South West Creek Precinct 5

Riparian Assessment

BHL Group

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DOCUMENT TRACKING

Project Name	South Creek West (South West) Precinct Riparian Assessment
Project Number	19SYD - 14547
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Status	**Final**
Version Number	**8**
Last saved on	**5 April 2024**

This report should be cited as 'Eco Logical Australia 2024. *South Creek West (South West) Precinct Riparian Assessment*. Prepared for BHL Group.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from BHL Group.

Template 2.8.1

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Abbreviations

Abbreviation	Description
BC Act	NSW *Biodiversity Conservation Act 2016*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ELA	Eco Logical Australia Pty Ltd
EP&A Act	*Environmental Planning and Assessment Act 1979*
DOtEE	Department of the Environment and Energy
DPIE	Department of Planning, Infrastructure and Environment
FM Act	NSW *Fisheries Management Act 1994*
ILP	Indicative Layout Plan
LGA	Local Government Area
NRAR	Natural Resources Access Regulator
SCW	South Creek West
SEPP	State Environmental Planning Policy
TSC Act	NSW *Threatened Species Conservation Act 1995* (repealed)
WM Act	NSW *Water Management Act 2000*

Executive Summary

Eco Logical Australia Pty Ltd (ELA) was engaged by BHL Group to undertake a Biodiversity Assessment for Precinct Planning of the South Creek West (South West) precinct, 'Precinct 5'. The aim of this report is to identify key ecological constraints to assist design of an Indicative Layout Plan (ILP).

ELA field-validated watercourses and riparian zones along watercourses within the precinct. The majority of the 1st order watercourses did not have a defined bed or bank and represent overland flow paths rather than 'rivers' as defined by the *Water Management Act 2000* (WM Act). The Natural Resources Access Regulator (NRAR) would determine if these can be removed from the map and therefore not need to be retained in the Precinct Plan as part of their formal review of the proposal.

Most 1st and 2nd order reaches that did meet the definition of a river were in poor condition, with ephemeral or intermittent flow only and limited habitat features. The 3rd and 4th order watercourses were in moderate to good condition, with larger pools, aquatic vegetation, and instream features.

Riparian habitat was generally poor, lacking canopy and mid-storey cover. Along the primary creek line, which flows through the centre of the study area, there was good condition Cumberland Plain Woodland which provides good habitat, shaded the creek, and stabilised the banks. Based on field validation, there is a total of 17.47 ha of riparian zone on the site. This assumes a Vegetated Riparian Zone (VRZ) around each existing on-line farm dam. If a 10 m-wide watercourse and associated VRZ through the centreline of the existing farm dam on the 3rd order watercourse were assumed, there is a total of 16.89 ha of riparian zone on the site.

An ILP has been prepared that provides 16.91 ha of riparian area. This report recommends that the protection and management of the riparian zone be achieved through:

- The use of a C2 Environmental Conservation zone
- The use of the Riparian Protection map in the *State Environmental Planning Policy (Precincts – Western Parkland City) 2021*, linked to the Camden Growth Centres Precincts Development Control Plan (DCP) clauses relating to water cycle management and native vegetation.
- Preparation and implementation of Vegetation Management Plans (VMPs) concurrently with development of land adjoining the riparian corridor. The VMPs are to be consistent with the objectives of the C2 zone, NRAR *Guidelines for Vegetation Management Plans on Waterfront Land*, and should allow for recreation infrastructure that does not have a significant impact on riparian values.
- Vegetation management to be generally in accordance with the Vegetation Management Strategy contained in this report.
- Where possible, major riparian zones should be in public ownership so that public access for recreation is possible.

1. Introduction

1.1 Description of the Project

Eco Logical Australia Pty Ltd (ELA) was engaged by BHL Group to undertake a Riparian Land Assessment for Precinct Planning of the South Creek West (SCW) Cobbitty Sub-Precinct 5. It accompanies a Planning Proposal for a proposed amendment to the *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* (Western Parkland City SEPP) for the study area located along the Northern Road and which forms part of Cobbitty Sub-Precinct 5, in the SCW Land Release Area.

SCW forms part of the South West Growth Area (SWGA). Given the scale of the release area, the Department of Planning and Environment (DPE) divided it into five distinct precincts numbered 1 – 5. The land to which this Planning Proposal relates to is referred to as Cobbitty Sub-Precinct 5, also known as Precinct 5. It totals approximately 303 ha and has been characterised by rural residential and agricultural land uses and activities. The Planning Proposal applies to a 172.74 ha portion of Precinct 5, defined as the study area in this report (Figure 1).

The precinct was released by the Minister for Planning on 24 November 2017 for urban development. The release formally commenced the rezoning process for land within the precinct, including the subject site.

Precinct 5 is located within the south-west portion of the South Creek West Land Release (SCWLA) area within the suburb of Cobbitty in the Camden Local Government Area (LGA). The Precinct adjoins the Lowes Creek Maryland Precinct, which has recently been rezoned to the north, the Pondicherry precinct to the east which is in the process of being rezoned and the growing town centre and suburbs of Oran Park to the south (Figure 1).

The aim of this assessment is to identify key riparian features and constraints of the site to inform the rezoning process, as well as to provide recommendations with respect to aquatic ecosystem management.

Specific objectives of this project are to:

- Undertake a Riparian Corridors Assessment to inform the precinct planning process and development of the Indicative Layout Plan (ILP).
- Work in collaboration with the Water Cycle Management Service Provider, to map riparian corridors using the Strahler system and provide recommendations and planning controls for riparian lands.
- Work in collaboration with the Water Cycle Management Service Provider to identify suitable locations for stormwater management such as detention basins, stormwater outlet structures and constructed wetlands.

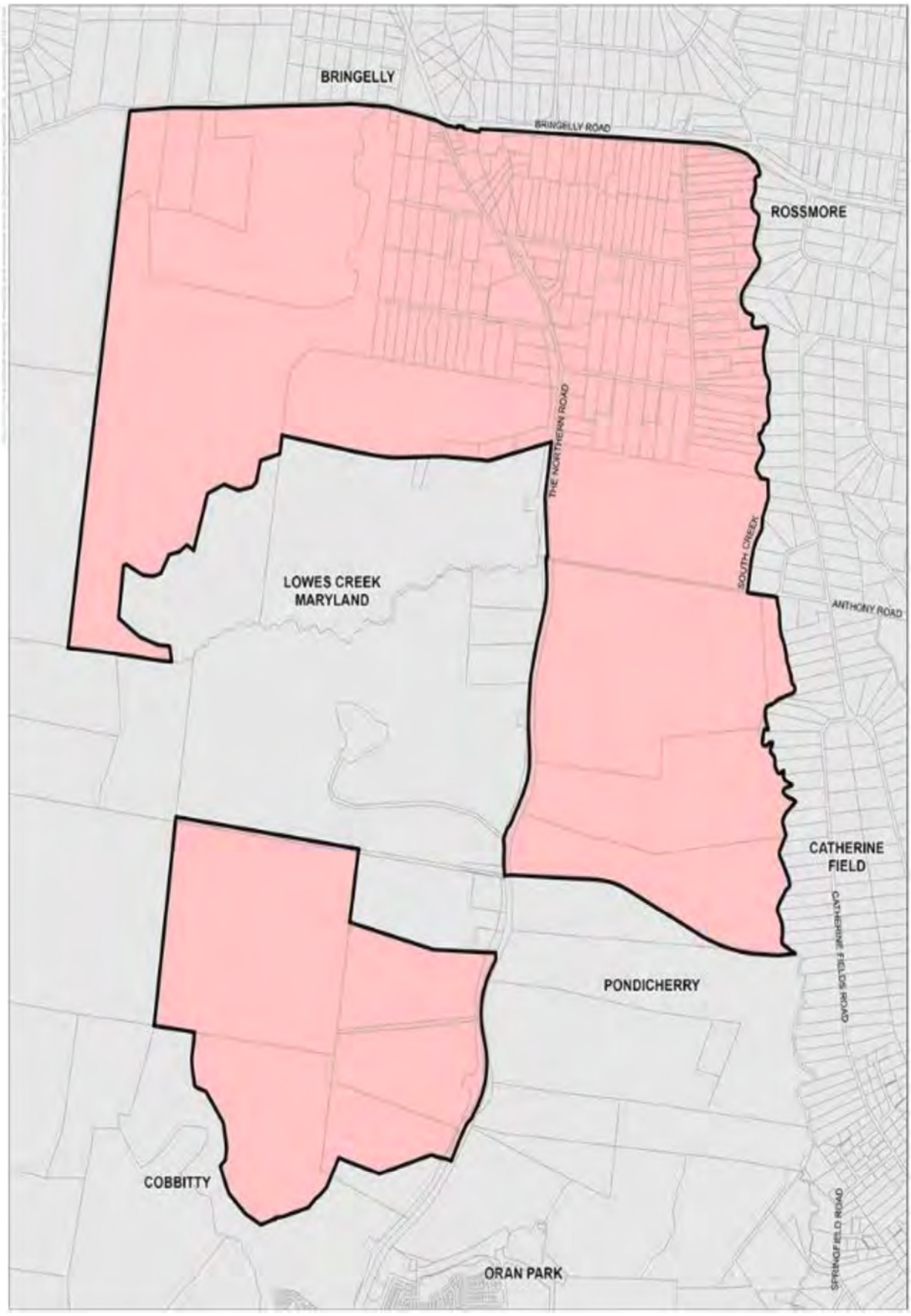

Figure 1: South Creek West release area

1.2 Study Area and Context

Figure 2 illustrates the broad location of the study area. The study area lies within the Hawkesbury-Nepean Catchment. The Hawkesbury-Nepean is the second largest in NSW and has its headwaters located within largely pristine regions including the Blue Mountains World Heritage Area and Sydney Catchment Authority's lands in the NSW Southern Highlands. These upper reaches provide over 90% of Sydney's drinking water. Once into flatter, floodplain country, the Hawkesbury River flows eastward towards the ocean through rural and semi-rural areas of western Sydney. These middle and lower reaches of the system are highly impacted and degraded, both directly through waterway modifications and indirectly through adjacent land-use practises. Hydrological and sediment regimes have been dramatically altered due to vegetation clearance and increasing urbanisation. Increasing impervious surfaces in the catchment are causing changes to hydrology which has greatly altered the geomorphology and ecology of the watercourses.

Numerous tributaries of Lowes Creek, north of the study area, flow through the site from south to north. Lowes Creek is the nearest mapped Key Fish Habitat.

1.3 Proposal

BHL, as the major landholder in the precinct, seeks to initiate the preparation of a planning proposal for the rezoning of Precinct 5 in accordance with the proposed Draft ILP (Figure 2). This is to facilitate the orderly redevelopment of Precinct 5 into a residential community.

The intended outcome of this Planning Proposal is to amend the current *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* to facilitate the urban development of Precinct 5 as part of the South West Growth Centre as envisaged in the Greater Sydney Commission's Regional Plan and District Plan.

The Draft ILP has been prepared to support the planning proposal and precinct rezoning and has been informed by extensive specialist consultant studies. The site will comprise approximately 2,312 dwellings and a population of approximately 7,056 people within a thriving community supported by:

- 19.97 ha of active and passive open space
- A thriving local centre
- Prominent creeks and riparian areas that retain water in the local environment
- Protection of ridgelines, creeks, and views through Connecting with Country design principles
- Integrated stormwater and services infrastructure that improve local amenity

The proposed new planning controls comprise amendments to *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* and associated environmental planning instruments including the rezoning of the precinct to reflect land uses shown in the Draft ILP.

This Planning Proposal also seeks to introduce a site-specific Schedule to the *Camden Growth Centre Precincts Development Control Plan* to support the Precincts development in accordance with the Draft ILP and supporting technical investigations.

