NSW GOVERNMENT | Chief Scientist & Engineer

Advice regarding the protection of koala populations associated with the Cumberland Plain Conservation Plan

14 May 2021

Note: This version of the report has been edited to remove confidential information to allow public release. No changes have been made to the principles or recommendations made by the Expert Panel.

NSW GOVERNMENT | Chief Scientist & Engineer

The Hon Matt Kean MP
Minister for Energy and Environment

The Hon Rob Stokes MP
Minister for Planning and Public Spaces

Dear Ministers

Advice regarding the protection of koala populations associated with the Cumberland Plain Conservation Plan

In April 2021 you requested expert advice on the adequacy of the Cumberland Plain Conservation Plan's (CPCP's) koala specific measures in supporting a long-term strategic landscape-scale outcome for koalas across Wilton and Greater Macarthur Growth Areas. Further advice was sought on principles for koala protection measures for consent authorities to apply in considering site by site applications and their spatial application.

This builds on the findings and recommendations report '*Advice on the protection of the Campbelltown koala population'* submitted in April 2020 and additional advice provided to the Department of Planning, Industry and Environment (DPIE) in February 2021. It should be noted that the report only considered the Greater Macarthur Growth Area (GMGA) and not the Wilton Growth Area (WGA), which is an area of overlap for two different koala populations (Campbelltown and Southern Highlands) with different disease status.

An independent expert panel was established to provide advice chaired by myself and included Associate Professor Mathew Crowther (the University of Sydney), Dr Ben Moore (Western Sydney University) and Dr Martin Predavec (former Principal Scientist, DPIE).

This report is submitted to fulfil the Terms of Reference. The advice provides principles that should be applied across both the CPCP and surrounding regions for the protection of the South Western Sydney koala population. This includes an assessment of the CPCP proposed protection measures and how they relate to the principles.

In providing its advice the panel undertook briefings with DPIE and Transport for NSW and regional koala experts and a site visit was conducted. The advice only considers the protection of the koala population. It is noted that there are many other biodiversity (both flora and fauna) and cultural considerations that need to be made.

The CPCP aims to provide measures that enable koalas to persist in the region. This is including the strategic protection of habitat through a range of mechanisms, revegetation, installation of connectivity structures, threat management, monitoring and research.

The persistence of the South Western Sydney koalas requires ensuring resilience in the region. This includes the retention or provision of habitat of sufficient size and quality to compensate for the negative direct and indirect impacts of urbanisation and climate change (heatwaves, bushfire, declining habitat nutritional quality) as well as ensuring the persistence of multiple connected viable koala subpopulations, allowing proper metapopulation dynamics.

The Panel found that while overall the koala specific provisions of the CPCP are broadly adequate, it provides in this report comments and suggestions that could improve outcomes for koalas. There will be uncertainty about what hurdles will emerge in implementing the CPCP, and unforeseen events are also possible; these uncertainties will present challenges to decision makers and land

managers. The CPCP needs to include risk mitigation strategies including embedding adaptive management practices throughout the timeframes of the plan.

Sincerely

Dr Chris Armstrong, PSM
Chair, Independent Expert Koala Panel
Deputy Chief Scientist & Engineer

Principles for koala protection in the Greater Macarthur and Wilton growth areas and surrounds

Habitat and connectivity

1. **Strategic planning -** Habitat protection should be enabled through forward planning and commitments at a regional scale and over the lifetime of the development.
2. **Protected and connected -** Retain, increase, restore and protect koala habitat, reducing fragmentation and increasing connectivity. The habitat should support the movement of koalas such that dispersing koalas can move through the landscape, can breed to ensure genetic diversity, and can access and persist in refugia in times of stress, bushfire, drought, or other threats.
3. **Avoid dead-ends and population isolation -** Ensuring (as far as possible) that the habitat has *multiple* connections can help to prevent the formation of dead ends and population sinks and ensure that koalas (and other species) have routes to move through the landscape.
4. **Corridors provide habitat -** The term 'corridor' should not be misinterpreted to mean that its only function is a thoroughfare and the provision of connectivity. Not all identified corridors are suitable to provide connectivity for koalas, but the habitat should be protected for biodiversity values and amenity in the region, as well as protected koala habitat in some cases.
5. **Corridor widths -** Corridors should be widened where feasible through revegetation to an average minimum width of 390 - 425 m, include a buffer on either side (30 m wide where fenced and wider to ~ 60 m where fencing is infeasible), and trees should 3 m from the fence (to prevent tree branch damage to fence)
6. **Larger area, shorter edges -** Revegetation should be targeted to widen habitat units and corridors where feasible and aim to reduce the edge: area ratio of habitat (i.e. 'fingers' or areas between strips of habitat could by infilled with vegetation).
7. **Habitat buffers separate from APZ -** Buffer zones in corridors/habitat should be separate from Asset Protection Zones (APZs), with APZs on the urban side of the exclusion fence.
8. **Target shale soils -** Where possible, revegetation should target relatively higher quality soils (i.e. to produce higher quality habitat) – shale-based 'Blacktown soil landscape' is preferred to 'Hawkesbury sandstone landscape'.
9. **Earlier planting leads to more mature trees -** Early implementation of koala habitat planting, and restoration can lead to trees being at a more mature stage by the time they are needed, areas that will improve connectivity and nutrition (based on soil type) should be prioritised.
10. **Prevent degradation of habitat -** Early protection and active management will prevent the degradation and loss of existing habitat over the time during development – engage community and stakeholders to protect habitat.
11. **Plan for climate change -** Consider water sources, soil types, tree varieties, and well connected refugia.

Fauna crossings for linear infrastructure

12. **Safe movement -** Infrastructure that will cut across a designated corridor should include underpass or overpass structures to enable the movement of koalas along the corridor. Any infrastructure (such as roads) that cross, or might have an impact on, the corridor should be designed to be sympathetic to the protections of the corridor and to enable safe access across or under the linear infrastructure.
13. **Fencing underpasses -** Suitable fencing and connecting habitat put in place early enough through the process so that it is complete by the time the infrastructure is constructed.

14. **Underpass design -** Construction of connectivity structures for roads: overpasses, underpasses (including road bridges) or culverts, with associated exclusion fencing, cattle grids, gates to prevent koalas entering the roadway. Designing underpasses to maximise the likelihood of koala use – look to the latest evidence, include attributes such as clear line of site, avoidance of predator death traps, keep dry, include furniture such as logs for koalas, the bigger the better.

Threat mitigation

15. **Exclusion fencing -** Maintaining a separation between koalas and threats using exclusion fencing should be a priority, and where this is not feasible (e.g. steep terrain), fallback measures to reduce risk (e.g. vehicle speed limits) and monitoring should be undertaken. Fencing should be adaptively managed with design, location and maintenance evaluated.
16. **Spatial and temporal planning for threats -** Threat mitigation and reducing stressors should be enabled through forward planning and commitments at a regional scale and over the lifetime of the development.
17. **Reducing impacts from construction -** Ensure processes are in place to protect koalas during construction and operational phases of the development. e.g. an onsite ecologist present through the duration of pre-clearance surveys and clearing works, koala and wildlife relocation protocols, tree-felling protocols, and education programs for construction workers.
18. **Sensitive urban design -** Traffic calming measures, planning of greenspace, avoid koala feed trees in urban footprint, domestic dogs secured in neighbourhood backyards, fauna sensitive design
19. **Avoid stressors that repel koalas -** Some effects of increasing urbanisation can increase koala stress levels which in turn can lead to changed patterns of behaviour, avoidance of exposed habitat, increased propensity to disease. Utilise approaches to reduce these effects including buffers.

Disease management

20. **Avoid chlamydia incursion -** Much of the koala population within the CPCP appears currently to be free of *Chlamydia pecorum* infection. Planning and delivering protection measures should be progressed to maintain this disease-free status as much as possible, and to respond to it should it emerge.
21. **Identify koala routes and monitor for disease -** There is a need to have a monitoring stream that targets chlamydia entry into, and potentially within, the Campbelltown population. This should target specific locations where the Southern Highlands population may intersect.
22. **Vaccine trials -** The Campbelltown koala population may be a good place to conduct a vaccination trial, given its chlamydia-free status. Given the early stage development of the vaccination, a trial could be conducted on the interface between the two populations (the Campbelltown and the northern Southern Highlands population). Vaccines are still unproven so not yet a basis for management.
23. **Adaptive management for disease -** There should be the development of monitoring that matches triggers for actions: actions should be commensurate to the detection level.

Adaptive management

24. **Baseline data set -** Baseline data are required to better understand the status of the population(s), including numbers, distribution and how they functionally use the landscape.
25. **Surveys and monitoring -** Ongoing and regular survey and monitoring efforts, compared against the baseline, to detected population trends over time and inform adaptive management approaches (including the development and understanding of appropriate triggers and responses, including timeframes).

26. **New monitoring technologies -** New monitoring approaches enabled by smaller, cheaper, more sensitive devices, that are connected and remote will increase the extent and value of monitoring programs.
27. **Interface monitoring with NSW Koala Monitoring Framework -** Monitoring should inform the *NSW Koala Strategy*, as a designated monitoring site. Site specific monitoring will need to be conducted within the CPCP and that will evolve over time.
28. **Adaptive management informed by triggers -** Monitoring should include evaluation points tied to management 'trigger' actions and responses.
29. **Timely mitigation -** As per an adaptive management approach, a lack of information should not preclude mitigation activities occurring in a timely manner.
30. **Understand alternatives -** There is also a need to map alternative management approaches that could be employed if actions are not achieving the desired results.
31. **Risk-based emergency response protocols -** Interested stakeholders undertake a risk assessment (likelihood and consequence) and establish monitoring and response protocols – for threats with a fast or slow onset.

Contents

1 Introduction

On 9 December 2019, the Minister for Energy and Environment and the Minister for Planning and Public Spaces requested that the Deputy Chief Scientist & Engineer chair an Independent Expert Panel to provide advice regarding the protection of the Campbelltown koala population.

This advice was to include:

- The adequacy of the proposed measures, by the property group Lendlease, for koala conservation on the land referred to as Mount Gilead Stage 2 (MGS2) and the consistency of these measures with the 2018 NSW Koala Strategy
- What, if any, additional conservation measures are considered necessary? What, if any, site specific measures for koala species should be incorporated into the Cumberland Plain Conservation Plan (CPCP) for the Greater Macarthur Growth Area (GMGA) to support the long-term viability of the koala population.
- Whether east-west corridors linking the Nepean and Georges Rivers can contribute to the conservation of the Campbelltown Koala population; and if so, which east-west corridors and what measures should be taken to ensure their effectiveness

The Panel included Dr Chris Armstrong PSM (Deputy Chief Scientist & Engineer; chair), Professor Kathy Belov AO (The University of Sydney), Dr Carolyn Hogg (The University of Sydney) and Professor Jonathan Rhodes (The University of Queensland).

The report "*Advice on the protection of the Campbelltown Koala population*" Report (the 2020 Report) was submitted to government on the 30 April 2020.[1] The 2020 Report provided the Panel's findings and four recommendations. These findings and recommendations provided advice on the primary and secondary corridors in the GMGA and the need for adaptive and active management.

In February 2021, additional advice (the February 2021 Advice) was provided to the Department of Planning, Industry and Environment (DPIE) on specific questions related to corridors and buffer zones in the proposed MGS2 development.In April 2021, the Minister for Planning and Public Spaces and the Minister for Energy and Environment requested the Office of the Chief Scientist & Engineer (OCSE) provide advice on the adequacy of koala specific measures in the Wilton Growth Area (WGA) and GMGA in the CPCP.

This includes advice regarding the adequacy of the CPCP's koala specific measures in supporting a long-term strategic landscape-scale outcome for koalas across WGA and GMGA. The advice is to consider constraints such as existing development and current and future infrastructure (e.g. Upper Canal and transport routes) and risks that may lead to habitat losses in other regions (e.g. through changes in urban capable footprint).

Further advice was requested regarding:

1. Principles for consent authorities to apply in considering site by site applications in light of the CPCP advice, including how this applies to the Technical Assurance Panel (TAP) process for the Appin precincts in the GMGA.
2. Spatial application of the advice to the GMGA leading to amendment of the Greater Macarthur Plan.

The full terms of reference are at Appendix 1. This report is in fulfilment of the terms of reference.

An expert panel was established to provide this advice, chaired by the Deputy Chief Scientist & Engineer and included Associate Professor Mathew Crowther (School of Life and Environmental Sciences, the University of Sydney), Dr Ben Moore (Hawkesbury Institute for the Environment, Western Sydney University) and Dr Martin Predavec (Retired, former Principal Scientist, DPIE). OCSE provided secretariat support.

[1] OCSE (2020), Advice on the protection of the Campbelltown Koala population

In providing its advice the Panel has reviewed several reports and documents. The Panel met with representatives from DPIE including Planning, as well as Energy, Environment and Science (EES), Transport for NSW (TfNSW), Associate Professor Damien Higgins (Koala Health Hub, The University of Sydney) and was provided additional information from Dr Stephen Phillips, Biolink Ecological Consultants. On 30 April 2021 the Panel conducted a site visit to the GMGA region of the CPCP with representatives of the three agencies and of Walker Corporation, which is seeking to develop in both growth areas.

1.1 Western Parkland City including the Greater Macarthur and Wilton Growth Areas

The Western Parkland City builds on the regions surrounding Liverpool, Greater Penrith and Campbelltown-Macarthur.[2] Over the next ~40 years, it will be developed to accommodate an additional 760,000 people[3] including residential dwellings, industrial and corporate sites the Western Sydney Airport and Badgerys Creek Aerotropolis. Biodiversity certification for development across the Western Parkland City is being sought through the CPCP under the *Biodiversity Conservation Act 2016.*

The GMGA and WGA are regions slated for increased development over the next 30 years as part of the Western Parkland City (Figure 1). These two growth areas will include ~55,000 new homes and associated transport, industrial and community infrastructure.[4,5] Running through the Growth Areas is the Upper Canal, which supplies water to Sydney and is State-Heritage listed. Strategic biodiversity conservation through most of the Growth Areas is being conducted through the CPCP.

