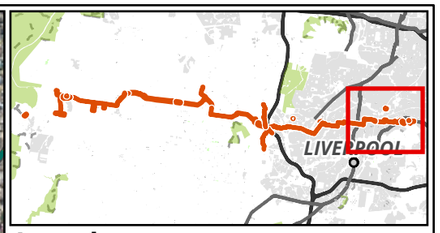

Legend

- Impact area
- Impact assessment area
- Underbore
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.1 Prescribed impacts and estimated zones of indirect impact for the proposal

0 250 500 750 1,000 N

Metres

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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Acknowledgements: Basemap © Land and Property Information 2016, Imagery © Nearmap 2020, public_NSW_Imagery: © Department of Customer Service 2020

Figure 15.2 Prescribed impacts and estimated zones of indirect impact for the proposal

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

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Date: 24 September 2021,
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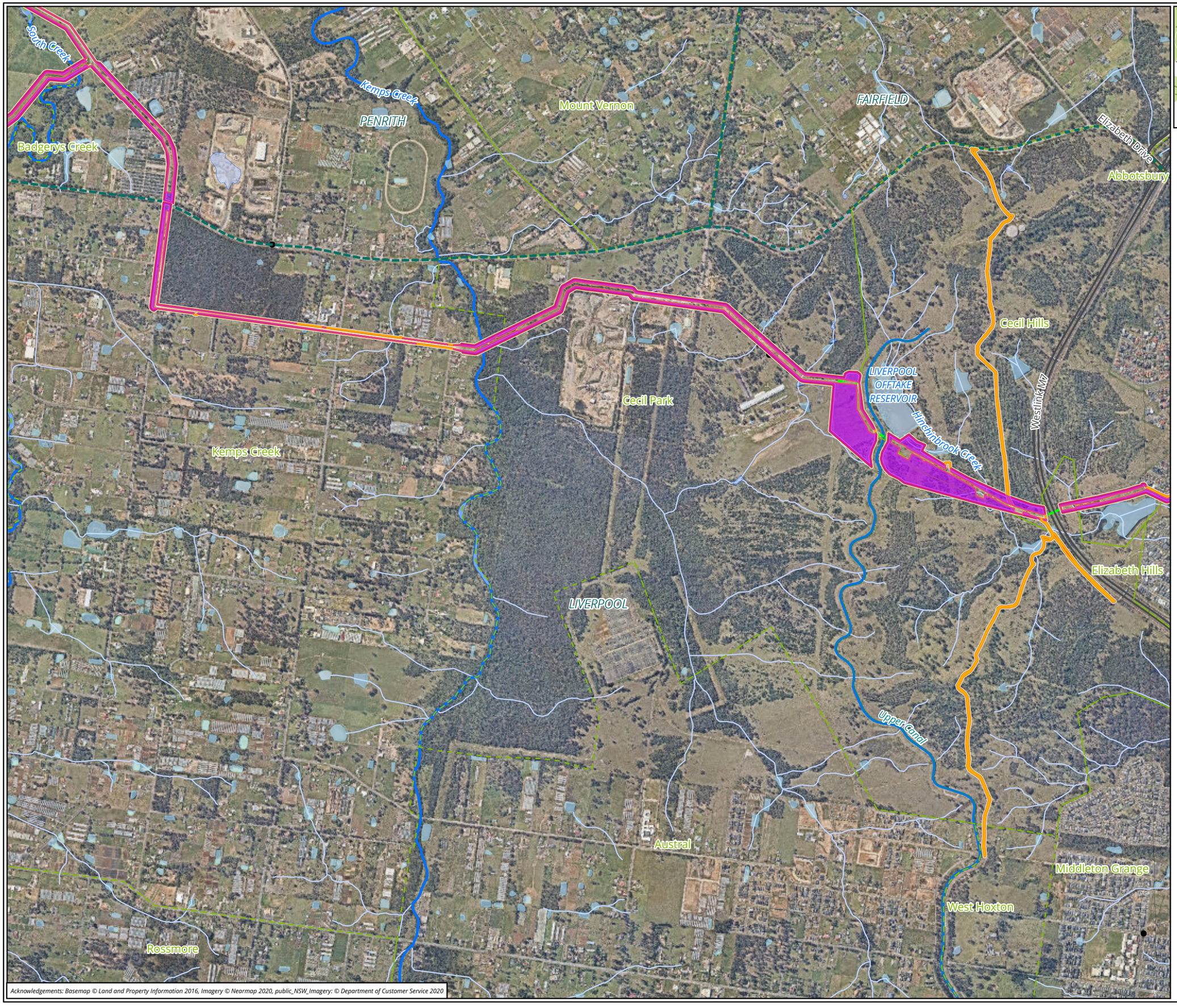

