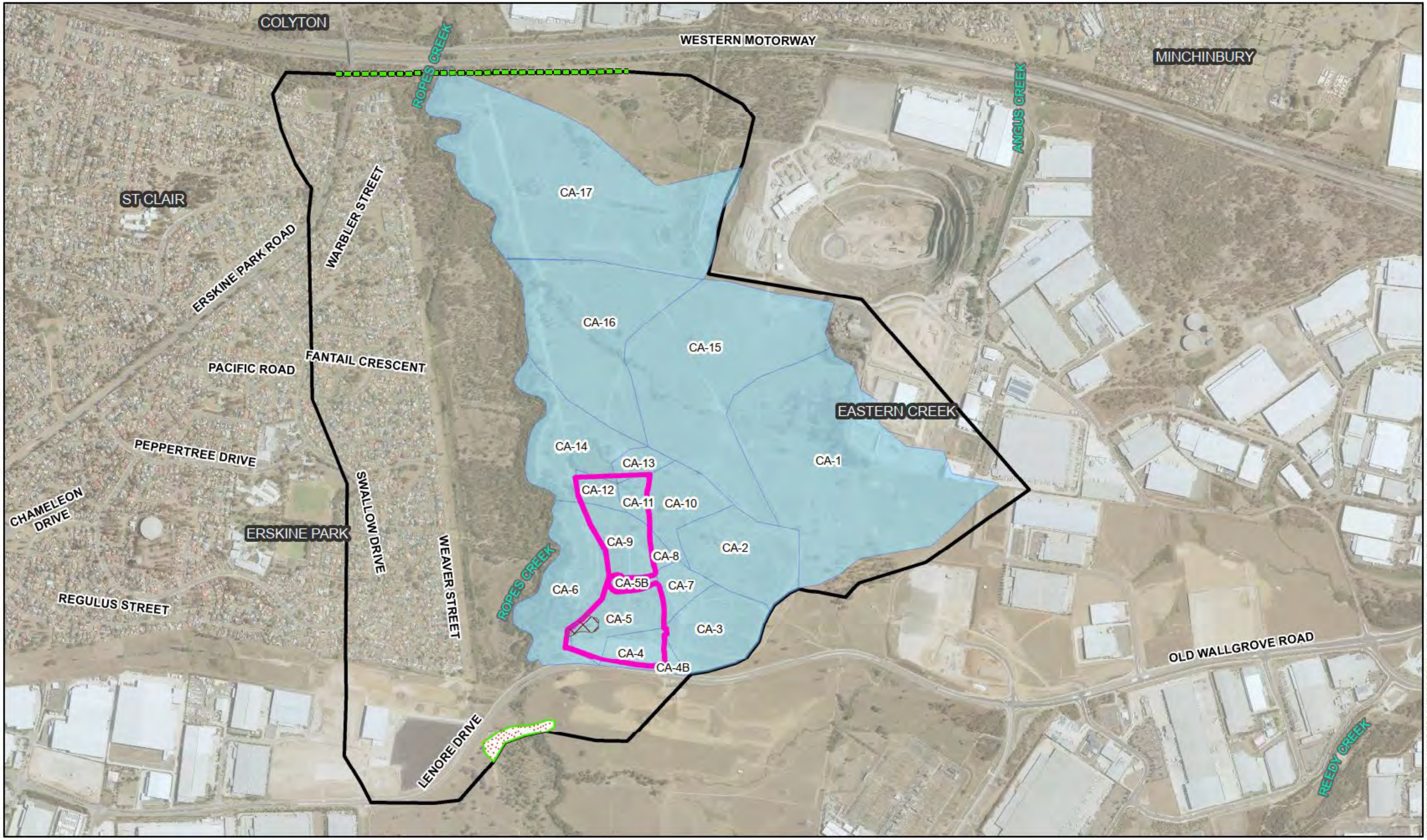
Downstream boundary in Ropes Creek was extracted from the *South Creek Flood Study* (Worley Parsons, 2015) report and was modelled as a steady water level boundary for the purposes of this study.

Hydraulic Roughness

Manning's n hydraulic roughness parameter values were defined based on typical values for different land use areas and consistent with the current ARR 2019 guidelines. Refer to Table A-3 for the adopted values. The land use types corresponding with the adopted Manning's n values in the TUFLOW model are mapped on Figure A-4.

Table A-3: Adopted Manning's n values

Land Use Type	Manning's n value
Grassland	0.05
Paved areas	0.02
Roads	0.025
Vegetation	0.10
Urban residential block (Erskine Park)	0.35



MAP PREPARED BY WATER RESOURCES TEAM - GIS MAP file : Figure A-3 TUFLOW model configuration_v03

Legend

- Proposal site
- Environmental protection area
- TUFLOW 2D model domain
- Tailwater boundary
- Local inflows
- Upstream inflows

GDA 1994 MGA Zone 56

0 125 250 500 Metres

Jacobs.

Disclaimer: Flood mapping is based on data and assumptions identified in this report. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

TITLE	TUFLOW model configuration				
PROJECT	Sydney Metro Precast Facility Hydrology and flooding				
DRAWN	AI	Project #	IA199800	Figure A-3	1:18,000
CHECK	LC	Date	7/09/2020		

Figure A-3: TUFLOW model configuration

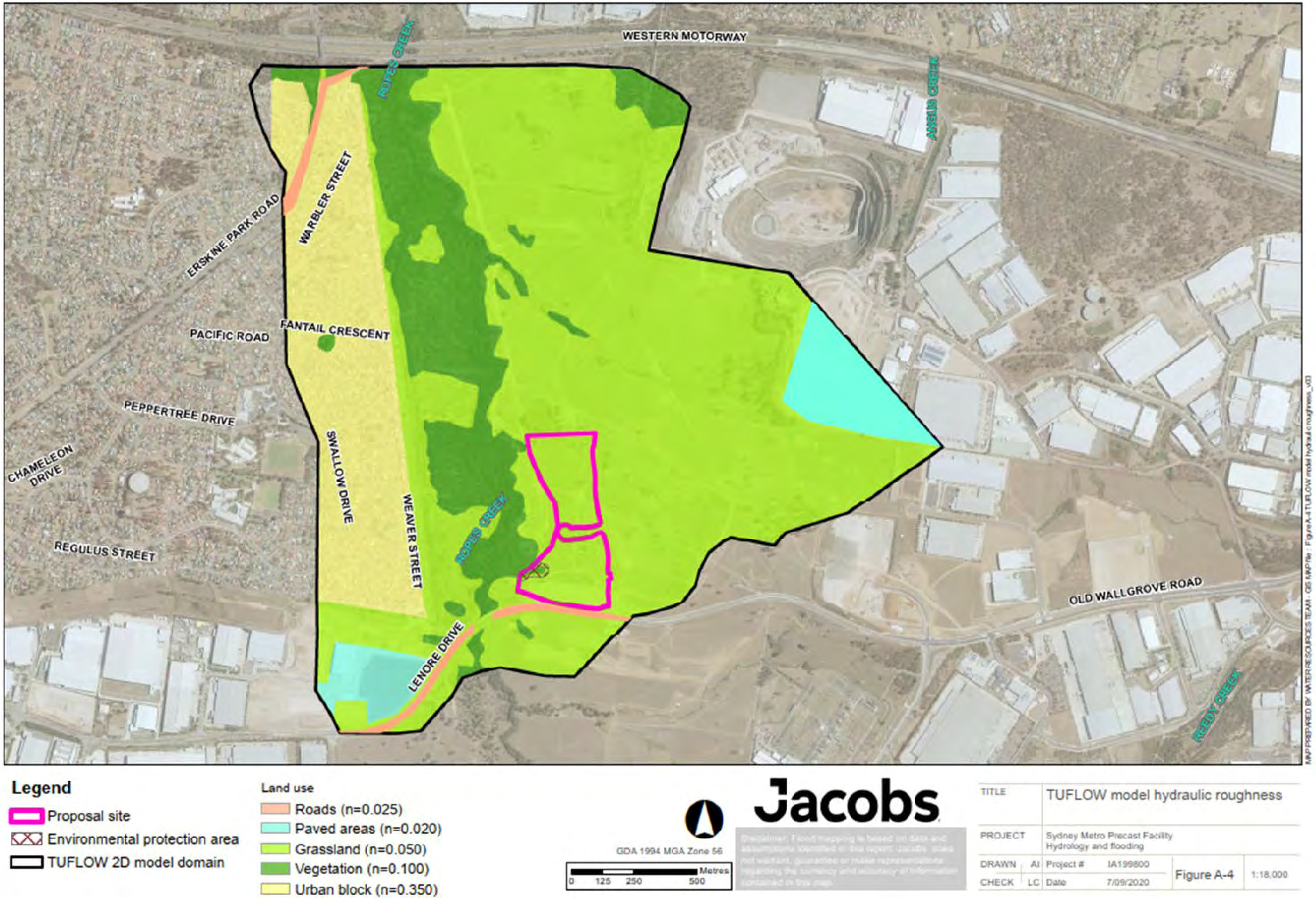


Figure A-4: TUFLOW model hydraulic roughness

Flood events analysed

The 1% AEP flood event was analysed to define the overland flooding conditions around the proposal site. The coincident flood event in Ropes Creek was assumed to be the 5% AEP event, in line with ARR 2019 guidelines. The modelled flooding in Ropes Creek needs to be considered in conjunction with the mainstream flood conditions for the 1% AEP event as described in Section 4.3.1 in the main body of this report.

Mapping of the overland flood depths is shown on Figure 4-6 in the main body of this report. The Ropes Creek 1% AEP flood extent is also shown.

Overland flow depths in the northern flow path are typically around 0.4 – 0.6 metres in the existing case. Depths of water in the existing farm dam is shown to be over 0.6 metres, however, are expected to be deeper than indicated due to the model topography showing the dam water surface and not reflecting the actual bed level of the dam.

Flood depths in the southern flow path are typically 0.4 – 0.7 metres deep in the main flow path. There are some shallow overflows from the main flow path up to 0.1 metres deep.

The minor middle flow path exhibits shallow (less than 0.05 metres depth) dispersed flow with some deeper ponding within an access track which is in cut below the surrounding ground level.

A.4 Assessment of developed case flooding

The XP-RAFTS hydrologic model was updated to reflect the developed case (construction final state and operational phases). Updates to the model included:

- The areas of sub-catchments CA-11, CA-12, CA-13 and CA-14 were adjusted to reflect a part of the proposal site now draining into CA-11 and CA-12 on the proposal site (previously draining out of the proposal site to CA-13 and CA-14).
- Developed parts of the proposal site are assumed to be 90% impervious. The sub-catchment properties were updated accordingly.
- The link network in the existing case was previously configured to reflect the natural directions of drainage. For the developed case the link network was adjusted such that areas within the proposal site drained to two centralised locations (one each for the northern and southern sites, which would be operated independently). External flows from sub-catchments to the east of the site are assumed to be diverted around or through the site separately from the site runoff.
- The external sub-catchments containing the proposed Archbold Road upgrade and extension were retained in their undeveloped states, so that the hydrologic impact of the proposal site only could be analysed. While there is potential for the external catchments to be developed during the operational phase of the proposal, it is expected that stormwater and flood detention would be provided on these developed areas to mitigate against the potential impacts on flooding.

The updated XP-RAFTS model layout is shown on Figure A-5, and the peak flows are summarised in Table A-4. The peak flows from the southern and northern site areas and the flows at their discharge points to Ropes Creek (combined with diverted external flows) are shown.

The results indicate that peak flows from the northern and southern sites increase as a result of development of the site. Peak flows from the southern site combined with the southern external flows increase for both the 0.5EY and the 1% AEP event. However, for the northern site combined with northern external flows, the peak flows increase of the 0.5EY event only but are reduced for the 1% AEP event. This is attributed to the developed case site flows running off faster due to quicker catchment response time, hence there is a reduced coincident timing of the site runoff peak and the external flow peak.

Although the 1% AEP northern combined discharge to Ropes Creek is reduced in the developed case, mitigation is still required to manage the flow impacts in the 0.5EY event, and potentially other flood events which have not been assessed.

Figure A-5: XP-RAFTS layout – Developed case (construction and operational)

Table A-4: Developed case (no mitigation) peak flows and critical storm duration at selected locations

Location	0.5EY		1% AEP	
	Existing	Developed	Existing	Developed
CA-6 Discharge point of southern precast site including diverted external flows	1.21 m^3/s 6 hrs critical duration	1.64 m^3/s 15 minutes critical duration	8.25 m^3/s 45 minutes critical duration	8.75 m^3/s 45 minutes critical duration
Node "ReprtDummy" Discharge point of northern precast site including diverted external flows	1.37 m^3/s 6 hrs critical duration	1.44 m^3/s 20 minutes critical duration	7.95 m^3/s 45 minutes critical duration	7.57 m^3/s 45 minutes critical duration

A.5 Assessment of mitigation case and flood detention requirements

The developed case XP-RAFTS model was updated to include flood detention basins at the outlet points for the southern and northern sites, refer to Figure A-6 for the updated model configuration. Basin dimensions and discharge configurations were iteratively adjusted to ensure site runoff and the combined discharge with diverted external flows are not increased from the existing case for the 0.5EY and 1% AEP events. Details of the proposed indicative detention basins are provided in Table A-5. The mitigated case peak flows are indicated on Table A-6, which demonstrate that the proposed basins mitigate developed case peak flows to below existing levels.