The GMGA extends from Glenfield to Appin and encompasses land in three Local Government Areas (LGAs): Campbelltown City Council, Camden Council and Wollondilly Shire Council. The GMGA, as set out in the *Greater Macarthur 2040* Plan, will include urban renewal precincts (Glenfield to Macarthur), land release precincts south of Campbelltown (including ~ 40,000 homes across Menangle Park, Gilead, North Appin and Appin), new transport routes, public and industrial infrastructure.[6] The WGA is wholly within the Wollondilly Shire Council LGA. The WGA, as set out in *Wilton 2040*, will include industrial, commercial, and residential infrastructure, as well as an additional 15,000 homes.[7]

1.2 The Cumberland Plain Conservation Plan

DPIE has undertaken strategic conservation planning to develop the CPCP. The CPCP covers the location and layout of urban development as well as biodiversity certification under the *Biodiversity Conservation Act 2016* (Figure 1), aiming to support biodiversity and urban growth by protecting important conservation values in a strategic manner. Under the draft CPCP, there is a conservation program that has been designed to *"improve ecological resilience and function, and to offset biodiversity impacts from new housing, employment areas and infrastructure."* The draft CPCP states that it will "*ensure that the condition of important koala habitat is improved, connectivity between koala sub-populations is maintained, threats to koalas are managed and the koala population in South Western Sydney persists*." Further information on the CPCP is in the 2020 Report.[8]

[2] https://www.greater.sydney/metropolis-of-three-cities/vision-of-metropolis-of-three-cities/western-parkland-city-vision
[3] The population of the Western Parkland City is projected to grow from 740,000 in 2016 to 1.1 million by 2036, and to well over 1.5 million by 2056. https://www.greater.sydney/metropolis-of-three-cities/vision-of-metropolis-of-three-cities/western-parkland-city-vision
[4] DPIE (2018) Greater Macarthur 2040. An interim plan for the Greater Macarthur Growth Area
[5] DPIE (2018) Wilton 2040. A plan for the Wilton Growth Area
[6] DPIE (2018) Greater Macarthur 2040. An interim plan for the Greater Macarthur Growth Area
[7] DPIE (2018) Wilton 2040. A plan for the Wilton Growth Area
[8] OCSE (2020), Advice on the protection of the Campbelltown Koala population

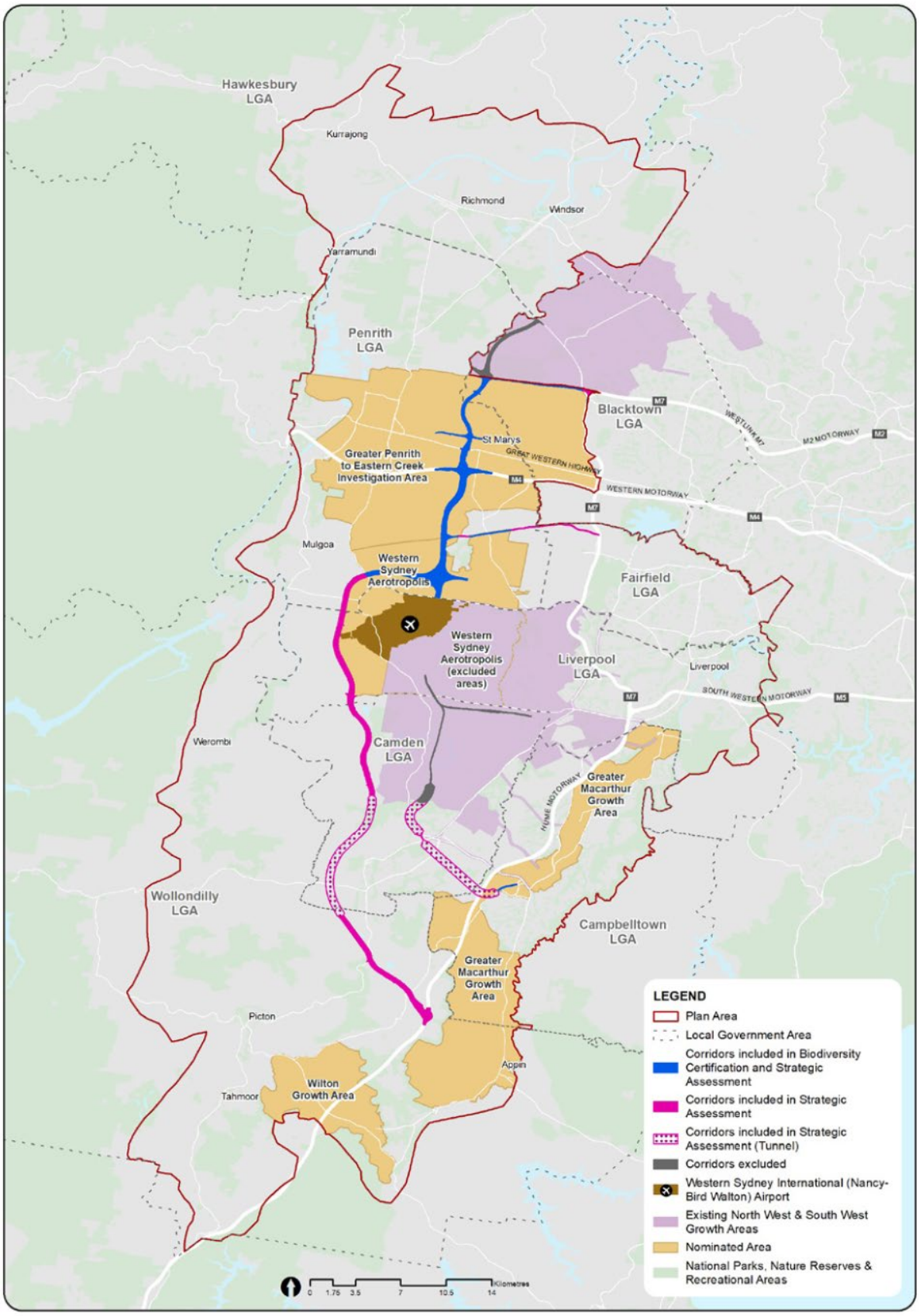

Figure 1: Draft CPCP area and scope
Source: DPIE (2020)[9]

[9] DPIE (2020) Highlights of the Draft Cumberland Plain Conservation Plan

2 Koala protection measures proposed in CPCP and related processes

2.1 The CPCP measures

The Sub-Plan B of the draft CPCP is a conservation program for koalas and has been developed to "*address impacts and potential risks to koalas in Western Sydney associated with existing and planned development in the Wilton and Greater Macarthur growth areas".* Sub-Plan B (and this current advice) is focussed on the WGA and GMGA since these two areas cover most koala records within the Cumberland Plain - two populations often referred to as the Campbelltown and Southern Highlands koala populations, but the level of distinction between them is unclear. There are five categories of commitments under the program: 1) Avoiding and minimising impacts, 2) Mitigating indirect and prescribed impacts, 3) Conserving koala habitat, 4) Managing landscape threats, and 5) Building knowledge and capacity.

Actions under the koala conservation program include, but are not limited to:

- Installation of exclusion fencing, along both sides of Appin Road and where feasible along koala corridors
- Establishment of the Georges River Koala Reserve
- Securing priority habitat and koala movement corridors
- Fauna crossings under Appin Road near Brian Road (near the Ousedale Corridor) and at the Kings Falls Bridge
- Habitat restoration and weed control
- A research program
- A health and welfare program

An updated list of commitments and actions, from the draft CPCP, provided to the Panel are at Table 1.

Sub-Plan B notes that there will be an evaluation program to track the progress and effectiveness of the conservation program over the life of the CPCP (35 years, until 2056).

The CPCP does not cover the whole Cumberland Plain region. There are areas that are subject to different biocertification processes (e.g. the proposed Lendlease MGS2 development in the GMGA) or are not part of the urban footprint (e.g. National Parks, WaterNSW Special Areas).

2.2 Other policies or processes

Koala habitat in the Wollondilly LGA is covered by *State Environmental Planning Policy (Koala Habitat Protection) 2021* (SEPP 2021).[10] Further it is noted that the Wollondilly Shire Council has closed its tender for the development of a Comprehensive Koala Plan of Management (CKPoM) (closed 24 March 2020).

The CKPoM[11] for Campbelltown City Council was approved in August 2020. This provides a strategic approach to the protection, management, and restoration of koala habitat for the entire Campbelltown LGA. Provisions in SEPP 2021 do not apply to Campbelltown LGA.

In the GMGA, DPIE have established a pilot TAP program to allow for state agencies, councils and landowners to work together to undertake strategic investigations for precincts.[12] The TAP, chaired

[10] https://www.planning.nsw.gov.au/Policy-and-Legislation/Environment-and-Heritage/Koala-Habitat-Protection-SEPP
[11] https://www.campbelltown.nsw.gov.au/LocalEnvironment/Koalatown/CouncilTakesActionOnKoalas
[12] https://www.planning.nsw.gov.au/Plans-for-your-area/Technical-Assurance-Panel

by DPIE, is made up of representatives from EES in DPIE, Government Architect NSW, Sydney Water, TfNSW, Wollondilly Shire and Campbelltown City Councils and other agencies such as Rural Fire Services (RFS) and Heritage NSW when required. The aim is to "*resolve complex planning issues and provide a recommended roadmap to resolve key issues upfront in a transparent way".*[13] This will include the implementation of any advice and recommendations from OCSE on koala protection measures.

[13] https://www.planning.nsw.gov.au/Plans-for-your-area/Technical-Assurance-Panel

Table 1: Draft CPCP commitments and actions for koala conservation

Commitments	Actions	Timing
Commitment 8 Mitigate indirect and prescribed impacts from urban, industrial, infrastructure and major infrastructure corridors development on the Southern Sydney koala population to best practice standards and in line with the Chief Scientist Koala Report (2020), and in accordance with Appendix E of the Plan.	1. Install koala exclusion fencing, including gates and grids, between the Plan's koala habitat that can safely support koalas and urban land within the Greater Macarthur Growth Area and Wilton Growth Area, except where exclusion fencing is not feasible or necessary due to slope, heritage or water courses. a. Ensure all koala-exclusion fencing is at least three metres from koala habitat trees. b. In nominated areas where exclusion fencing is not feasible, apply koala specific mitigation actions 60m from the koala habitat in accordance with Appendix E. c. Where fencing must cross existing or planned linear infrastructure such as gas and electricity transmission, consider appropriate access treatments such as gates to ensure the integrity of the koala-exclusion fencing. d. Fence off koala habitat corridors that are too narrow to safely support koalas and relocate koalas out of the unsafe corridors, noting the corridors will be protected and can be considered for future restoration to support koala movement. 2. Deliver a feasibility study into the koala exclusion fencing to help inform the design, locations and construction of the fencing. The feasibility study will ground-truth the fencing locations identified in the Plan and identify priorities for fencing in the first three years. 3. Install koala-exclusion fencing along the western alignment of the Georges River Koala Reserve where existing urban land is a threat to koalas. 4. Install koala-exclusion fencing at roadkill hotspots and at koala habitat, along both sides of Appin Road between Rosemeadow and Appin, to mitigate koala vehicle strikes. Fencing along Appin Rd will be in addition to planned fencing works to be delivered by Transport for NSW. 5. Undertake targeted stakeholder and community engagement to support the delivery of koala-exclusion fencing. 6. Establish a koala working group with representation from relevant government agencies to support implementation of the koala commitments and actions. The working group will provide advice to support implementation of the koala sub-plan, including advice to inform: • alignment, staging, and design of the koala exclusion fencing and fauna crossing, including advice about providing appropriate koala movement corridors • priority locations and approach for koala habitat restoration	Action 1: Life of Plan Action 2: Year 1 Action 3,4: Life of Plan Action 5: Years 1-3 Action 6: Before start of Plan Action 7: Life of Plan Action 8: Year 1-5

	• monitoring and evaluation of the koala commitments set out in Plan, including providing advice to support adaptive management based on monitoring and evaluation data • community and stakeholder engagement for the koala conservation commitments and actions • research and management actions relating to koalas. 7. Work with local councils, NPWS and OSL to ensure the threats posed by dogs on all public land identified as the Plan's koala habitat are managed. • For land that is not publicly accessible, either through the installation of signs and/or installation of fences • For land managed as a reserve or for recreation, incorporate requirements in a relevant Plan of Management 8. Provide safe fauna crossings, based on current best practice design, across Appin Road by: • installing a koala underpass culvert under Appin Road, near the intersection with Brian Road • augmenting the existing Kings Falls Bridge at the Georges River by constructing a bench adjacent to the bridge abutments, to allow dry passage for koala (and other fauna) under Appin Road, supporting north–south koala movement from the Georges River Koala Reserve to the southern koala habitat	
Commitment 9 Protect a minimum of 5,475 hectares of native vegetation[1] in the Cumberland subregion to conserve biodiversity values in perpetuity in accordance with the conservation lands selection steps which will require at least 11,000 hectares of conservation land.	1. Purchase land within the strategic conservation area to commence establishing reserves under the Plan with priority given to land listed for sale and land in the proposed Koala Reserve (Years 1-3).	Action 8: Life of Plan
Commitment 11 Establish a reserve to protect the north-south koala movement corridor along the Georges River between Appin and Kentlyn.	1. Protect up to 700 hectares of land between Appin and Kentlyn that is currently in ownership of NSW Government as the first stage in establishing the Georges River Koala Reserve. 2. Transfer the first stage of the Georges River Koala Reserve to National Parks and Wildlife Service (by December 2021) 3. Gazette the first stage of the Georges River Koala Reserve as a conservation reserve under the management of National Parks and Wildlife Service (by the end of 2023)	Action 1: Year 1 Action 2: Year 3-10 Action 3: Year 3-10 Action 4: Year 10-20

[1] While there is overlap between the TEC targets listed in commitments 8.1 and 8.2, there are differences in the listings between EPBC Act-listed and BC Act-listed TECs, such as differences in approach and criteria. Therefore, the BC Act-listed TECs in commitment 7.2 incorporate targets for EPBC Act-listed TECs.