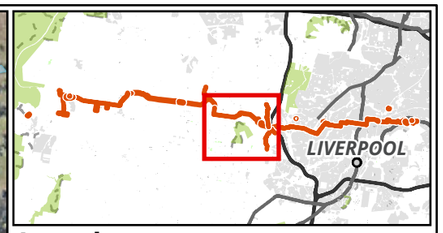

Legend

- Impact area
- Impact assessment area
- Underbore
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.3 Prescribed impacts and estimated zones of indirect impact for the proposal

0 250 500 750 1,000 N

Metres

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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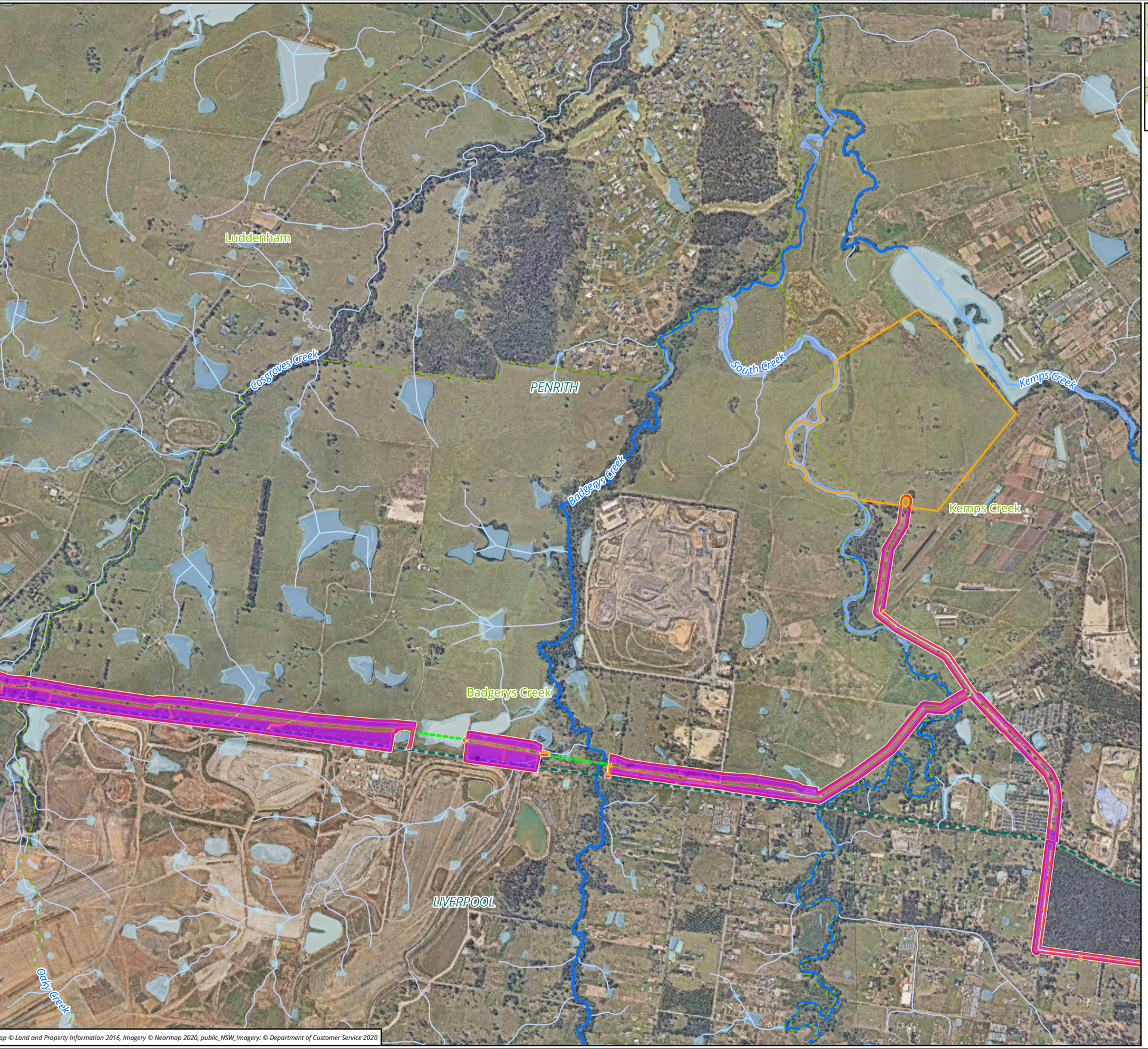