While this assessment refers to the detention facility as a basin, it would be satisfactory to incorporate the detention facility as an equivalent underground tank facility if appropriate.

Figure A-6: XP-RAFTS layout – Mitigation case (construction and operational)

Table A-5: Proposed indicative detention basin details

	Basin 1 Southern precast site	Basin 2 Northern precast site
Basin volume, m^3	3,500	3,200
Assumed depth, m	2.0	2.3
Surface area, m^2	1,750	1,400

Table A-6: Mitigated case peak flows and critical storm duration at selected

Location	0.5EY		1% AEP	
	Existing	Developed +Mitigation	Existing	Developed +Mitigation
CA-6 Discharge point of southern precast site including diverted external flows	1.21 m^3/s 6 hrs critical duration	1.14 m^3/s 6 hrs critical duration	8.25 m^3/s 45 minutes critical duration	7.63 m^3/s 45 minutes critical duration
Node “ReprtDummy” Discharge point of northern precast site including diverted external flows	1.37 m^3/s 6 hrs critical duration	1.25 m^3/s 6 hrs critical duration	7.95 m^3/s 45 minutes critical duration	7.7 m^3/s 45 minutes critical duration

A.6 Management of external flows

External catchment overland flows need to be intercepted at the proposed Archbold Road cross drainage and road drainage structure outlets and diverted around the southern and northern precast sites in channel or culvert. The XP-RAFTS mitigated case model was updated to include the new impervious areas associated with the proposed road. The model was run for the 1% AEP event and peak flows defined.

Details on the proposed site grading are not known at this stage, although it is assumed that site finished levels would be relatively flat. Hence for the purposes of this assessment it is assumed that diversion channel and/or culverts would be installed at a 1% grade.

The estimated external catchment peak flows, including Archbold Road runoff, and the required flow diversion structure dimensions are provided in Table A- 7. The estimated flows were compared to the Archbold Road concept design cross drainage flows (refer to Table 3-1) and are observed to be comparable. The proposed routes for the external catchment flow diversion structures are shown on Figure A-7. Appropriate scour protection works are required at discharge points to Ropes Creek.

Table A- 7: External catchment flows and diversion structure dimensions

Location	1% AEP Flow (m^3/s)	Flow diversion dimensions*	
		Open channel option	Culvert option
northern precast site external flow diversion (discharge from Archbold Road drainage)	5.0	Width, bottom: 0.3m Width, top: 3.3m Side: 1:1 batter slope Depth: 1.5m	1 x 1200mm x 1000mm

Location	1% AEP Flow (m^3/s)	Flow diversion dimensions*	
		Open channel option	Culvert option
southern precast site external flow diversion (discharge from Archbold Road drainage)	3.4	Width, bottom: 0.3m Width, top: 3.0m Side: 1:1 batter slope Depth: 1.35m	1 x 1200mm x 750mm

* Assumed 1% longitudinal grade for channel and culvert.

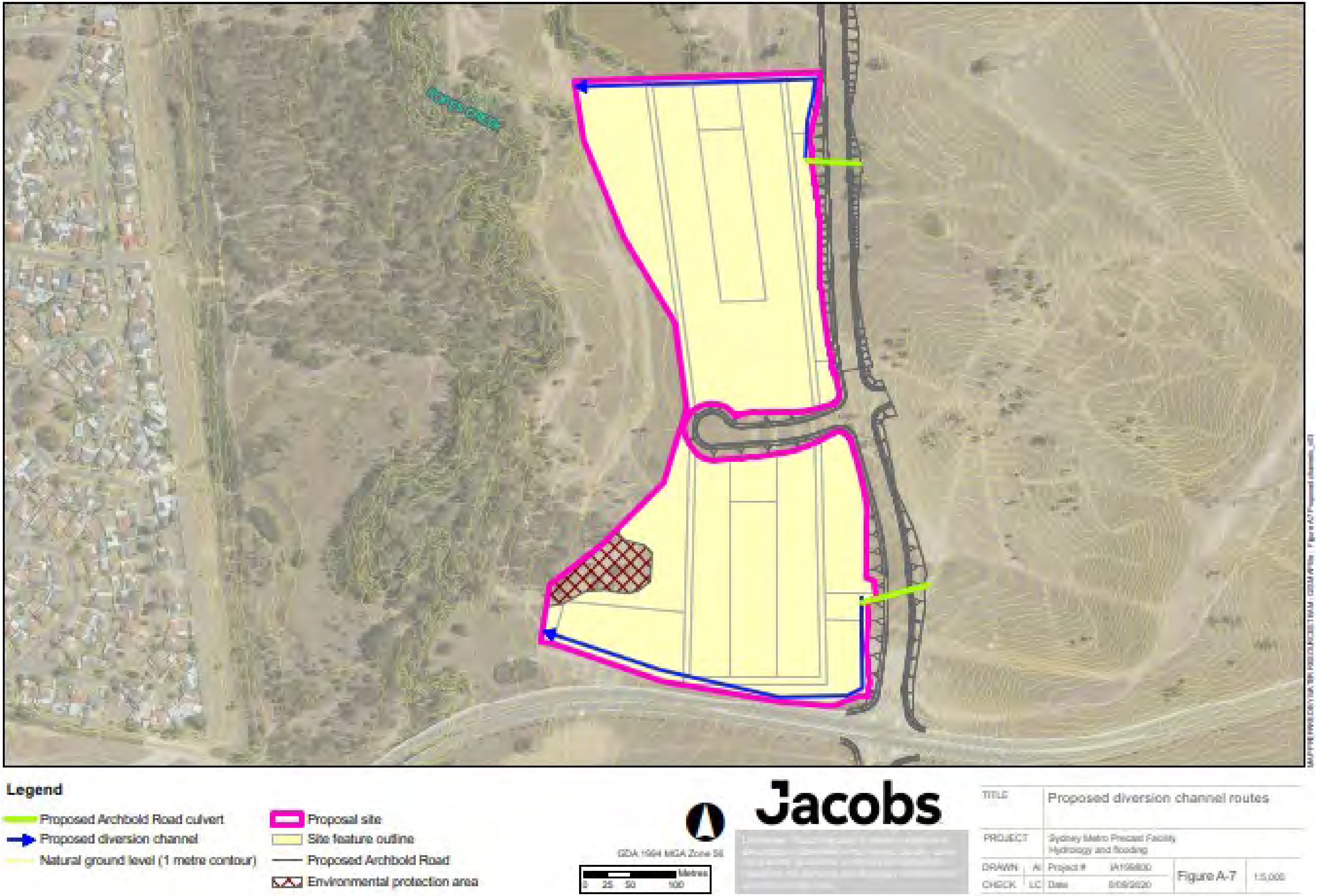


Figure A-7: Proposed route of external flow diversion structures

Appendix B. Hydrologic modelling input data

Table B-1: ARR 2019 Design rainfall data for Precast Facility

All Design Rainfall Depth (mm)

Issued:	20-Apr-20			
Location Label:	Precast Facility			
Requested coordinate:	Latitude	-33.808406	Longitude	150.8175
Nearest grid cell:	Latitude	33.8125 (S)	Longitude	150.8125 (E)

Duration	Duration in min	0.5EY	0.2EY	10%	5%	2%	1%
1 min	1	2.58	3.29	3.85	4.47	5.31	5.96
2 min	2	4.15	5.17	6.03	6.97	8.27	9.31
3 min	3	5.79	7.25	8.46	9.78	11.6	13.1
4 min	4	7.31	9.22	10.8	12.5	14.8	16.6
5 min	5	8.7	11	12.9	14.9	17.7	19.9
10 min	10	13.9	17.9	20.9	24.3	28.9	32.4
15 min	15	17.4	22.3	26.2	30.4	36.1	40.5
20 min	20	19.9	25.5	29.9	34.8	41.3	46.3
25 min	25	21.9	28	32.8	38.1	45.2	50.7
30 min	30	23.5	30	35.1	40.8	48.4	54.3
45 min	45	27.1	34.3	40.1	46.5	55.3	62.1
1 hour	60	29.7	37.4	43.7	50.7	60.2	67.7
1.5 hour	90	33.7	42.1	49.1	56.9	67.7	76.3
2 hour	120	37	45.9	53.5	62	73.8	83.3
3 hour	180	42.4	52.4	60.9	70.6	84.2	95.3
4.5 hour	270	49.1	60.6	70.4	81.9	97.9	111
6 hour	360	54.9	67.9	79	92	110	125
9 hour	540	64.9	80.8	94.4	110	132	150
12 hour	720	73.3	92.2	108	127	152	172
18 hour	1080	87.3	111	131	155	186	211
24 hour	1440	98.5	127	151	178	214	243
30 hour	1800	108	141	168	199	239	270
36 hour	2160	115	152	182	216	259	293
48 hour	2880	128	170	205	244	292	330
72 hour	4320	144	194	235	281	336	377
96 hour	5760	154	208	252	302	359	403
120 hour	7200	160	215	260	313	371	416
144 hour	8640	164	219	264	317	376	422
168 hour	10080	167	221	264	318	376	422

Table B-2 Overland flow sub-catchment data – Existing case

	Total Area [ha]	Catchment Mannings 'n'	Vectored Slope [%]
CA-1	43.4	0.05	2
CA-2	11	0.05	6.2
CA-3	8.3	0.05	8.8
CA-4	2.8	0.05	5.1
CA-5	5.2	0.05	2.7
CA-6	11.6	0.05	3
CA-7	2.5	0.05	9.2
CA-8	0.8	0.05	6.6
CA-9	4.5	0.05	2.4
CA-10	5.9	0.05	5.7
CA-11	1.5	0.05	3.8
CA-12	1.6	0.05	1.7
CA-13	1.7	0.05	6
CA-14	10.5	0.05	2.6
CA-15	33.9	0.05	4
CA-16	23.6	0.05	3.7
CA-17	45	0.05	3.5
CA-4A	0.7	0.05	5.1
CA-5B	0.8	0.05	2.7

Appendix J

Bushfire Risk Assessment

BLACKASH
BUSHFIRE CONSULTING

Bushfire Risk Assessment

Sydney Metro West Precast Facility

Prepared for

Arcadis

BPAD
Bushfire Planning & Design
Accredited Practitioner
Level 3

Version 1.7

28 October 2020

Project Name:	Bushfire Risk Assessment Sydney Metro Precast Facility
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Version	Primary Author(s)	Description	Date Completed
1.7	Lew Short	Final	28 October 2020

Lew Short | Principal
BlackAsh Bushfire Consulting
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Fire Protection Association of Australia BPAD Level 3 BPD-PA 16373

Disclaimer
This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The client may, at its discretion, use the report to inform regulators and the public.

Contents

Glossary

This section defines those core terms and concepts which are adopted throughout the body of this report.

Term	Definition
Asset Protection Zone (APZ)	A fuel-reduced area surrounding a built asset or structure which provides a buffer zone between a bushfire hazard and an asset. The APZ includes a defendable space within which firefighting operations can be carried out. The size of the required APZ varies with slope, vegetation and FFDI.
Bushfire	A general term used to describe fire in vegetation, includes grass fire.
Bushfire attack mechanisms	The various ways in which a bushfire can impact upon people and property and cause loss or damage. These mechanisms include flame contact, radiant heat exposure, ember attack, fire wind and smoke.
Bushfire Attack Level (BAL)	A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact. The BAL is used as the basis for establishing the requirements for construction to improve protection of building elements and to articulate bushfire risk.
Bushfire Management Committee	A Bushfire Management Committee (BFMC) provides a forum for cooperative and coordinated bushfire management in a local area. The BFMC is responsible for preparing, coordinating, reviewing and monitoring the Bush Fire Risk Management Plan for the Local Government Area. The BFMC consists of a range of stakeholders such as land managers, fire authorities and community organisations.
Bushfire prone land (BFPL)	An area of land that can support a bushfire or is likely to be subject to bushfire attack, as designated on a bushfire prone land map.
Bushfire Hazard	Any vegetation that has the potential to threaten lives, property or the environment.
Bushfire Threat	Potential bushfire exposure of an asset due to the proximity and type of a hazard and the slope on which the hazard is situated.
Forest Fire Danger Index (FFDI)	Measures the degree of danger of fire in Australian forests. The index combines a record of dryness, based on rainfall and evaporation, with meteorological variables for wind speed, temperature and humidity.

Term	Definition
Risk	The degree of risk presented by that interaction will depend on the likelihood and consequence of the bushfire occurring. Risk may be defined as the chance of something happening, in a specified period of time that will have an impact on objectives. It is measured in terms of consequences and likelihood.
Risk assessment	A systematic process of evaluating the potential risks that may be involved in a projected activity or undertaking, having regard to factors of likelihood, consequence, vulnerability and tolerability.
Risk-based land use planning	The strategic consideration of natural hazard risk and mitigation in informing strategic land use planning activities.
Hazard	A hazard is any source of potential harm or a situation with a potential to cause loss. A hazard is therefore the source of risk.
Likelihood	The chance of an event occurring. Likelihood may be represented as a statistical probability (such as an Annual exceedance probability), or whether this is not possible, it can be represented qualitatively using measures such as 'likely', 'possible' and 'rare'.
Managed land	Land that has vegetation removed or maintained to a level that limits the spread and impact of bushfire. This may include developed land (residential, commercial or industrial), roads, golf course fairways, playgrounds, sports fields, vineyards, orchards, cultivated ornamental gardens and commercial nurseries. Most common will be gardens and lawns within curtilage of buildings. These areas are managed to meet the requirements of an APZ.
Mitigation	The lessening or minimizing of the adverse impacts of a bushfire event. The adverse impacts of bushfire cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques, retrofitting and hazard-resistant construction as well as on ground works to manage fuel and separate assets from bushland.
Planning for Bushfire Protection 2019 (PBP 2019)	NSW Rural Fire Service publication effective from 1 March 2020 which is applicable to all new development on bushfire prone land in NSW.