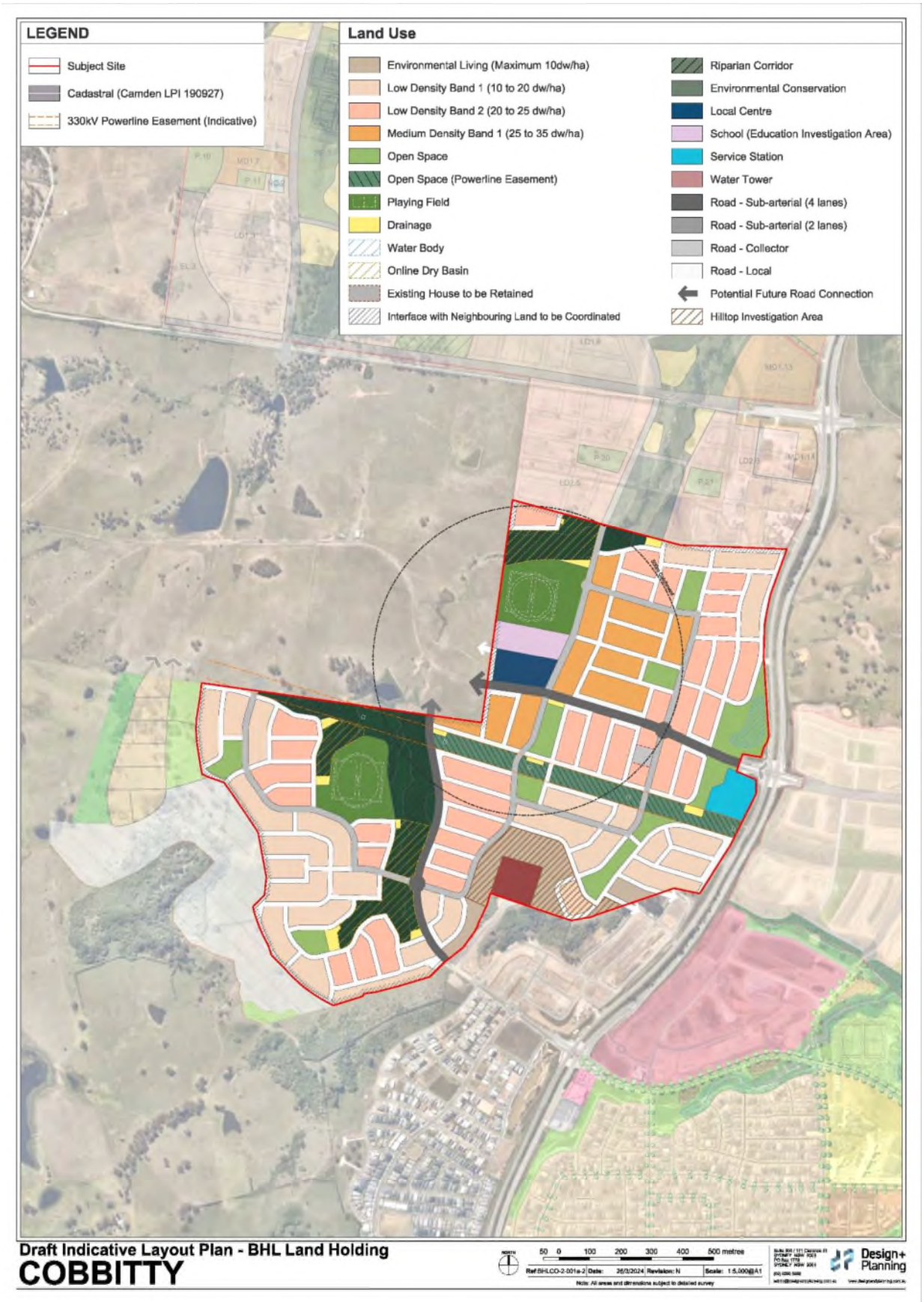

Figure 2: Draft Indicative Layout Plan (ILP)

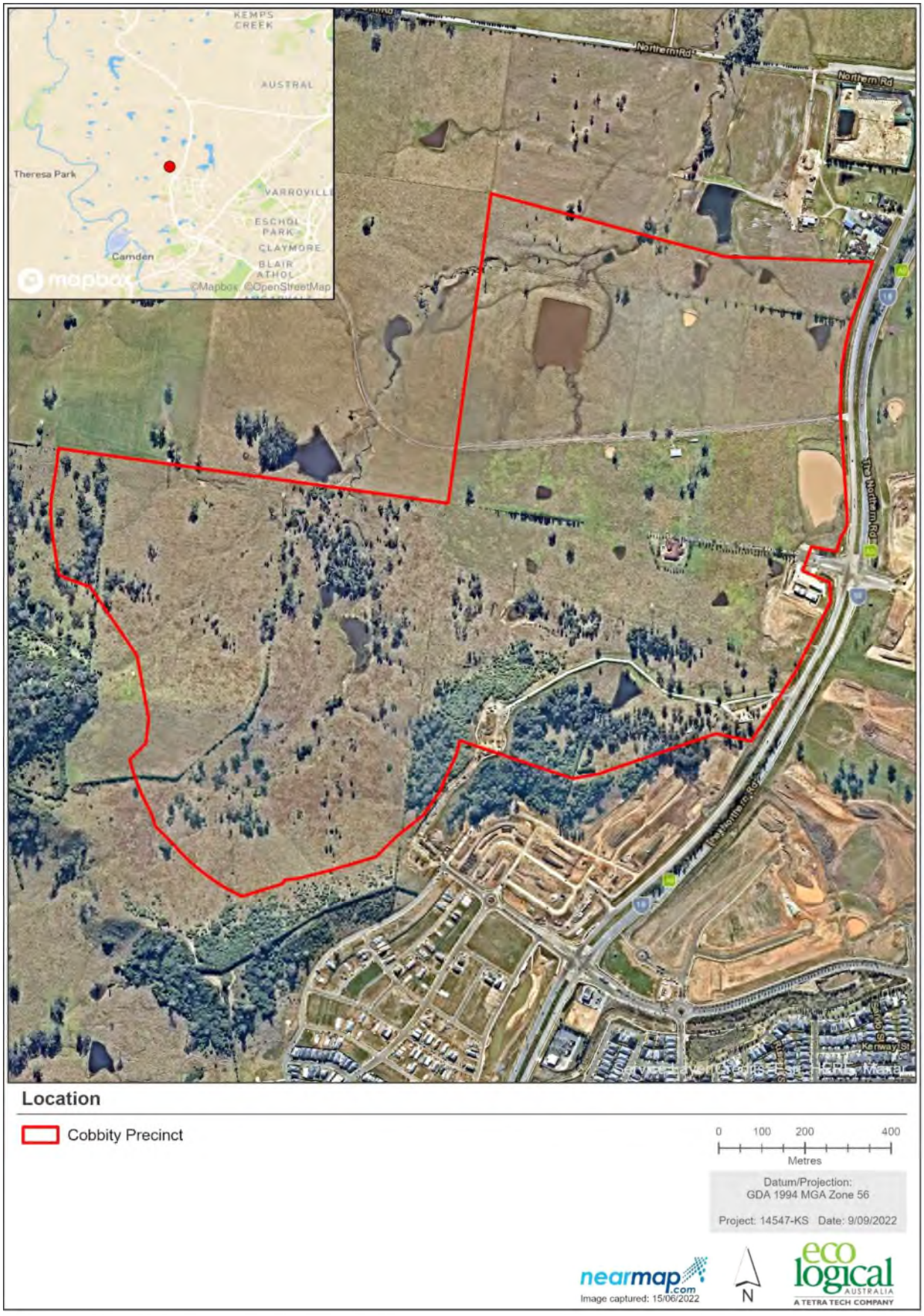

Figure 3: Location and study area

1.4 Background

Following an extensive review by Council (and the APP Group) and the Local Planning Panel, the planning proposal and Biodiversity Assessment have been amended to reflect feedback from the Environment and Heritage Group (EHG) and enable Council endorsement for its progression to gateway. This report addresses the comments and feedback received from EHG, Council and the Local Planning Panel (Table 1).

Table 1: Response to EHG comments

EHG Comment	Response
The need to increase the amount of Additional High Conservation Value Vegetation (AHCVV) being retained within riparian corridor and the Ridgeline Park.	The previous ILP proposed to protect: • 2.94 ha of AHCVV within the Riparian Corridor. • 0.81 ha of AHCVV within the Easement, subject to future Development Control Plan (DCP) controls. • 2.61 ha of AHCVV within Open Space areas, subject to future DCP controls. The current ILP now proposes to protect: • 3.26 ha of AHCVV within the Riparian Corridor, demonstrating an increase from the previous ILP. • 0.15 ha of AHCVV within the Easement, subject to future Development Control Plan (DCP) controls. • 1.71 ha of AHCVV within Open Space areas, subject to future DCP controls. This reduction is due to the required removal of the Ridgeline Park, which is further discussed below. In turn, the current ILP will also protect 12.19 ha of Cumberland Plain Woodland in varying conditions and 0.18 ha of River-flat Eucalypt Forest within the Environmental Conservation area. Further, the ridgetop towards the southern area of the precinct around the water tower is proposed to be revegetated utilising species endemic to Cumberland Plain Woodland and River-flat Eucalypt Forest. It should be noted that the ILP has been updated to reflect Council's amendment to the Oran Park Contribution Plan, finalised by Council at its March 2023 meeting. The major amendment removed land and works associated with the open space areas known as treed hilltop parks in the Oxley Ridge precinct. As such, the Ridgeline Park has been converted to large lot residential, which is considered to be the most suitable land use as it achieves the objectives of retaining the character of a vegetated ridgeline whilst still effectively using the land.
The need to provide greater certainty about the conservation of AHCVV within proposed open space areas	The protection of AHCVV within the Easement and Open Space areas will be guided by specific controls within the DCP. The preparation of the DCP is currently underway and will be exhibited with the Planning Proposal.
The need to relocate proposed detention basins outside of the proposed C2 Zone/riparian corridors and limit proposed drainage works within the C2 zone.	The current ILP has removed the previously proposed online wet basin within the Riparian Corridor, and this has been replaced by an online dry basin. The ILP will allow for protected and rehabilitated watercourses to be established, which will improve their current condition, as currently they receive no observable maintenance and exotic flora species dominate some areas of the Riparian Corridor. Watercourse protection will also allow for an improvement in water quality within the precinct, as revegetation and weed control would create stable beds and banks and a buffer between residential areas and the watercourse.

EHG Comment	Response
	Although the *Controlled Activities – Guidelines for Riparian Corridors on Waterfront Land* (DPE, 2022), do not allow for online dry basins on 3rd and 4th order watercourses, it is noted that: • **All basins will be dry and vegetated:** Any existing native vegetation will be retained and in currently cleared areas the Riparian Corridor will be revegetated to a full-structured vegetation community (Cumberland Plain Woodland or River-flat Eucalypt Forest). This has been reflected in the relevant flood modelling undertaken by J. Wyndham Prince (2024), where a Mannings Value of 0.12 has been assumed. • **All basins will be for temporary flood detention only:** Basin inundation hours will be confirmed upon completion of the flood modelling (J. Wyndham Prince, 2024). It should be noted that the riparian corridors would nevertheless be inundated during storm events even as part of the development of these areas as defined by the NSW Government Growth Centre 2011. • **The basins will have an equivalent Vegetated Riparian Zone (VRZ) for the corresponding watercourse:** The existing VRZ area across the site is 16.89 ha, assuming a 10 m-wide watercourse and associated VRZ through the centreline of the existing farm dam on the 3rd order watercourse. The area of VRZ proposed to be retained under the ILP is 16.91 ha. • **The basins will not be used for water quality treatment purposes:** Water quality management will be undertaken in separate stand-alone devices outside the outer 50% VRZ. The online basins are proposed for water retention only. It is also noted that the Drainage Areas shown within the ILP (Figure 2) have not been counted towards the native vegetation retention values. Further, any road crossings within the Riparian Corridor will include bridges and/or culverts. The type of recreation infrastructure likely to be required within the Riparian Corridor is shown within the Landscape Masterplan (Urbis, 2024).
The proposed zoning of the Ridgeline Park as C4 Environmental Living as opposed to C2 Environmental Conservation which would allow for an increased security of the conservation and restoration of native vegetation	The Ridgeline Park has been removed from the current ILP / precinct to reflect Council policy as discussed above. However, it is noted that ridgetop towards the southern area of the precinct around the water tower is proposed to be revegetated utilising species endemic to Cumberland Plain Woodland and River-flat Eucalypt Forest.
The applicants proposed zoning of Open Space Areas as Low Density Residential as opposed to RE1 Public recreation which would have an increased security for remnant native vegetation.	All Open Space areas are currently zoned RE1 (Public Recreation).

2. Statutory Framework

An array of strategic plans, legislation, policies, and guidelines apply to the planning and management of biodiversity issues within the study area. This information was reviewed and used to identify priority issues and approaches for the study area and are summarised below.

1.1. Statutory Framework

Table 2 summarises the relevant legislation and policies that apply to the study area, which are required to be considered.