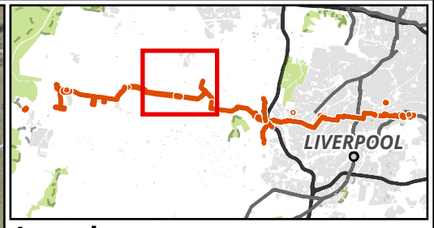

Legend

- Impact area
- Impact assessment area
- Underbore
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.4 Prescribed impacts and estimated zones of indirect impact for the proposal

0 250 500 750 1,000 N

Metres

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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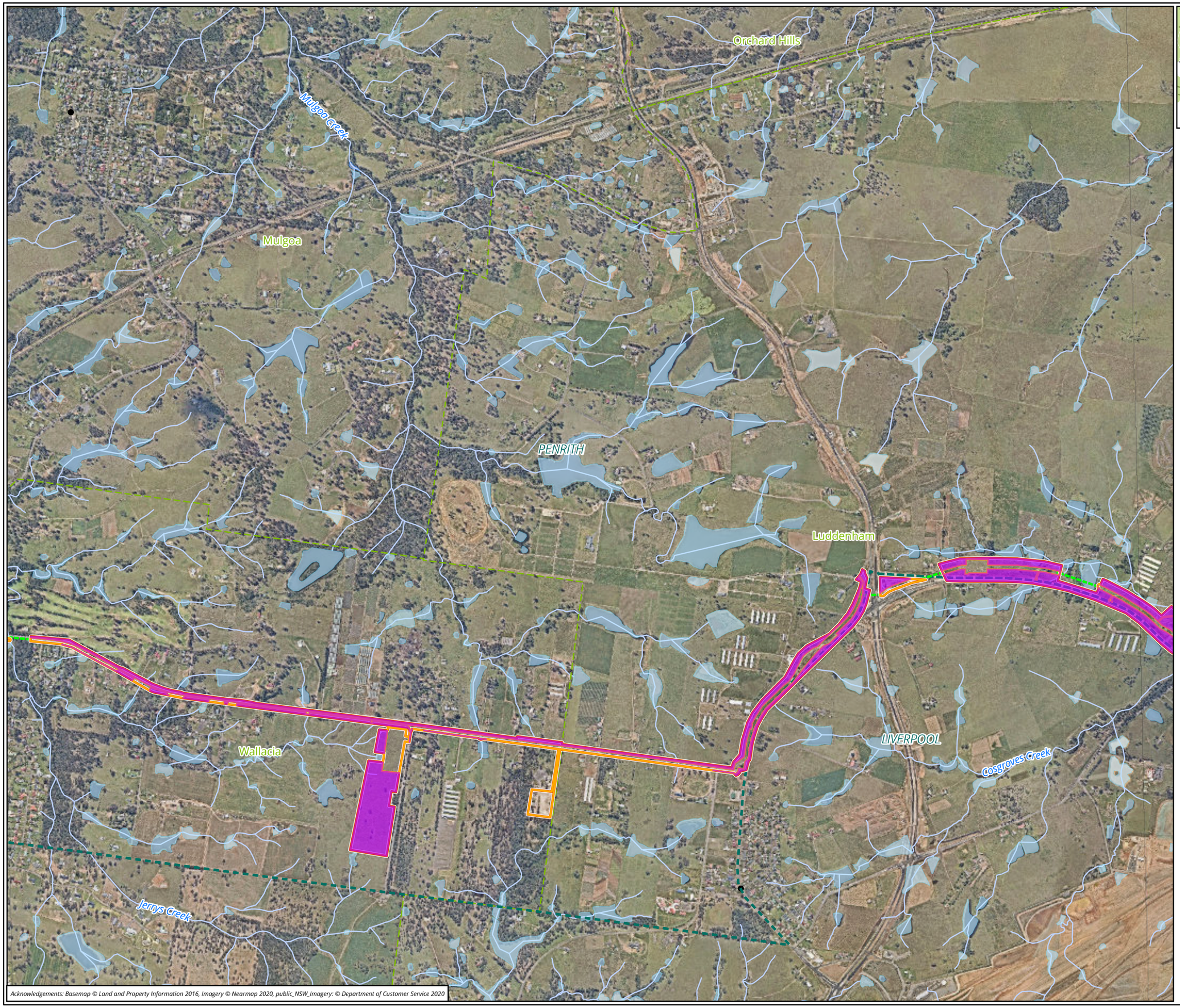