Term	Definition
Tolerable risk	Organisation's readiness to bear the risk after risk treatment to achieve its objectives.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards. The degree of susceptibility and resilience of the community and environment to hazards.

1. Introduction

Blackash Bushfire Consulting has been engaged by Arcadis to complete a Bushfire Hazard Assessment Report for Sydney Metro to provide specialist bushfire services in support of the proposed precast facilities (the proposal) at Lenore Drive opposite Old Wallgrove Road, Eastern Creek (the proposal site) (Figure 1).

Sydney Metro (as 'the proponent') is seeking approval for the construction and operation of two precast facilities (the proposal) to support the construction of the proposed Sydney Metro West. The precast facilities would manufacture precast concrete segments necessary for lining the underground tunnels.

The northern and southern precast facilities would operate concurrently, 24 hours a day, 7 days a week, for the majority of the lifespan of the project.

A small portion of the south-western portion of the proposal site would be conserved as an environmental protection area associated with the presence of Cumberland Plain Woodland. Vegetation within this area would be retained and protected during works.

The proposed layout of the proposal is provided in Figure 2.

On completion of the operation of the proposal, the future use beyond the operation of the proposal would be determined by Sydney Metro and would be subject to separate approvals, as required. If no future use of the site is proposed at that time, the site would be placed into care and maintenance.

The proposal does not include the construction of the surrounding road network (extension of Archbold Road), which would be undertaken by Transport for NSW (TfNSW) under separate approval.

The objective of the report is an analysis of bushfire risk and compliance with the NSW Rural Fire Service (RFS) document *Planning for Bushfire Protection 2019* (PBP 2019). The proposal site is partially located within designated bushfire prone land and bushfire impact is a key consideration to ensure risk is understood and mitigation measures are implemented to reduce the consequences of any bushfire impacts.

This bushfire risk assessment has adopted a risk-based land use management and planning approach to analyse the extent of bushfire risk exposure to the site and associated facilities.

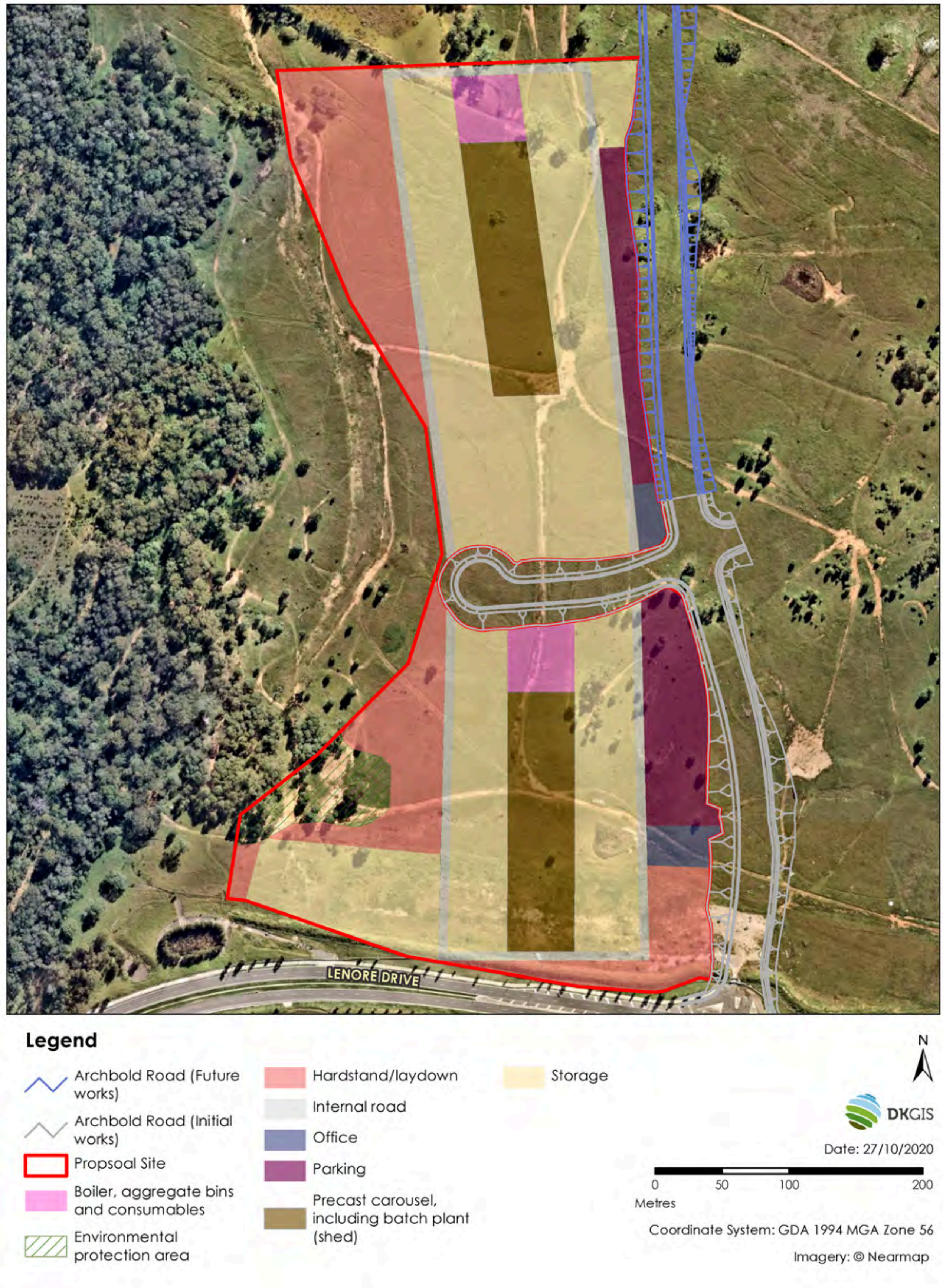
The purpose of this bushfire report is to support the Review of Environmental Factors (REF) for the proposal.

The proposal is in a designated bushfire prone area. All new development on bushfire prone land must comply with the RFS document PBP 2019. The Bushfire Hazard Assessment is a review of the proposal to ensure that the aim and objectives of PBP 2019 are met.

This assessment has been prepared by Lew Short, Principal Blackash Bushfire Consulting (Level 3 FPAA BPAD-A Certified Practitioner No. BPD-PA-16373) who is recognised by the RFS as qualified in bushfire risk assessment and has been accredited by the Fire Protection Association of Australia as a suitably qualified consultant to undertake alternative solution proposals. An external inspection (from publicly accessible areas) of the proposal site and surrounding area was completed on 4 May 2020.

Figure 1 Site Location

Figure 2 Site Plan



2. The Proposal

The proposal would comprise the following key features and activities:

Site preparation consisting of:

- Vegetation clearing, including the removal of about two hectares of native vegetation
- Site remediation
- Connection of utilities (e.g. power, water, sewerage, gas and communications)
- Earthworks to level the site (this may involve the use of retaining walls)
- Installation of lighting and signage

Construction and operation of two adjacent precast facilities, a northern and a southern precast facility, each being sited on about eight hectares. Each precast facility would encompass the following:

- A double-sided casting carousel
- Segment storage
- A concrete batching plant (inside shed with a height of around eight metres)
- Boiler, aggregate bins and consumables
- A laydown/hardstand area
- Offices and site amenities
- Loading and unloading and circulation space for heavy vehicles
- On-site parking for up to 60 light vehicles

Internal roads (one lane each direction) generally around the key operational areas of the facility with entrances to each facility from the Western Access Road located between the northern and southern precast facilities

Landscaping works along the frontage to Lenore Drive and about 50 metres north along Archbold Road.

2.1. Operation

The proposal would produce and deliver precast segments. Operational elements of the proposal would include:

- The proposal would produce precast tunnel lining segments to be transported to the Sydney Metro West tunnelling support sites

- The proposal would have a capacity to produce 730 tonnes of concrete per day and would operate up to 24 hours per day and seven days per week (with the implementation of the necessary controls for noise emissions, air quality, traffic movements, etc.)
- The total operational workforce would be around 120 personnel (60 for each facility) on the proposal site at any one time.

3. Legislative and policy framework

This section provides an overview of the relevant legislation, policy and guidelines as it relates to the proposal.

3.1. Relevant legislation

Environmental Planning and Assessment Act, 1979 (EP&A Act): Part 5

The application is made under Part 5 of the EP&A Act. The purpose of the Part 5 assessment system is to ensure public authorities fully consider environmental issues, including bushfire, before they undertake or approve activities that do not require development consent from a council or the Minister for Planning and Public Spaces. In this application, Sydney Metro is the Determining Authority. Where an environmental assessment is completed, referral to concurrence of agencies, such as the RFS is not required. On this basis, referral to the RFS is not required.

***Environmental Planning and Assessment Act, 1979: Section* 10.3 Bushfire Prone Land**

The designation of Bushfire Prone Land (BPL) in NSW is required under the EP&A Act (s.10.3). BPL Maps provide the trigger for the various development assessment provisions. The BPL Map is a trigger for the consideration of bushfire matters for new development. It is not intended as a detailed measure of risk. The map does not form part of the site assessment process.

Rural Fires Act, 1997

The Rural Fires Act establishes the NSW Rural Fire Service, defines its functions and makes provision for the prevention, mitigation and suppression of rural fires.

Section 52 of the Rural Fires Act requires Bushfire Management Committees to prepare Bushfire Risk Management Plans. The Bushfire Risk Management Plan provides a risk assessment across a fire district, which have been reviewed as part of this bushfire assessment. The proposal site is within the Cumberland Bushfire Risk Management Plan area (refer to section 3.5).

Section 63 Rural Fires Act of the RF Act requires public authorities and owners and occupiers of land to prevent bushfires and to manage land they are responsible for:

> *s. 63 Duties of public authorities and owners and occupiers of land to prevent bushfires*
>
> > *(1) It is the duty of a public authority to take the notified steps (if any) and any other practicable steps to prevent the occurrence of bushfires on, and to minimise the danger of the spread of a bushfire on or from:*
> >
> > > *(a) any land vested in or under its control or management, or*

(b) *any highway, road, street, land or thoroughfare, the maintenance of which is charged on the authority.*

Section 63 places on ongoing bushfire management requirement on Sydney Metro to mitigate the risk of bushfire within the proposal site.

3.2. Relevant guidelines

Planning for Bushfire Protection 2019 NSW Rural Fire Service
Contains specifications for planning and building on land identified as bushfire prone.

Standards for Asset Protection Zones NSW Rural Fire Service
Provides standards for the establishment and maintenance of asset protection zones.

3.3. Bushfire risk

With respect to property loss and fire impact, CSIRO studies have found that approximately 98% of all building loss has been found to occur on days when the Forest Fire Danger Index (FFDI) exceeded 45 (Blanchi & Lucas, 2010). The McArthur FFDI was developed in the 1960s by CSIRO scientist A. G. McArthur to measure the degree of danger of fire in Australian forests. The index combines a record of dryness, based on rainfall and evaporation, with meteorological variables for wind speed, temperature and humidity. The scale starts at 0 and tops out at an FFDI of 100. However, in recent years, FFDI above 100 have been calculated by the Bureau of Meteorology during catastrophic fire weather conditions.

The FFDI measures the degree of danger of fire in Australian vegetation. For the purposes of PBP 2019, the FFDI is required for development assessment purposes and is based on local government boundaries. PBP 2019 uses a design fire for bushfire risk assessment based on a 1:50 year fire weather scenario. Most of the state was determined as FFDI 80, however, a number of areas including the Greater Sydney, Greater Hunter, Illawarra, Far South Coast and Southern Ranges Fire Areas have higher FFDIs which are set at 100 by PBP 2019 (see Section 6 for the assessment methodology).

In events where the FFDI exceeds 50 (which is the point where a total fire ban is declared), fire suppression at any part of a fire line is virtually impossible due to the intensity and unpredictable behaviour of a fire (Leonard & Blanchi, 2012). Building design and construction, fuel management, and restriction of use of the sites during forecast bad fire weather are the only effective defence mechanisms available once the FFDI has exceeded 50 (Blanchi & Lucas, 2010; Leonard & Blanchi, 2012). These are provided by PBP 2019 and the construction requirements provided within the Australian Standard for Construction of Buildings in Bushfire Prone Areas (AS3959).