Table 2: Statutory framework and relevance to this study

Act	Relevance
	Commonwealth
Environment Protection & Biodiversity Conservation Act 1999 (EPBC Act)	On 28 February 2012, the Commonwealth Minister for the Environment announced the program of development related activities within the Growth Centres that had been approved under the Growth Centres Strategic Assessment. (This was the second stage of the approval of the Strategic Assessment of the Growth Centres under the Commonwealth EPBC Act). Specifically, *"All actions associated with the development of the Western Sydney Growth Centres as described in the Sydney Region Growth Centres Strategic Assessment Program Report (Nov 2010) have been assessed at the strategic level and approved regarding their impact on the following matters of national environmental significance (MNES):* • *World Heritage Properties* • *National Heritage Places,* • *Wetlands of International Importance,* • *Listed threatened species, populations, and communities, and* • *Listed migratory species."* This approval essentially means that the Commonwealth is satisfied that the conservation and development outcomes that will be achieved through development of the Growth Centres Precincts will satisfy their requirements for environmental protection under the EPBC Act. Therefore, provided development activity proceeds in accordance with the Growth Centres requirements (such as the Biodiversity Certification Order, the Western Parkland City SEPP and Development Control Plans (DCPs), Growth Centres Development Code etc), then there is no requirement to assess the impact of development activities on MNES and hence no requirement for referral of activities to the Commonwealth. The requirement for assessment and approval of threatened species and endangered ecological communities and the other MNES issues listed above under the EPBC Act has now been "turned off" by the approval of the Strategic Assessment.
	State
Biosecurity Act 2015 (Biosecurity Act)	The *Noxious Weed Act 1993* was repealed and replaced with the Biosecurity Act. Under the Biosecurity Act all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable. Specific legal requirements apply to State determined priorities under the *Greater Sydney Regional Strategic Weed Management Plan 2017-2022*. Weeds listed as 'other weeds of regional concern' warrant resources for local control or management programs and are a

Act	Relevance
	priority to keep out of the region. Inclusion in this list may assist Local Control Authorities and/or land managers to prioritise action in certain circumstances where it can be demonstrated the weed poses a threat to the environment, human health, agriculture etc.
Fisheries Management Act 1994 (FM Act)	The *Fisheries Management Act 1994* (FM Act) governs the management of fish and their habitat in NSW. The FM Act applies to fish and marine vegetation and requires a separate assessment from the NSW *Biodiversity Conservation Act 2016* (BC Act), which only relates to terrestrial animals and plants. The objectives of the FM Act are to conserve fish stocks and key fish habitats, conserve threatened species, populations and ecological communities of fish and marine vegetation and to promote ecologically sustainable development. The FM Act also regulates activities involving dredging and/or reclamation of aquatic habitats, obstruction of fish passage, harming marine vegetation and use of explosives within a waterway. Any activity that will block fish passage, involve dredging or reclamation of channel bed or banks or involve use of explosives in the waterway within key fish habitat, will require a permit under Part 7 of this Act.
Water Management Act 2000 (WM Act)	The *Water Management Act 2000* control the extraction of water, the use of water, the construction of works such as dams and weirs and the carrying out of activities in or near water sources in New South Wales. 'Water sources' are defined very broadly and include any river, lake, estuary, place where water occurs naturally on or below the surface of the ground and coastal waters. The relevant objectives of this act are to: *a. Apply the principles of ecologically sustainable development* *b. Protection, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality* *c. Recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including benefits to:* *i the environment, and* *ii urban communities, agriculture, fisheries, industry and recreation, and* *iii culture and heritage, and* *iv the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water.* If a 'controlled activity' is proposed on 'waterfront land', an approval is required under the Water Management Act (s91). 'Controlled activities' include: • the construction of buildings or carrying out of works; • the removal of material or vegetation from land by excavation or any other means; • the deposition of material on land by landfill or otherwise; or • any activity that affects the quantity or flow of water in a water source. 'Waterfront land' is defined as the bed of any river or lake, and any land lying between the river or lake and a line drawn parallel to and forty metres (40 m) inland from either the highest bank or shore (in relation to non-tidal waters) or the mean high-water mark (in relation to tidal waters). It is an offence to carry out a controlled activity on waterfront land except in accordance with an approval. The riparian corridors that exist within South Creek-west Precinct have been mapped according to their stream order (Figure 7).

2.1 Strategic Plans

Table 3 summarises the relevant strategic assessments that apply to the study area, which should be considered within the Planning Proposal.

Table 3: Strategic plans and relevance to this study

Strategic Plan	Biodiversity / Sustainability Objectives
The Greater Sydney Region Plan, *A Metropolis of Three Cities* (Greater Sydney Commission, 2018)	The Greater Sydney Region Plan, *A Metropolis of Three Cities* (Greater Sydney Commission, 2018) is built on a vision of three cities where most residents live within 30 minutes of their jobs, education and health facilities, services, and great places. To meet the needs of a growing and changing population the vision seeks to transform Greater Sydney into a metropolis of three cities: • The Western Parkland City. • The Central River City. • The Eastern Harbour City. The Plan includes directions and objectives for liveability and sustainability, productivity, and infrastructure within Greater Sydney, including two sustainability objectives, which are most relevant to this study, being: • The coast and waterways are protected and healthier. • A cool and green parkland city in the South Creek corridor; and • the Green Grid links parks, open spaces, bushland and walking and cycling paths. The Plan is supported by five District Plans, which provide greater details regarding conservation objectives, including the Western Sydney District Plan.
Our Greater Sydney 2056 – Western Sydney District Plan (Greater Sydney Commission, 2018)	The Western Sydney District Plan is a 20-year plan to manage economic, social, and environmental growth and provides a guide for implementing the Greater Sydney Region Plan at a district level. The Plan outlines two relevant sustainability planning priorities, which coincide and build on the objectives listed within the Greater Sydney Region Plan, being: • Protecting and improving the health and enjoyment of the district's waterways. • Creating a Parkland City urban structure and identity, with South Creek as a defining spatial element.
Greener Places - An Urban Green Infrastructure Design Framework for New South Wales (Government Architect NSW, 2020) and Draft Greener Places Design Guide (Government Architects NSW, 2020)	Greener Places is a design framework to guide the planning, design, and delivery of green infrastructure in urban areas across NSW. It aims to create a healthier, more liveable, and sustainable urban environment by improving community access to recreation and exercise, supporting walking, and cycling connections and improving the resilience of urban areas. The Draft Greener Places Design Guide framework provides information on how to design, plan, and implement green infrastructure in urban areas throughout NSW. The draft guide provides a consistent methodology to help State and local government, and industry create a network of green infrastructure. This study focuses on one of the three major components of the green infrastructure network, being bushland and waterways. Five key strategies have been developed to connect, protect, restore, enhance, and create urban habitat as an integral part of how urban areas are planned, constructed, and maintained, which include: • protect and conserve ecological values; • restore disturbed ecosystems to enhance ecological value and function; • create new ecosystems; • connect people to nature; and • connect urban habitats.

2.2 Relevant Guidelines

2.2.1 Guidelines for Controlled Activities on Waterfront Land – Riparian Corridors

The NSW Government Natural Resources Access Regulator's *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (DPE guidelines) published in May 2022 outlines the need for a Vegetated Riparian Zone (VRZ) adjacent to the channel to provide a transition zone between the

terrestrial environment and watercourse. This vegetated zone helps maintain and improve the ecological functions of a watercourse whilst providing habitat for terrestrial flora and fauna. The VRZ plus the channel (bed and banks of the watercourse to the highest bank) constitute the 'riparian corridor' (Figure 4). To be consistent with the DPE guidelines, VRZ widths should be based on watercourse order as classified under the Strahler system of ordering watercourses and using Hydroline Spatial Data which is published on the department's website (Table 4).

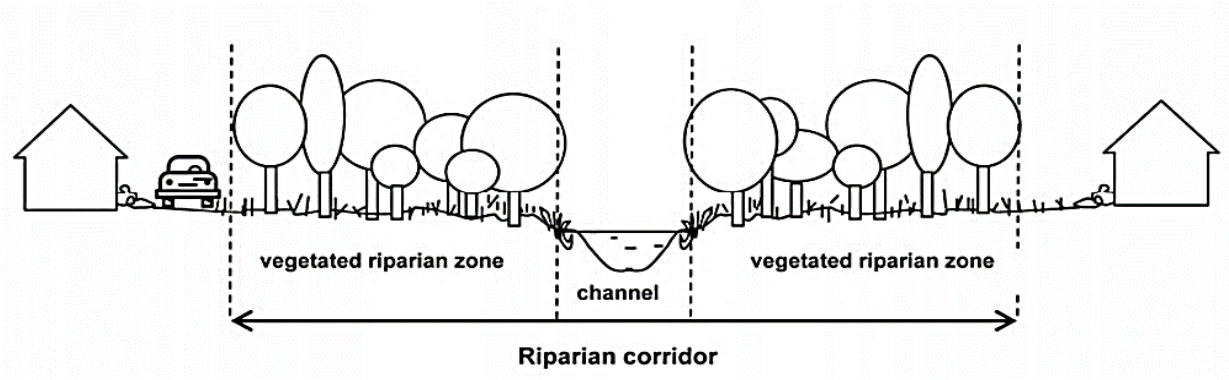

Figure 4: Vegetated riparian corridor widths relative to Strahler stream order (DPE 2022)

Table 4: Recommended riparian corridor widths relative to Strahler stream order (DPE 2022)

Watercourse Type	VRZ Width (Each Side of Watercourse)	Total Riparian Corridor Width
1st order	10 m	20 m + channel width
2nd order	20 m	40 m + channel width
3rd order	30 m	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 m	80 m + channel width

Certain works are permissible within the riparian zone if specific design criteria are met (Table 5). Non-riparian uses in the outer 50% of the VRZ are permitted as long as compensation (1:1 offset) is achieved within the site using the 'averaging rule' (Figure 5).

Table 5: Riparian corridor (RC) matrix of permissible use (DPE 2022)

Stream Order	Vegetated Riparian Zone (VRZ)	RC Offsetting for Non-RC Uses	Cycleways and Paths	Detention Basins		Stormwater Outlet Structures and Essential Services	Stream Realignment	Road Crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10 m	●	●	●	●	●	●	●		
2nd	20 m	●	●	●	●	●		●		
3rd	30 m	●	●	●		●			●	●
4th +	40 m	●	●	●		●			●	●

KEY TO RIPARIAN CORRIDOR MATRIX

STREAM ORDER: THE WATERCOURSE ORDER AS CLASSIFIED UNDER THE STRAHLER SYSTEM BASED ON HYDROLINE SPATIAL DATA PUBLISHED ON THE DEPARTMENT'S WEBSITE[1]

VEGETATED RIPARIAN ZONE (VRZ): THE REQUIRED WIDTH OF THE VRZ MEASURED FROM THE TOP OF THE HIGH BANK ON EACH SIDE OF THE WATERCOURSE.

RIPARIAN CORRIDOR (RC) OFF-SETTING FOR NON RC USES: NON-RIPARIAN USES, SUCH AS BUSHFIRE ASSET PROTECTION ZONES, ROADS AND URBAN DEVELOPMENT ARE ALLOWED WITHIN THE OUTER 50% OF THE VRZ, SO LONG AS OFFSETS ARE PROVIDED IN ACCORDANCE WITH THE AVERAGING RULE AS SEEN IN FIGURE 5.

CYCLEWAYS AND PATHS: CYCLEWAYS OR PATHS NO WIDER THAN FOUR METRES TOTAL DISTURBANCE FOOTPRINT CAN BE BUILT IN THE OUTER 50% OF THE VRZ.

DETENTION BASINS: DETENTION BASINS CAN BE BUILT IN THE OUTER 50% OF THE VRZ OR ONLINE WHERE INDICATED. ONLINE BASINS MUST: BE DRY AND VEGETATED, BE FOR TEMPORARY FLOOD DETENTION ONLY WITH NO PERMANENT WATER HOLDING, HAVE AN EQUIVALENT VRZ FOR THE CORRESPONDING WATERCOURSE ORDER AND NOT BE USED FOR WATER QUALITY TREATMENT PURPOSES.

STORMWATER OUTLET STRUCTURES AND ESSENTIAL SERVICES: STORMWATER OUTLETS OR ESSENTIAL SERVICES ARE ALLOWED IN THE RC. WORKS FOR ESSENTIAL SERVICES ON A FOURTH ORDER OR GREATER STREAM ARE TO BE UNDERTAKEN BY DIRECTIONAL DRILLING OR TIED TO EXISTING CROSSINGS.

STREAM REALIGNMENT: INDICATES THAT A WATERCOURSE MAY BE REALIGNED.

ROAD CROSSINGS: INDICATES PERMITTED ROAD CROSSING METHODS. ALSO REFER TO DPI FISHERIES POLICY AND GUIDELINES FOR FISH FRIENDLY WATERWAY CROSSINGS (FAIRFULL 2013, DISCUSSED BELOW).

[1] https://www.industry.nsw.gov.au/water/licensing-trade/hydroline-spatial-data

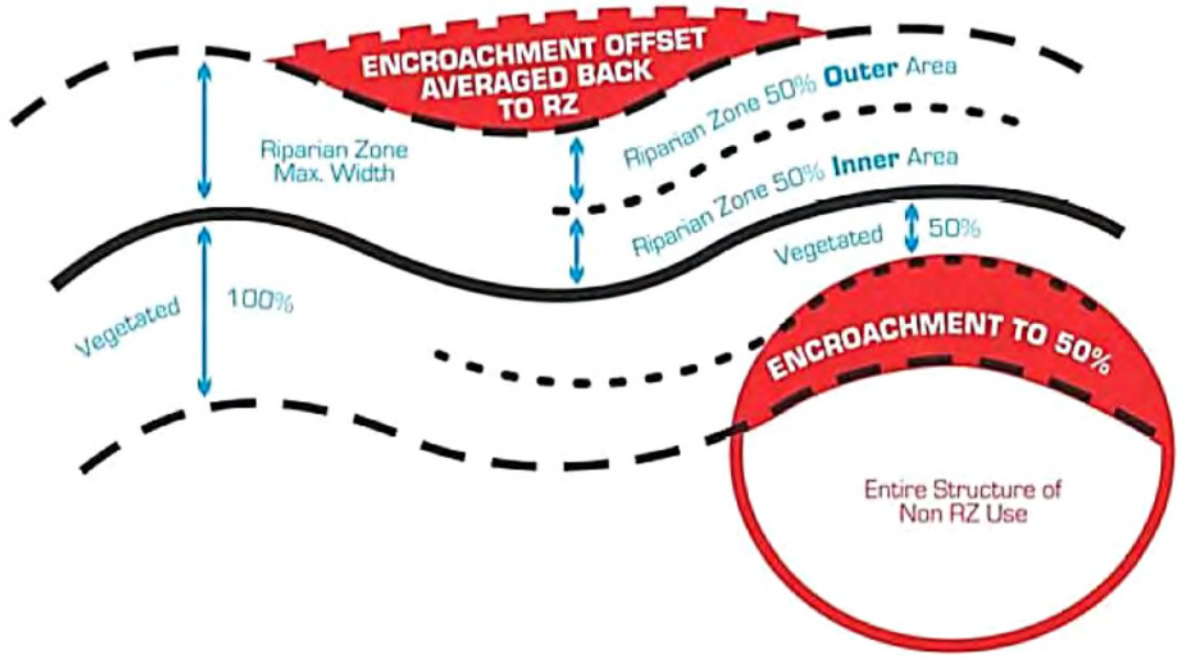

Figure 5: Riparian 'averaging rule' for offsetting encroachment into the outer 50% of the VRZ (DPE, 2022)

2.3 Policy and Guidelines for Fish Habitat Conservation and Management

The DPI Policy and guidelines for fish habitat conservation and management (Fairfull, 2013) (DPI Policy and Guidelines) is a supplementary document that outlines the requirements and obligations under the FM Act and the Fisheries Management (General) Regulation 2010 and were developed to maintain and enhance fish habitat and assist in the protection of threatened species. The DPI Policy and Guidelines provides a definition of key fish habitat and provides guidance for assigning a classification of waterways for fish passage, which informs the types of infrastructure suitable for the creek line (Table 6) and sensitivity of the key fish habitat present, which determines the potential disturbance and offsetting required for development.