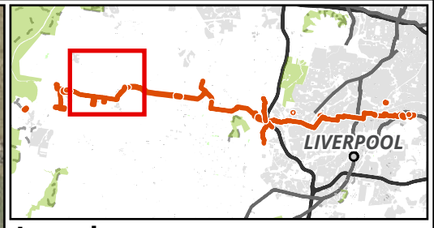

Legend

- Impact area
- Impact assessment area
- Underbore
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.5 Prescribed impacts and estimated zones of indirect impact for the proposal

0 250 500 750 1,000 N

Metres

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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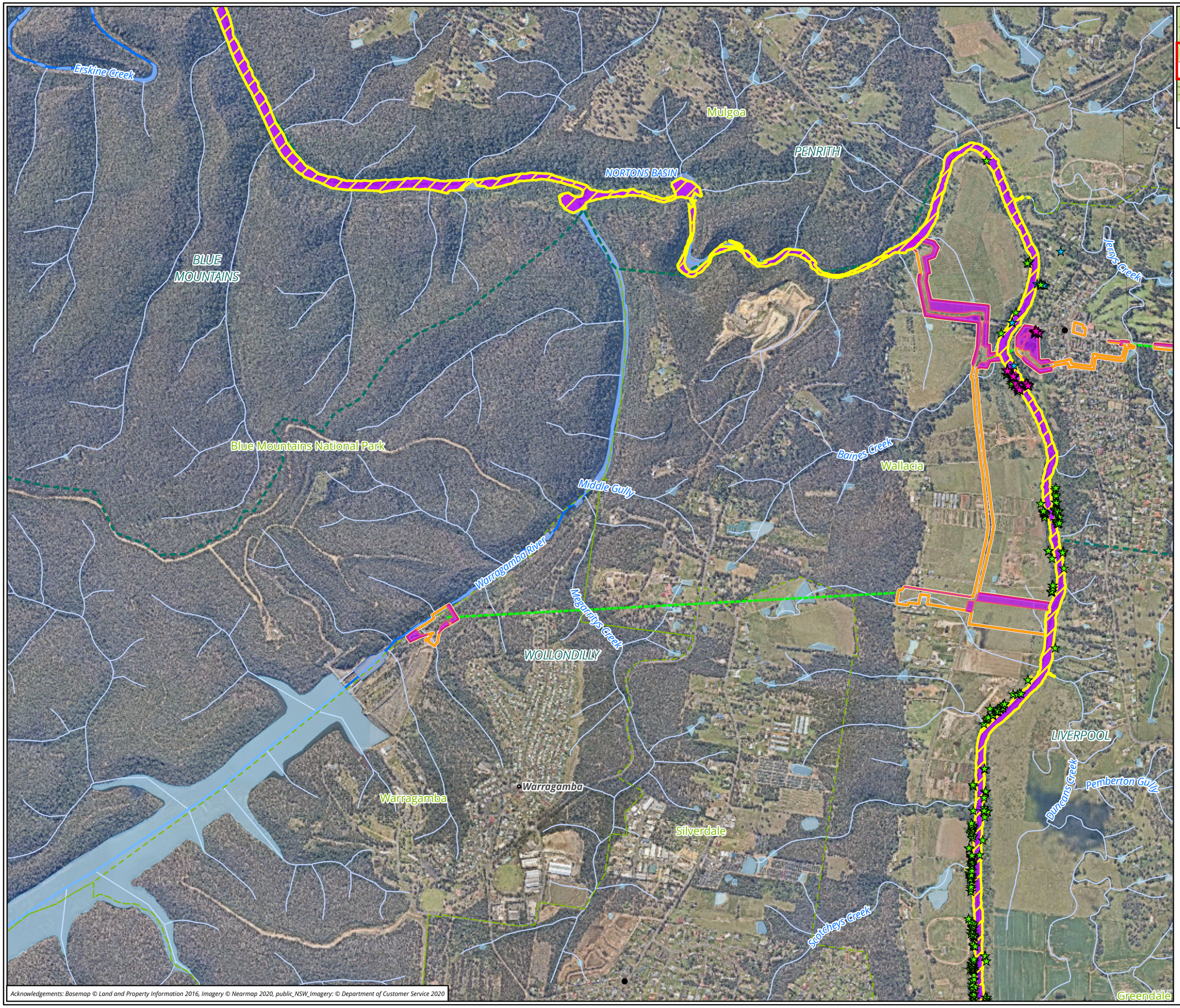