	4. Protect an additional 430 hectares of land between Appin and Kentlyn through the purchase of land for the Georges River Koala Reserve. 5. Protect up to 755 hectares of land between Kentlyn and Long Point as future additions to the Georges River koala reserve. 6. Restore up to 80 hectares of cleared land for koala habitat within the Georges River Koala Reserve to strengthen the north-south koala movement corridor.	Action 5: Year 1-20
Commitment 13 Secure key koala habitat corridors in the Cumberland subregion in perpetuity	1. Secure priority habitat and koala movement corridors in accordance with the Conservation Lands Implementation Strategy (Commitment 8 Action 1) to protect habitat corridors in the Cumberland subregion. 2. Protect koala habitat as avoided land and through the application of new development controls in potential east–west koala movement corridors between the Georges River and the Nepean River. 3. Through restoration, ensure at least one north–south corridor (the Georges River Koala Reserve is at least an average of 390-425m wide and is contiguous (gaps between trees less than 100m). 4. Facilitate koala movement for at least one east–west corridor (Ousedale Creek) by a. constructing a koala underpass at Ousedale Creek corridor under Appin Road b. through restoration and koala exclusion fencing to ensure the corridor is contiguous (gaps between trees less than 100m) and a minimum average of 390-425m. 5. Fence off east–west koala habitat corridors that are too narrow to safely support koalas and relocate koalas out of the unsafe corridors, noting the corridors will be protected and can be considered for future restoration to support koala movement.	Action 1,2: Before start of Plan Action 3: Years 1-5 Action 4, 5: Years 1-3
Commitment 14 Undertake ecological reconstruction of up to a maximum of 25% of the Plan's offset target for native vegetation (Commitment 8) in conservation land established under the Plan.	1. Establish a Weed and Restoration control working group to guide the implementation of weed control activities under the Plan including the preparation of a Weed Control Implementation Strategy. 2. Develop a Restoration Implementation Strategy in consultation with key stakeholders and delivery partners, to: • provide a clear purpose for undertaking restoration, including when the Plan will require ecological reconstruction to meet its offset targets for impacted native vegetation communities • ensure the long-term sustainability of restoration considers genetic diversity in what is planted • identify restoration potential of land within priority sites • provide guidance on restoration expectations at priority sites • identify opportunities for landholders to undertake active restoration as part of a biodiversity stewardship agreement	Action 1: Year 1 Action 2: Year 1 Action 3: Life of Plan Action 4: Year 1-5 Action 5: Year 1-5

	• identify and potentially fund restoration on land adjacent to conservation land established under the Plan • develop a seed-procurement approach • determine any research needs. 3. Enter into written agreements with delivery partners and engage specialist providers where necessary to implement the restoration plan. 4. Undertake up to a maximum of 1,365 hectares of ecological reconstruction on conservation land targeting the following threatened ecological communities: • Cooks River Castlereagh Ironbark Forest • Cumberland Plain Woodland • River-flat Eucalypt Forest • Shale Gravel Transition Forest • Swamp Oak Forest. 5. Ecological restoration including planting trees to restore koala habitat in Georges River Koala Reserve and other priority locations in the strategic conservation area including: • along Ousedale Creek • around Appin The restoration of the Plan's koala habitat will primarily include the restoration of Cumberland Plain Woodland and Shale/Sandstone Transition Forest. 6. Establish pilot sites for ecological restoration of threatened ecological communities within the Plan Area.	Action 6: Year 2 onwards
Commitment 21 Provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation including koala conservation.	1. Invest in the *NSW Koala Strategy* to raise awareness of the Southern Sydney koala population and encourage community participation in koala conservation in Western Sydney.	Action 1: Year 4 Actions 2,3,4,: Year 5 Actions 5: Year 1 onwards
Commitment 23 Invest in research priorities that will support the implementation of the	1. Implement the research program with key outcomes including: • research that increases knowledge of population demographics, life-history and ecology of the Southern Sydney koala population, as part of the NSW Koala Strategy Research Plan	Action 1: Year 1 Actions 2,3: Year 2 onwards

Plan and help to deliver the Plan's outcomes.		
Commitment 24 Support rehabilitation measures to help maintain koala health and welfare.	1. Invest in the *NSW Koala Strategy* and other potential partners to implement the koala health and welfare program in South Western Sydney with key deliverables including: • monitoring of koalas including key threats and effectiveness of mitigation measures as part of the NSW Koala Strategy Monitoring Framework • designating the koalas in South Western Sydney as one of the dedicated monitoring sites for the NSW Koala Strategy • providing enhanced training in wildlife treatment for veterinarians • providing grants for community wildlife organisations for resources and carer recruitment and training • establishing health and welfare programs to support koalas from threats including vehicle strike, fire, disease and climate change. 2. Koalas that are captured and/or handled as part of a monitoring program will be vaccinated against chlamydia and have a tissue sample taken for genetic analysis, with the tissue samples lodged with the NSW Koala Biobank	Action 1: Year 1 onwards

3 Adequacy of Koala protection measures in South Western Sydney

This chapter provides a commentary from the Panel (Table 2) on the adequacy of the measures proposed for koala protection in the draft CPCP (Table 1).

3.1 Definition of adequacy and assessment

The Panel has been requested to provide advice regarding the 'adequacy' of the CPCP's koala specific measures in supporting a long-term strategic landscape-scale outcome for koalas across the WGA and GMGA. However, there is no clear definition of adequacy.

The CPCP has the aim of ensuring that the *"condition of important koala habitat is improved, connectivity between koala sub-populations is maintained, threats to koalas are managed and the koala population in South Western Sydney persists."*[14]

The 2020 Report assessed the adequacy of protection measures proposed in relation the 2018 NSW Koala Strategy which has the objective of stabilising and increasing koala numbers over the longer-term to ensure genetically diverse and viable populations across NSW.[15] The guiding principles were to *"maximise koala population persistence and abundance, koala habitat amount and connectivity, and minimise contact between koalas and the urban environment to reduce hazards and threats"*.[16]

In June 2020, after the 2020 Report was completed, the Legislative Council inquiry into koala populations and habitat in New South Wales found that *"given the scale of loss to koala populations across New South Wales as a result of the 2019-2020 bushfires and without urgent government intervention to protect habitat and address all other threats, the koala will become extinct in New South Wales before 2050".*[17]

In July 2020, the Minister for Energy and Environment announced the goal of doubling the number of koalas in NSW by 2050 and the development of a 30-year plan to achieve that goal. A panel chaired by OCSE is working on that plan separately.

The Panel for the CPCP advice in this report, assessing the adequacy of actions in the CPCP, has based its analysis against the stated CPCP aims, abbreviated to: 1) improve habitat, 2) maintain connectivity, 3) manage threats, which together should 4) enable the population to persist. The Panel notes the difficulty in the term 'persist' but notes that it must aim towards a thriving and resilient koala population rather than simply a population 'hanging-on'.

The Panel's assessment of adequacy of mitigations and commitments in enabling persistence has considered:

a) what we know about the current status of the habitat and koala populations
b) plans around urban development and transport corridors for the GMGA and WGA that have been shared with the Panel
c) other trends that will affect the habitat and population over the 36-year timeframe, in particular the impacts of climate change, and the foreseeable movement of chlamydia disease into and within the area. These trends are described in more detail in Section 3.2.

[14] DPIE (2020) Sub-Plan B: Koalas. Draft Cumberland Plain Conservation Plan
[15] https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/nsw-koala-strategy
[16] OCSE (2020), Advice on the protection of the Campbelltown Koala population
[17] NSW Government (2020) Legislative Council. Portfolio Committee No. 7 – Planning and Environment. Koala populations and habitat in New South Wales

This assessment does carry with it considerable uncertainty due, in part, to information on current status of habitat and koalas being imperfect with gaps in our knowledge; plans and decisions about transport and layout and sequencing still being determined; fundamental epistemic uncertainty in our ability to know the climate change pathway that we are on, and as a result the local implications of that at a point of time in the future.

However, efforts are being made to improve our understanding of the current habitat and koala conditions (including proposed studies by EES on chlamydia, and a koala genetic baseline project as part of the NSW Koala Strategy) and deploying adaptive management approaches can enable some decisions to be made into the future that are informed by measurements and observations at the time.

Table 2 sets out the Panel's comments on the actions and commitments of the CPCP (detailed in Table 1). These comments reflect Panel observations including whether there is misalignment with previous advice from OCSE (2020 Report and/or February 2021 Advice), whether the action appears adequate based on the information available, whether there are additional issues that the Panel has deemed relevant in operationalising the actions.

A number of these elements are elaborated on further in Section 3.3 where more detailed discussion is provided. Section 3.3 also sets out overarching principles that can be used by proponents in moving forward in the CPCP, to maximise as much as possible the outcomes for koalas. These principles are applicable to identified locations within the CPCP (GMGA and WGA), locations in South Western Sydney within the CPCP but outside of the growth areas such as the area between the WGA and GMGA, or areas that may be in the near vicinity but outside the CPCP such as near Appin. These Principles for application outside the CPCP envelope are in response to the Panel's Term of Reference 2.

Table 2: Draft CPCP commitments and actions and associated Panel comments.
This Table should be read in conjunction with Table 1 that presents a fuller description of commitments and actions as provided by CPCP team in DPIE.

Commitment	Actions	Panel comments
8. Mitigate impacts	1. Install koala exclusion fencing	• Arrangements for the ongoing care and maintenance of mitigation structures, such as fencing, will need to be established in perpetuity. • Fencing is due to be delivered over the life of the CPCP, with the first stage to be completed by 2023. Installation of fencing, especially in road hotspots and around connectivity structures, should occur as a matter of priority. • Fencing should not have trees (including koala feed trees, shelter trees, and other tree species) within 3 m, to avoid falling branches compromising the structural integrity of the fences. The 3 m distance should be measured from the canopy of the tree (not the trunk) and the fence should be constructed on urban capable lands. • Where fencing is not feasible due to steep terrain the actions suggest specific development controls 60 m from the koala habitat will be used. The 2020 Report and February 2021 Advice provides guidance on habitat buffer zones for the corridors (summary at Appendix 2). This includes a 30 m buffer in areas with exclusion fencing and 60 m buffer in areas where exclusion fencing is not possible. The advice also provides guidance on Asset Protection Zones (APZs) which should be considered as separate to the habitat buffer as they serve different purposes. • Other corridors, that will be fenced-off, will provide insurance habitat if the main east-west corridors are unable to provide connectivity or are affected by events such as bushfires, etc. • There is a need to ensure that there is consistency of fencing across other tenures within and not within the CPCP. For example, it is not clear what fencing measures are occurring on the south side of Woodhouse Creek/Beulah Biobank Corridor, noting that the north side is subject to a biodiversity certification process separate but adjacent to the CPCP. Similarly, fencing proposed for the south-east WGA is subject to the Walker Corporation draft Koala Plan of Management (KPoM). • In the east of the WGA, there is a road that bisects koala habitat and results in it requiring connectivity (Figure 2, red circle). The islanded component would not be of a sufficient size to encourage one, let alone multiple, individual koalas to persist within the landscape, and the habitat serves no connectivity function. As it stands, the panel believes a better approach would be to not consider this as koala habitat (See Section 3.3.1.4).
	2. Feasibility for fencing and locations	
	3. Fencing along western alignment of Georges River koala reserve	• Fencing along other corridors and habitat units (in addition to the Georges River Koala Reserve), in both GMGA and WGA areas, will also be needed to separate koalas from threats.

	4. Fencing at roadkill hotspots and both sides of Appin Rd	• These areas should be prioritised to reduce the impact of current levels of vehicle strike and should be developed in conjunction with connectivity structures (See Commitment 13 comments). • As roads and transport infrastructure are implemented out across and adjacent to habitat, attention will be required to the creation of further roadkill sites, fencing and underpasses and adaptive responses will be required.
	5. Stakeholder engagement on fencing	• Community will be key to identifying and reporting the integrity of mitigations day-to-day that may not be picked up by a monitoring network or inspections – such as damaged fencing, incursion of dogs, etc. Stakeholder engagement will be essential to ensure support for the fence – if people understand its purpose, they may support it, otherwise there is a risk it will be resented or vandalised. The Panel supports the community engagement process that is currently being procured.
	6. Working group for implementation	• There is need to include independent koala experts in the working group
	7. Dogs on public land managed	• The 2020 Report noted that there is the potential for areas of vegetation to be utilised for public amenity (via double-gating or similar protection), but this should be with the absence of dogs (i.e. dogs should not be in any of the corridors). Appropriate signage, community awareness programs, etc. should be used to convey this. • Community will be key to identifying and reporting the integrity of mitigations day-to-day that may not be picked up by a monitoring network or inspections – such as damaged fencing, incursion of dogs into habitat. • In Port Macquarie there are dog training courses that help dogs avoid koalas. This could be investigated and included as part of a community awareness program.[18]

[18] https://www.abc.net.au/news/2017-11-13/how-to-train-your-dogs-to-protect-native-wildlife/9144748

	8. Safe fauna crossings	• Design, layout, and maintenance of these crossings will influence their use by koalas (Section 3.3.2). Irrespective of the type of structure employed, all crossings should be dry (and could include wildlife furniture such as logs) and should have line-of-sight to the other side (i.e. no bends but should be a straight structure) to encourage usage. Further they should be constructed alongside fencing, effectively providing fauna no other crossing options or the ability to move onto roads. • If a culvert option is preferred, there is benefit in exploring the feasibility of multiple culverts as a proactive measure to maximise connectivity (e.g. at the Ousedale corridor crossing Appin Rd). • The set of options for the crossings at Ousedale that the Panel was shown with minimal or no habitat evident. This issue is a priority and needs to be addressed as it is difficult to see how the connectivity would function. The Ousedale connectivity structures should connect directly to habitat on both the eastern and western side of Appin Road. • The Panel notes that the Walker Corporation has explored the option of an overpass at the Ousedale corridor. This option should be investigated as a priority as the east-west connection between the Georges River and Nepean River corridors is a primary element of the effectiveness and adequacy of the CPCP. • The Panel supports the Kings Falls Bridge connectivity structure as per the 2020 Report. It is understood that early planning has identified construction of 500m of fencing to the east of Kings Falls Bridge.. This area should be monitored and further fencing and/or other mitigations may be required. • The Plan proposes no additional koala crossings for WGA. However, the Walker Corporation KPoM[19] proposes koala crossings along Picton Road (Figure 2, blue and yellow circles) for south-east Wilton. This needs clarification, the Panel understands that there is currently an underpass in place but is uncertain of its condition and details of its design, and evidence of koala use, so can't advise on adequacy or refurbishment.
9. Protect native vegetation	1. Purchase land, with priority of land for sale and in koala Reserve	• The purchase, protection (via Biodiversity Stewardship Agreements (BSAs)) and/or maintenance of lands should be a priority action and conducted in a timely manner, as delays could cause degradation to the environment. The Panel recommends that this protection proceeds independent of the progression of development parcels. The Panel believes this is a key risk in the implementation of the CPCP – to achieve the aim of the CPCP, protections based on tenure must be put in place as soon as possible and must not be allocated over the life of the plan. • Land purchases and/or protection in the Ousedale corridor should also be prioritised, as it is proposed to be the key east-west corridor in the CPCP for connectivity between the Nepean and Georges Rivers. The Panel notes, prioritisation should not be the only criteria.