2.4 Wetlands Management Policy 2010

The NSW Wetlands Management Policy (DECCW 2010) aims to provide for the protection, ecologically sustainable use, and management of NSW wetlands. Wetlands include lakes, lagoons, estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs, and seagrass beds. Wetlands within the study area occur within the riparian corridor.

Table 6: Classification of waterways for fish passage and crossing type (Fairfull 2013)

Classification	Characteristics of Waterway Class and Preferred Crossing Type
CLASS 1 Major key fish habitat	• Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g., river or major creek), habitat of a threatened or protected fish species or 'critical habitat'. • Bridge, arch structure, or tunnel. • Bridges are preferred to arch structures.
CLASS 2 Moderate key fish habitat	• Non-permanently flowing (intermittent) stream, creek, or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pool or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.

Classification	Characteristics of Waterway Class and Preferred Crossing Type
	• Bridge, arch structure, culvert [1] or ford. • Bridges are preferred to arch structures, box culverts and fords (in that order).
CLASS 3 Minimal key fish habitat	• Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for 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 other CLASS 1-3 fish habitats. • Culvert [2] or ford. • Box culverts are preferred to fords and pipe culverts (in that order).
CLASS 4 Unlikely key fish habitat	• Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or freestanding water or pools post rain events (e.g., dry gullies or shallow floodplain depressions with no aquatic flora present). • Culvert [3], causeway or ford. • Culverts and fords are preferred to causeways (in that order).

KEY TO CROSSING TYPE

[1] HIGH PRIORITY GIVEN TO THE 'HIGH FLOW DESIGN' PROCEDURES PRESENTED FOR THE DESIGN OF THESE CULVERTS—REFER TO THE "DESIGN CONSIDERATIONS" SECTION OF FAIRFULL AND WITHERIDGE 2003.

[2] MINIMUM CULVERT DESIGN USING THE 'LOW FLOW DESIGN' PROCEDURES; HOWEVER, 'HIGH FLOW DESIGN' AND 'MEDIUM FLOW DESIGN' SHOULD BE GIVEN PRIORITY WHERE AFFORDABLE—REFER TO THE "DESIGN CONSIDERATIONS" SECTION OF FAIRFULL AND WITHERIDGE (2003).

[3] FISH FRIENDLY WATERWAY CROSSING DESIGNS POSSIBLY UNWARRANTED. FISH PASSAGE REQUIREMENTS SHOULD BE CONFIRMED WITH NSW DPI.

AS NOTED IN FAIRFULL AND WITHERIDGE 2003, THERE ARE ADDITIONAL FACTORS THAT MUST BE TAKEN INTO CONSIDERATION BY THOSE INVOLVED IN WATERWAY CROSSING DESIGN AND CONSTRUCTION, INCLUDING PUBLIC SAFETY, SOCIAL AND BUDGETARY CONSTRAINTS. EACH CROSSING IS THEREFORE ASSESSED BY NSW DPI ON A CASE-BY-CASE BASIS.

Table 7: Key fish habitat types (Fairfull 2013)

Key fish habitat and associated sensitivity classification scheme (for assessing potential impacts of certain activities and developments on key fish habitat types)	
TYPE 1 – Highly sensitive key fish habitat	• *Posidonia australis* (strapweed). • *Zostera*, *Heterozostera, Halophila and Ruppia* species of seagrass beds >5 m^2 in area. • Coastal saltmarsh >5 m^2 in area. • Coral communities. • Coastal lakes and lagoons that have a natural opening and closing regime (i.e., are not permanently open or artificially opened or are subject to one off unauthorised openings). • Marine Park, an aquatic reserve or intertidal protected area. • Coastal wetlands mapped under the *State Environmental Planning Policy (Resilience and Hazards) 2021*, wetlands recognised under international agreements (e.g., Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia. • Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants. • Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act. • Mound springs.
TYPE 2 – Moderately sensitive key fish habitat	• *Zostera, Heterozostera, Halophila and Ruppia* species of seagrass beds <5 m^2 in area. • Mangroves. • Coastal saltmarsh <5 m^2 in area. • Marine macroalgae such as *Ecklonia* and *Sargassum* species. • Estuarine and marine rocky reefs.

Key fish habitat and associated sensitivity classification scheme (for assessing potential impacts of certain activities and developments on key fish habitat types)	
	• Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g., managed in line with an entrance management program). • Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area. • Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna. • Freshwater habitats and brackish wetlands, lakes, and lagoons other than those defined in TYPE 1. • Weir pools and dams up to full supply level where the weir or dam is across a natural waterway.
TYPE 3 – Minimally sensitive key fish habitat may include:	• Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna. • Coastal and freshwater habitats not included in TYPES 1 or 2. • Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

3. Methods

3.1 Stream Categorisation

The Strahler stream order classification was extracted from the State Government's GIS dataset. Top of bank was estimated using aerial photographs and 0.5 m contours before being field validated on 19th and 20th of February 2020 by two aquatic ecologists, using a GPS enabled tablet. Each watercourse that met the definition of a 'river' under the WM Act was assigned the appropriate riparian corridor width in accordance with the Strahler stream order. Riparian widths were then applied using ArcPro.

3.2 Condition Assessment

The watercourses and riparian zones were visually assessed for ecological value regarding physical form, benthic substrate, fish habitat, instream woody debris and vegetation condition.

The condition assessment was undertaken to recognise key components of watercourse health and function. The level of assessment conducted was chosen to assist with future management of watercourse and riparian environments within the study area by highlighting current values, threats and limits to potential improvements along the watercourse. All dams were inspected for habitat, with time spent listening for frogs and observing birds at each.

3.3 Groundwater Dependant Ecosystems

Groundwater dependant ecosystems were initially identified by review of the Groundwater Dependent Ecosystem (GDE) Atlas (BOM 2020) for the site. There are no aquatic GDEs mapped in the site, however there are two terrestrial ecosystems, Cumberland Shale Hills Woodland, mapped in the south-eastern corner and along the northern boundary of the site with high potential to be groundwater dependent.

4. Results

4.1 Aquatic and Riparian Habitat Condition Assessment

The creek lines in the study area have been altered from their natural state due to works along the creek (creation of dams and crossings), removal of native riparian vegetation to facilitate agricultural land uses, increases in sediment and nutrient transport through the system and various other factors.

Nonetheless, all tributaries have value as a component of the catchment and riparian corridors that exist in the region. Where present, the tributaries of each creek also provide instream habitat for local fish species, aquatic macrophytes and aquatic macroinvertebrates all of which contribute to local ecosystem health. Programs that encourage improvements in these ecosystem values would be crucial to improving the condition of downstream environments.

Creeks bordering the site were assessed where possible to determine if their riparian buffers would encroach into the study area. The location of each reach and whether it was a defined channel is shown in Figure 6. The current condition of the creeks is summarised in Section 4.2.

The *Guidelines for Riparian Corridors on Waterfront Land* (Natural Resources Access Regulator (NRAR) 2018) acknowledge that some hydrolines on topographic maps may not meet the definition of a river under the WM Act. This is generally the case where there is no defined bed or bank and no evidence of channelised flow or geomorphic processes such as erosion and deposition. ELA has identified several hydrolines which do not have the characteristics of a river and should not require protection in the precinct (Figure 6). NRAR would determine if these can be removed from the map and therefore not need to be retained in the Precinct Plan as part of their formal review of the proposal.

NRAR must also be consulted if there is the intention to remove any hydrolines which do meet the definition of a river. This has occurred in other precincts, usually where:

- The river is a first-order watercourse.
- The river is in a degraded or poor condition and doesn't provide any important habit linkages.
- The loss of riparian zone is offset by the increase of riparian zone in the remaining watercourses at a ratio of 1:1.