In considering risk to life, it is incumbent to examine historical bushfire-related life loss research. In 2012, the CSIRO in conjunction with the former Bushfire Corporative Research Centre undertook a comprehensive study into matters of both life and house loss utilising over 110 years (1901-2011) of data across 260 bushfire events (Blanchi et al. 2012). Over this period, a total of 825 known civilian and firefighter fatalities have occurred (Blanchi et al. 2012). Important findings of this seminal research are as follows:

- It is evident that fire weather and proximity to forest are very strong contextual drivers for defining the potential for fatalities to occur
- 85 per cent of fatalities occur within 100m of bushland
- 50 per cent of all recorded facilities have occurred on days exceeding FFDI 100 (most fatalities occur as a result of infrequent but high magnitude events)
- Late evacuation is the most common activity persons were engaged in at time of death (30.3 per cent) followed by sheltering inside a structure (24.8 per cent) and defending a property outside (22.4 per cent)
- For those instances where sufficient data is available with respect to fatalities occurring during the act of evacuation, most were trapped on roads by either fallen trees or become bogged, the remainder having run off the road due to poor visibility as a result of smoke conditions
- In terms of location of fatal exposure, 50 per cent occurred out in the open (including persons found outside structures and outside vehicles), 28 per cent occurred inside structures and in events where FFDI exceeded 100, fatalities within structures represented over 75 per cent of life loss
- The percentage of fatalities within structures appears to be increasing over time, mostly attributed to the 2009 Victorian Bushfires where 118 of the 173 fatalities occurred inside a structure
- Most fatalities occur between the hours of 3pm and 9pm – when FFDI is at its peak (3pm) and when summer cool-change winds occur. 90 per cent of fatalities occur immediately after afternoon wind changes.

In considering the above findings, there remain two key contextual matters which reflect the extent of fatalities in certain situations, including:

1. there is a direct relationship between fire intensity (as a function of FFDI) and both property and life loss, over distance from the bushland interface; and
2. the afternoon cool-wind change is likely a key phenomenon in situations where life loss occurs. These winds change the direction of the fire front, where the wide fire flank transitions to the head of the fire, creating a drastic spike in fire intensity and rate of spread over a wide distance and in a direction, which is not anticipated by the general community. These

situations can lead to higher proportions of people taking passive shelter (i.e. the window to evacuate has passed) and attempting late evacuation, as can the 'wait and see' mindset. Topographic conditions can also result in the same effect, where residents may not be aware of an approaching fire until it reaches a nearby ridgeline.

3.4. Land use planning and bushfire risk

Australia has a history of high consequence bushfires, which have caused loss of life, damage and disruption. Risk based land use planning provides the tolerable bushfire risk levels through documents such as PBP 2019, legislation, policy and guidelines.

Risk based land use planning has consistently been identified as one of the key means to reduce natural disaster risks to assets and communities. Improved risk based land use planning in areas that are subject to natural hazard are fundamental to developing and enhancing resilient development, critical infrastructure and communities.

The objectives of PBP 2019 articulates the criteria to determine tolerable risk to assets and people associated with 'other' development.

3.5. Cumberland Bushfire Risk Management Plan

The Cumberland Zone Bushfire Management Committee (BFMC) *Bushfire Risk Management Plan 2010* (Risk Plan) includes the Local Government Area/s of Blacktown, Fairfield and Penrith. The Risk Plan is a strategic document that identifies community assets at risk and sets out a five-year program of coordinated multi-agency (state and local) treatments to reduce the risk of bushfire to the assets.

The Risk Plan (p. 9) identifies the typical climate in the Cumberland Zone BFMC area (in which the proposal site in located) as warm temperate experiencing warm to hot summers and cool to mild winters with predominately summer/autumn rainfall and dry winter and spring. The bushfire season generally runs from October to March, and may occasionally be brought forward due to dry winter conditions and long cured grassland.

The prevailing weather conditions associated with the bushfire season in the Cumberland Zone BFMC area are in two parts, the dry winter with August / September winds providing potential fire conditions for the cured grassland areas, and the second is the north-westerly winds accompanied by high temperatures and low relative humidity providing weather conditions conducive for large spreading bushfires.

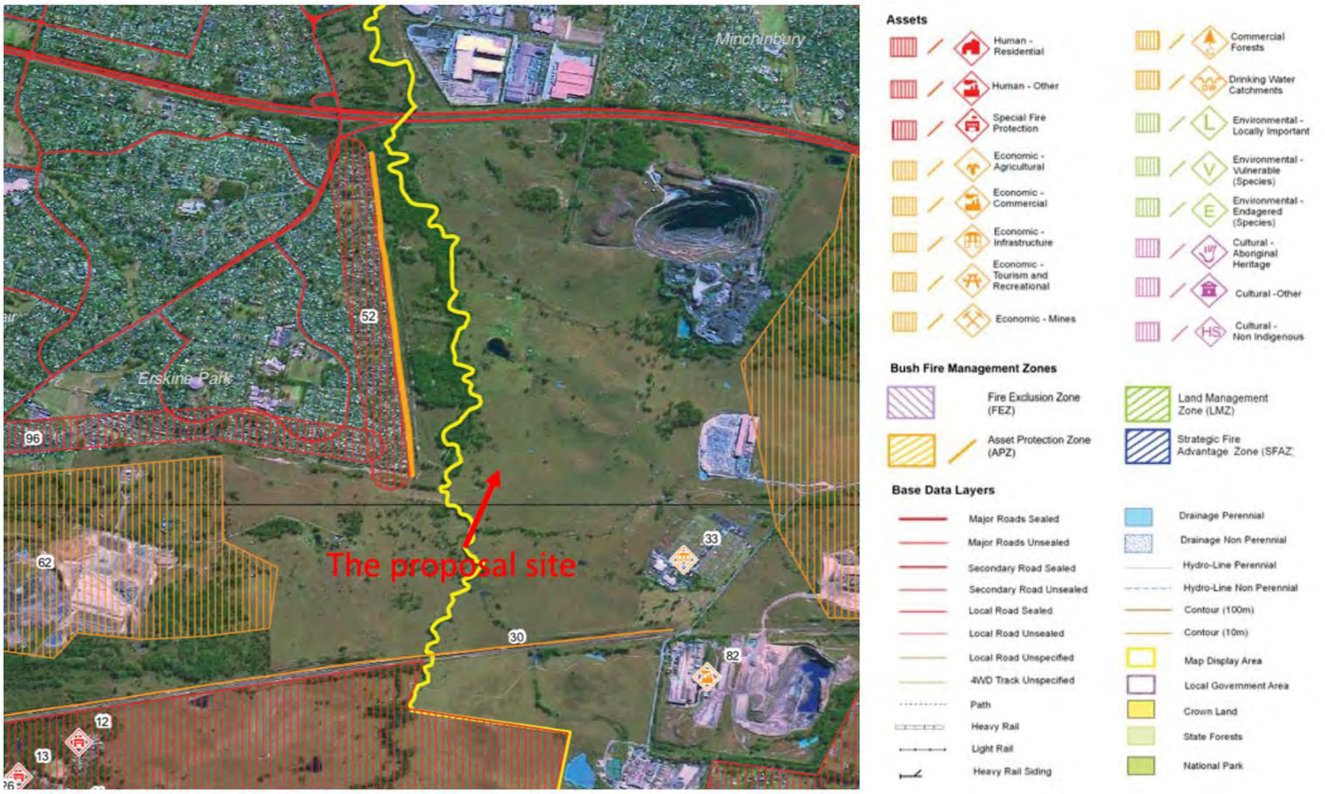
The prevailing weather conditions associated with the bushfire season in the proposal site are north-westerly winds accompanied by high day-time temperatures and low relative humidity.

The Cumberland Zone BFMC area has on average over 450 bush and grass fires per year, of which only a few are considered to be major fires (Risk Plan p. 12). The Risk Plan identifies that the main sources of ignition in the Cumberland Zone BFMC area are:

- *Illegal burning: mainly within the rural areas of all three local government areas*
- *Car dumping: the dumping of cars and setting them alight in bushland areas is a regular occurrence, mainly in the Castlereagh and Londonderry area*
- *Lightning: is generally associated with the summer thunderstorm activity and mainly affects the southern areas of the Zone, however, is known to occur in the northern parts of the Penrith LGA*
- *Deliberately lit fires: there is a high occurrence of deliberately lit fires within the Wilmot / Bidwill, Glenmore Park,* ***Ropes Creek areas****, where there are areas of bushland around and within built up areas.*

The Ropes Creek area has been identified in the Risk Plan as an area of known arson and high ignition sources. The site and surrounds are shown in Figure 4 from the Risk Plan with an asset protection zone on the western side of Ropes Creek adjacent to residential properties.

Figure 3 Extract from Cumberland Bushfire Risk Management Plan (p. 42)



3.6. Assessment framework

The proposal is seeking approval under Part 5 of the *Environmental Planning and Assessment 1979* (EP&A Act) for the construction and operation of two precast facilities and associated ancillary infrastructure. The purpose of the Part 5 assessment system is to ensure public authorities fully consider environmental issues, including bushfire, before they undertake or approve activities that do not require development consent from a council or the Minister. In this application, Sydney Metro is the Determining Authority. Where an environmental assessment is completed, referral to concurrence of agencies, such as the RFS is not required. On this basis, referral to the RFS is not required.

The identification of BPL in NSW is provided under S.10.3 of the EP&A Act. The proposal site is on designated Bushfire Prone Land and the surrounding grassland area is not managed which causes a bushfire risk. The BPL Maps provide the trigger for the consideration of bushfire matters for new development. All new development on bushfire prone land must comply with PBP 2019.

The aim of PBP 2019 is *to provide for the protection of human life and minimise impacts on property from the threat of bushfire, while having due regard to development potential, site characteristics and protection of the environment*.

The objectives are to:

- *Afford buildings and their occupants protection from exposure to a bushfire*
- *Provide for a defendable space to be located around buildings*
- *Provide appropriate separation between a hazard and buildings which, in combination with other measures, prevent the likely fire spread to buildings*
- *Ensure that appropriate operational access and egress for emergency service personnel and occupants is available*
- *Provide for ongoing management and maintenance of BPMs; and*
- *Ensure that utility services are adequate to meet the needs of firefighters.*

PBP 2019 articulates the regulatory framework for new development in NSW, along with the relevant bushfire protection measures to be contemplated in the delivery of bushfire-resilient development design. The document provides detailed provisions for various types of development which is focussed at residential and Special Fire Protection Purpose development.

On 1 March 2020, PBP 2019 was given legislative effect and replaced Planning for Bushfire Protection 2006 (PBP 2006). The Environmental Planning and Assessment Amendment (Planning for Bush Fire Protection) Regulation 2020 under the Environmental Planning and Assessment Act 1979 came into effect on 1 March 2020.

The proposal is considered as 'other development' in PBP 2019. 'Other development' includes industrial and infrastructure development. PBP 2019 does not provide a framework for the proposal in a meaningful way as the document is focussed at residential development in Bushfire Prone Areas. However, 'other development' must only satisfy the aim and objectives of PBP 2019. This assessment includes an analysis of the hazard, threat and subsequent bushfire risk to the proposal and provides recommendations that satisfy the aims and objectives of PBP 2019.

4. Existing environment

4.1. Bushfire prone land

The proposal site has a small section at the north western corner identified as being within the 100-metre vegetation buffer of 'bushfire prone land' (see Figure 4) for the purposes of Section 10.3 of the EP&A Act. The legislative requirements for development on bushfire prone lands are applicable. Bushfire prone land maps provide a trigger for the development assessment provisions and consideration of sites that are bushfire prone.

Bushfire prone land (BFPL) is land that has been identified by Blacktown City Council and Penrith City Council, which can support a bushfire or is subject to bushfire attack. Bushfire prone land maps are prepared by Blacktown City Council and certified by the Commissioner of the NSW RFS.

Figure 4 shows the Bushfire Prone Land Map for the proposal site. The north-western portion of the proposal site is within Category 1 Bushfire Prone Land vegetation buffer (approximately 1157m^2). Other areas of the proposal site are not within areas designated as being bushfire prone.

Based on the external site inspection and review of high-resolution aerial photography for the site and surrounds, the certified Bushfire Prone Map under represents the on ground bushfire hazard. Additional areas of forest and woodland vegetation within the Ropes Creek corridor and the grassland surrounding the proposal site is not managed and falls into the designation of Category 3 land. The categories of Bushfire Prone Land are designated in the NSW RFS document *Guideline for the Mapping of Bushfire Prone Land* (2015) and described below. The vegetation buffer is a requirement of the vegetation category provided, i.e. the higher the risk associated with the vegetation type, the larger the vegetation buffer.