[19] EEM (2020) Wilton Koala Plan of Management. Prepared for Walker Corporation

11. Establish a reserve to protect koala movement Georges River	1. First stage government land 700 ha for Georges River Koala Reserve 2. Transfer to National Parks 3. Gazette as a conservation reserve 4. Protect additional 430 ha through purchases for Georges River Koala Reserve 5. Protect 755 ha for Georges River Koala Reserve 6. Restore 80 ha to koala habitat within Georges River Koala Reserve	• The establishment of and the current and proposed efforts to protect and improve the habitat in the Georges River Koala Reserve appear adequate and will help protect the habitat and provide a linkage across the landscape. • Like Commitment 9 comments, there is an extended period of time associated with this action, which could lead to the degradation of the habitat and other perverse consequences unless measures are taken to maintain quality, these could be through community programs or more formalised arrangements. • Further, revegetation and restoration efforts here (and elsewhere throughout the CPCP) should also occur as soon as possible, to ensure that vegetation has maximum time to establish and grow for koala and other fauna use. An additional benefit is carbon capture.
13. Secure habitat corridors in perpetuity	1. Secure habitat and corridors in accordance with CLIS	• Like Commitment 9 and 11, there is a need to ensure that this is conducted as soon as practical, as this will ensure the best outcomes for the habitat (i.e. reduction in threat ingress or degradation of the environment).

	2. Protect habitat as avoided land in east-west corridors	• As per Commitment 9 and 11 comments, there is a difference between development controls and maintaining the environment. There is a risk, if not managed, this could lead to degradation of koala habitat (e.g. weed invasion, death of trees due to age or dieback, dumping, firewood removal, vandalism, etc.) • The Panel is not sure if the Nepean Creek to Beulah Corridor (Corridor C) and Mallaty Creek (Corridor D) are included (counted) as koala habitat, as koalas will not be able to access these lands. Regardless, the lands should be protected for their other biodiversity values and potential alternative connectivity routes.

	3. Ensure at least 1 north-south corridor (Georges River) is average minimum with of 390-425 m	• Based on the Panel's review of draft CPCP maps the Georges River Corridor appears to meet the minimum average width (Appendix 2: Figure A3). • This habitat is also connected to large areas of habitat to the east, although it is understood that this easterly region is predominantly sandstone landscape and therefore poorer quality for koalas compared with the shale transition landscape in higher parts of the GMGA • The Georges River and Nepean River Corridors, Ousedale Creek habitat and the Elladale Creek habitat in the GMGA are all important for koala habitat with multiple subpopulation units building resilience into the population. The separation between habitat near the Georges River and to the west toward the Nepean River means that in the case of fire on one side or the other, there will be refugia to increase resilience and help ensure regional persistence of koalas in the face of an acute threat. • The Nepean corridor in the draft CPCP does not appear to the Panel to meet the average minimum width (Appendix 2: Figure A3). One of the drivers for this is a narrow section of habitat that the Panel identified early in the process, then followed up with a site inspection. The visit also revealed the steep topography in this area. A corridor in the north-west WGA also does not appear to the Panel to meet the minimum average width (Appendix 2: Figure A4). • The Panel has questions about the Primary Corridor along the Nepean River (Appendix 2: Figure A3), in relation to the methodology used to estimate width in respect of the functionality of the corridors – see below further discussion in Section 3.3.1.4. • The material supplied to the Panel currently focuses on Georges River Koala Reserve (acknowledged as important) but is almost silent on the Nepean River Primary Corridor in both the GMGA and WGA. The CPCP should acknowledge (and address) this importance. Also, of note is that the GMGA and WGA borders are not directly connected, yet the Nepean Corridor connects both these Growth Areas. The CPCP document is not clear on the intentions or protections for this habitat. The Panel notes that this report will provide principles and advice that can be used in locations outside of the two growth areas under TOR 2; see Section 3.3. • As set out in documents provided to the Panel, the plan west of Appin Road seems to prioritise secondary above primary corridors. Primary corridors may be more important than secondary corridors in terms of the extent of primary koala habitat, although the koala presence mapping is inconclusive in terms of whether more koalas use habitat that has been designated as Primary versus Secondary. The Nepean River Primary Corridor should be protected as Primary Corridor. • All areas to the west of Appin Road are important in part because they provide population resilience (e.g. refugia habitat against future fires that may occur in the Georges River Koala Reserve)

	4. At least one east-west corridor (Ousedale Creek) a. underpass at Appin b. average 390-425 m and fenced	• The east-west connectivity function of Ousedale Creek Corridor is important. • The habitat in the north-south arm of Ousedale Creek (parallel to Appin Road), as well as the east-west oriented section are also important for the habitat they provide to koalas. • The habitat in Elladale Creek also provides considerable hectares of habitat that is important to conserve, and to maintain linkages to (for koalas) in the case that transport corridors dissect the unit. • The Ousedale Corridor is reliant on land purchases and restoration. Sub-Plan B notes that that securing and enhancing the corridor is due to start, but not finish, within the first five years of the plan's implementation. This should occur as soon as possible, to maximise the growth of revegetation and minimise the possible degradation of the environment. • The Upper Canal could be an impediment to koalas moving through the Ousedale Corridor. How koalas will be able to cross the Upper Canal needs to be considered as if koalas cannot easily cross the Upper Canal, the Ousedale corridor may not adequately provide east-west connectivity. • See comments on Commitment 8.8 • The overall east-west connectivity should not rely on one corridor. Multiple corridors must be protected. • The Panel notes that additional corridors with underpasses at Appin Road have been proposed at the Beulah Biobank and Noorumba Reserve in the proposed Lendlease MGS2 development. These will provide one or two additional routes between Georges River and Nepean River in the GMGA area and will prevent a dead end at the North end of the Nepean Corridor which was a highlighted concern in the 2020 Report.
	5. Fence off east west corridors too narrow, relocate koalas, habitat will be protected.	• Fencing corridors that are too narrow for koalas (e.g. Corridor C and D) at east-west ends facilitates use by residents, while bushland would be preserved. The Panel agrees with this approach for these Corridors. • These east-west corridors, whilst not currently slated for use for koalas, will provide vital insurance habitat if other options do not have the desired outcome for koala persistence • See Section 3.3.1.1 for the Panel's comments on a similar issue in the WGA.
14. Ecological reconstruction up to max 25% of offset target	1. Weed and restoration control working group and Weed Control Implementation Strategy	• This action is particularly important for land that will be either in private hands or will be subject to a BSA or land purchases. Efforts to avoid land degradation will require planning and collaboration with landholders across tenures. These efforts will also need clear monitoring.

in conservation land	2. Restoration Implementation Strategy	• This action is particularly important for land that will be either in private hands or will be subject to a BSA or land purchases. Efforts to avoid land degradation will require planning and collaboration with landholders across tenures. • Consideration should be given to factors such as soil types for restoration of habitat, to target and/or maximise the highest quality habitat • Much extant koala habitat is on steeper land on Hawkesbury (sandstone) soil landscapes and shale-sandstone transitions, whereas shale-based soil landscapes were mostly historically cleared but offer significant potential for augmenting the nutritional quality of existing adjacent habitat. • Some mapping seen by the Panel pointed to revegetation and restoration efforts occurring on the south side of the WGA area within or adjacent to the Water NSW area (Special Area of the Sydney Drinking Water Catchment), which has been identified as a Primary Corridor (Figure 2, purple circles). The Panel has not seen detail on the planning or confirmation that this revegetation will go ahead, and some mapping doesn't show revegetation of this area. There is considerable land in this zone on some shale Blacktown soil landscape and with good quality revegetation potential.
	3. Written agreements to implement restoration plan	• Agreements for restoration should be enforceable so that the best possible chances to deliver quality habitat are in place.
	4. Maximum of 1,365 ha of ecological reconstruction on conservation land targeting 5 TECs	• See Principles on Habitat and Connectivity

	5. Ecological restoration including in Georges River Koala Reserve, Appin, Ousedale Creek (primarily Cumberland Plain Woodland and Shale/ Sandstone transition forest)	• Absent in this Commitment 14 is any reference to the north-south Primary Corridor along the Nepean River (east side or west side of the river), and any discussion of securing habitat associated with the WGA, including the status of land at the eastern edge south of Picton Road (Figure 2, yellow circle), and habitat along corridors east/west of the Nepean River (Appendix 2: Figure A4). • Habitat south of the WGA within the Water NSW tenure had also been identified as suitable for revegetation but that is not mentioned (Figure 2, purple circles) • Soil type and quality, which includes water-holding capacity, is an important contributor to koala feed tree health and nutrition content (i.e. the quality of the habitat). This should be considered, with priority for higher quality habitat (especially in the context of a changing environment), although noting that this may not always be possible. Targeting revegetation on shale soil in preference to sandstone is recommended, due to the greater nutritional and water carrying properties of shale soils (Section 3.3.1.3). • The earlier the restoration efforts can be started, the more mature the habitat will be by the time development rolls out across the two growth areas.
	6. Pilot sites for restoration of TECs	• The Panel is unaware of what actions might arise or be reliant on this pilot. Nevertheless, this pilot should not preclude management and revegetation actions occurring in the meantime
21. Residents participation in biodiversity conservation	1. Invest in NSW Koala Strategy to raise awareness and encourage participation in koala conservation	• Citizen science will play an important part in understanding and protecting the koala population in the region. The Panel notes that there are existing and active community groups in this region. • Awareness around potential threats, particularly dogs, will be a vital component of community awareness
23. Invest in research priorities that support Plan's implementation	1. Research programs with outcomes of population demographics, life-history, and ecology as part of NSW Koala Strategy	• Whilst it is important that the CPCP monitoring can feed into and support the NSW Koala Strategy, there will be site specific monitoring that will need to be conducted to ensure the persistence of koalas in the region. Further, all monitoring should address clear goals. This is further outlined in Section 3.3.5.1 • Monitoring protocols should be established, and baseline monitoring should be conducted as soon as possible, as it can be used to set targets against which success can be measured. This will ensure consistency of methodology for valid comparisons and identification of trends. • Monitoring how koalas are using the landscape will also inform mitigation actions.

24. Rehabilitation measures to maintain koala health and welfare	1. Implement Koala health and welfare program in South Western Sydney – monitoring threats and mitigation effectiveness; designated monitoring site; veterinarian training; grants for community wildlife orgs and carers; establish health and welfare programs for koalas from threats	• As Commitment 23 (Action 1), there will be region-specific monitoring that will need to be conducted.
		• A good example is monitoring related to chlamydia. This would include monitoring of the possible ingress of chlamydia into the area, and work should be undertaken that is informed by the chlamydia mapping work that will be undertaken by DPIE-EES in June 2021. This could provide early identification of:
		  ○ presence and absence of disease; and,
		  ○ routes of ingress of chlamydia through the landscape. Considerable movement barriers through the landscape (roads, rivers, reservoirs) provide opportunities to identify certain choke points where monitoring can occur to detect the presence of chlamydia and intervene in the spread of the disease.
		• In understanding where chlamydia is occurring or entering, this could inform approaches to koala health management to treat chlamydia if it eventuates in the area.
		• The NSW Government-supported genetics work on NSW koalas will also provide data that could inform ongoing management actions.

	2. Koalas handled to be vaccinated against chlamydia and tissue sample taken for genetic analysis and sent to Biobank	• Chlamydia vaccine development is still in the trial phase with efforts underway to explore effectiveness against disease variants and impacts for koalas in NSW. Given trial stage of vaccines, they should be deployed under a research protocol so that outcomes can be interpreted and contribute to development effort, until an agreed vaccine is established and approved (see Section 3.3.4.1). The Panel notes that trials are currently underway, and this can be rolled out quickly in the region. • Vaccines are yet an unproven technology and may not ever achieve their potential. While it is appropriate for the CPCP to recognise their potential and to incorporate them as part of the plan as a trial or research direction, at this stage they cannot be a substitute for other actions.

3.2 Major trends in South Western Sydney

There are several major trends that will impact koala populations in the South Western Sydney region over the coming decades. These will influence the viability and persistence of the koala populations over the next 30 - 40 years and are crucial factors to consider in making judgements on the adequacy of measures to enable koala persistence. Section 3.2 briefly describes these trends, while the discussion in Section 3.3 provides Panel commentary on the CPCP approach to mitigation and management actions considering these trends and the proposed planning developments.

3.2.1 Urbanisation

As discussed in Section 1.1 the GMGA and WGA are slated for development. These areas will include ~55,000 new homes, associated retail and community facilities, roads, and major infrastructure (including the Outer Sydney Orbital). This will change this region from semi-rural/peri-urban to urban/suburban. Conversion from rural-type landscapes toward urban has led to declines in koala numbers in other parts of NSW and in the southeast corner of Queensland.

Such declines in koala numbers are associated with "*habitat loss and fragmentation, reduced connectivity or isolation of populations reducing genetic diversity, increasing susceptibility to disease and increasing threats from vehicle strikes and dog attacks.*"[20]

The landscape wide approach to planning for the CPCP has been undertaken with a view to incorporating measures that will maintain habitat (including for koalas), reduce interactions with threats as the numbers of vehicles and domestic dogs increase, and maintain connectivity of habitat through the landscape. Development and construction in the area will occur over the next 36 years, with residents, industry and human activity then continuing indefinitely, so change will happen relatively quickly.

3.2.2 Koala populations and disease

There are two koala populations associated with the region of the GMGA and the WGA. These populations are known as the Campbelltown and Southern Highlands populations. Campbelltown koalas have a low population density (compared with other populations in NSW), but are understood to be growing in number, one of the few growing populations in NSW at the present time. More detailed information on the Campbelltown population is available in the 2020 Report (Section 1.3.1) [21]

Koalas in the vicinity of Campbelltown, based on current knowledge, have not shown evidence of chlamydia infection. Further south toward Wilton, into the north Southern Highlands and then further south the prevalence of chlamydia infection in koalas gradually increases. Evidence from other sites in NSW where Panel members have worked has demonstrated that when chlamydia infection enters a koala population, this can lead to a considerable decline in koala health, numbers and resilience as it reduces reproductive potential and the ability for population replacement and expansion. It is understood that based on current connectivity and observations, chlamydia could enter the Campbelltown region in the near term. A study to be conducted by EES in mid-2021 will look over the Campbelltown and Wilton regions, map koala presence using drone technology and sample for chlamydia.

A combination of mitigations, management and monitoring actions for chlamydia infection is described in Section 3.3.4 to reduce the impact of this into the future, as chlamydia could be an important threatening agent for these populations. Processes such as disease incursion can occur in a matter of months to years; this timing influences the options for management which is discussed more in Section 3.3.3.

[20] OCSE (2020), Advice on the protection of the Campbelltown Koala population
[21] OCSE (2020), Advice on the protection of the Campbelltown Koala population

The NSW Koala Strategy, which is in preparation, will have a goal to double the koala population in NSW by 2050. Whilst this population in Campbelltown only plays one part of the greater state-wide goal, the population is one of the few that is currently understood to be expanding and appears to be disease free, and as such a reduction in koala numbers would impact the ability to achieve the goal of doubling koala numbers across the state.