Legend

- Impact area
- Impact assessment area
- Underbore
- Camden White Gum (Biosis)
- Camden White Gum (CTE 2020)
- Camden White Gum (BioNet)
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.6 Prescribed impacts and estimated zones of indirect impact for the proposal

0 250 500 750 1,000 Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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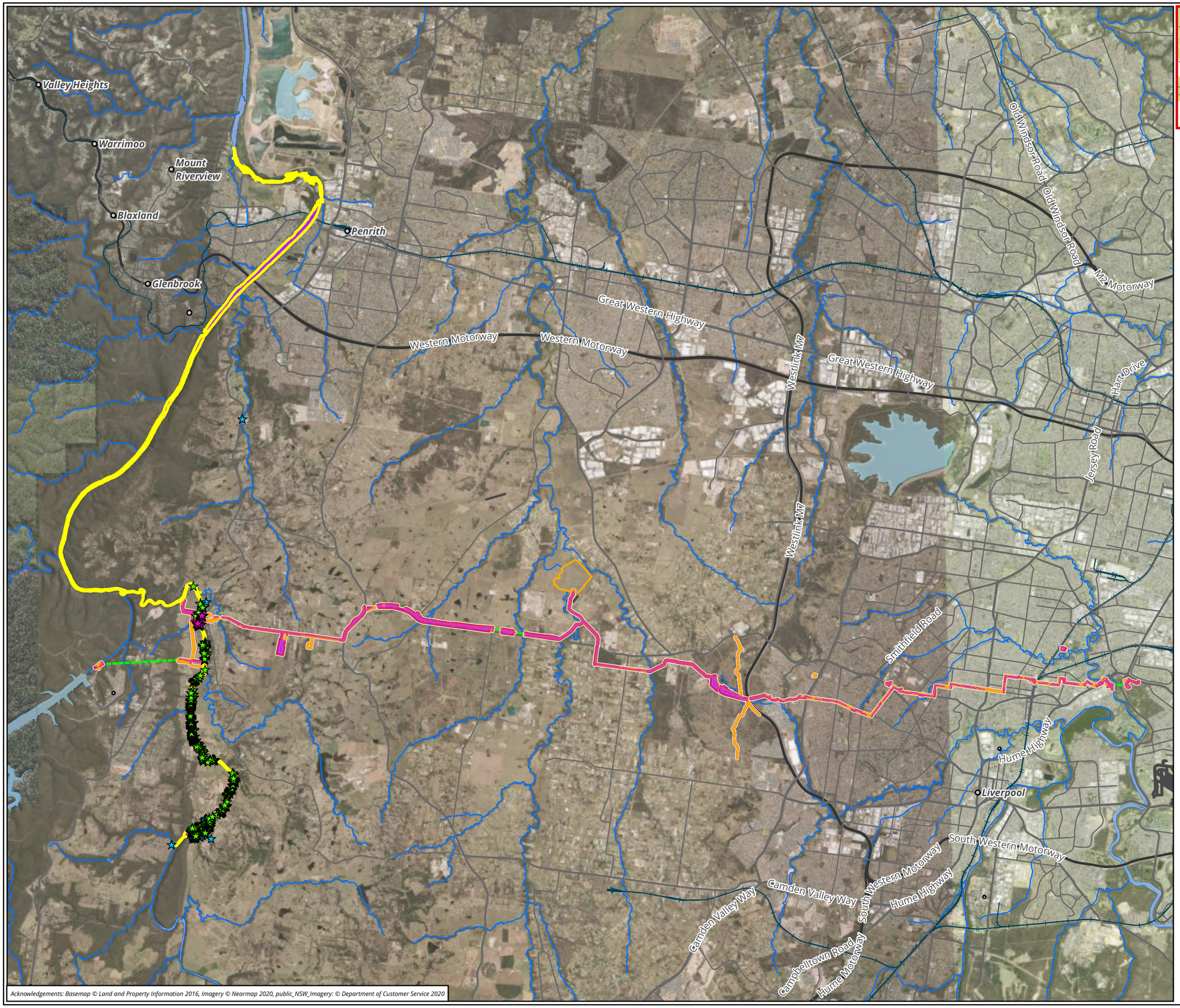