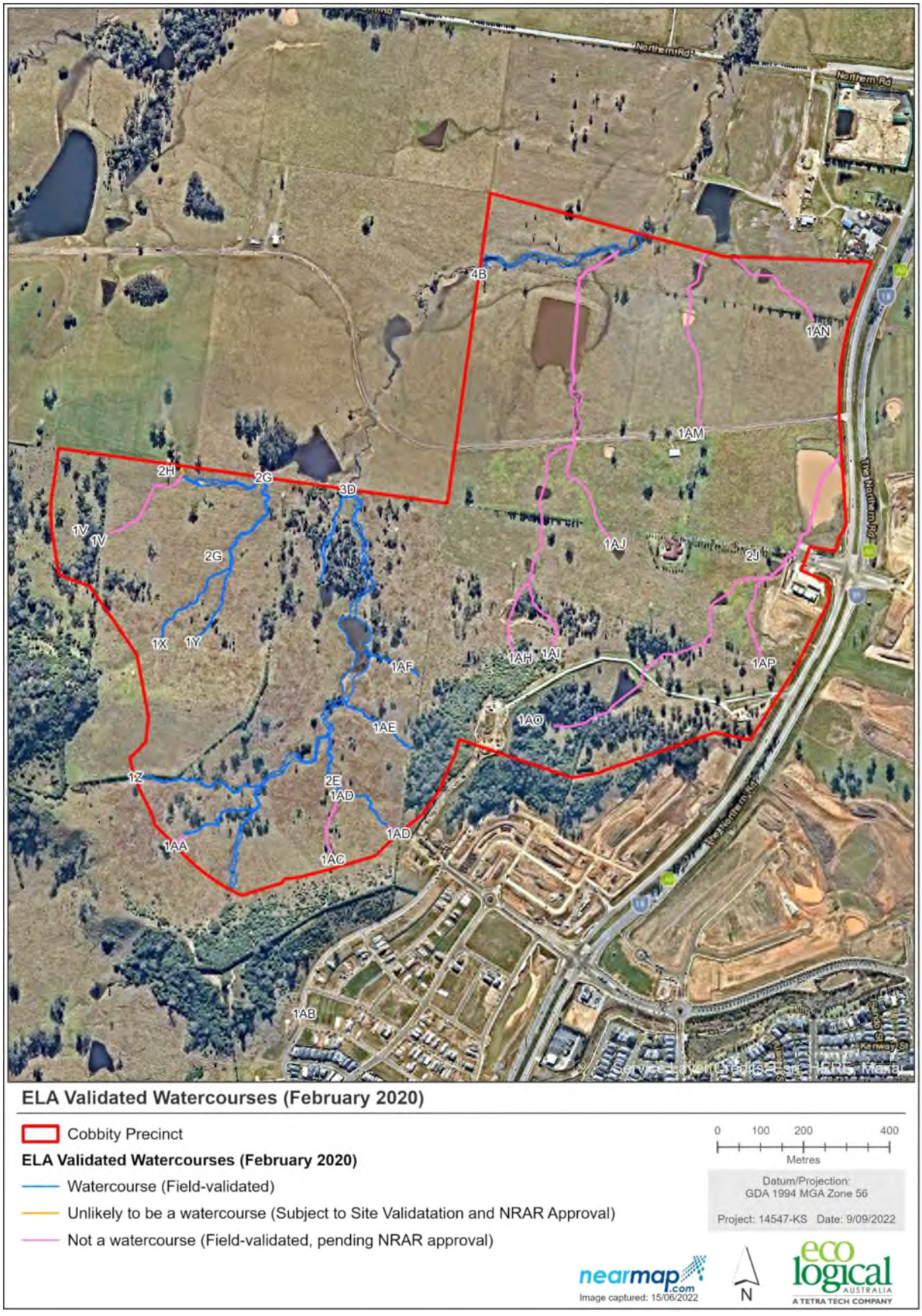

Figure 6: Riparian survey reaches and results

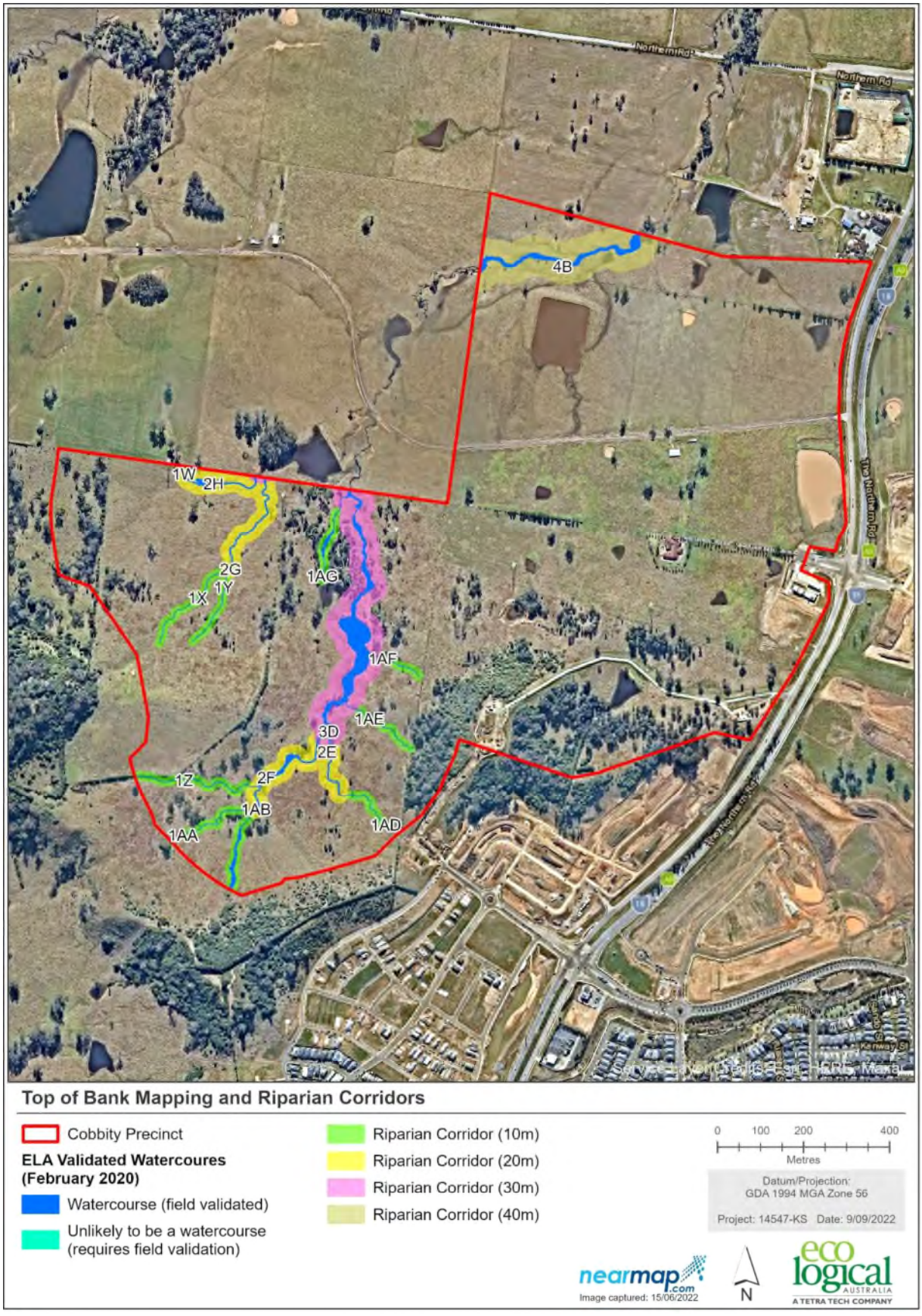

Figure 7: Indicative final creek and associated riparian corridor constraints (pending NRAR approval)

4.2 Reach Descriptions

Reach descriptions for first-order creeks are detailed in Table 8. Where a watercourse had defined bed and banks upstream, the downstream mapped watercourse was classified as a 'river', regardless of the presence of bed and banks. For each reach, a condition of good, moderate, or poor was applied based on the:

- Stream shape and size
- Frequency of flow (ephemeral or perennial)
- Presence of aquatic habitat (pools, riffles, snags, vegetation)
- Potential for threatened or protected fish species or fauna
- Connection with other habitats.

Watercourses in good condition had clearly defined bed and banks with intermittent to semi-permanent water in pools with aquatic vegetation present. Snags were present, with good fish habitat. Watercourses in moderate condition had clearly defined bed and banks with ephemeral or intermittent water after a rain event. Aquatic vegetation may or may not be present, with less in stream features such as snags. These creeks would provide fish passage during rain events and refuge for fauna such as turtles. Poor condition watercourses had poor or no defined bed and banks and were typically a dry gully or depression, lacking aquatic vegetation with no habitat for fish or other fauna.

Dams were present throughout the site and have been described in Table 9, overall dams provided habitat for fish, frogs, turtles, and wader birds.

4.2.1 First-order Creeks

Table 8: First-order reach descriptions

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1AN	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AM	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AP	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1AO	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AJ	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AI	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1AH	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AF	River	Channel approximately 0.5 m wide, with gently sloping grassed banks. Ephemeral creek, with no water at the time of survey. Riparian vegetation was pasture grass only, no trees or shrubs. Scattered *Eucalyptus moluccana* were observed in the broader riparian zone.	Poor		
1AE	River	Channel varied between 0.5 – 1.5 m wide. Upstream, the channel was shallow with gently sloped banks. Water was present, in long narrow pools. No aquatic vegetation was observed. The channel was vegetated with grass and sedges. Upstream of the confluence with the dam, the channel was deeply eroded with a 1.5 m vertical head cut. One turtle was observed at the confluence. The riparian vegetation along the length of the channel was a mix of native and exotic grasses. *Bursaria spinosa* and Cotton Bush were present in the wider riparian area.	Moderate		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1AD	River	Channel 0.5 – 1 m upstream, beginning with a narrow-incised channel before widening downstream with gently sloped grassed banks. The channel was dry with no aquatic vegetation present. There was a small head cut present at the confluence with 1AC. Riparian vegetation was pasture grasses only, no shrubs or trees were present.	Poor		
1AC	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1AB	River	The channel began upstream with a small head cut and defined exposed channel for 40 m before becoming overland flow with no defined bed or banks. There was no aquatic vegetation present, and the bed was a course clay. The riparian vegetation was African Olive shrubs, and a pasture grasses.	Poor	 Head cut upstream	 Channel meandering through olives

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
				 Overland flow only	 Overland flow only
1AA	River	The channel was defined upstream, 1 m with 0.5 high banks that were grassed and gently sloped. The riparian vegetation was mainly absent, except for pasture grasses and scattered African Olive shrubs. Moving downstream, the channel dispersed into overland flow, before becoming defined again at the start of the small patch of native vegetation predominately juvenile *E. tereticornis*. The bed was bare, with a clay silt benthic substrate. Small turbid pools were present at the low points. Flood debris was evident at the base of riparian vegetation. No aquatic vegetation was observed.	Poor	 Upstream section  Channel through vegetated riparian zone	 Upstream section – sparse riparian vegetation  Flood debris on up sides of tree trunks

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1Z	River	At the upstream extent of the creek, there was an eroded head cut with a small tannin stained pool of water and vegetation that differed to the surrounding pasture grasses. Downstream, the channel dispersed into overland flow, and a single turtle was observed in the grass. The channel developed definition approximately halfway to the confluence with 2F. The channel was 1 m wide, with sloped grassy beds. Water was pooled in at the low points and woody debris was scattered throughout the reach. Riparian vegetation throughout was pasture grasses, patches of African Olive and scattered *Eucalyptus* sp. The creek had some shading, where vegetation was present. One Common Eastern Froglet was heard calling.	Moderate	 Head cut at upstream extent  Defined channel	 Channel disperses into overland flow  Pooling water in channel
1Y	Not a 'river'	No defined bed or banks. Overland flow at low point only.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1X	River	Channel was defined approximately 100 m downstream from start of Strahler mapping. The banks were 0.5 m wide, with shallow pools of clear water present. The channel then dispersed downstream, becoming overland flow, until it was mapped to flow offsite.	Poor		
1V	Not a 'river'	No defined bed or banks. Overland flow at a low point only.	Poor		
1W	Not a 'river'	No defined bed or banks. Overland flow at a low point only. Upstream of site boundary was not validated.	Poor		

4.2.2 Second-order Creeks

4.2.2.1 2H

2H begins at the confluence of 1V and 1W. At the confluence of the two first-order creeks, the channel was not defined. The channel began at the top of the first dam, which was dry at the time of the survey. Scattered Juncus lined the dam, however, there was no aquatic vegetation present in the dam. The second dam had clear water, with submerged grass. Juncus lined the edge of the dam. Downstream of the dams, the channel became overland flow with no defined geomorphic processes. There was a headcut at the boundary of the site, which defined the upstream extent of the dam downstream. There was limited variation along the watercourse, with no snags or boulders present. Turbid water was present in this headcut. No aquatic vegetation was observed in the surveyed reach, no frogs were heard, and no aquatic fauna was observed. The overall condition was moderate.

Facing upstream – confluence of first-orders

Facing downstream – dry dam

Facing upstream at second dam – clear water

Facing downstream – channel disperses into grass

4.2.2.2 2G

The mapped channel began at the confluence of 1X and 1Y. There was no defined channel for the extent of the reach. No defined bed or banks were observed, or geomorphic processes. The reach has been mapped as a creek however, as there was a channel defined upstream along watercourse 1X. Riparian vegetation was pasture grasses only, no shrubs or trees were present. The condition of this watercourse was poor.

Facing upstream

Facing downstream

4.2.2.3 2F

Channel began at the confluence of 1AA and 1AB, the banks were both vertical with undercutting erosion. The channel widened into a pool approximately 7 m wide and 10 m wide, with shallow clear water. An eastern long-necked turtle was observed in the pool. Juncus and *Persicaria decipiens* (Slender Knotweed) were present along the edge and shallows of the pool. Algae covered grass was present in the centre. Moving downstream, the channel narrowed to between 1.5 m and 2.5 m wide, with tannin-stained water and no aquatic macrophytes. The right bank was consistently steeper than the left, which had less gradient. Both banks were vegetated with pasture. The channel meandered through the paddock, with few shrubs or trees present, before joining 2E upstream of a dam. Woody debris was present throughout and there was potential fish habitat throughout the reach. The condition of 2F was good.

Upstream pool with *aquatic macrophytes, turtle and Juncus.*

Narrower channel with tannin-stained water

4.2.2.4 2E

The channel began with a headcut at the confluence of 1AC and 1AD. The channel was 1 m wide, with intermittent pools of water, which had an oily sheen on the surface. No aquatic macrophytes were observed in these pools. Scattered African Olive shrubs lined the channel and the remaining riparian vegetation consisted of pasture grass with no native tree species observed. The channel stopped after 50 m, dispersing into overland flow with no defined bed or banks to direct flow. Approximately 60 m downslope, the channel became defined with a clear eroded headcut. Downstream the channel was 2 m wide, with slumping banks vegetated with grass. Water was present, in depressions in the channel. There was no difference in the vegetation in the channel to the riparian zone. No trees or shrubs were present. No frogs, fish or wader birds were observed using the watercourse. The condition of 2E was moderate.

Upstream – pools of water with sheen

Facing downstream – channel disappears

Defined headcut that begins channel downstream

Banks slumping with pasture in channel

4.2.2.5 2I

The mapped channel began at the confluence of 1AI and 1AH. There was no defined channel for the extent of the reach. No defined bed or banks were observed, or geomorphic processes. Riparian vegetation was pasture grasses only, no shrubs or trees were present. This watercourse was in poor condition.


Representative upstream and downstream photos of overland flow

4.2.2.6 2J

The mapped channel began at the confluence of 1AP and 1AO. There was no defined channel for the extent of the reach, only overland flow at a low point. No defined bed or banks were observed, or geomorphic processes. Riparian vegetation was pasture grasses only, no shrubs or trees were present. This watercourse was in poor condition.


Representative upstream and downstream photos of overland flow

4.2.3 Third-order Creeks

4.2.3.1 3D

The third-order creek began at the confluence of 2E and 2F, slightly upstream of the large dam. The channel was 2 m wide with gently sloping banks and no riparian trees or shrubs, before entering the dam, at a severely eroded 2 m drop off. Downstream of the dam, the channel was up to 5 m wide and well defined with long, wide pools present throughout which had turbid water and no aquatic macrophytes. Water was also present in other low-lying depressions. Sedges including Juncus were observed in wet areas. Banks transitioned from gently sloping with grassy vegetation upstream to bare, steep and undercut downstream. The riparian corridor downstream of the dam had a native canopy with *Eucalyptus tereticornis* and *Angophora* spp. with exotic African Olive dominating the shrub layer. Ground cover was typical pasture grasses. Although no aquatic vegetation was present, there was woody debris throughout to diversify flow after rain. Pools and runs provided habitat for fish, frogs and wader birds. The overall condition was good.

Facing upstream to confluence *of second-orders*

Channel joins dam at large eroded feature

Downstream of dam – facing upstream large wide

Facing downstream – gently sloped grassy banks

Bare banks with undercutting

Long pool present at downstream extent of channel

4.2.4 Fourth-order Creeks

4.2.4.1 4B

The downstream extent of this fourth order was field-validated. At the upstream extent of the surveyed reach, the channel was evident as 3 m wide and over 1 m deep. Snags and the native aquatic plants *Typha orientalis* (Cumbungi) and Slender Knotweed were present. Birds including *Anas superciliosa* (Pacific Black Duck), *Egretta novaehollandiae* (White-faced Heron) and *Egretta pacifica* (White-necked Heron) were observed using the pool. *Limnodynastes tasmaniensis* (Spotted Marsh Frog) was also heard calling. The left bank was severely eroded, near vertical and bare. The right bank had less gradient and was vegetated by grass. Riparian vegetation was mostly absent, with two large *Melaleuca styphelioides* the only trees observed. The channel meandered downstream, with narrow runs widening into larger pools and low lying saturated grassy depressions. Both banks were vegetated by grass only and were

eroded on the out bends. Water in the pools was mostly stagnant with a thick oily sheen. There was evidence of cattle tracking through the creek. At the downstream extent, where the creek flowed outside the study area, was a long deep pool, with clear water. The fence line was filled with debris, damming the pool upstream. Many snags were present. The banks were high, approximately 1.5 m, and bare. There was a small, vegetated area with *Melaleuca* sp. and *Angrophora* sp. surrounding the creek. The roots of some trees were evident sticking out of the eroded banks. *Limnodynastes peronii* (Striped Marsh Frog) and Spotted Marsh Frog were heard calling along the entire reach and frog eggs were observed in many of the pools. The overall condition was good.