3.2.3 Future climate

Current predictions are that average global temperature increases of between 1.5ºC and 3ºC compared to pre-industrial levels may occur over the coming decades. Whether the change is closer to 1.5ºC or 3ºC will depend in part on the extent and success of international mitigation efforts to reduce emissions and minimise global temperature rise.

These global changes are expected to result in change at the local scale. The risks to habitat and landscapes from warming climate depend on factors such as the rate, duration, and magnitude of warming and geographical location. In NSW changes in temperature, evaporation, rainfall, and other climate variables are modelled using the NSW and ACT Regional Climate Model (NARCliM).[22]

Change could include increased intensity, duration or frequency of droughts, bushfires, and heatwaves, and changed rainfall patterns. Increased atmospheric CO_2 concentrations and temperatures and changes in rainfall will impact vegetation and in so doing alter the profile and nutritional status of koala foliage. The aggregated effect of these changes will be an overall reduction in the likelihood of koala persistence given the *status quo*. Mitigation measures such as improved availability and access to refugial habitat can compensate for these changes to some extent.

A key risk for koalas and demonstrated in 2019/20 is the threat of bushfires to wildlife and habitat. Maintaining a connected population from the Georges River Koala Reserve, west to the Nepean River Primary Corridor and associated GMGA habitat provides some resilience for the population which is described in more detail in Section 3.3.1.

As was evident in 2019/20 bushfires can have major impact on koala populations in a very short time frame - hours to days - which limits the possible mitigation efforts that can be put in place. This is described further in Section 3.3.1.2.

3.3 Principles for koala protection

As stated in the 2020 Report "*efforts to increase the availability of habitat while reducing the interface with threats, and maintain genetic and physical health status, are important pillars upon which to plan measures"*.[23]

This section of the report provides Panel feedback on some proposed mitigations in the CPCP including overarching principles that can inform the approach to koala protection measures across the GMGA, WGA and surrounding areas. This section builds on information in Table 2 and 3 and is informed by guidance in the *Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas* report[24], the 2020 Report and February 2021 Advice. The section also provides an assessment, as far as it can, of the adequacy of the current draft CPCP proposed for koalas and provides recommendations on areas that will assist in ensuring the persistence of the koala populations.

A concern for the Panel is, if changes are recommended by it to the CPCP, whether these can be accommodated directly or whether they will require trade-offs in a planning sense, and if trade-offs are required, can these be done in a way that does not lead to perverse outcomes where the result is less satisfactory that the original situation. The Panel will not be involved with such negotiations

[22] https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM
[23] OCSE (2020), Advice on the protection of the Campbelltown Koala population
[24] DPIE (2019) Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas

but has tried to provide principles below that can be used by the CPCP proponents to get to positions where the outcomes for koalas are improved. The Panel requests those involved with these discussions to consider the implications for koalas actively, considering the habitat and other species that may use the habitat, including in applying the principles. Every location and situation will be different and nuanced, and considering the situation on the ground will help avoid negative outcomes.

3.3.1 Habitat and connectivity

"Access to increased (or retained) koala habitat has prima facie benefits for koalas".[25] Koala habitat across the region needs to be retained, protected, managed (to prevent degradation) and increased (e.g. through revegetation) to support koala movement and persistence so that dispersing koalas can move through the landscape, can breed to ensure genetic diversity, and can access refugia in times of stress, bushfire, drought, or other threats.

Regional planning upfront and on the broad scale is beneficial in that it allows restrictions and requirements to be established now in planning policies and approval conditions that can help improve outcomes for natural assets and environmental values across a wide area of land. [26]

However, the *long term and ongoing program of urban development, out to 2056, will result in future unknown events and risks, and possibly opportunities, so scenario planning and mitigation options should be a core component of adaptative planning for preparedness and resilience*.[27]

[25] OCSE (2020), Advice on the protection of the Campbelltown Koala population
[26] OCSE (2020), Advice on the protection of the Campbelltown Koala population
[27] OCSE (2020), Advice on the protection of the Campbelltown Koala population

Principles for habitat and connectivity

1. **Strategic planning -** Habitat protection should be enabled through forward planning and commitments at a regional scale and over the lifetime of the development.
2. **Protected and connected -** Retain, increase, restore and protect koala habitat, reducing fragmentation and increasing connectivity. The habitat should support the movement of koalas such that dispersing koalas can move through the landscape, can breed to ensure genetic diversity, and can access and persist in refugia in times of stress, bushfire, drought, or other threats.
3. **Avoid dead-ends and population isolation -** Ensuring (as far as possible) that the habitat has *multiple* connections can help to prevent the formation of dead ends and population sinks and ensure that koalas (and other species) have routes to move through the landscape.
4. **Corridors provide habitat -** The term 'corridor' should not be misinterpreted to mean that its only function is a thoroughfare and the provision of connectivity. Not all identified corridors are suitable to provide connectivity for koalas, but the habitat should be protected for biodiversity values and amenity in the region, as well as protected koala habitat in some cases.
5. **Corridor widths -** Corridors should be widened where feasible through revegetation to an average minimum width of 390 - 425 m, include a buffer on either side (30 m wide where fenced and wider to ~ 60 m where fencing is infeasible), and trees should 3 m from the fence (to prevent tree branch damage to fence)
6. **Larger area, shorter edges -** Revegetation should be targeted to widen habitat units and corridors where feasible and aim to reduce the edge: area ratio of habitat (i.e. 'fingers' or areas between strips of habitat could by infilled with vegetation).
7. **Habitat buffers separate from APZ -** Buffer zones in corridors/habitat should be separate from Asset Protection Zones (APZs), with APZs on the urban side of the exclusion fence.
8. **Target shale soils -** Where possible, revegetation should target relatively higher quality soils (i.e. to produce higher quality habitat) – shale-based 'Blacktown soil landscape' is preferred to 'Hawkesbury sandstone landscape'.
9. **Earlier planting leads to more mature trees -** Early implementation of koala habitat planting, and restoration can lead to trees being at a more mature stage by the time they are needed, areas that will improve connectivity and nutrition (based on soil type) should be prioritised.
10. **Prevent degradation of habitat -** Early protection and active management will prevent the degradation and loss of existing habitat over the time during development – engage community and stakeholders to protect habitat.
11. **Plan for climate change -** Consider water sources, soil types, tree varieties, and well connected refugia.

3.3.1.1 Tenure and protection

A range of landholder tenures are associated with the CPCP and neighbouring land and are managed under differing legislative and policy instruments, which needs to be considered when making decisions. The habitat corridors across the Greater Macarthur and Wilton region cross multiple tenures and landscapes, connect internally and with each other. The koalas, in using these corridors, do not recognise lines on maps.[28]

[28] OCSE (2020), Advice on the protection of the Campbelltown Koala population

There is a need to understand the potential risks associated with different tenure, and the ability to holistically protect koalas and their habitat. If there is not a consistent approach across different tenures this may result in adverse impacts on koala populations. Shared and coordinated efforts across tenures within and outside the CPCP can help to ensure habitat and threat protection and improvement measures are aligned or consistent across the region (such as make sure both sides of a corridor are managed e.g. fencing etc.). Issues of habitat and potential threats beyond the CPCP nominated regions need to be considered as they will impact the outcomes for koalas.

Within the CPCP, due to the range of tenures and ownership, the protection and restoration of habitat requires many BSAs as well as by land purchases. These agreements and purchases will occur over the lifetime of the CPCP.

Any habitat included in the corridor needs to be protected in perpetuity. There may be the need to investigate methods and/or levers to ensure the corridor and its fencing is protected on other tenures or in a change of tenure, including any future developments.

The upfront protection of the habitat early in the process will aid in ensuring that habitat is not lost through degradation over time. Further areas that are to be acquired for habitat restoration will benefit through beginning early in the Plan, as koala feed trees can take up to 10-15 years to grow to a size and quality that is preferred by koalas. The Panel notes that wet weather conditions are ideal for tree planting and survival.

3.3.1.2 Climate change

The CPCP identifies climate change as a threat to native species and natural ecosystems. The CPCP states that it will *"support existing and new conservation programs"* for climate change adaptation, this includes research, priority strategic conservation areas and providing advice and support to councils to integrate research results, including the identification of climate refugia, in reserve management programs.[29]

Leaf Quality

Planning for future koala needs in a changing climate would assist to mitigate for the likely declining nutritional quality of foliage as a consequence of increasing atmospheric CO_2 concentrations and heat and drought stress, and given the fact that koalas nutritional needs are likely to change with increasing exposure to heatwaves. Increased atmospheric CO_2 is likely at the very least to cause the nutritional quality of foliage at some times of the year to decline[30] and more severe and frequent droughts and heatwaves can be expected to reduce leaf water content at times when it becomes most important to koalas. During heatwaves, we can expect koalas to become less tolerant of plant toxins, and this may change their tree choice.

Planning for the future nutritional adequacy of koala habitat (including the availability of free-standing water and water in foliage) should not be based upon an assumption of unchanged leaf quality in future but should assume an overall decline in the ability of habitats to support koalas in the future, and consequently, a greater reliance of today's high-quality habitat than we see at present. These risks could be mitigated by the introduction of artificial water stations like the Tree Troffs (formerly known as Blinky Drinkers) which could help sustain populations during drought conditions, and the expansion of habitat on higher-quality soil landscapes.

Bushfires

Bushfires also present a real threat to koalas in the region. As mentioned in the 2020 Report, "…*a recent report by Lane, Wallis, and Phillips (2020), that analysed koala records and the extent of the bushfire, found that over the preceding three koala generations the NSW koala population has declined by at least 28.52% and may be a large as 65.95%. The report also notes that the ongoing*

[29] DPIE (2020) Highlights. Draft Cumberland Plain Conservation Plan.
[30] Research in this area is ongoing at EucFACE at Western Sydney University. https://www.westernsydney.edu.au/hie/EucFACE

threat of climate change and its associated impacts (e.g. more frequent and intense bushfires) will severely affect koala populations and increase the risk of localised extinction events".

The *NSW Wildlife and Conservation Bushfire Recovery: Medium-term response plan*[31] includes actions that address koala recovery following the 2019–20 fires. The plan includes *'Appendix A – NSW Koala Strategy: Bushfire Recovery Actions'*. The actions include the identification of habitat refuges for koalas, conservation of koala habitat on private land, raising awareness about roaming domestic dog attacks, providing expert wildlife care, and training, measuring long-term trends in koala population and translocating koala to support population recovery.

There is need to understand how koalas are using the current landscape in regard to refugia, and this also highlights the need to ensure that there are multiple locations where koalas could persist within the CPCP. For example, the Nepean, Elladale and Ousedale Corridors could act as refugia for koalas from a bushfire event in the Georges River (and vice versa) and which individuals could expand from there to repopulate post-bushfire.

Changes in the climate also reflect the need for management and mitigation actions to be developed and employed sooner rather than later. There is a risk if these actions to protect koalas and their habitat are not coordinated in a consistent manner across both tenure and time. This includes the potential degradation of the environment or the lack of protections from threats.

3.3.1.3 Revegetation

To contextualise revegetation in the CPCP, the Panel noted that previous high-quality habitat often coincides with soil types that are now cleared farmland. The vegetation that remained, whilst not suitable for farming due to topography, also occurred in sandstone-dominated riverine incisions, which are lower quality for koalas in terms soil quality.

Therefore, revegetation should be strategic and targeted at achieving the best outcome for koala populations. This relates to aspects of the size and shape of habitat (increasing the area, reducing the jaggedness of edges, reducing linear habitat by infilling between these features, etc.). Where revegetation should look towards soil as an indicator of quality (i.e. relatively higher-quality typically occurs on shale-based soil types, such as Blacktown soil landscapes in this region). Revegetation should also look to maximise corridor widths (see Section 3.3.1.4).

However, revegetation should not result in perverse outcomes, such as increasing the habitat at one key location at the expense of reducing to below adequate at another location, when there are trade-offs are made.

Revegetation should also occur as a matter of priority. This will prevent the degradation of the environment (via either neglect or other forces, such as erosion), and will also allow the trees to mature by the time that those areas are subject to surrounding development.

3.3.1.4 Habitat and connectivity corridors

Corridors function to provide habitat and safe passage across the landscape to ensure connectivity for koalas. Relevant draft CPCP Commitments and Actions (Tables 1 & 2) include securing the habitat corridors in perpetuity (Commitment 13). As noted in the 2020 Report a *"wildlife corridor is a stretch of habitat that joins two or more areas of similar habitat. They can be in the form of a sequence of stepping-stones across the landscape or as a continual linear strip of vegetation/habitat".* Currently, koalas in the landscape can make use of both sparse paddock trees and trees in greater densities in the river incisions. The urbanisation of the region will remove the sparse paddock trees and combined with koala protective measures (i.e. fencing), elevates the importance of the corridors.

Corridors without a destination/linked population are meaningless. Corridors should facilitate the proper functioning of metapopulations, which require multiple interacting subpopulations.

[31] DPIE (2021) NSW Wildlife Conservation Bushfire Recovery. Medium-term response plan

It is important to ensure the preservation of multiple linked pieces of habitat. This builds resilience, and thereby persistence in the population by providing access to refugia and alternative habitat if an event (for example, bushfire) was to occur in another habitat.

An aim protecting corridors should be to reduce 'dead-ends' in the environment (as discussed in 2020 Report). An example of this is in the east of the WGA, where a planned collector road bisects koala habitat and results in it requiring connectivity (Figure 2, red circle) (See Commitment 8, Action 2). The islanded component would not be of a sufficient size to encourage one, let alone multiple, individual koalas to persist within the landscape, and the habitat serves no connectivity function to the land. As it stands, the Panel believes a better approach would be to not consider this as koala habitat, but rather maintain the habitat for other benefits (public amenity, other species, etc.). This could be done without exclusion fencing, depending on the other species in place, whilst preventing koalas from entering (via the installation of koala proof fencing on the northern corridor and no connectivity structure also depending on the other fauna species).

The Panel acknowledges that there are a range of constraints but notes that all efforts should be made to widen corridors where feasible. The corridors are important for connectivity, but they must also ensure the ability for koalas to persist within (i.e. they should also be considered habitat). In some cases, corridors that provide connectivity between habitat units may be comprised of non-habitat trees, although for the purposes of this advice, it is assumed that the trees that comprise corridors contain koala food or habitat trees. All the corridors that are to be protected should not be treated as set-and-forget, as this could lead to degradation.