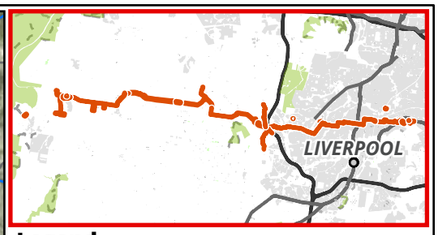

Legend

- Impact area
- Impact assessment area
- Underbore
- Camden White Gum (Biosis)
- Camden White Gum (CTE 2020)
- Camden White Gum (BioNet)
- Altered hydrological regime assessment area
- Indirect impacts

Figure 15.7 Prescribed impacts and estimated zones of indirect impact for the proposal

0 1,000 2,000 3,000 4,000

Metres

N

Scale: 1:117,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: SSK, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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11.4 Impacts to groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are known to occur within the impact area, impact assessment area and more broadly across the project's study area. GDEs are defined as ecosystems that require access to groundwater to meet all or some of their water requirements in order to maintain their ecological components and processes. The dependence of GDEs on groundwater varies from seasonal or episodic, to continual. They can range in size from a few square metres to many square kilometres (DPIE 2021).

Impacts to GDEs will occur as a result of the project through direct removal of vegetation comprising the surface expression of the GDE, and through indirect impact associated with impacts on groundwater through vectors such as drawdown and aquifer interference.

The potential for groundwater dependence has been mapped by the Australian Bureau of Meteorology (BOM) and included in the GDE Atlas. This data has been used to assess the potential for GDEs to be present within and surrounding the impact area, and to determine the PCTs and TECs to which these GDEs equate, which are likely to be subject to potential impacts.

Table 50 provides the potential GDEs mapped on the BOM GDE Atlas within and surrounding the impact area. The determination of PCTs and TECs is based on the mapping undertaken by the project, which has been overlain on the GDE Atlas mapping to determine the potential for groundwater interactions. The GDE Atlas does provide vegetation types, however this is based on existing aerial mapping projects and is therefore superseded by the ground-truthed mapping completed for the project. The area of each GDE directly impacted by the project is also provided in the table below.

Table 50 Potential GDEs mapped within and surrounding the impact area

PCT	TEC	Location description	Direct impacts to GDE
High potential for groundwater interaction			
724	Shale Gravel Transition Forest	Present at Kemps Creek north of Elizabeth Drive and south of Park Road. Both occurrences are part of larger patches adjacent to the impact area.	0.19
781	Freshwater wetlands on coastal floodplains	Present adjacent to Jerrys Creek	No direct impact
835	River-flat Eucalypt Forest	Present surrounding the Kemps Creek watercourse, Cosgroves Creek, south of Park Road (with patch of PCT 724), and along the Nepean River.	0.83
849	Cumberland Plain Woodland	Present in Lansdowne Reserve, and south of Park Road	0.66
883	Castlereagh Scribbly Gum Woodland	Present at Kemps Creek adjacent to Western Road	No direct impact
1083	Not a TEC	Present at the treated water outlet at the Warragamba River	0.89
1105	Not a TEC	Present at the treated water outlet at the Warragamba River	0.02
1181	Not a TEC	Present adjacent to Bents Basin Road on the edge of a large patch of intact vegetation.	0.02

PCT	TEC	Location description	Direct impacts to GDE
1800	Swamp Oak Floodplain Forest	Present surrounding Cosgrove Creek and Oaky Creek	0.12
Moderate potential for groundwater interaction			
724	Shale Gravel Transition Forest	Present at Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.	0.07
725	Cooks River/Castlereagh Ironbark Forest	Present within the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek and north of Elizabeth Drive between South Creek and Badgerys Creek.	No direct impact
835	River-flat Eucalypt Forest	Present surrounding Clear Paddock Creek	0.07
849	Cumberland Plain Woodland	Present along Park Road as part of a larger patch of vegetation.	0.02
883	Castlereagh Scribbly Gum Woodland	Present within the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.	No direct impact
1081	Not a TEC	Present near the treated water outlet at the Warragamba River.	No direct impact
1083	Not a TEC	Present near the treated water outlet at the Warragamba River.	No direct impact
Low potential for groundwater interaction			
724	Shale Gravel Transition Forest	Present at Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.	0.17
725	Cooks River/Castlereagh Ironbark Forest	Present within the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.	No direct impact
883	Castlereagh Scribbly Gum Woodland	Present on the edge of the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.	No direct impact