Vegetation Category 1

Vegetation Category 1 is considered to be the highest risk for bush fire. It is represented as red on the bush fire prone land map and will be given a 100m buffer. This vegetation category has the highest *combustibility and likelihood of forming fully developed fires including heavy ember production. Vegetation Category 1 consists of:*

- *Areas of forest, woodlands, heaths (tall and short), forested wetlands and timber plantations.*

Vegetation Category 2

Vegetation Category 2 is considered to be a lower bush fire risk than Category 1 and Category 3 but higher than the excluded areas. It is represented as light orange on a bush fire prone land map and will be given a 30 metre buffer. This vegetation category has lower combustibility and/or limited potential fire size due to the vegetation area shape and size, land geography and management practices. Vegetation Category 2 consists of:

- *Rainforests.*
- *Lower risk vegetation parcels. These vegetation parcels represent a lower bush fire risk to*
- *surrounding development and consist of:*
    - *Remnant vegetation;*
    - *Land with ongoing land management practices that actively reduces bush fire risk. These areas must be subject to a plan of management or similar that demonstrates that the risk of bush fire is offset by strategies that reduce bush fire risk; AND include:*
        - *Discrete urban reserve/s;*
        - *Parcels that are isolated from larger uninterrupted tracts of vegetation and known fire*
        - *paths;*
        - *Shapes and topographies which do not permit significant upslope fire runs towards development;*
        - *Suitable access and adequate infrastructure to support suppression by firefighters;*
        - *Vegetation that represents a lower likelihood of ignitions because the vegetation is surrounded by development in such a way that an ignition in any part of the vegetation has a higher likelihood of detection.*

Vegetation Category 3

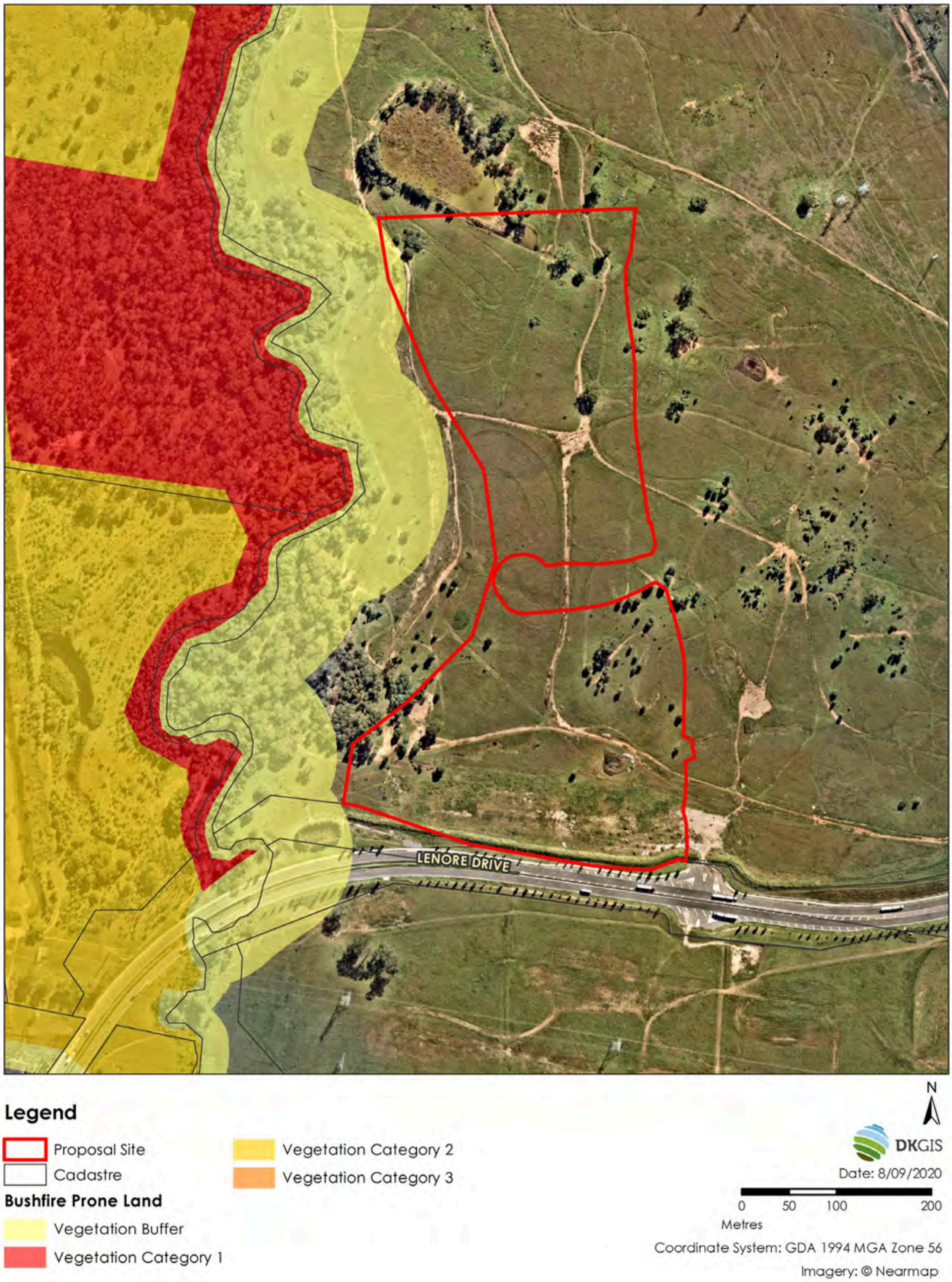
Vegetation Category 3 is considered to be medium bush fire risk vegetation. It is higher in bush fire risk than Category 2 (and the excluded areas) but lower than Category 1. It is represented as dark orange on a Bush Fire Prone Land map and will be given a 30 metre buffer. This category consists of:

- *Grasslands, freshwater wetlands, semi-arid woodlands, alpine complex and arid shrublands.*

PBP 2019 (p. 111) notes that grass, whether exotic or native, which is regularly maintained at or below 10 centimetre in height (includes maintained lawns, golf courses, maintained public reserves, parklands, nature strips and commercial nurseries) is regarded as managed land. Managed land is land that has vegetation removed or maintained to limit the spread and impact of bushfire. It may include existing developed land (i.e. residential, commercial or industrial), roads, golf course fairways, playgrounds or sports fields, vineyards, orchards, cultivated ornamental gardens and commercial nurseries. Most common would be gardens and lawns within curtilage of buildings. Areas within the proposal site would be managed to meet the requirements of an Asset Protection Zone (refer to section 6.3).

While the grassland surrounding the proposal site is not designated as being bushfire prone on the Bushfire Prone Land Map, it is able to carry a bushfire. As such, the unmanaged grassland areas have been treated within this Bushfire Hazard Assessment as a hazard. The unmanaged grassland areas off site, should be designated as Category 3 land by the NSW RFS where it is capable of sustaining a fire.

Figure 4 Bushfire Prone Land (source NSW Rural Fire Service)



5. Assessment methodology

PBP 2019 identifies the methodology to determine Bushfire Attack Levels (BAL) based on calculated radiant heat levels at a site. This assessment is based on mapping of vegetation formations and slope assessment in accordance with PBP 2019. This assessment is based on a desktop assessment of the site utilising the following resources:

- *Planning for Bushfire Protection* (NSW RFS, 2019)
- Aerial mapping
- Detailed GIS analysis.

Bushfire risk as influenced by fire history and future mitigation strategies (e.g. hazard reduction burning) has no bearing on the determination of bushfire protection strategies for future development at the sites. This is due to the fact that PBP 2019 assesses bushfire threat based purely on vegetation and slope (i.e. hazard and not risk), making the assumption that a fire may occur at a near worst-case scenario and with maximum fuel loads.

In undertaking the report, Blackash has followed the methodology outlined in accordance with PBP 2019. The following methodology is from PBP 2019 (p. 80) which has been used to determine the BAL at the site. The process to determine BAL is outlined below:

To Determine Bushfire Attack Level

Step 1: *Determine vegetation formation in all directions around the building to a distance of 140 metres*

Step 2: *Determine the effective slope of the land from the building for a distance of 100 metres*

Step 3: *Determine the relevant FFDI for the council area in which the development is to be undertaken*

Step 4: *Determine the separation distance by measuring from the edge of the unmanaged vegetation to the closest external wall of an asset*

Step 5: *Match the relevant FFDI, appropriate vegetation, distance and effective slope to determine the appropriate BAL using the relevant tables in PBP 2019.*

The vegetation formations (bushfire fuels) and the topography (effective slope) combine to create the bushfire threat that may affect bushfire behaviour at the proposal site, and which determine the planning and building response of PBP 2019.

5.1. Fire weather

The fire weather is dictated by PBP 2019 and assumes a credible worst-case scenario and an absence of any other mitigating factors relating to aspect or prevailing winds. The FFDI measures the degree of danger of fire in Australian vegetation.

For the purposes of PBP 2019, the FFDI required to be used for development assessment purposes is based on local government boundaries. The proposal site has a FFDI of 100 as required by the RFS and PBP 2019[1].

It may be possible that days of higher FFDI may be experienced at the proposal site. This may result in fire situations where conditions challenge survivability of buildings and their occupants. The framework provided for by PBP 2019 has been used in this assessment.

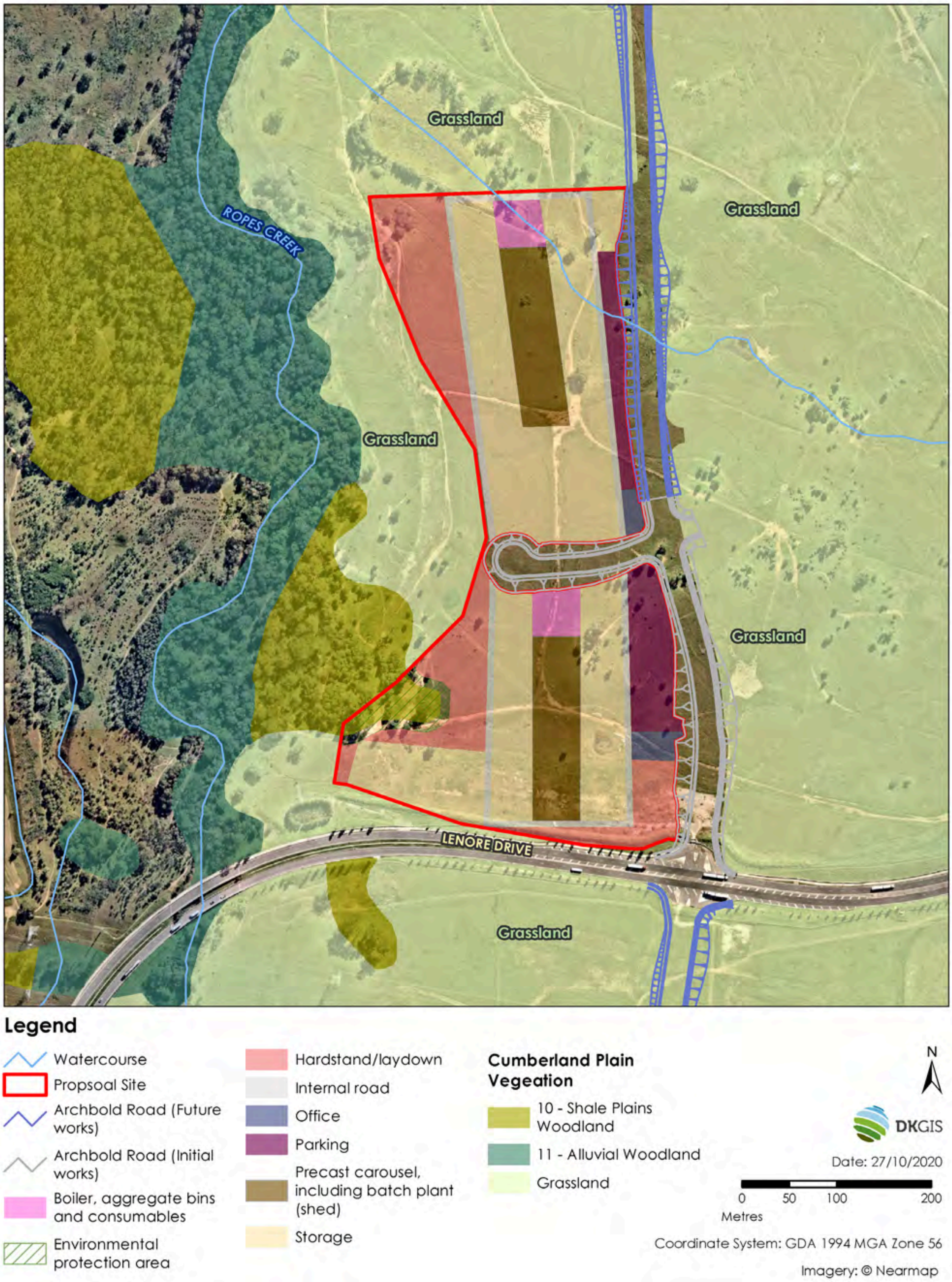
5.2. Vegetation

Predominant vegetation is classified by structure or formation using the system adopted by David Keith (2004) and by the general description using PBP 2019. Vegetation types give rise to radiant heat and fire behaviour characteristics. The predominant vegetation has been determined for the proposal site over a distance of at least 140 metres in all directions from the proposed site boundary or key assets on the proposal site. Where a mix of vegetation types exist, the type providing the greater hazard is said to predominate.

The land to the west of the proposal site is identified as bushfire prone land (see Figure 3) and is made up of a mix of vegetation with the most significant being dry sclerophyll forest, woodland and grassland vegetation (Figure 5).

[1] https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0007/55285/Local-government-areas-and-FDI.pdf

Figure 5 Vegetation



5.3. Slope assessment

The slope assessment (Figure 6) for the proposal site has been undertaken in the GIS analysis and is a component of determining the BAL rating for each site.

The slope is to be categorised into one of following classes (as required by PBP 2019), relative to the location of the hazard:

- all upslope vegetation (considered 0 degrees)
- >0 to 5 degrees downslope vegetation
- >5 degrees to 10 degrees downslope vegetation
- >10 degrees to 15 degrees downslope vegetation; and
- >15 degrees to 20 degrees downslope vegetation.