In Commitment 13 (Actions 3 and 4) there is a focus on the Georges River for north-south connectivity and Ousedale Creek for east-west connectivity. The Nepean River is considered a primary corridor and habitat, in a similar manner to the Georges River.[32] It is of the opinion of the Panel that the treatment of the Georges River Corridor (e.g. including increasing the width through restoration) is not mirrored to the same extent at the Nepean River corridor. The Nepean Corridor will provide access to refugia/alternative habitat if an event (for example, bushfire) was to occur in the Georges River. There are opportunities to improve the amount and quality of habitat in this corridor that could be explored to improve persistence.

Not all the identified corridors are suitable to provide connectivity for koalas (e.g. the Mallaty Creek corridor (Corridor D) does not cross Appin Road and is narrow), but the habitat should be protected for biodiversity values and amenity in the region. The habitat in Elladale Creek (Corridor F) also provides considerable hectares of habitat that is important to conserve, and to maintain linkages to or koalas in the case that transport corridors dissect the unit.

In the context of reducing threats, it would be viable to reduce the occurrence of fingers of habitat that have a large edge: area ratio by retaining the habitat strips and revegetating the gaps in between. Koala habitat in river and creek valleys provides important refugia and resilience to warming and drying climates, a characteristic that is likely to become increasingly important with climate change.

The connectivity whilst ensuring genetic diversity can also increase the likelihood that disease will spread. This is of particular importance in the intersection between the Campbelltown and Southern Highlands populations. This is expanded on in Section 3.3.4.

[32] DPIE (2019) Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas

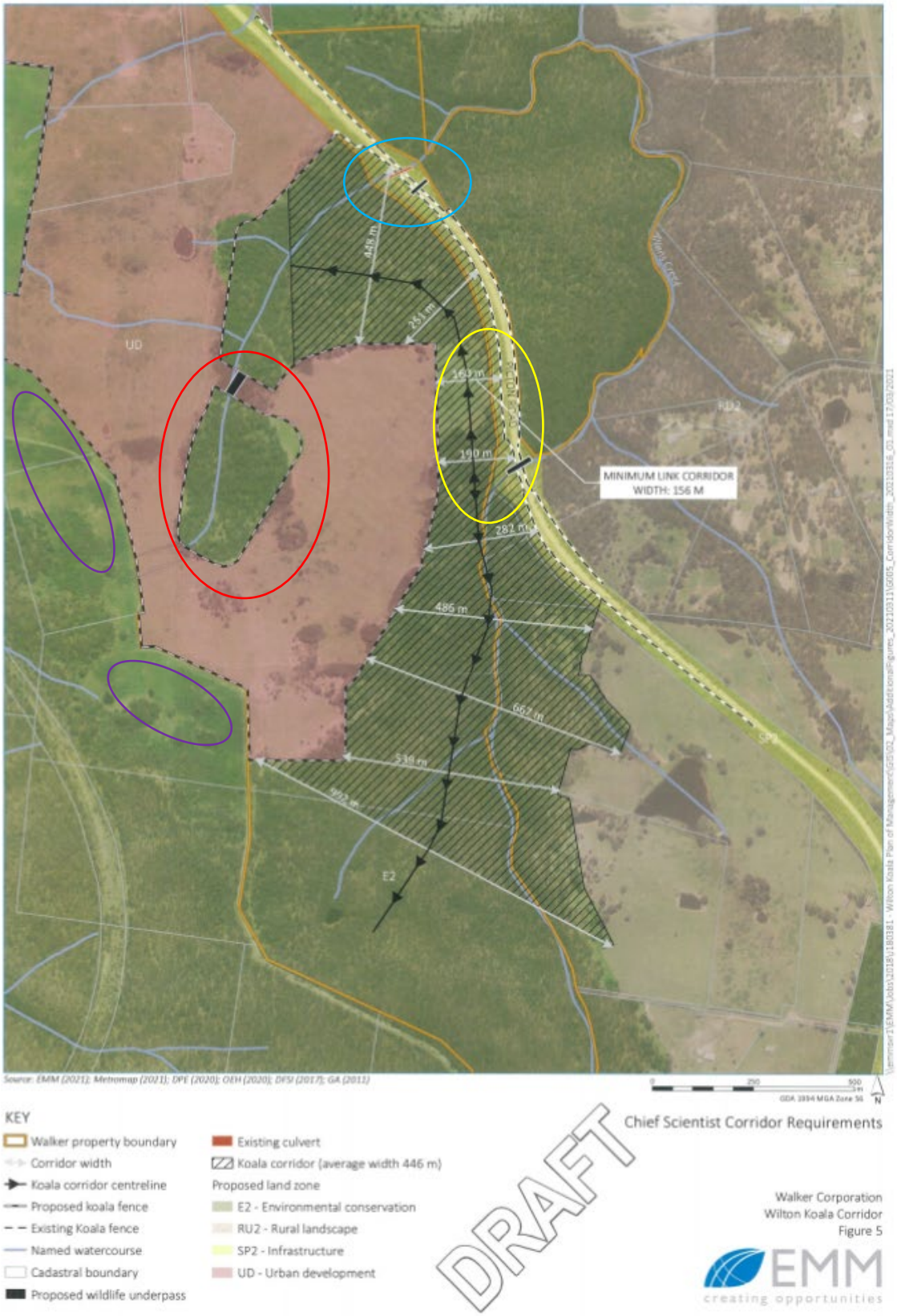

Figure 2: Dead-end and fenced proposed koala habitat including possible underpass in WGA
Circles: Red – Possible dead end/islanded habitat, Blue and Yellow – location of possible underpasses or existing underpasses for augmentation, Purple – Areas for possible revegetation
Source: Walker Corporation (2021) Pers comm.

Corridor widths and buffers

Recommendation 2 from the 2020 Report provides guidance on features of corridors in the GMGA. This includes habitat protection, widening (average minimum width 390 – 425 m or greater), inclusion of a buffer and exclusion fencing. Comments on corridors and buffers from the 2020 Advice and the February 2021 Advice are in Appendix 2. The February 2021 Advice in response to a question about the categorisation of habitat on opposite sides of a river is also relevant here, as well as the advice that on-the-ground inspection should be undertaken as to whether koalas are using the steep riverbank slope or instead the plateau.

Sub-Plan B notes habitat corridors that meet, or with restoration can meet, the requirements of the 2020 Report. 'Safe habitat' was considered to include *"corridors with an average minimum width of 390m - 425m that are fenced to protect koalas from urban threats such as vehicle strike and include safe crossings for koalas at Appin Road".* This includes the north to south corridors along the Nepean and Georges Rivers, and the east to west Ousedale creek corridor, and Elladale Creek habitat.

The maps provided to the Panel by DPIE indicate that the Georges River and the Ousedale Corridors in the GMGA meet the average minimum width recommended in the 2020 Report (390 - 425 m). However, the Nepean River Corridor does not appear to meet the minimum average width (Appendix 2: Figure A3). A noticeable driver of this is the very thin section that the Panel visited on their site inspection, where the topography is also noticeable steep. Further, most of the corridors in the WGA meet the average minimum width, but the northern bank of the north-west corridor does not appear to (Appendix 2: Figure A4).

Site inspections, if they haven't already occurred, should confirm the habitat and terrain characteristics and koala use if possible. A similar matter was raised in the February 2021 Advice for a different site. This includes an understanding of the local topography and how the current koala population moves through the landscape, including if the koalas have a preference for moving long the steep riverbank or whether they use the plateau (where the suburban footprint is planned), which will inform any additional protections. This is also important when considering the risk of fire. These issues should be addressed in the planning phase but prior to approval.

Noting the topography around the waterways, koalas could move through and persist in all but the steepest terrain. In saying that, as these barriers increase in their difficulty to navigate, this could lead to individuals spending more time in these landscapes. Koalas can swim and climb but to what extent and are there limits to the width of swimmable rivers and steep cliffs. Therefore, corridor measurements should reflect their functionality for koalas. Figure 3 is a cartoon aiming to demonstrate the potential for this issue of different topographies in the riparian zone and their differing functionalities (noting that the purple trees represent habitat that is less accessible/useable by koalas). It is not clear to the Panel whether and how much the mapped corridor widths along rivers in the CPCP truly represent the functional corridor as related to koalas. Efforts to check on the ground whether and where koalas do and don't use the rivers edges will inform the functionally useful corridor dimensions. Whether this work could be done by boat or drone survey or by foot is a matter for consideration.

The Panel also notes previous advice regarding riverbanks, in that "… *given that the two sides/corridors are parallel and adjacent to each other, some functions of one side will assist in the minimisation of stressors and/or threats to the adjacent bank. In particular, increasing separation from direct and indirect threats on the river side of the corridor (i.e. from the opposite side): for example, sound and noise attenuation from the adjacent side. Other functions, however, would not be provided by the adjacent corridor: for example, the amount and quality (both food and shelter) of vegetation available to use and move through*".

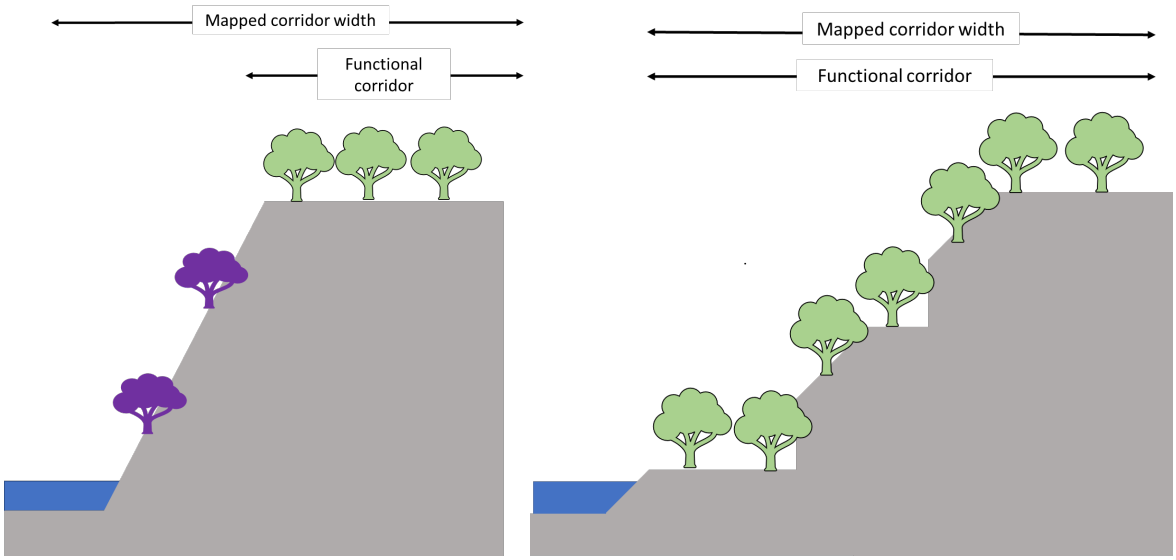

Figure 3: Corridors in riverine areas

The 'green' trees are those in the functional area of the corridor, the 'purple' trees are less likely to be easily accessible.

3.3.2 Connectivity and fauna crossings for linear infrastructure

Linear infrastructure including roads, gas pipelines, electricity infrastructure and the Upper Canal all present potential barriers to koala movement across the landscape. Panel comments on actions to improve connectivity and vehicle strike mitigation are at Table 2.

Principles for fauna crossings for linear infrastructure

12. **Safe movement -** Infrastructure that will cut across a designated corridor should include underpass or overpass structures to enable the movement of koalas along the corridor. Any infrastructure (such as roads) that cross, or might have an impact on, the corridor should be designed to be sympathetic to the protections of the corridor and to enable safe access across or under the linear infrastructure.
13. **Fencing underpasses -** Suitable fencing and connecting habitat put in place early enough through the process so that it is complete by the time the infrastructure is constructed.
14. **Underpass design -** Construction of connectivity structures for roads: overpasses, underpasses (including road bridges) or culverts, with associated exclusion fencing, cattle grids, gates to prevent koalas entering the roadway. Designing underpasses to maximise the likelihood of koala use – look to the latest evidence, include attributes such as clear line of site, avoidance of predator death traps, keep dry, include furniture such as logs for koalas, the bigger the better.

Crossing structures should be incorporated into planning and design of proposed infrastructure from the earliest stage.

The Actions commit to a connectivity structure at Kings Falls Bridge (as per 2020 Report Recommendation 1) and an underpass culvert under Appin Road (near the intersection with Brian Road). However, there is no mention of any structures in the WGA. The corridors in the WGA are all considered as Primary Corridors and connectivity structures will be required to prevent vehicle strike hotspots. The Walker Corporation KPoM shows proposed culverts in the WGA to improve connectivity (See Figure 2), these are mostly existing drainage culverts that could be augmented to improve usability for koalas. This is particularly important for the function of the area as the area will change significantly with development, koalas can use all the landscape at the moment and this will change with development with corridor widths in some places being only ~160 m width.

The GMGA and WGA will include several new transport routes and additional local roads as part of development. This includes the Link Road Corridor through or north of Mount Gilead and the Outer Sydney Orbital Connection through West Appin. The Panel was shown a set of options for these and notes that the routes with less impact on koala habitat appeared to the panel to be slightly favourable for koalas compared with options with more impact.

From the perspective of koala protection there is a need for these routes for transport and the infrastructure design for them to be compatible with and sympathetic to the aims of the CPCP in protecting koalas and their habitat. This includes preventing or minimising the dissection of habitat/corridors (the number of times transport routes that bisect koala habitat) i.e. reducing the amount of separations between habitats, thereby reducing habitat patchiness.

Other factors will need to be considered as they could have an impact. For example, the physical footprint (both during construction and post-construction), speed limits, noise breaks, lighting, etc.

The Upper Canal could be an impediment to koalas moving through the Ousedale Corridor. The Upper Canal infrastructure includes the canal, pipes over Ousedale Creek, a road and fencing. The area is Heritage Listed and considered a Controlled Area under the *Water NSW Act 2014*. The CPCP needs to consider how koalas will be able to cross the Upper Canal. If they cannot easily cross the Upper Canal the Ousedale corridor will not provide east-west connectivity. This needs to be assessed and should include site inspections.

3.3.3 Threat mitigation

There are several strategies and methods that can mitigate the impact of disturbances on koalas and their habitat, particularly at the interface of urban and native environments. This includes, but it is not limited to, vegetated buffer zones and managed habitat areas, koala exclusion fencing (includes fencing at the interface to roads, but also around residential pools and yards), predator and pest management (including weeding programs), disease monitoring and management (Section 3.3.4), vehicle-strike mitigation measures (under and overpasses, road grids, traffic calming devices and road design, signage, speed limits, etc.), and community awareness programs. Specific Panel comments on the threat mitigation are in Table 2.