Potential indirect impacts to GDEs surrounding the impact area, associated with the construction and operational phases of the project, have been assessed by Aurecon Arup in the *Upper South Creek AWRC Groundwater Impact Assessment* (Aurecon Arup 20211b).

The assessment report notes that construction of the proposed AWRC and pipelines have the potential to impact the groundwater systems in several ways, including:

- Induced drawdowns from required dewatering activities during trenching works, temporarily reducing the availability of groundwater for GDEs and surrounding groundwater users.
- Disruption of surface water and groundwater connectivity.

Furthermore, operation of the proposed AWRC and pipelines have the potential to impact the groundwater systems in several ways, including:

- Induced drawdowns from any underdrainage systems employed for underground structure floatation management, reducing the availability of groundwater for GDEs and surrounding groundwater users. (Aurecon Arup 20211b)

Where trenching activities would require dewatering due to inflows of groundwater, drawdowns would occur that would likely effect the surrounding GDEs. However, it is concluded by Aurecon Arup (20211b) that drawdowns would be constrained to a short period of time during construction, and therefore the predicted impacts are not expected to prevent the long-term viability of the affected ecosystems. (Aurecon Arup 20211b)

To minimise impacts to groundwater systems, a range of mitigation measures would be implemented during the detailed design, construction and operational phases of the project and detailed in a project CEMP and operational procedures. The assessments concludes that following the implementation of suggested mitigation measures the severity of any residual impact to GDEs would be considered low. (Aurecon Arup 20211b)

Based on the assessment undertaken by Aurecon Arup (2020b) the project is not expected to result in substantial or significant indirect impacts to GDEs surrounding the impact area, and thus the PCTs and TECs which represent their surface expression.

11.5 Mitigation for residual impact

Residual impacts occur once all efforts have been made to reduce and minimise impact through the design phase of the project. Mitigation of those unavoidable impacts is the next step in the impact reduction hierarchy and includes commitments made by the proponent that filter down to the contractors undertaking the work.

Mitigation measures committed to by Sydney Water for the detailed design, construction and operational phased of the Upper South Creek Advanced Water Recycling project and are detailed in Table 51. Also provided is an assessment of the expected effectiveness of the mitigation measures at further reducing impacts to biodiversity values.

Table 51 Proposed mitigation measures and effectiveness

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
Removal of native vegetation / TECs and threatened / non-threatened flora and fauna species habitats	• Prescriptions for mitigation of potential impacts of construction activities on retained native vegetation and habitat should be addressed in a site-specific CEMP. The CEMP should include all measures outlined below. • Vegetation is highly sensitive. Trimming or clearance is not to proceed without written authorisation from the Sydney Water Project Manager (in consultation with Environmental Representative). • Map and report native vegetation clearing (and any associated rehabilitation) to the Sydney Water Environmental Representative. Track vegetation clearing as per Sydney Water Contractor Native Vegetation Clearing and Rehabilitation template. ○ This will be essential to achieve the desired flexibility in assessment of the impact assessment area. • Minimise vegetation clearance and disturbance, including impacts to standing dead trees and riparian zones. Where possible, limit clearing to trimming rather than the removal of whole plants. • Physically delineate vegetation to be cleared and/or protected on site and install appropriate signage prior to works commencing. • Adjust methodology (e.g. avoid area, hand excavate, implement exclusion fencing) to protect sensitive areas where possible (such as mature trees, known threatened species, populations or ecological communities). • Protect trees in accordance with the requirements of Australian Standard 4970-2009 for the Protection of Trees on Development Sites. Do not damage tree roots unless absolutely necessary, and engage a qualified arborist where roots >50mm are impacted within the Tree Protection Zone. • Retain dead tree trunks, bush rock or logs in-situ unless they are in the impact area and moving is unavoidable. Reposition material elsewhere on the site or approved adjacent sites. If native fauna is likely to be present, a licenced ecologist should inspect the removal and undertake fauna relocation. • Undertake pre-clearance inspections by a licenced ecologist of vegetation for potential fauna prior to clearing or trimming, including the banks of larger watercourses to be impacted. If fauna is present, or ecological assessment has determined high likelihood of native fauna presence, including removal of hollow bearing trees, relocate fauna before works. • If native fauna is encountered on site, stop work and allow the fauna to move away un-harassed. Engage a licenced ecologist if assistance is required to move fauna. • If dewatering farm dams, engage a licensed ecologist to undertake fauna relocation (e.g. turtles, frogs, etc.) into an appropriate nearby habitat.	The significant of the removal of native vegetation and habitats for the project is considered moderate, but acceptable for a project of this scale. Suggested mitigation measures will ensure ongoing efforts are made to further reduce impacts to biodiversity during consideration and operational phases of the project. Mitigation measures will also ensure that impacts are kept within the parameters of what is deemed acceptable by the approval authority.