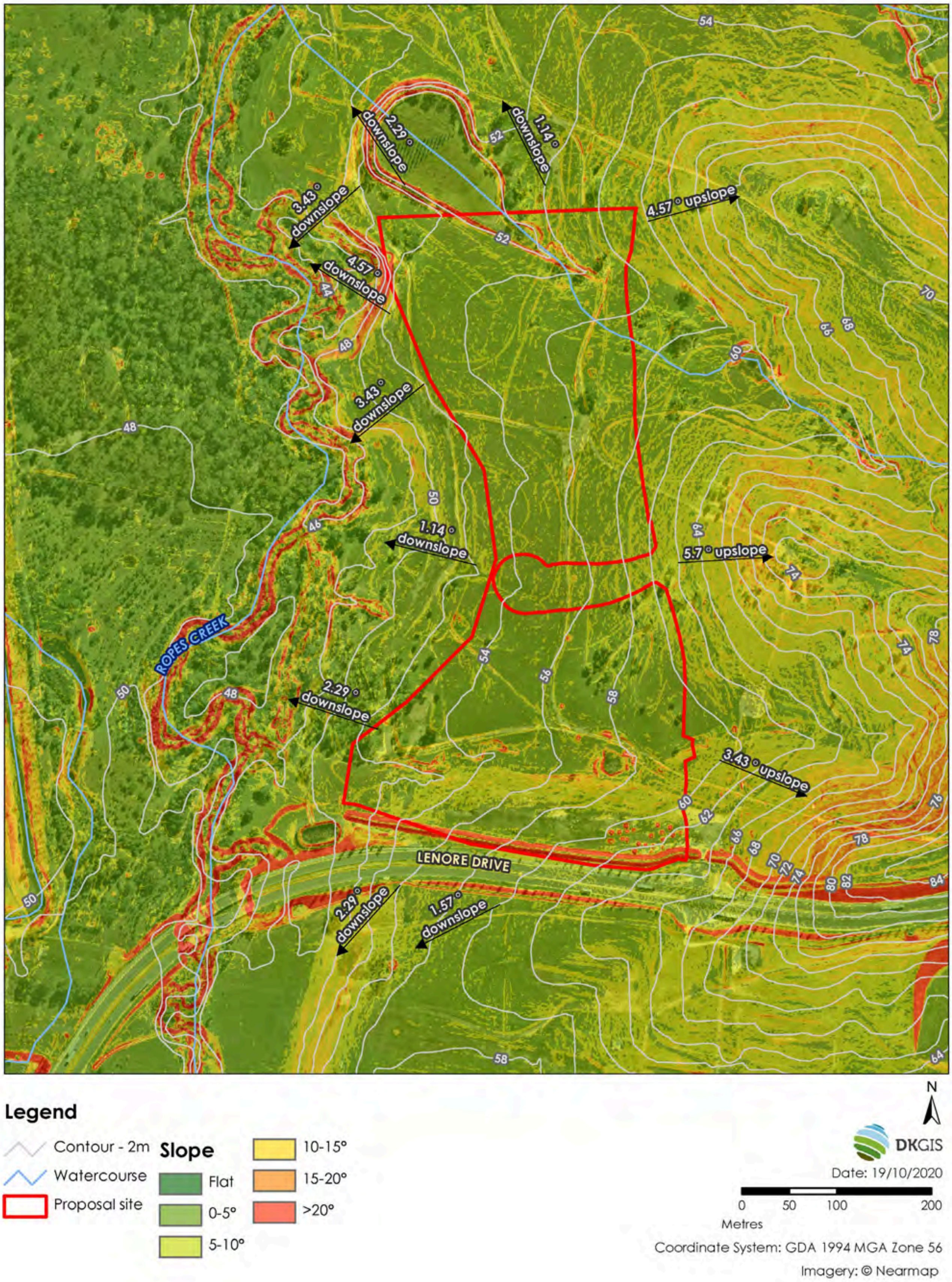
The slope of the land under the classified vegetation has a direct influence on the rate of fire spread, the intensity of the fire and the ultimate level of radiant heat flux. The effective slope is the slope of the ground under the hazard (vegetation). It is not the slope between the vegetation and the building (slope located between the asset and vegetation is the site slope).

In identifying the effective slope, it may be found that there are a variety of slopes covering different distances within the vegetation. The effective slope is considered to be the slope under the vegetation which will most significantly influence the bushfire behaviour for each aspect. This is usually the steepest slope which has been used in this assessment.

The slopes to the west of the proposal site slope gently down to Ropes Creek between 1.14 and 4.57 degrees downslope. Similar gentle slopes are present to the north of the proposal site.

Slopes to the east of the proposal site are steeper upslope and away from the site ranging from 3.43 – 5.7 degrees upslope. Slopes within the proposal site are flat with some areas of gentle gradients. These areas would be developed and are not part of the assessment of bushfire threat.

Figure 6 Slope Assessment



6. Impact assessment

6.1. Bushfire attack levels

The predominant (direct) threat to the proposal site is from grassfire being driven by north westerly or westerly winds into the proposal site. The risk posed by grass fires is different to that of fires in other vegetation types. Grass fires burn at a higher intensity and spread more rapidly with a shorter residence time. Embers produced by grass fires are smaller and fewer in number.

The Bushfire Attack Levels (BAL) for the proposal site have been determined in accordance with PBP 2019 and the Australian Standards for *Construction of Buildings in Bushfire Prone Areas* (AS3959).

The BAL is a means of measuring the severity of a building's or sites potential exposure to ember attack, radiant heat and direct flame contact (see Table 1).

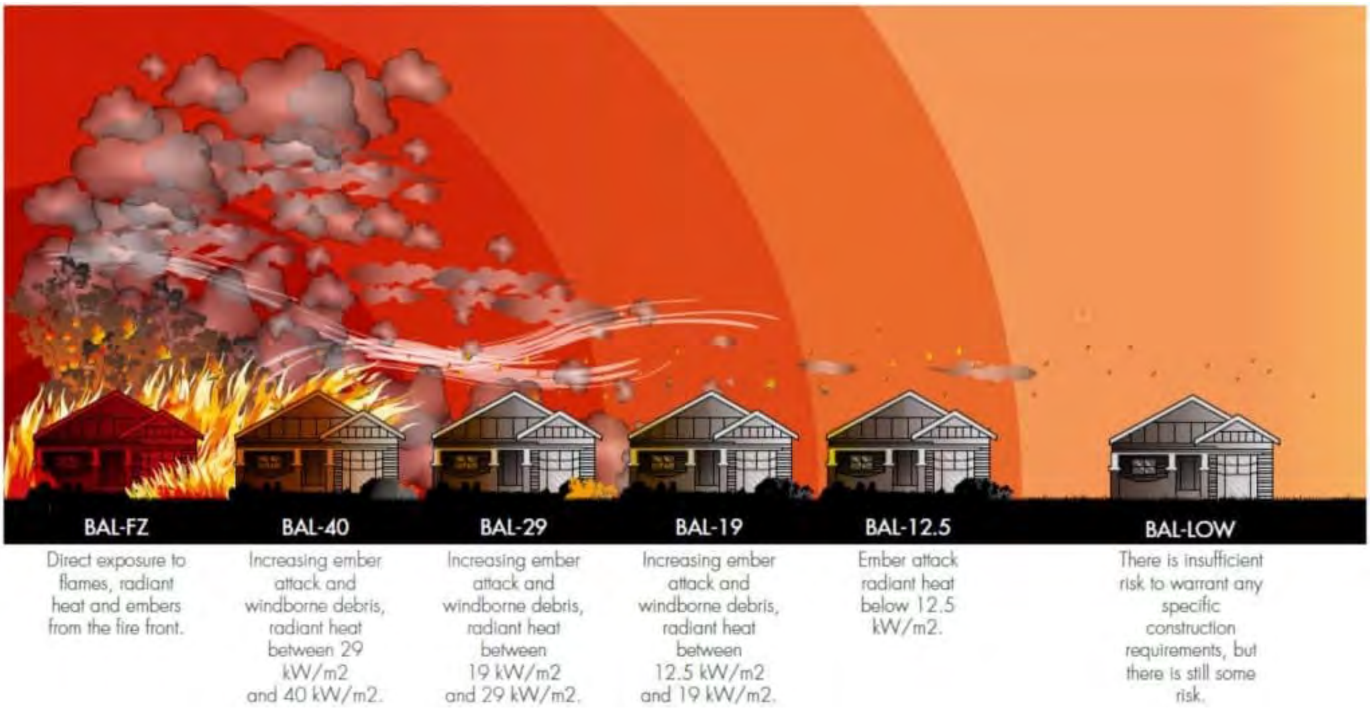
In the Building Code of Australia through AS3959, the BAL is used as the basis for establishing the requirements for construction to improve protection of building elements and to understand the radiant heat exposures for people in the open. The BAL output for the sites can be viewed with Table 2 for the effects of radiant heat. The BAL levels, the associated radiant heat flux and the predicted bushfire attack mechanisms from AS3959 are shown in Table 3. Figure 7 shows the effects of the various forms of bushfire attack.

Table 1 Bushfire Attack Levels (source AS3959 p. 34)

Bushfire Attack Level	Radiant Heat Flux exposure	Description of predicted bushfire attack and levels of exposure
BAL - Low	NA	There is insufficient risk to warrant specific construction requirements
BAL – 12.5	<12.5kWm^2	Ember attack
BAL – 19	>12.5kWm^2 - <19kWm^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux
BAL – 29	>19kWm^2 - <29kWm^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux
BAL – 40	>29kWm^2 - <40kWm^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux with the increased likelihood of exposure to flames

Bushfire Attack Level	Radiant Heat Flux exposure	Description of predicted bushfire attack and levels of exposure
BAL – Flame Zone	>40kWm2	Direct exposure to flames from the fire front in addition to radiant heat flux and ember attack.

Figure 7 Forms of Bushfire Attack (source cfa.vic.gov.au)

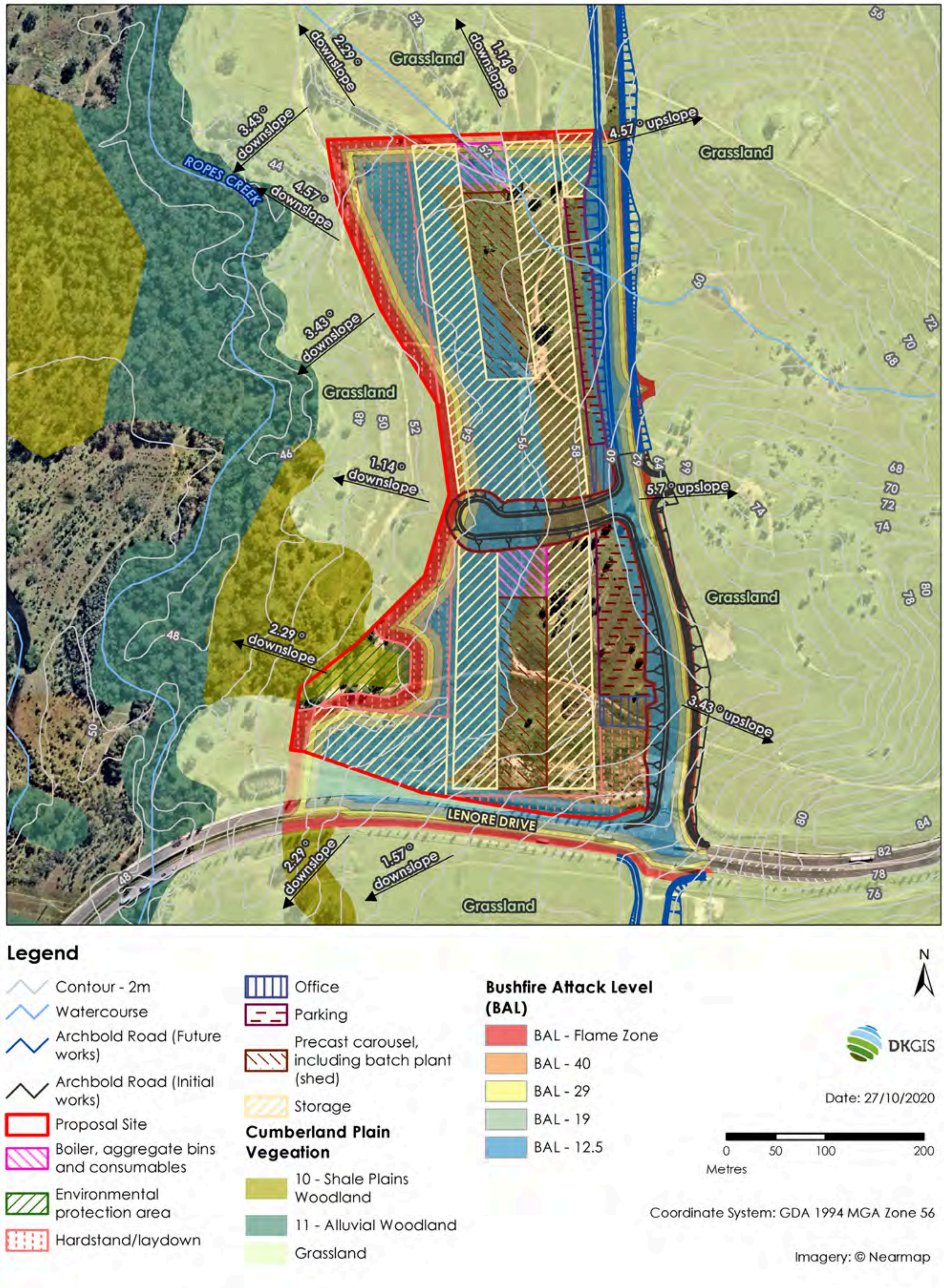


The BAL assessment (Figure 8) has been completed based on the current site boundary and the assumption that all vegetation (if any) within the proposal site would be managed as an APZ. This is with the exception of the environmental protection area which would be retained.