Upstream where creek enters site – long clear pool

Facing downstream – sparse riparian vegetation

Centre of surveyed reach – run of shallow water

Runs flowing into pools with stagnant water

Downstream pool with debris along the fence line of property

Table 9: Habitat in dams

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
1AN	1	Dam nearing capacity, fringing vegetation was good frog habitat.	*Crinia signifera* (Common Eastern Froglet), *Tachybaptus novaehollandiae* (Australasian Grebe)	*Ludwigia peploides* (Water Primrose), *Ottelia ovalifolia* (Swamp Lily), Juncus	
1AN	2	Dam nearing capacity, fringing vegetation, water was clear and shallow.	No fauna observed	Scattered Juncus	
1AM	1	Dam nearing capacity, eroded bank, water was clear with tannins.	2 turtles	Scattered Juncus	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
1AM	2	Dam nearing capacity, eroded bank, water was clear with tannins.	2 turtles	Fringing Juncus	
1AO	1	Clear deep water, dam was full with submerged terrestrial vegetation.	4 turtles, Australasian Grebe, White-faced Heron, *Chenonetta jubata* (Australian Wood Duck)	Fringing Juncus	
1AO	2	Clear, shallow water. Dam was nearing capacity with submerged terrestrial vegetation.	No fauna observed	No flora observed	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
1AO	3	Dam was deep with turbid water and grassy banks.	No fauna observed	Water Primrose, *Eleocharis* sp. (Bulrush), Juncus, Swamp Lily	
1AJ	1	Water was clear and dam was nearing capacity.	3 Turtles, 1 Common Eastern Froglet	Fringing Juncus	
1AH	1	Water was shallow and extremely turbid. A large tunnel had eroded through the dam wall and there were big rills eroding on the upstream side.	5 Turtles, Australasian Grebe, White-faced Heron, Striped Marsh Frog	Cumbungi in centre of dam, fringing Juncus.	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
2l	1	Water was turbid, with grass the only fringing vegetation.	Australian Wood Duck, Australasian Grebe, 2 Turtles	Cumbungi	
2l	2	Water was less turbid than dam 1, grass only fringing vegetation.	No fauna observed	No flora observed	
2l	3	Very large dam, reaching capacity. Water was turbid and submerging terrestrial vegetation.	Australian Wood Ducks, Australasian Grebe, Pacific Black Duck, White-faced Heron, 3 Turtles	No flora observed	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
2I	4	Dam walls were very steep, with dam almost at capacity with clear water. Grass was only fringing vegetation.	3 Turtles	No flora observed	
2H	1	Dam was almost dry, with a clay capped silty benthic substrate.	No fauna observed	No flora observed	
2H	2	Dam had clear, shallow water. Terrestrial grass was submerged.	No fauna observed	No flora observed	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
3D	1	Very large dam, with a narrow eroding upstream extent that was dry. The wide downstream extent had turbid water with submerged terrestrial vegetation.	1 Turtle, White-faced Heron	Sparse Swamp Lily, Fringing Juncus	 

**dams are numbered in order along creek: upstream to downstream*

4.3 Riparian Habitat

The riparian vegetation throughout the site varied in quality. Throughout the north-eastern extent of the site, the vegetation was pasture with scattered poor condition Cumberland Plain Woodland (Figure 5). In the south-western extent of the site, where most creeks met the definition of a river, riparian condition was highly modified and generally poor, with limited shrubs or canopy cover. The dominate vegetation was derived native grassland. The central creek system, of 2F and 3D, had the highest quality riparian vegetation, with good quality Cumberland Plain Woodland present (Figure 5). These areas were characterised by a canopy dominated by *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus moluccana* (Grey Box). The open midstorey was dominated by exotic species *Lycium ferocissimum* (African Boxthorn) and *Olea europaea* subsp. *cuspidata* (African Olive), with scattered *Lantana camara* (Lantana) and *Gomphocarpus fruticosus* (Narrow-leaved Cotton Bush) in some areas. The groundcover was dominated by a large number of native grasses and forbs, including *Microlaena stipoides* (Weeping Grass), *Bothriochloa macra* (Red Grass), *Einadia hastata* (Berry Saltbush) and more. Exotic groundcover species were also present, though to a significantly lesser extent, and included *Eragrostis curvula* (African Lovegrass), *Setaria parviflora* and *Sida acuta* (Spinyhead Sida).

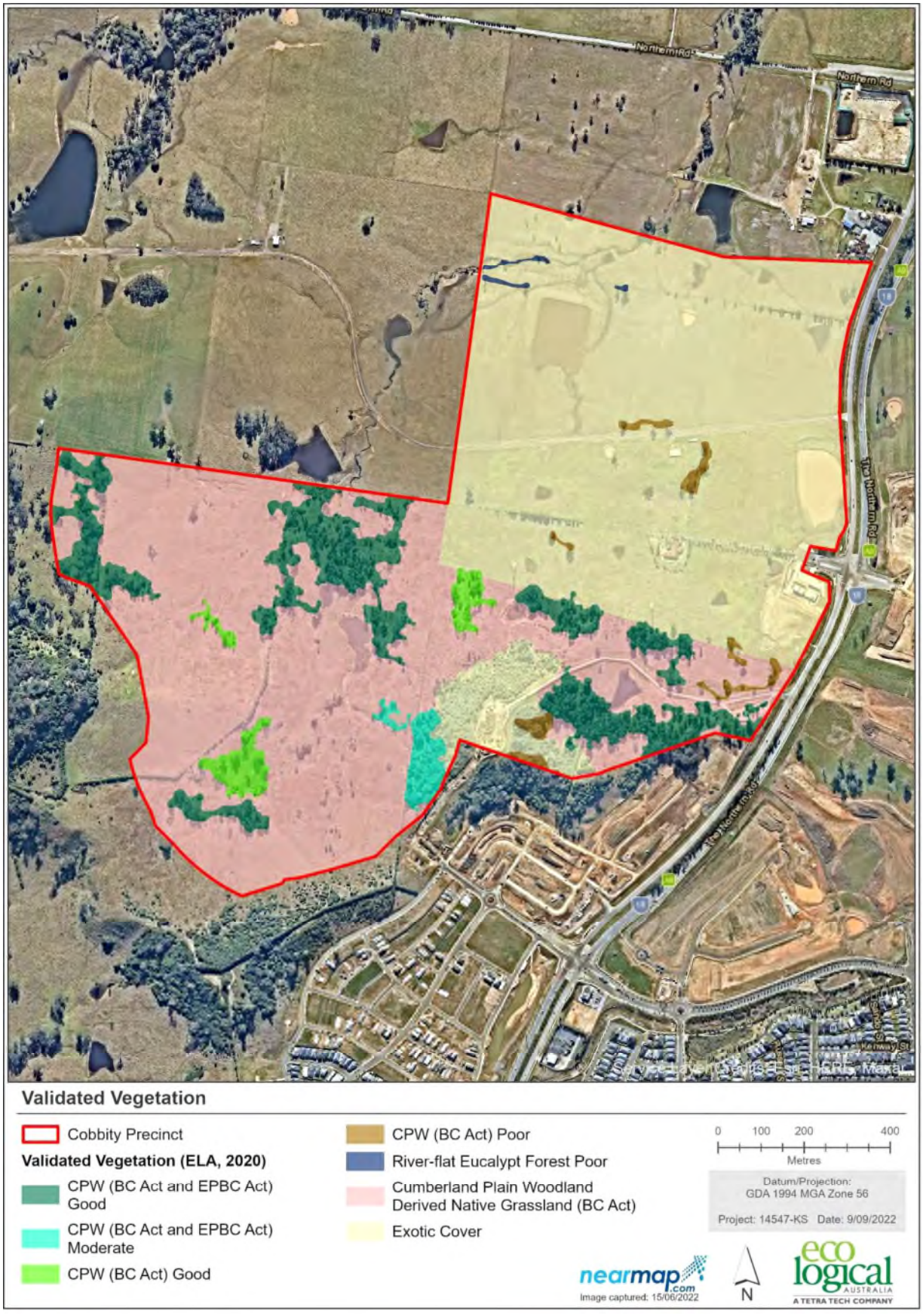

Figure 8: Validated vegetation communities and condition

4.4 Groundwater Dependant Ecosystems

There are two GDEs mapped in the study area (Figure 9). A site inspection indicated that it was likely that the GDE mapped on the south-eastern corner of the site was not present. The validated vegetation in that area was exotic cover with no mature native trees present. The GDE mapped on the northern extent to the site along creek 4A, has been desktop validated as River Flat Eucalyptus Forest. This has a high likelihood of being a GDE, however, definitive determination regarding the reliance on groundwater would require a hydrological survey to determine the level of the groundwater table.

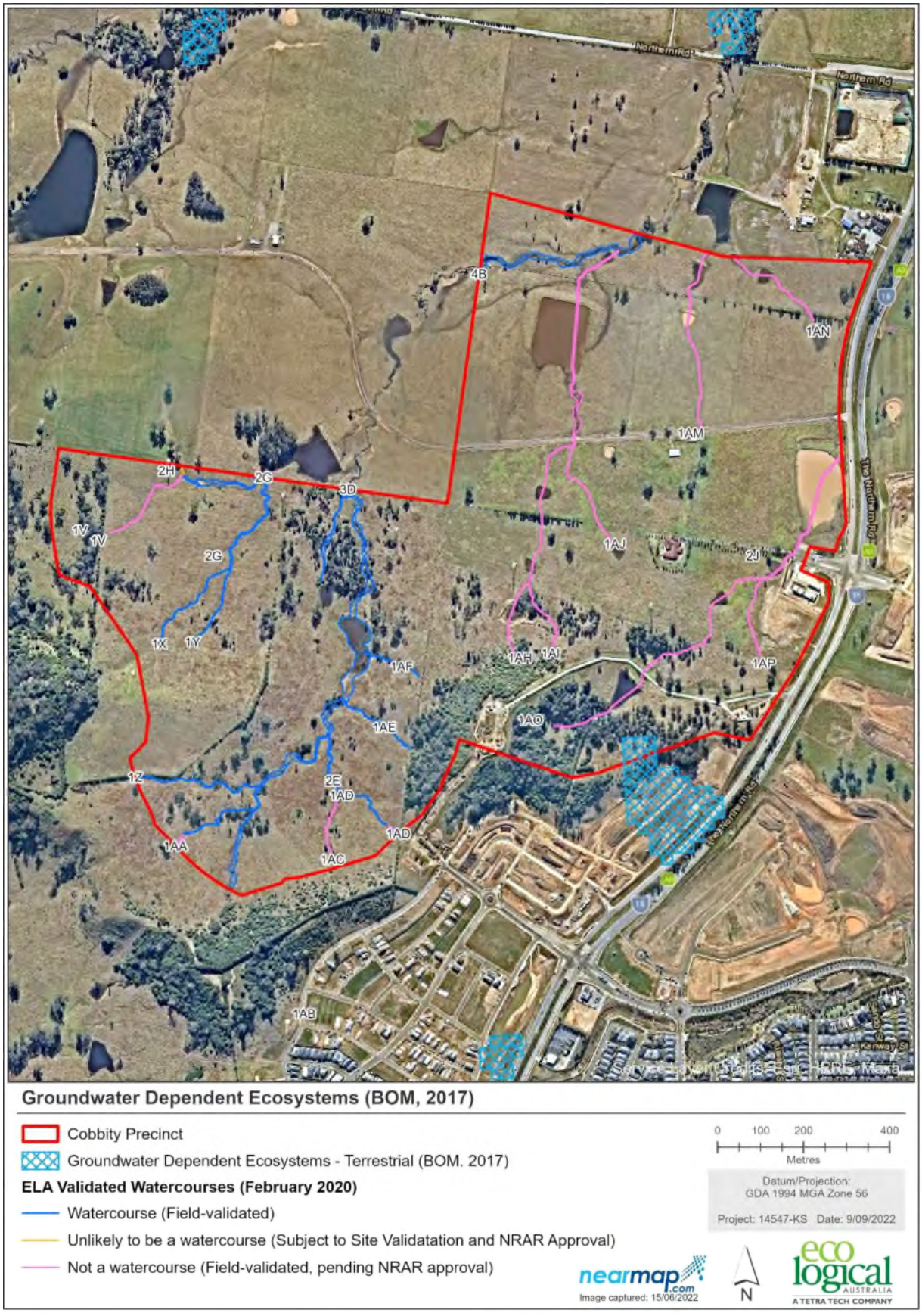

Figure 9: Groundwater dependent ecosystems within the study area

5. Discussion and Recommendations

5.1 Indicative layout plan

As outlined within the Western City District Plan (Greater Sydney Commission, 2018), improving sustainability is at the forefront of future strategic planning and development. Such improvements are focused on incorporating natural landscape features into the urban environment and protecting and managing natural systems. It is recognised that all aspects of sustainability rely on maintaining and managing green infrastructure such as waterways and remnant patches of native vegetation. Therefore, optimising and protecting existing assets will be essential in ensuring the ongoing health and sustainability of the Cobbity Sub-Precinct 5.