Principles for threat mitigation

15. **Exclusion fencing -** Maintaining a separation between koalas and threats using exclusion fencing should be a priority, and where this is not feasible (e.g. steep terrain), fallback measures to reduce risk (e.g. vehicle speed limits) and monitoring should be undertaken. Fencing should be adaptively managed with design, location and maintenance evaluated.
16. **Spatial and temporal planning for threats -** Threat mitigation and reducing stressors should be enabled through forward planning and commitments at a regional scale and over the lifetime of the development.
17. **Reducing impacts from construction -** Ensure processes are in place to protect koalas during construction and operational phases of the development. e.g. an onsite ecologist present through the duration of pre-clearance surveys and clearing works, koala and wildlife relocation protocols, tree-felling protocols, and education programs for construction workers.
18. **Sensitive urban design -** Traffic calming measures, planning of greenspace, avoid koala feed trees in urban footprint, domestic dogs secured in neighbourhood backyards, fauna sensitive design
19. **Avoid stressors that repel koalas -** Some effects of increasing urbanisation can increase koala stress levels which in turn can lead to changed patterns of behaviour, avoidance of exposed habitat, increased propensity to disease. Utilise approaches to reduce these effects including buffers.

3.3.4 Disease

The Plan targets chlamydia as a key threat, with koalas in Campbelltown uninfected - although the 'Southern Highlands' population is considered to have chlamydia. Table 2 provides specific comments on actions related to chlamydia monitoring and management.

Monitoring that targets chlamydia is also a priority focus for the persistence of koalas within the CPCP region, as current sampled individuals have not shown a positive result for chlamydia. There should be clear triggers that lead to management actions to reduce the risks posed by chlamydia infection.

Principles for disease management

20. **Avoid chlamydia incursion -** Much of the koala population within the CPCP appears currently to be free of *Chlamydia pecorum* infection. Planning and delivering protection measures should be progressed to maintain this disease-free status as much as possible, and to respond to it should it emerge.
21. **Identify koala routes and monitor for disease -** There is a need to have a monitoring stream that targets chlamydia entry into, and potentially within, the Campbelltown population. This should target specific locations where the Southern Highlands population may intersect.
22. **Vaccine trials -** The Campbelltown koala population may be a good place to conduct a vaccination trial, given its chlamydia-free status. Given the early stage development of the vaccination, a trial could be conducted on the interface between the two populations (the Campbelltown and the northern Southern Highlands population). Vaccines are still unproven so not yet a basis for management.
23. **Adaptive management for disease -** There should be the development of monitoring that matches triggers for actions: actions should be commensurate to the detection level.

3.3.4.1 Comments on the Chlamydia vaccines

The Panel understands that the chlamydia vaccines are still in the development and trial phase. However, given the different chlamydia infection status across South Western Sydney (i.e. not found in Campbelltown and prevalent in the Southern Highlands), this could make the CPCP a perfect location for a vaccination trial. This trial could also be incorporated into a broader monitoring and management program.

The Panel notes that a trial could commence soon. There are currently trials underway, funded through the Research Plan of the NSW Koala Strategy, in the Liverpool Plains by Professor Mark Krockenberger and A/Prof Mathew Crowther (The University of Sydney) and Professor Peter Timms (University of the Sunshine Coast). [33]

3.3.5 Monitoring and adaptive management

As stated in the 2020 Report:

- *Adaptive management relies on the ongoing collection of information and data that informs future decisions about management, responding to threats as they emerge for acute issues, or changing the direction of management approaches to address longer term threats. This relies on appropriately targeted monitoring activities and the development of thresholds and targets and triggers to guide decisions.*

[33] https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/nsw-koala-strategy/nsw-koala-research-plan

- *Management decisions can include vaccination; fence repair; predator capture; relocation, translocation for breeding and gene dispersal; and education and social engagement programs.*
- *Nothing is guaranteed, and both chronic and acute threats can emerge in a landscape to deteriorate the situation for koalas. There will be uncertainty about what hurdles will emerge in implementing a proposed pathway forward, and unforeseen events are also possible; these uncertainties will present challenges to decision makers and land managers.*

Such hurdles could include outbreaks of insects such as psyllid and moth caterpillars that impact habitat quality. There have been numerous examples over the past decade affecting the Cumberland Plain. The most famous was the outbreak of *Cardiaspina* psyllids, around 2013, which caused widespread defoliation and dieback of *Eucalyptus moluccana* (commonly known as Grey Box, a dominant tree species of the endangered Cumberland Plain Woodland Community) from Blacktown to the foot of the Blue Mountains.[34] More recent outbreaks of caterpillars hit *Eucalyptus tereticornis* (commonly known as forest red gum, blue gum or red iron gum) and ironbark's near Pitt Town. These outbreaks are unpredictable, varying in extent, and often involve pest species that have not previously been known to impact these eucalyptus species. Such outbreaks in corridors could severely impact habitat quality, at least for periods of time

Principles for adaptive management

24. **Baseline data set -** Baseline data are required to better understand the status of the population(s), including numbers, distribution and how they functionally use the landscape.
25. **Surveys and monitoring -** Ongoing and regular survey and monitoring efforts, compared against the baseline, to detected population trends over time and inform adaptive management approaches (including the development and understanding of appropriate triggers and responses, including timeframes).
26. **New monitoring technologies -** New monitoring approaches enabled by smaller, cheaper, more sensitive devices, that are connected and remote will increase the extent and value of monitoring programs.
27. **Interface monitoring with NSW Koala Monitoring Framework -** Monitoring should inform the *NSW Koala Strategy*, as a designated monitoring site. Site specific monitoring will need to be conducted within the CPCP and that will evolve over time.
28. **Adaptive management informed by triggers -** Monitoring should include evaluation points tied to management 'trigger' actions and responses.
29. **Timely mitigation -** As per an adaptive management approach, a lack of information should not preclude mitigation activities occurring in a timely manner.
30. **Understand alternatives -** There is also a need to map alternative management approaches that could be employed if actions are not achieving the desired results.
31. **Risk-based emergency response protocols -** Interested stakeholders undertake a risk assessment (likelihood and consequence) and establish monitoring and response protocols – for threats with a fast or slow onset.

3.3.5.1 Comments on monitoring and adaptive management

The CPCP has committed to '*invest in research that will help to secure threatened species and increase understanding of threats and land management issues*' (Commitment 24) and has designated the koala as one of the dedicated species to be monitored. This will include investing in the NSW Koala Strategy to deliver research, monitoring and actions from the first year of the plan

[34] https://www.westernsydney.edu.au/newscentre/news_centre/story_archive/2013/climate_changing_for_bug_battle_in_western_sydney

via the NSW Koala Strategy Monitoring Framework. The 2020 Report provided recommendations for monitoring and adaptive management (Recommendation 3).

Sub-Plan B discusses the development of a monitoring plan and program. It is noted that monitoring efforts will include *"population monitoring (dynamics); genetics sampling; disease monitoring; tests for chlamydia; and monitoring of the effectiveness of mitigation actions, including for example, predator threat monitoring (including at the entrances of bridges and underpasses); infrastructure integrity (holes in fences); movement trackers (predators); location sensors – movement of koalas through landscape; and the effectiveness of underpasses for koala safety. All data collected from monitoring the Southern Sydney koala population will be used in the Plan's evaluation program to ensure the outcome for koalas is met."*[35]

It is difficult for the Panel to assess the proposed monitoring without reviewing a draft monitoring plan.

In the development of the monitoring plan it is important that the monitoring has clear goals, and that triggers are developed that will lead to management actions if they are exceeded. As a first step the baseline needs to be determined. The divergence of the metrics from the baseline data can then be used to gauge the success (or otherwise) of management actions, and population changes, and can indicate when new management actions are needed using an adaptive management approach.

The goals for monitoring could include but are not limited to:

- Threat management
- Understanding koala movements
- Population health (including chlamydia)
- Supporting and understanding broader climate change impacts

Monitoring should include, but is not limited to:

- Number of koalas
- Spatial distribution (this could be through drone surveys, trackers/location sensors or both)
- Sex ratios (is it only males that are moving through corridors or are there breeding females)
- Number of young (is the population breeding)
- Mortality (cause)
- Genetics (this will be enabled through the NSW Koala Strategy and the action to whole genome sequence koalas across NSW to develop management actions)[36]
- Disease status (to detect incursion of disease)
- Use of connectivity structures (predator threat monitoring)

Monitoring could also investigate the change in water availability, changes in vegetation (species dominance, nutritional leaf profiles, etc.). This will help improve management and understanding of climate change impacts.

Whilst this monitoring effort may feed into and support the monitoring of the NSW Koala Strategy, there will be site-specific monitoring for the CPCP that will evolve over time. As noted in the previous report, there could be a developer-fund that helps to support CPCP specific actions.

At the centre of any monitoring should be an adaptive management approach, which is informed by current monitoring and data, and can trigger management actions where required or trigger new monitoring priorities. Noting that Sub-Plan A of the CPCP sets out the adaptive management

[35] DPIE (2020) Sub-Plan B: Koalas. Draft Cumberland Plain Conservation Plan
[36] https://www.chiefscientist.nsw.gov.au/news/world-first-genomic-program-to-help-koalas

approach, and not the evaluation program, there is a need to include both into a clear framework that is updated over time and informed by new data and in consultation with experts. Further to this, there is a need for the Evaluation Committee and the Koala Working Group (Commitment 8.6) to include expertise on koalas and landscape ecology.

Appendices

Appendix 1 – Draft Terms of Reference

Advice regarding the protection of koala populations associated with the Cumberland Plain Conservation Plan

Following the report 'Advice on the protection of the Campbelltown koala population' released by the Deputy Chief Scientist & Engineer in August 2020, advice is sought on how to consider that report's recommendations in relation to the Cumberland Plain Conservation Plan (the CPCP).

The CPCP operates over a greater geographic area and within a different context to the original report.

The CPCP is seeking to avoid and minimise impacts to biodiversity and offset residual impacts on biodiversity from development in the Wilton and Greater Macarthur Growth Areas, the Western Sydney Aerotropolis and the Greater Penrith to Eastern Creek Urban Investigation Area, as well as parts of several major Western Sydney Transport Corridors. Koala habitat has been mapped in Wilton and Greater Macarthur Growth Areas and as such provides the scope for this Terms of Reference.

The CPCP is based on taking a landscape approach to offsetting these impacts, and includes a range of koala specific measures such as establishing the Georges River Koala Reserve, providing connectivity by protecting and restoring vegetation on public and private lands, reducing hazards from cars and predators by installing koala-exclusion fencing and by working with the community to promote actions that improve koala health and welfare.

There is further advice about the CPCP and its koala specific measures as an attachment to this Terms of Reference and a briefing will be provided for you by the Department of Planning, Industry and Environment and Transport for NSW.

Development and infrastructure impacts will occur on koalas in Greater Macarthur and Wilton Growth Areas through the CPCP, noting strong upfront avoidance of biodiversity values has occurred. The CPCP aims to improve condition of koala habitat, maintain connectivity between koala sub-populations, manage threats and ensure the koala population in South Western Sydney persists by avoiding, minimising, and offsetting these impacts through a strategic landscape-scale conservation program.

Advice is sought regarding the adequacy of the CPCP's koala specific measures in supporting a long-term strategic landscape-scale outcome for koalas across Wilton and the Greater Macarthur Growth Areas.

The advice should take into account constraints and risks including:

a. existing development and infrastructure
b. physical constraints such as the Sydney Water Canal and necessary major infrastructure such as the OSO2 Transport Corridor
c. increased corridor width into cleared land currently proposed for development which may result in trade-offs that lead to vegetation degradation or loss in other areas
d. loss of upfront conservation land through the negotiations underway with Walker Corporation for a Voluntary Planning Agreement if changes required to urban capable footprint.

The advice is requested by 30 April 2021 to be provided jointly to the Minister for Planning and Public Spaces and the Minister for Energy and Environment.

Following the CPCP advice, further advice is subsequently requested by 14 May 2021 to be provided jointly to the Minister for Planning and Public Spaces and the Minister for Energy and Environment, regarding:

1. Principles for consent authorities to apply in considering site by site applications in light of the CPCP advice, including how this applies to the Technical Assurance Panel process for the Appin precincts in the Greater Macarthur Growth Area.
2. Spatial application of the advice to the Greater Macarthur Growth Area leading to amendment of the Greater Macarthur Plan.

Appendix 2 – Corridors and Buffers

- Habitat within identified corridors should be:
    - protected (especially from development creep)
    - widened through revegetation (average size 390 to 425 m)
    - include a buffer on either side of the corridor habitat that is at least 30 m wide from the corridor to the exclusion fence with feed trees permitted in this buffer area
    - include, between the buffer area and the urban areas, koala proof fencing to prevent the movement of koalas out of the corridor into urban areas (with trees more than 3 m from the fencing to avoid damage) and the movement of domestic dogs (amongst other potential threats) into the corridor
    - for sites where exclusion fencing is infeasible due to steep terrain, then additional buffer width should be utilised (buffer ~60 m), with a traffic speed limit of 40 km/h and predator / dog monitoring asset protection zone is outside the exclusion fencing, within the development footprint
- Connectivity structures within corridors should also be assessed including local roads and other infrastructure (e.g. the Upper Canal).
- The buffer is designed to reduce the impact of direct and indirect impacts from humans, such as light and noise. Koalas could still persist in these areas and use them as part of the functional corridor but would also be able to retreat to existing habitat areas where the edge effects are less apparent.
- Buffer zones provide a mechanism to minimise edge effects – they reduce interactions between koalas and the urban environment. The buffer zones should:
    - provide separation between the built environment and other associated infrastructure (including roads) be wider when it is not feasible to have an exclusion fence at the edge of the buffer
    - not include APZs, particularly when subject to revegetation
    - not include roads, playgrounds, and picnic areas
    - facilitate the complete avoidance of direct impacts (i.e. road strike)
    - mitigate the impact of indirect impacts, such as attenuating noise and light pollution from the urban development, for native species within the environment
    - prevent koalas moving into urban areas and prevent threat such as dog attacks
    - give consideration to the long-term maintenance of the koala habitat and any proposed mitigation strategies (such as fence maintenance in perpetuity)
- Buffers should be at least 30 m wide from the edge of existing corridor habitat, occur on both sides of the corridor, and have exclusion fencing at their edge, with koala feed trees allowed to grow to the fence, with a suitable distance between trees and fencing to prevent fallen boughs creating damage to the fence.
- If there are not adequate measures to prevent koalas entering the urban environment, revegetation should discourage koalas utilising these buffer zones, this could be achieved by revegetating the buffer with native vegetation that include no koala preferential feed trees. In some locations such as steep terrain, exclusion fencing may not be feasible, and in these cases wider buffers would be required (~60 m), that don't include koala feed trees, and monitor for predators.
- If the preferred method of koala exclusion fencing is used, the buffer zone should be revegetated with preferred koala feed and shelter tree species, with thought given to how far back from the fence line revegetation occurs to ensure that the fence is still effective and that treefall does not pose a risk to its integrity.