The assessed BAL level for each of the sites should be used to determine the vulnerability of assets and mitigation strategies that can be utilised to reduce the bushfire threat. The objectives of PBP 2019 (P. 10) requires that an appropriate separation between a hazard and buildings which, in combination with other measures, prevent the likely fire spread to buildings. The BAL has been determined for the site as shown in Figure 8. Key assets including the office are at BAL 12.5 as per Figure 8. It is understood that some key assets such as the warehouse, office and shed within the BAL 12.5 are not highly vulnerable to the impact of bushfire. By virtue of the site layout, the broader site is considered a low risk.

Any alterations to the internal design configuration of the proposal site may change the risk associated with the placement of the asset. Table 3 can be used to determine BAL levels for assets or distances of APZs to reduce or increase the level of exposure of an asset.

Figure 8 Bushfire Attack Levels



6.2. Overview of bushfire attack mechanisms

Bushfires have long remained a fundamental characteristic of the Australian bush landscape, and likewise Australians have long retained a strong affinity with bush environments. There remain a number of common factors which are associated with bushfire hazard and events and these include the incidence of fire weather, availability of fuel along with its type, structure and continuity or fragmentation, and the context of development at the bushland interface.

Bushfire attack refers to the various methods (see section 6) in which bushfire may impact upon life and property and principally encompass:

- Direct flame contact
- Ember attack
- Radiant heat flux
- Fire-driven wind
- Smoke.

In the progression of a bushfire event, these methods interact either exclusively or in concert and are explained in the following section.

6.2.1. Direct flame contact

Direct flame attack refers to flame contact from the main fire front, where the flame which engulfs burning vegetation is one and the same as that which assumes contact with the building. It is the highest level of bushfire attack as a consequence of direct flame contact from the fire front in addition to heat flux and ember attack.

6.2.2. Ember attack

The convective forces of bushfire raise burning embers into the atmosphere on prevailing winds and deposit them to the ground ahead of the fire front. Typically, ember attack occurs approximately 30 minutes prior to the arrival of the fire front and continues during the impact of the fire front and for several hours afterwards, thus it is the longest lasting impact of bushfire attack.

Ember attack is attack by smoldering or flaming windborne debris that is capable of entering or accumulating around a building, and that may ignite the building or other combustible materials and debris.

In essence, building loss via ember attack relates largely to the vulnerabilities and peculiarities of each building, its distance from hazardous vegetation and whether an occupant (or the like) is present to actively defend it. It is estimated by the CSIRO that approximately 80 to 90 per cent of buildings lost by bushfire are lost as a result of ember attack either in isolation or in combination with radiant heat impact.

6.2.3. Radiant heat flux

Exposure to radiant heat remains one of the leading causes of fatalities associated with bushfire events. Measured in kilowatts per square metre (kWm^2), radiant heat is the heat energy released from the fire front which radiates to the surrounding environment, deteriorating rapidly over distance.

In terms of impact on buildings, radiant heat can pre-heat materials making them more susceptible to ignition, or can cause non-piloted ignition of certain materials if the energy transmitted reaches a threshold level. Radiant heat can also damage building materials such as window glazing, allowing openings into a building through which embers may enter. Radiant heat impact is an especially important factor in building-to-building ignition.

In terms of radiant heat exposure for humans, it can cause pain to unprotected skin in milder situations or life threatening and fatal injury in higher exposure thresholds. The effects of radiant heat are shown in Table 2.

Table 2 The effects of radiant heat (NSWRFS 2006; Drysdale, 1999; CFA, 2012)

Radiant Heat Flux kW/m^2	Observed Effect
1	Maximum for indefinite skin exposure
3	Hazardous conditions, fire fighters expected to operate for a short period (10 minutes)
4.7	Extreme conditions, fire fighters in protective clothing will feel pain after 60 seconds exposure
6.4	Pain after 8 seconds of skin exposure
7	Likely to be fatal to unprotected person after exposure for several minutes
10	Critical conditions, fire fighters not expected to operate in these conditions although they may be encountered. Considered to be life threatening in less than 60 seconds in protective equipment. Fabrics inside a building could ignite spontaneously with long exposure
12.5 (BAL 12.5)	Volatiles from wood may be ignited by pilot after prolonged exposure. Standard float glass could fail during the passage of a bushfire
16	Blistering of skin after 5 seconds
19 (BAL 19)	Screened float glass could fail during the passage of a bushfire
29 (BAL 29)	Ignition of most timbers without piloted ignition (3 minutes exposure) during the passage of a bushfire. Toughened glass could fail.
40+	Flame zone – exposure to direct flame contact from fire front

6.2.4. Fire driven wind

The convective forces of bushfire typically result in strong to gale force fire-driven winds which in itself, can lead to building damage. The typical effects of fire driven wind include the conveyance of embers, damage from branches and debris hitting the building, as well as direct damage to vulnerable building components such as lifting roofs or roof materials and the damage / breakage of windows.

6.2.5. Smoke

Smoke emission remains a secondary effect of bushfire and is one which is typically not addressed by bushfire assessments. Irrespective, it is important to note the potentially severe impact of smoke emission on the human respiratory system. It can lead to difficulties in breathing, severe coughing, blurred or otherwise compromised vision, and can prove fatal. It is also important to note that toxic smoke can occur during bushfire, particularly where buildings or materials are ignited. With regard to evacuation, it can reduce visibility and create difficulties for particularly vulnerable persons.

6.3. Asset protection zones

An APZ is a buffer zone between a bushfire hazard and buildings. The APZ is managed progressively to minimise fuel loads and reduce potential radiant heat levels, flame, smoke and ember attack. The appropriate APZ distance is based on vegetation type, slope and the nature of the development. The APZ can include roads or land managed to be consistent with APZ standards set out in RFS document *Standards for Asset Protection Zones* (Standards for APZ).

The APZ provides a fuel-reduced, physical separation between buildings and bushfire hazards is a key element in the suite of bushfire measures and dictates the type of construction necessary to mitigate bushfire attack.

It is recommended that the proposal site is managed as an APZ as per Figure 9. Access roads, carparks, hardstand areas and the batching plants are all non-combustible and meet the requirements of an APZ. APZs widths have been determined in accordance with PBP 2019 (see Table 3).

Buildings would need to meet the requirements of Australian Standard for *Construction of Buildings in Bushfire Prone Areas* (AS3959) or risk of loss is to be understood by Sydney Metro.

APZs would be implemented in the proposal site based on the following:

- APZ (10 metres): located outside the eastern boundary of the proposal site, adjacent to the planned Archbold Road upgrade and extension, where there is a lower risk for bushfire
- APZ (12 metres): located adjacent to Lenore Drive (outside the south boundary of the proposal site), and the dam and grassland (north of the proposal site) where there is medium risk for bushfire
- APZ (16 metres): located at the western boundary of the proposal site, adjacent to the riparian vegetation along Ropes Creek and the environmental protection area at the south-western portion of the proposal site where there is a higher risk for bushfire. However, hardstand and laydown areas in the western boundary of the proposal site would effectively operate as APZs to the Ropes Creek vegetation as these areas are non-combustible.

The *Standards for APZs* require extensive modification of vegetation such that an area will not support a bushfire. An APZ is a fuel reduced area surrounding a built asset or structure. An APZ provides:

- a buffer zone between a bushfire hazard and an asset
- an area of reduced bushfire fuel that allows suppression of fire

- an area from which backburning by fire fighters may be conducted; and
- an area which allows emergency services access and provides a relatively safe area for firefighters to defend property.

The requirement for an APZ allows for vegetation and planting. However, bushfire fuels are minimised within an APZ. This is so the vegetation within the planned zone does not provide a path for the transfer of fire to the asset either from the ground level or through the tree canopy or ground vegetation.

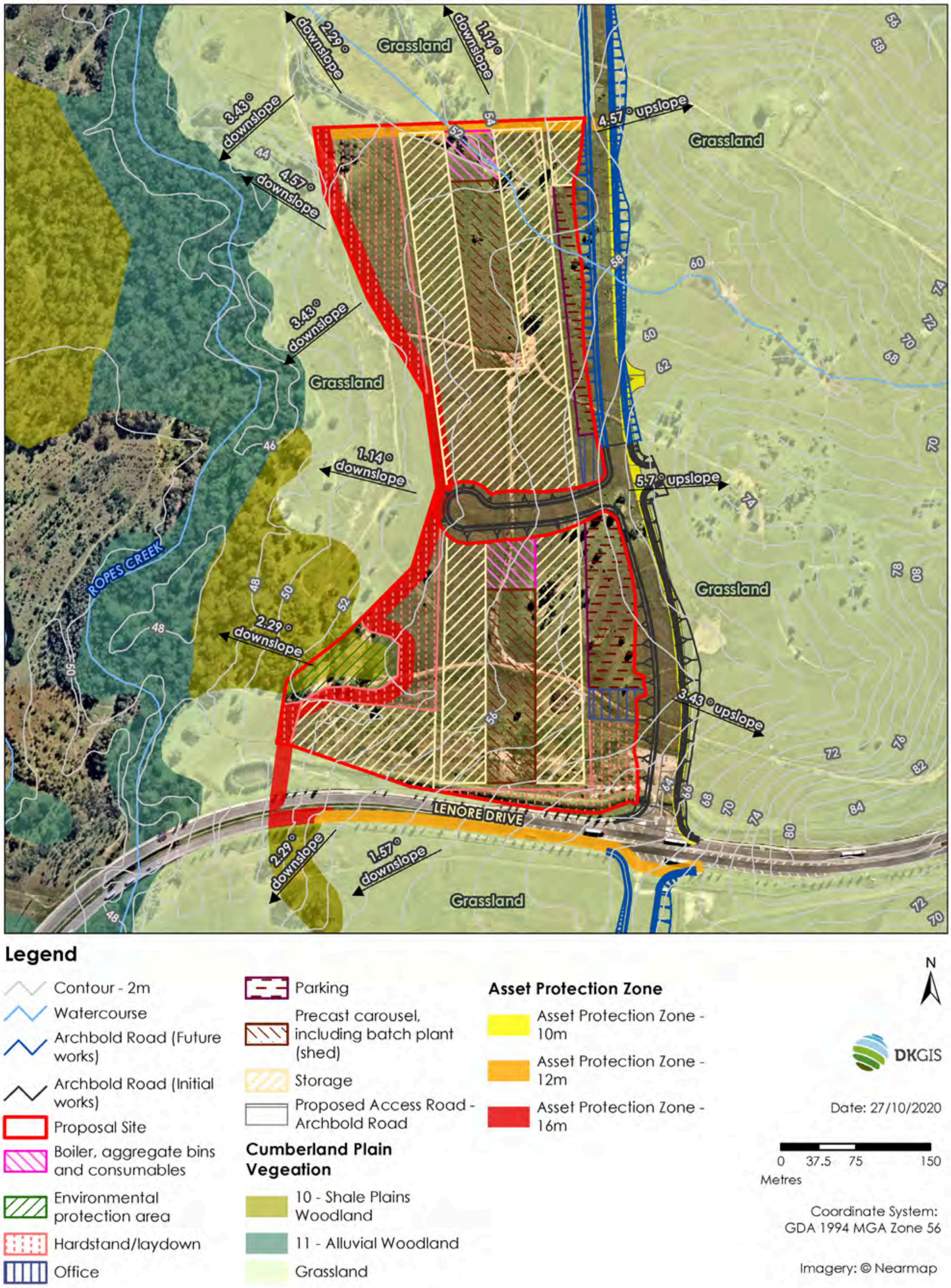
The *Standards for APZ* requirements include:

- *raking or manual removal of **fine fuels**. Ground fuels such as fallen leaves, twigs (less than 6 mm in diameter) and bark should be removed on a regular basis*
- *mowing or grazing of grass. Grass needs to be kept short and, where possible, green.*
- ***removal** or pruning of trees, shrubs and understorey. The control of existing vegetation involves both selective fuel reduction (removal, thinning and pruning) and the retention of vegetation*
- *prune or remove trees so that you do not have a continuous tree canopy leading from the hazard to the asset*
- ***separate tree crowns by two to five metres***
- *a canopy should not overhang within two to five metres of a dwelling*
- *native trees and shrubs should be retained as clumps or islands and should maintain a covering of no more than 20% of the area.*

Table 3 Bushfire Attack Levels (source PBP 2019. p. 92)