An ILP has been developed (Figure 10), which proposes to retain 16.91 ha of riparian corridor.

The primary creek corridor, consisting of 2E, 2F, 3D and 4A in the centre of the site has been proposed to be retained and rehabilitated. The ILP proposes removal of all other creeks and dams. The proposed ILP will therefore provide an opportunity to:

- Improve the necessary health and quality of the existing waterways and riparian corridors within the Precinct.
- Improve public access to, and along, the riparian corridors, providing connected green space.
- Protect and enhance flora, fauna, and urban bushland.
- Reduce erosion and sedimentation and improve bank stabilisation.
- Provide riparian vegetation buffers, allowing the recovery and reinstatement of more natural conditions within currently highly modified waterways.

The ILP proposes to retain the areas of watercourses and riparian land that were in moderate to good condition at the time of the survey and have the highest recovery potential.

An ILP has been prepared that provides 16.91 ha of riparian area. Based on the results of the field validation, there is a total of 17.47 ha of riparian zone on the site, assuming all existing on-line dams are retained. If a 10 m-wide watercourse and associated VRZ through the centreline of the existing farm dam on the 3rd order watercourse were assumed, there is a total of 16.89 ha of riparian zone on the site. The ILP would therefore be in accordance with the 'averaging rule'.

Further, the proposal would improve the structure and integrity of vegetation within the riparian corridor and support Connecting to Country objectives through the preservation of ridgelines, views, and waterways. Restoration of the riparian zone will be achieved through the Riparian Management Strategy and future Vegetation Management Plans (VMPs). These measures will be focused on improving the riparian areas which have limited native vegetation, and protecting and improving areas of intact native vegetation which will contribute to broader landscape connectivity.

Where proposed works are not consistent with the *Guidelines for Controlled Activities on Waterfront Land* (NRAR, 2018), the principles of the WM Act can guide activities that are to take place on waterfront land and be used to provide a merit-based assessment of the proposed development.

The principles set out in this section are the water management principles of the WM Act described below:

Generally:

a. *water sources, floodplains, and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded, and*
b. *habitats, animals, and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored, and*
c. *the water quality of all water sources should be protected and, wherever possible, enhanced, and*
d. *the cumulative impacts of water management licences and approvals and other activities on water sources and their dependent ecosystems, should be considered and minimised, and*
e. *geographical and other features of Aboriginal significance should be protected, and*
f. *geographical and other features of major cultural, heritage or spiritual significance should be protected, and*
g. *the social and economic benefits to the community should be maximised, and*
h. *the principles of adaptive management should be applied, which should be responsive to monitoring and improvements in understanding of ecological water requirements.*

In relation to controlled activities:

a. *the carrying out of controlled activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and*
b. *the impacts of the carrying out of controlled activities on other water users must be avoided or minimised.*

The ILP allows for protected and rehabilitated watercourses to be established. Under the Riparian Management Strategy and future VMPs, these vegetated channels will become protected waterways within the precinct which will improve their current condition, as currently they receive no observable maintenance and exotic flora species dominate some areas of the riparian buffer.

Watercourse protection also allows for an improvement in water quality within the precinct, as revegetation and weed control would create stable beds and banks and a buffer between residential areas and the watercourse.

The proposal includes several online dry basins within the riparian corridor. NRAR Guidelines do not provide for online dry basins on 3rd or 4th order watercourses, however the proposed basins do provide some ecological merit as it is proposed that any existing native vegetation will be retained and in currently cleared areas the riparian corridor will be revegetated to a full-structured vegetation community (Cumberland Plain Woodland or River-flat Eucalypt Forest). This has been reflected in the relevant flood modelling undertaken by J. Wyndham Prince (2024), where a Mannings Value of 0.12 has been assumed.

Further, although a 3rd and 4th order watercourse, the requirements outlined in Table 2 of the *Guidelines for Controlled Activities on Waterfront Land* (NRAR, 2018) have been addressed in Table 10 to further justify this proposal.

Table 10: NRAR guidelines requirements for online basins

Requirement	Comment
Online detention basins must be dry and vegetated.	The proposed dry detention basins will be fully vegetated, not requiring the removal of existing native vegetation. Current riparian vegetation includes both the Cumberland Plain Woodland and River-flat Eucalypt Forest vegetation communities, and the existing watercourses are predominantly ephemeral. The hydraulic model allows for a fully structured riparian corridor to form part of the new development with a Manning's n value of 0.12 for flood levels less than 0.5 m deep and 0.03 for flood levels greater than 0.5 m deep when it is likely that shrub and grass vegetation would fold over and offer limited resistance. The VRZ is expected to be periodically inundated. This may result in a change in species composition to include species that are adapted to longer periods of inundation, such as those typically found in within the River-flat Eucalypt Forest and freshwater wetlands vegetation communities. It is possible that species in both the Melaleuca and Casuarina genus may establish in the future. It is therefore recommended that revegetation works in the currently cleared areas within the riparian corridor consist of species that can tolerate periodic inundation from the Cumberland Plain Woodland, River-flat Eucalypt Forest, and Freshwater Wetland vegetation communities.
Online detention basins must be for temporary flood detention only, with no permanent water holding.	Basin inundation hours will be confirmed upon completion of the flood modelling (J. Wyndham Prince, 2024). It should be noted that the riparian corridors would nevertheless be inundated during storm events even as part of the development of these areas as defined by the NSW Government Growth Centre 2011.
Online detention basins must have an equivalent VRZ for the corresponding watercourse order.	The existing VRZ area across the site is 16.89 ha, assuming a 10 m-wide watercourse and associated VRZ through the centreline of the existing farm dam on the 3rd order watercourse. The area of VRZ proposed to be retained under the ILP is 16.91 ha.
Online detention basins must not be used for water quality treatment purposes.	Water quality management will be undertaken in separate stand-alone devices outside the outer 50% VRZ. The online basins are proposed for water retention only.

In general, the ILP is consistent with the objectives of the WM Act and aims to apply the principles of ecological development by rehabilitating areas with the highest recovery potential to restore natural ecological processes along the primary watercourse. It considers the site in terms of the broader catchment and focusses on rehabilitating areas that have the highest potential for recovery.

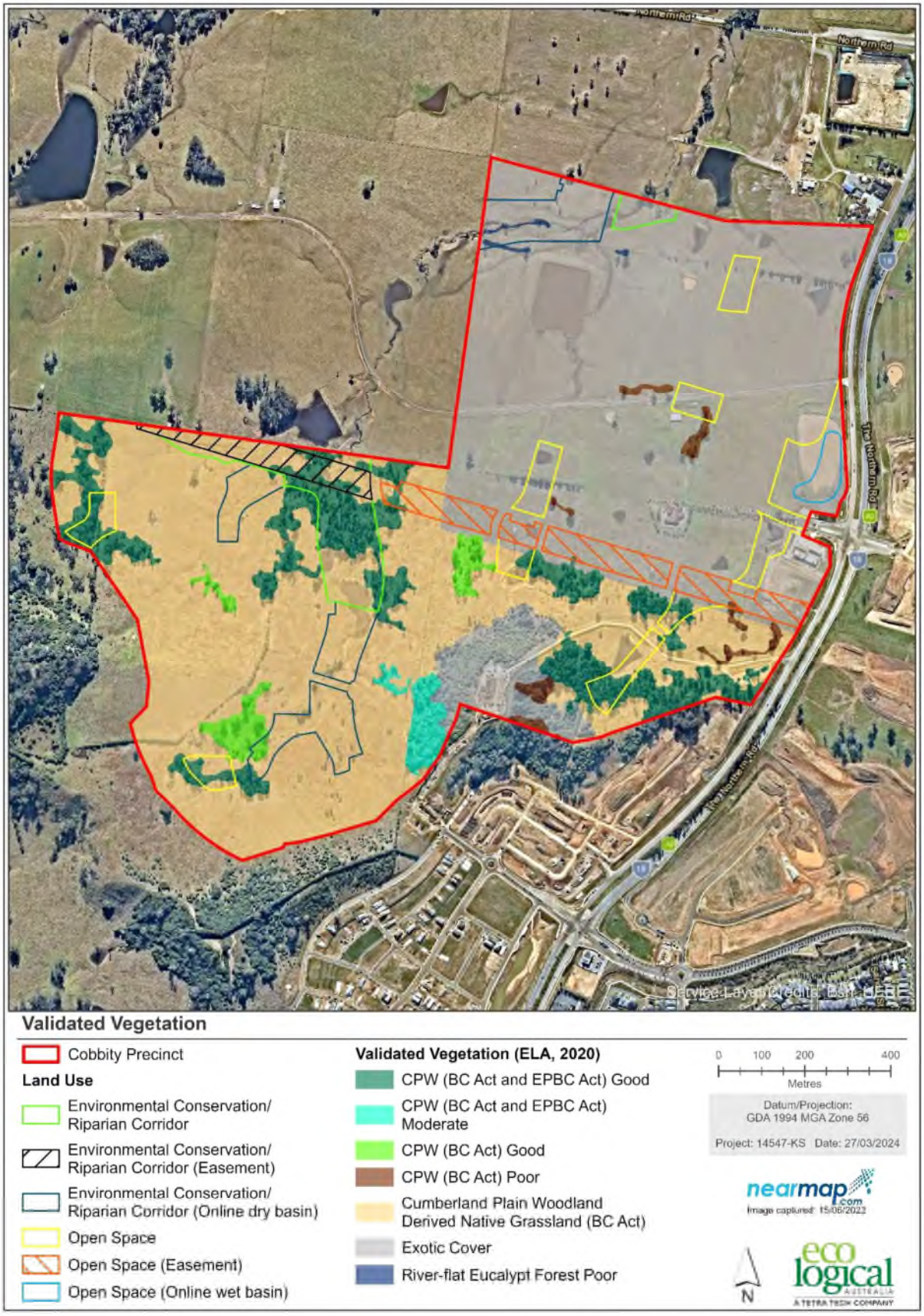

Figure 10: Indicative Layout Plan and existing native vegetation

5.2 Watercourses

The aim of this report is to identify key riparian constraints to assist the design of the ILP and the principles of the legislation addressed in Section 2, are to provide for the sustainable and integrated management of the waterways of the state.

There were 18 first order reaches in the study area, of which 11 did not meet the definition of a 'river' under the WM Act, as they had no defined bed and banks. Additionally, two second-order creeks which had no defined bed or bank upstream of the mapped dam. NRAR should be consulted to confirm that these do not meet the definition of a river under the WM Act.

Assuming the above 'watercourses' are removed from the mapping, there would be 17.47 ha of riparian corridor within the precinct (or 16.91 ha if a centreline is assumed through the existing farm dams). Watercourses that meet the definition of a river in moderate or good condition, should be retained where possible. The ILP aligns with this current position, by retaining the central creek system which had the highest habitat value of assessed watercourses. The ILP proposes to 'rationalise' the TOB through the large dam at the juncture of streams 3D and 1AF, to resemble the channel downstream. In general, NRAR would support the removal of dams, however, the value of habitat this dam provides should be considered. The dam holds large volumes of water and would provide refuge for frogs, wetland birds and fish during times of drought.

In general, NRAR's policy requires management and rehabilitation of the riparian land to a functional community, fully protected and vegetated with native endemic riparian plant species. If, however, the intention is to manage the vegetation for non-riparian purposes, such as Asset Protection Zones in the outer 50%, the riparian offsetting guidelines would apply to compensate the reduced VRZ. The inner 50% would still require protection. If offsets are required elsewhere, the average width of the riparian zone would need to be maintained to meet the NRAR's guidelines. To be consistent with the guidelines, offsets should seek to preserve any native vegetation. There is the opportunity to rehabilitate the VRZ with native riparian species which will ultimately improve the instream habitat. Online dry basins in the outer 50% of the VRZ along second-order creeks are in accordance with NRAR's guidelines.

5.3 Groundwater Dependant Ecosystems

The mapped GDEs were confirmed to not be present in precinct. Furthermore, in lieu of an extensive groundwater assessment, groundwater is unlikely to be a significant constraint to the development. Provided that water cycle management measures are implemented in the design, changes to spatial and temporal flows are likely to be minimal and not significantly affect the groundwater table.

5.4 Riparian Management Strategy

The subject site is dominated by Cumberland Plain Woodland in varying conditions with large patches of Derived Native Grassland. The subject site also contains large areas of Exotic Cover at the northern extent of the subject site. Areas of River-Flat Eucalypt Forest are comparatively minimal and limited in location along few watercourses.

While all the Cumberland Plain Woodland within the subject site meets the description of the critically endangered ecological community listed under the BC Act, most of the remnants do not meet the definition of the federally listed Cumberland Plain Shale Woodland and Shale Gravel Transition Forest. Large patches of Cumberland Plain Woodland are present along the main creek lines of the site and should be retained and rehabilitated as part of the ILP. The overarching riparian management strategy outlines future restoration potential of native vegetation along riparian zones in the precinct with broad objectives to re-establish characteristic diversity of indigenous plants and communities whilst reducing exotic weed cover.