- The purpose of having a buffer separate to the APZ is to ensure that there is protection of the habitat and the species within that buffer and not subject them to the management activities required to maintain the APZ as well as the activities permitted within it.
- In undertaking revegetation in the buffer, the layout and tree species chosen should achieve the function of protecting koalas from noise, light, etc. and provide possible refuge from fires. These images illustrate that looking through and across the corridor, any koalas within the corridor would be relatively exposed, therefore designing vegetation in the buffers on either side of the corridor could be done in a way that reduces exposure and increases protection.
- The Panel acknowledges that koalas will move along and utilise the buffer zone, so food and other habitat trees (shelter, etc.) could be incorporated into the design, whilst also recognising other metrics that would protect the current habitat (such as canopy height, canopy density, fuel load contribution, etc.)
- The Panel notes that tree species (for feed and shelter for koalas) and vegetation density are the key characteristics that would lead to functional connectivity, in conjunction with the removal and mitigation of threats (including indirect threats such as light and noise pollution). Buffer zones (of at least 30 m in fenced and 60 m in unfenced) and other mitigations here would aim to reduce these threats.
- the functional roles of Asset Protection Zones (APZ) and of buffer zones to protect koalas are different, and as such need to be differentiated in the design of the interface. APZs serve a role of protecting people and property from bushfire hazard, while buffers associated with koala protection reduce the impact of threats, light, and noise on koalas.

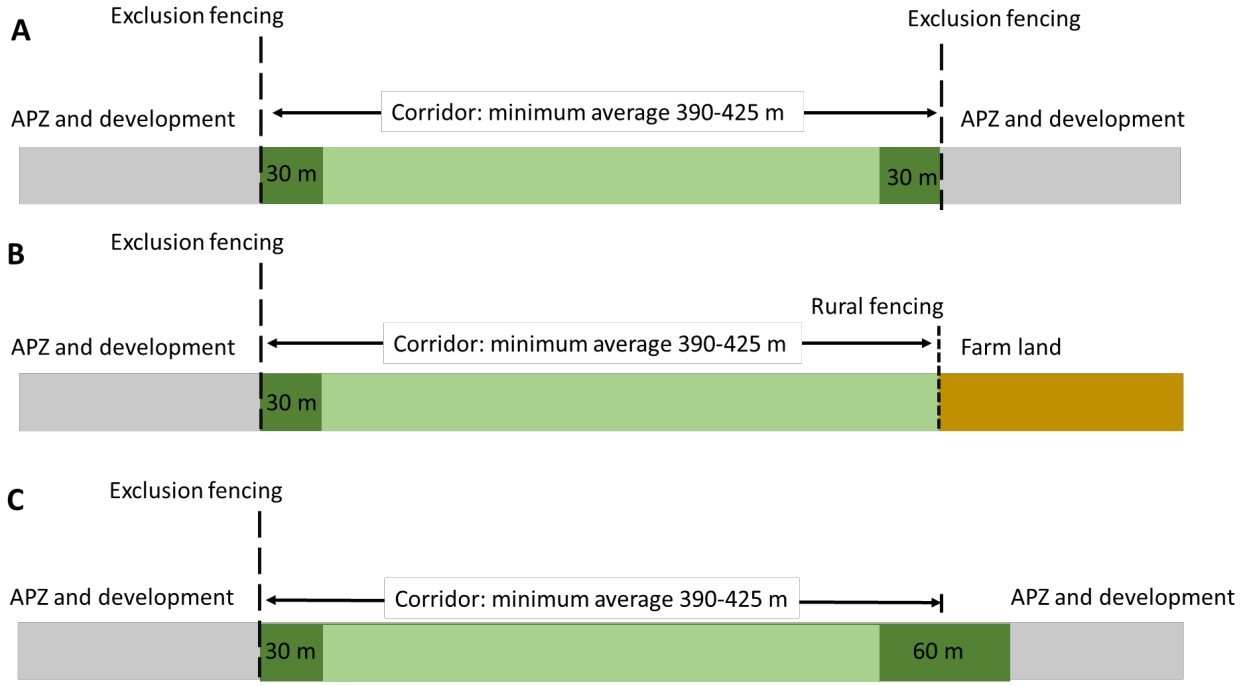

Figure A1: Recommendations for corridors. A) Development either side of the corridor, B) Development on one side and farmland on the other, C) Development on both sides, but with one side unable to be fenced.
Source: February 2021 Advice

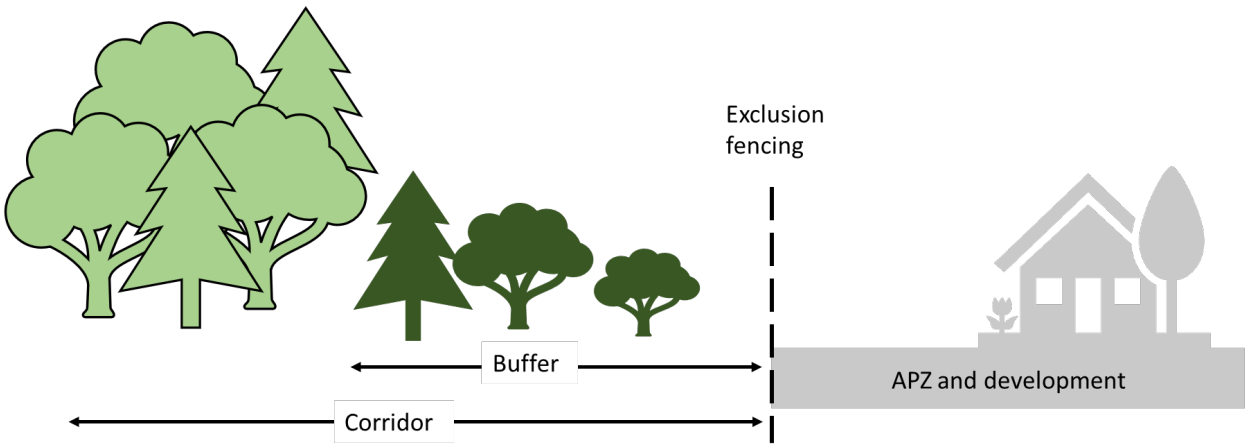

Figure A2: The separation of the vegetated buffer (which can include koala feed and shelter trees, with a bias towards the area adjacent to the corridor) and APZ
Source: February 2021 Advice

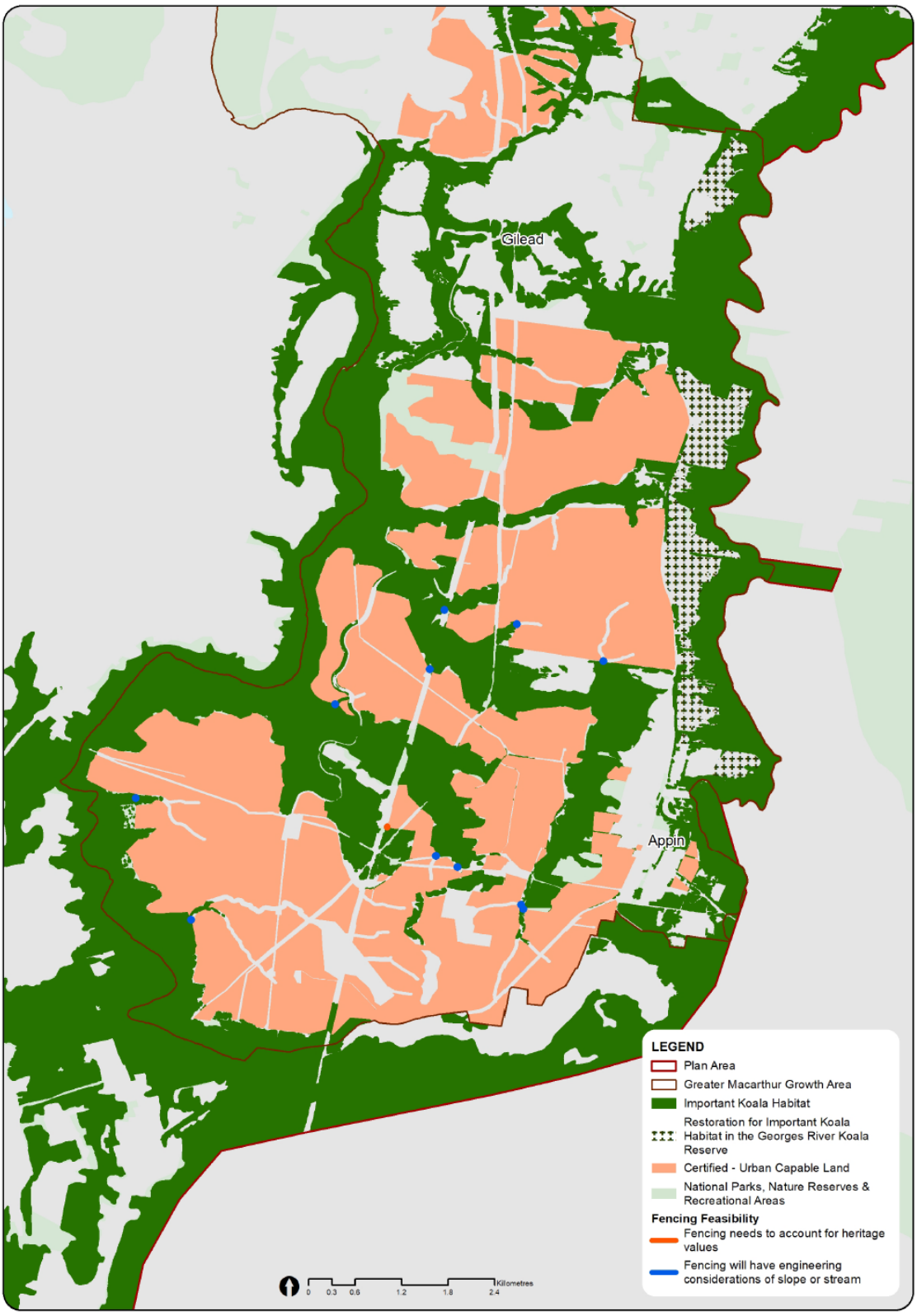

Figure A3: Koala important habitat, corridors and land categories in the GMGA
Source: DPIE (2020) Sub-Plan B: Koalas. Draft Cumberland Plain Conservation Plan

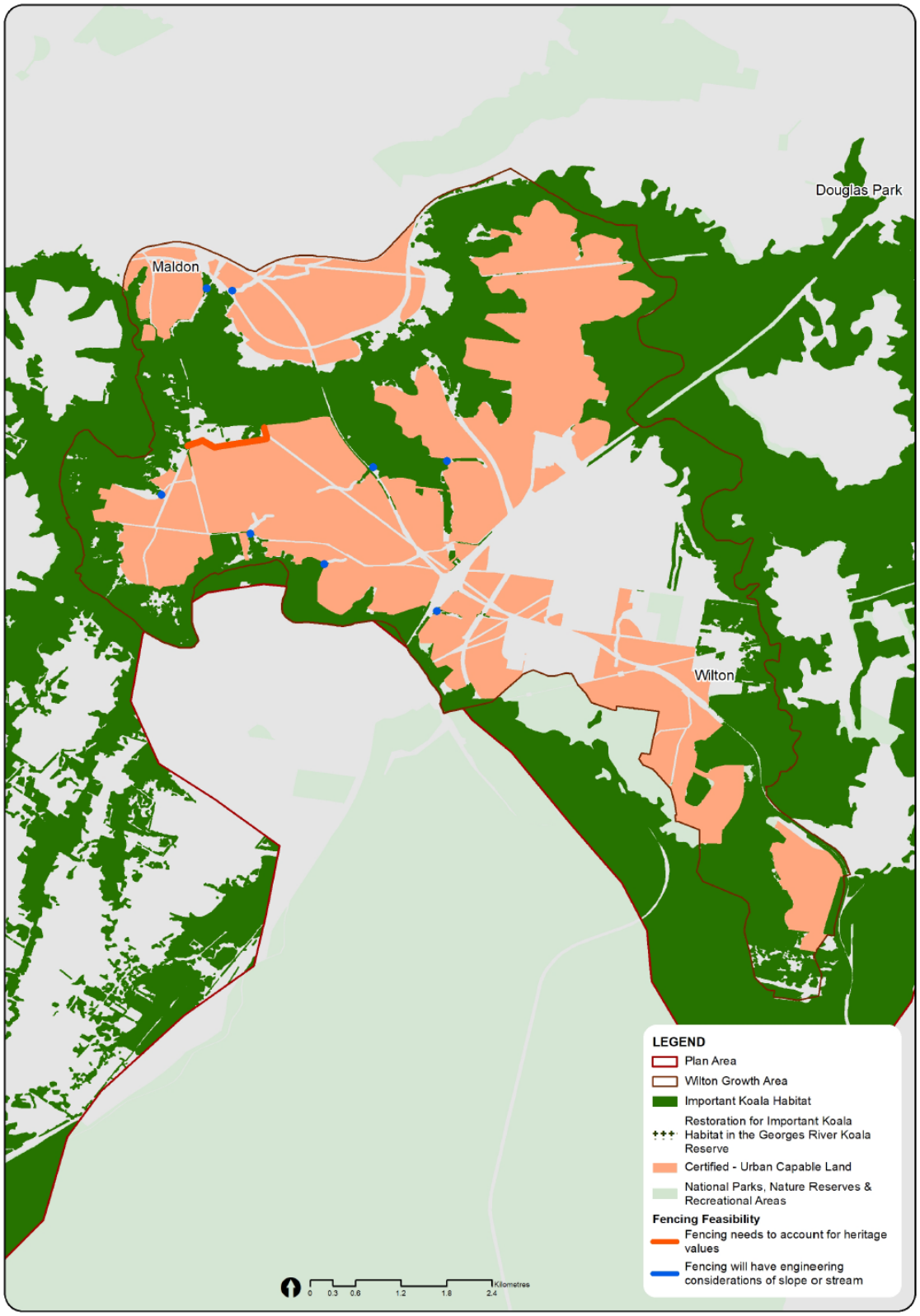

Figure A4: Koala important habitat, corridor and land categories in the WGA
Source: DPIE (2020) Sub-Plan B: Koalas. Draft Cumberland Plain Conservation Plan