	KEITH VEGETATION FORMATION	BUSH FIRE ATTACK LEVEL (BAL)				
		BAL-FZ	BAL-40	BAL-29	BAL-19	BAL-12.5
		Distance (m) asset to predominant vegetation class				
ALL UPSLOPE AND FLAT LAND	Rainforest	< 8	8 -< 11	11 -< 16	16 -< 23	23 -< 100
	Forest (wet and dry sclerophyll) including Coastal Swamp Forest, Pine Plantations and Sub-Alpine Woodland	< 18	18 -< 24	24 -< 33	33 -< 45	45 -< 100
	Grassy and Semi-Arid Woodland (including Mallee)	< 9	9 -< 12	12 -< 18	18 -< 26	26 -< 100
	Forested Wetland (excluding Coastal Swamp Forest)	< 7	7 -< 10	10 -< 14	14 -< 21	21 -< 100
	Tall Heath	< 12	12 -< 16	16 -< 23	23 -< 32	32 -< 100
	Short Heath	< 7	7 -< 9	9 -< 14	14 -< 20	20 -< 100
	Arid-Shrublands (acacia and chenopod)	< 5	5 -< 6	6 -< 9	9 -< 14	14 -< 100
	Freshwater Wetlands	< 4	4 -< 5	5 -< 7	7 -< 11	11 -< 100
	Grassland	< 8	8 -< 10	10 -< 15	15 -< 22	22 -< 50
> 0 > 5 DEGREES - DOWNSLOPE	Rainforest	< 11	11 -< 14	14 -< 21	21 -< 29	29 -< 100
	Forest (wet and dry sclerophyll) including Coastal Swamp Forest, Pine Plantations and Sub-Alpine Woodland	< 22	22 -< 29	29 -< 40	40 -< 54	54 -< 100
	Grassy and Semi-Arid Woodland (including Mallee)	< 12	12 -< 16	16 -< 23	23 -< 32	32 -< 100
	Forested Wetland (excluding Coastal Swamp Forest)	< 9	9 -< 12	12 -< 18	18 -< 26	26 -< 100
	Tall Heath	< 13	13 -< 18	18 -< 26	26 -< 36	36 -< 100
	Short Heath	< 8	8 -< 10	10 -< 15	15 -< 22	22 -< 100
	Arid-Shrublands (acacia and chenopod)	< 5	5 -< 7	7 -< 11	11 -< 16	16 -< 100
	Freshwater Wetlands	< 4	4 -< 6	6 -< 8	8 -< 12	12 -< 100
	Grassland	< 9	9 -< 12	12 -< 17	17 -< 25	25 -< 50
> 5 > 10 DEGREES - DOWNSLOPE	Rainforest	< 14	14 -< 18	18 -< 26	26 -< 37	37 -< 100
	Forest (wet and dry sclerophyll) including Coastal Swamp Forest, Pine Plantations and Sub-Alpine Woodland	< 28	28 -< 36	36 -< 49	49 -< 65	65 -< 100
	Grassy and Semi-Arid Woodland (including Mallee)	< 15	15 -< 20	20 -< 28	28 -< 39	39 -< 100
	Forested Wetland (excluding Coastal Swamp Forest)	< 12	12 -< 16	16 -< 23	23 -< 33	33 -< 100
	Tall Heath	< 15	15 -< 20	20 -< 29	29 -< 40	40 -< 100
	Short Heath	< 9	9 -< 12	12 -< 18	18 -< 25	25 -< 100
	Arid-Shrublands (acacia and chenopod)	< 6	6 -< 8	8 -< 12	12 -< 18	18 -< 100
	Freshwater Wetlands	<5	5 -< 6	6 -< 10	10 -< 14	14 -< 100
	Grassland	< 10	10 -< 13	13 -< 20	20 -< 28	28 -< 50
> 10 > 15 DEGREES - DOWNSLOPE	Rainforest	< 17	17 -< 23	23 -< 34	34 -< 46	46 -< 100
	Forest (wet and dry sclerophyll) including Coastal Swamp Forest, Pine Plantations and Sub-Alpine Woodland	< 36	36 -< 45	45 -< 60	60 -< 77	77 -< 100
	Grassy and Semi-Arid Woodland (including Mallee)	< 19	19 -< 25	25 -< 36	36 -< 49	49 -< 100
	Forested Wetland (excluding Coastal Swamp Forest)	< 15	15 -< 20	20 -< 29	29 -< 41	41 -< 100
	Tall Heath	< 17	17 -< 22	22 -< 32	32 -< 44	44 -< 100
	Short Heath	< 10	10 -< 13	13 -< 20	20 -< 29	29 -< 100
	Arid-Shrublands (acacia and chenopod)	< 7	7 -< 9	9 -< 14	14 -< 20	20 -< 100
	Freshwater Wetlands	< 5	5 -< 7	7 -< 11	11 -< 16	16 -< 100
	Grassland	< 11	11 -< 15	15 -< 23	23 -< 32	32 -< 50
> 15 > 20 DEGREES - DOWNSLOPE	Rainforest	< 23	23 -< 30	30 -< 42	42 -< 56	56 -< 100
	Forest (wet and dry sclerophyll) including Coastal Swamp Forest, Pine Plantations and Sub-Alpine Woodland	< 46	46 -< 56	56 -< 73	73 -< 92	92 -< 100
	Grassy and Semi-Arid Woodland (including Mallee)	< 24	24 -< 32	32 -< 44	44 -< 59	59 -< 100
	Forested Wetland (excluding Coastal Swamp Forest)	< 19	19 -< 26	26 -< 37	37 -< 50	50 -< 100
	Tall Heath	< 19	19 -< 25	25 -< 36	36 -< 49	49 -< 100
	Short Heath	< 11	11 -< 15	15 -< 23	23 -< 32	32 -< 100
	Arid-Shrublands (acacia and chenopod)	< 7	7 -< 10	10 -< 16	16 -< 23	23 -< 100
	Freshwater Wetlands	< 6	6 -< 8	8 -< 13	13 -< 18	18 -< 100
	Grassland	<13	13 -< 17	17 -< 26	26 -< 36	36 -< 50

Figure 9 Areas to be managed as an Asset Protection Zone



6.4. Access

PBP 2019 requires that the location and design of access roads enables safe access and egress for people attempting to leave the area at the same time that emergency service personnel are arriving to undertake firefighting operations. Subject to a separate approval by Transport for NSW, Archbold Road would be extended and upgraded with a new intersection at Lenore Road (approximately 350m south of the site) as part of the initial works servicing the site. Archbold Road would be two way. It is proposed that a future upgrade (future works) would provide an extension of Archbold Road to the north which would providing access to the north and the south of the proposal site. However, the timing of this future works is not known. The site will have a single entry point off Archbold Road as per Figure 2.

A perimeter road (Figure 2) is provided within the proposal site that would facilitate emergency access within and throughout the proposal site. All roads within the proposal site would be a minimum of 5.5m wide.

The following **recommendations** are provided consistent with PBP 2019 (p. 44) for design specifications for access roads within the proposal site:

- *Access roads are two-wheel drive, all-weather roads*
- *Minimum 5.5m carriageway width kerb to kerb*
- *Maximum grades for sealed roads do not exceed 15 degrees and an average grade of not more than 10 degrees or other gradient specified by road design standards, whichever is the lesser gradient*
- *Curves of roads have a minimum inner radius of 6m*
- *Dead end roads incorporate a minimum 12 metres outer radius turning circle, and are clearly sign posted as a dead end*
- *A minimum vertical clearance of 4m to any overhanging obstructions, including tree branches, is provided.*

6.5. Water Supply and Utilities

PBP 2019 (p. 47) requires that adequate services of water for the protection of buildings during and after the passage of a bushfire, and to locate gas and electricity so as not to contribute to the risk of fire to a building.

The following **recommendations** regarding water are provided:

- A minimum static water supply of 20,000 litres should be provided at the proposal site for firefighting purposes. The firefighting water can be available in single tank or a number of tanks around the proposal site
- A hardened ground surface for truck access is to be supplied up to and within 4 metres of the water source
- A 65 millimetres metal Storz outlet with a gate or ball valve shall be provided as an outlet on each of the tanks
- The water tank, if located above ground, shall be of a non-combustible material
- Underground tanks shall have an access hole of 200 millimetres to allow tankers to refill direct from the tank. A hardened ground surface for truck access is to be supplied within 4 metres of the access hole
- All associated above ground fittings to the tank shall be non-combustible.

6.6. Evacuation and emergency management

A comprehensive Bushfire Emergency Management and Evacuation Plan should be completed for the construction and operational phase of the proposal. The bushfire evacuation procedures should be completed in accordance with NSW Rural Fire Service *Guide to Developing A Bushfire Emergency Management Plan* and meet the requirements of Australian Standard AS 3745-2010 – *Planning for Emergencies in facilities*. On-site and off-site evacuation procedures should be included.

The Cumberland *Bushfire Risk Management Plan* identifies a history of arson risk within the Ropes Creek area. As such, procedures should be put in place within the management plan for the proposal to ensure this risk is highlighted as part of the induction of people on the site and for timely notification of emergency services of fires (arson or otherwise) within the vicinity of the site.

The focus of the Bushfire Emergency Management and Evacuation Plan should be to put in place strategies that do not expose the workers to the effects of bushfire attack and focus on eliminating exposure to bushfire threat. The management team will be able to determine the safest options regarding forecast bushfire risk and providing for early evacuation from proposal site if there are fires in the vicinity.

6.7. Defining acceptable risk

In order to understand the nature of bushfire risks posed to the assets, people working within the sites and people using the access road to and from the site, it is critical to contemplate the elements of bushfire risk which may be relevant.

The tolerable level risk has not been determined by Blackash in this report for the sites. Tolerable risk is the readiness to bear the risk after risk treatment to achieve the overall objectives. To determine the tolerable risk, Sydney Metro should work through the bushfire risk (BAL and corresponding level of radiant heat) currently facing each of the assets within the site with a discussion about the vulnerability of assets (i.e. tolerable level of radiant heat).

The radiant heat and forms of bushfire attack can be reduced at the sites by increasing the size of the asset protection zone. This may have other knock on effects such as impacts on ecological integrity of adjoining land however, it is understood that Sydney Metro does not have the ability to undertake fuel management outside the site boundary and that mitigation measures would generally be contained within the site.

Considering the bushfire risk to the proposal site, a key risk management activity would be to not expose people to unreasonable risk. The most effective way to reduce loss of life risk is to not occupy the proposal site on above established thresholds for FFDI and fires within the surrounding landscape. This would need to occur with an understanding of the evacuation time from the sites and potential for fire to burn through the evacuation roads. Planning for bushfire evacuation is an immensely difficult task. Unlike flood and other events, bushfire events are not a 'known quantity'. There is no surety in when or where an ignition may occur, the direction is may spread, the extent of possible ember attack, etc. The impact of smoke and limited visibility in emergency situations, coupled with wind impact, can lead to issues on the tracks and roads as workers attempt to evacuate.

The evacuation planning for the construction and operational phase would be a crucial mitigation measure. A Bushfire Emergency Management and Evacuation Plan would be prepared in accordance with RFS guidelines.

7. Mitigation and management measures

During the construction and operational phase of the proposal site, measures must be put into place to manage ignition potential on or from the proposal site and to reduce the risk of fire impacting the site.

The following mitigation and management measures are recommended:

No.	Impact	Management and mitigation measures
BF1	Bushfire	The proposal site would be managed as an APZ. At the commencement of building works for each of the sites, The entire proposal site would be managed as an APZ as outlined within Appendix 4 of 'Planning for Bushfire Protection 2019' and the NSW Rural Fire Service's document 'Standards for asset protection zones'. The APZ would not extend into the environmental protection area in the south-west of the site.
BF2	Bushfire	Vulnerable buildings and/or critical assets (in particular warehouse, office buildings and sheds)would be constructed to appropriate BAL levels in accordance with the Australian Standard for the *Construction of Buildings in Bushfire Prone Areas* (AS3959).
BF3	Bushfire	The following measures would be implemented for access roads within the proposal site: 1. access roads would be two-wheel drive, all-weather roads; 2. access roads would have a minimum 5.5 metres carriageway width kerb to kerb; 3. maximum grades for sealed roads would not exceed 15 degrees and an average grade of not more than 10 degrees or other gradient specified by road design standards, whichever is the lesser gradient; 4. curves of roads would have a minimum inner radius of 6 metres 5. dead end roads would incorporate a minimum 12 metres outer radius turning circle, and are clearly sign posted as a dead end; 6. a minimum vertical clearance of 4 metres would be provided to any overhanging obstructions, including tree branches.

No.	Impact	Management and mitigation measures
BF4	Bushfire	The following water supply and utilities would be installed during construction and maintained during operation of the proposal: 1. A minimum static water supply of 20,000 litres would be provided at the site for firefighting purposes. The firefighting water can be available in a single tank or a number of tanks around the proposal site 2. A hardened ground surface for truck access would be supplied up to and within 4 metres of the water source 3. A 65mm metal Storz outlet with a gate or ball valve would be provided as an outlet on each of the tanks 4. The water tank if located above ground would be of a non-combustible material 5. Underground tanks shall have an access hole of 200mm to allow tankers to refill direct from the tank. A hardened ground surface for truck access is to be supplied within 4 metres of the access hole. 6. All associated fittings to the tank shall be non-combustible.
BF5	Bushfire	A comprehensive Bushfire Emergency Management and Evacuation Plan would be completed for the construction and operational phase of the proposal. The bushfire evacuation procedures would be completed in accordance with NSW Rural Fire Service *Guide to Developing A Bushfire Emergency Management Plan* and meet the requirements of Australian Standard AS 3745-2010 – *Planning for Emergencies in facilities*.
BF6	Bushfire	Activities that generate sparks or excessive heat would be minimised when a total fire ban is declared by Rural Fire Service.

8. Conclusion

This Bushfire Hazard Assessment has been completed for Sydney Metro for the construction and operation of two precast facilities to support the construction of the proposed Sydney Metro West.

The proposal site is partially located in designated bushfire prone area and bushfire impact is a key consideration to ensure mitigation and risk is understood to reduce the consequences of any bushfire impacts. The proposal site could be impacted by bushfire from adjoining lands.

This Report is a Bushfire Hazard Assessment that assesses the potential impacts associated with bushfire risk and provides the required information to assist Sydney Metro undertake planning for the construction and operation of the proposal.

Appendix 1 References

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