5.4.1 Averaging rule

As discussed in Section 5.2, NRAR's guidelines provide an Averaging Rule, which allows non-riparian works / activities to be carried out within the outer riparian corridor provided that the average width of the riparian zone can be achieved over the length of the watercourse within the development site. Under this rule, the outer 50% of the riparian corridor may be used for development lots, infrastructure, etc, provided that an equivalent area connected to the riparian corridor is offset on the site. The inner 50% must be protected and fully revegetated.

The future riparian management areas are based on the locations of existing riparian corridors, that have the highest likelihood of full rehabilitation but may vary be varied in the future subject to detailed designs. Infrastructure, development lots, recreational areas, etc, may encroach the outer 50% of riparian corridors, in which case an equivalent area would be provided along the same riparian corridor or offset in a Riparian Protection Area. As such, the riparian rehabilitation areas are subject to change following detailed design.

5.4.2 Recovery potential

Recovery potential relates to the degree, manner, and pace of an area to recovery after disturbance or stress and is impacted by factors including vegetation composition, structure, and function of remaining vegetation, biodiversity, and presence of key weed species. A moderate to good recovery potential allows the land to be managed for an improvement in the condition of the remnant vegetation and to increase linkages (wildlife corridor) between extant stands of vegetation.

With appropriate management actions, areas identified as having a moderate recovery potential would improve the condition of threatened species habitat and ecosystem connectivity within the precinct. Management actions would need to be on-going and facilitate the natural regeneration of the over-storey and/or regeneration of native species (grasses, herbs, and forbs) in the seed bank.

The following four classes of recovery potential have been identified within the subject site (Figure 8):

- High Recovery Potential: Native vegetation mapped as areas which generally have native canopy cover of greater than 10% and contained native species in each structural layer.

- Moderate Recovery Potential: Other areas of native vegetation with some canopy, less structural complexity, and a higher level of weed infestation or ongoing disturbance.
- Low Recovery Potential: Areas which show some potential for natural regeneration. Some native species present in some structural layers, very high level of weed infestations, not all structural layers present.
- Very Low Recovery Potential: All other areas including cleared and heavily cultivated and/or pasture improved areas.

Areas along the central creek line have moderate to high recovery potential which indicates that rehabilitating the riparian corridor along the central and north-western creek lines has a high feasibility. The recommended areas of rehabilitation target the watercourses that already have moderate to good condition vegetation established for example around 2F and 3D. Vegetating along these watercourses and linking the isolated vegetation patches would allow for an improvement in wildlife corridors and overall creek condition. This would incidentally facilitate the recovery of the creek systems to a functioning natural waterway.

5.4.3 Management Zones

The area of the riparian corridor proposed to be retained and managed within the ILP is approximately 16.91 ha. The rehabilitation works for the riparian corridor will be focused on weed control, assisted regeneration and revegetation. The riparian corridor consists of two management zones as identified below and in Figure 9.

- Zone 1: Rehabilitation and Weed Management
- Zone 2: Revegetation
- Zone 3: Revegetation (Groundcover and Mid-Storey Species)

An assessment of the native resilience and weed densities was conducted during field surveys. The vegetation within the riparian corridor is generally in poor to moderate condition with high weed densities in the ground layers. Areas of exotic pasture will require maintenance to prevent the continued incursion of weeds into the riparian corridor. This will best be achieved by regular mowing or ongoing weed control along the interface of the riparian corridor and proposed developable areas.

5.4.3.1 Revegetation

The key management priorities and required management actions are:

- Target removal of priority and environmental weeds
- Control of exotic grasses and other exotic species
- Tubestock planting following weed control in areas of low resilience (either fully structured, ground cover only or wetland species based on locations shown in Figure 12).
- Monitor native vegetation and weed densities.

5.4.3.2 Rehabilitation and Weed Management

The key management priorities and required management actions are:

- Target removal of priority and environmental weeds
- Control of exotic grasses and other exotic species

- Monitor native vegetation and weed densities.

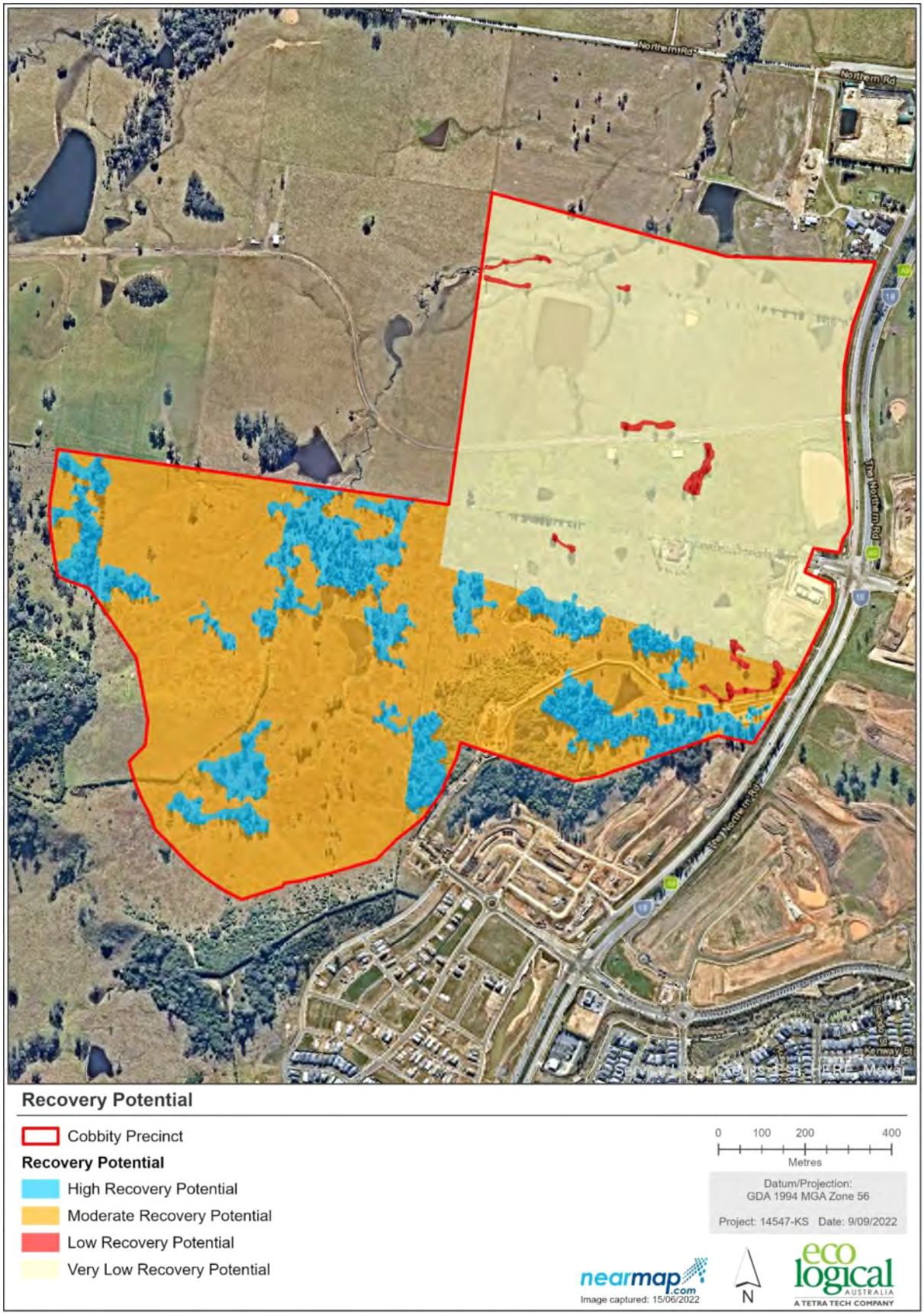

Figure 11: Recovery potential

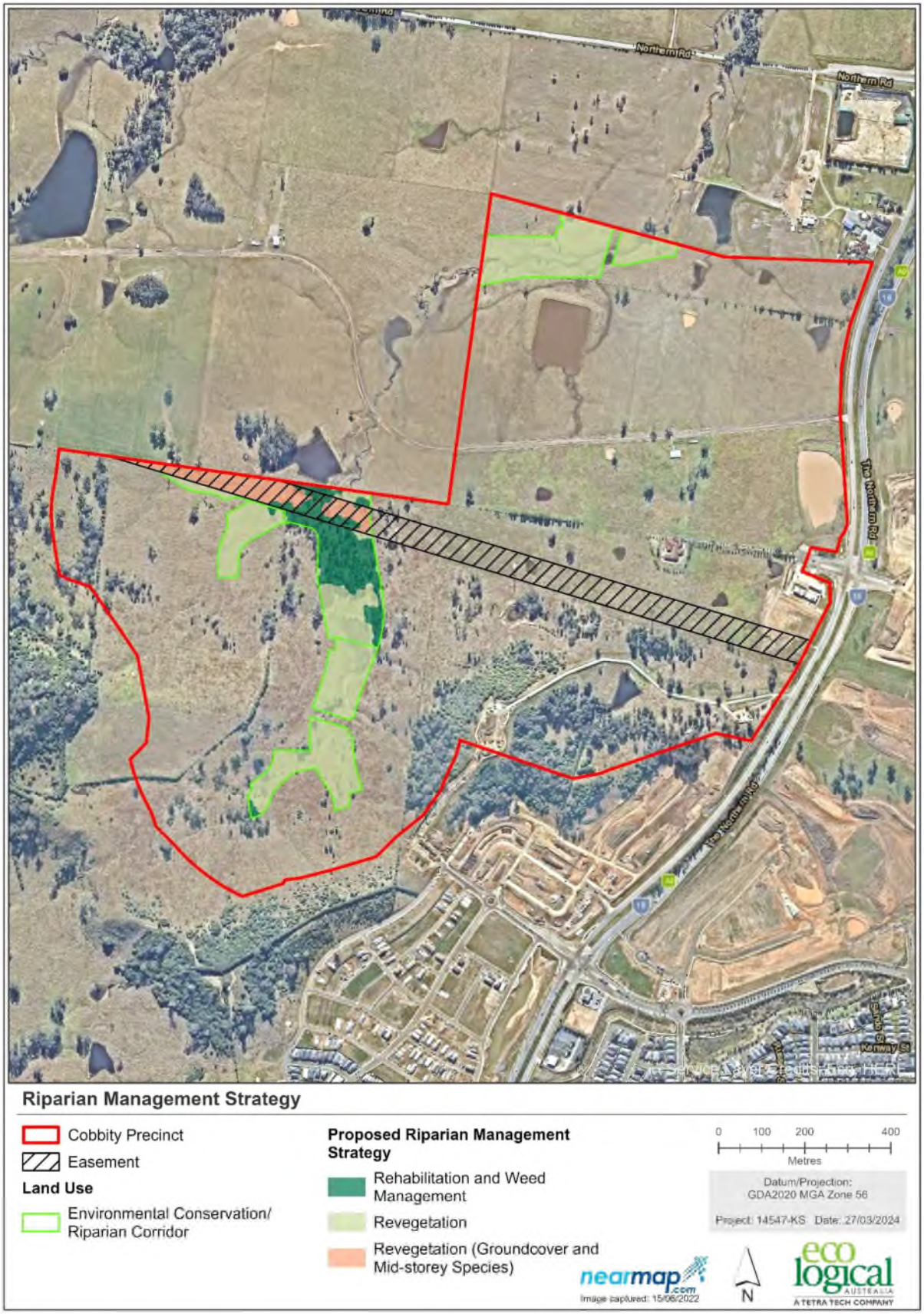

Figure 12: Indicative riparian management zones

5.4.4 SEPP and DCP Provisions

Major riparian corridors should be zoned C2 Environmental Conservation under the Growth Centres SEPP as this provides clear objectives for the protection and management of the riparian corridor. The permissible uses within the Environmental Conservation zones are shown below.

Zone	Permitted without consent	Permitted with consent	Prohibited
Environmental Conservation	Nil	Drainage; Earthworks; Environmental facilities; Environmental protection works; Flood mitigation works; Information and education facilities; Kiosks; Recreation areas; Roads; Signage; Waterbodies (artificial)	Business premises; Hotel or motel accommodation; Industries; Multi dwelling housing; Recreation facilities (major); Residential flat buildings; Restricted premises; Retail premises; Seniors housing; Service stations; Warehouse or distribution centres; Any development not specified in item 2 or 3

Where multiple land uses are proposed, for example public access for recreation, other land use zones may be appropriate such as RE1 Public Recreation, as long as the management regime for the land has a primary objective of environmental protection. However, the proponent is proposing to zone riparian corridors and adjacent accessible areas as C2 with hatching on the riparian corridors to identify where the corridor must be maintained for conservation purposes.

The riparian areas should also be subject to the Camden City Council Growth Centres Precincts DCP clauses that relate to Water Cycle Management (2.3.2) and Native Vegetation and Ecology (2.3.5). The clauses are triggered by including the riparian areas on the Western Parkland City SEPP Riparian Protection Area map. The DCP (section 2.3.5) has controls specifically for the Riparian Protection Areas which should apply to the South Creek West precinct:

- *Within land that is in a Riparian Protection Area, native vegetation is to be conserved and managed in accordance with the Guidelines for riparian corridors on waterfront land prepared by the NSW Office of Water*.

The conservation and management regime for the vegetation should be described in a Vegetation Management Plan that has been prepared to be consistent with the zone objectives, the above guidelines and Landscape plans prepared for the development.

Where public access for recreation is proposed, public ownership of riparian lands is likely to be the best solution. Discussion with local government regarding the infrastructure and vegetation management in the riparian zone is recommended.

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