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
	• If any threatened species (flora or fauna) is discovered during the works, stop work immediately and notify the Sydney Water Project Manager. Work will only recommence once the impact on the species has been assessed and appropriate control measures provided. • If any damage occurs to vegetation outside of the impact area (as shown in the CEMP), notify the Sydney Water Project Manager and Environmental Representative so that appropriate remediation strategies can be developed. • A biosecurity management plan prepared as part of the project's CEMP is recommended and will prevent the spread of weeds and pathogens, and other biosecurity items into or out of the impact area upon implementation. • Secure biodiversity offsets in accordance with the NSW BOS.	
Removal of habitats considered to be potential SAIIs.	• Minimise clearing of Cumberland Plain Woodland TEC vegetation throughout the project area, and all native vegetation at the treated water outlet at the Warragamba River, by ensuring only the minimum level of impact necessary to undertake the required works. • Avoid impacts to as much caves, crevices, cliffs, rocky habitat as is practicable. • As much as is practicable locate ancillary areas/infrastructure outside these potential SAII entities, this includes stockpiles and access routes. • Ensure No-Go Zones are established early and maintained throughout the life of the construction period. • Implement passive exclusion measures for microbats detailed below at the treated water outlet to ensure the potential direct impact to individual bats is minimised. • As much as is practicable do not undertake works that impact directly on potential microbat habitat at the Warragamba River during breeding season (i.e. November to February). • Implement all relevant safeguards outlined above for minimising impacts to native vegetation and habitats.	Whilst considered potential SAIIs the significance of these potential impacts is considered acceptable. This is based on the avoidance of impacts to Cumberland Plain Woodland TEC undertaken throughout the design phase of the project and the limiting of impacts largely to more degraded areas the conclusions made around the low likelihood of breeding habitat actually being present on site, and the temporary nature of the indirect impacts to potential habitat outside the impact area. The mitigation measures proposed will ensure these impacts remain at acceptable levels.

Inadvertent impacts on adjacent habitat or vegetation within the impact assessment area.	• Ensure all works areas and access routes are clearly delineated and sign-posted from the outset of the project construction phase.
	• No access is to be gained to Lansdowne Reverse BioBank Site.
	• Develop and implement specific erosion and sediment controls described in a CEMP, such as:
	  ○ Minimising the area and duration of soil disturbance.
	  ○ Progressively rehabilitating disturbed areas.
		Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
	○ Maintaining sheet flow conditions to the maximum possible extent. ○ Water velocity reduction measures and redirection of runoff to stable ground. ○ Temporary or permanent earth banks and silt fences. ○ Trench blocks (i.e. trench/sack breakers) and compaction of backfilled soils to be used to prevent subsurface erosion and subsidence along backfilled trench. ○ Properly constructed turn-off drains to direct water flows to stable ground. ○ Specific erosion and sediment control plans for waterway crossings. • All material stockpiles, vehicle parking and machinery storage, and other ancillary works are to be located within areas considered within the current assessment and not be located within retained vegetation outside the impact area unless an updated impact assessment is undertaken. • Cleared vegetation, which may be mulched or stored for re-use on site, should be: ○ Stockpiled separately from topsoil in a manner which facilitates respreading or salvaging, avoids damage to adjacent live vegetation and does not impede wildlife. ○ Stockpiled away from watercourses and not stored or felled so as to land in watercourse. • Dust suppression is to be undertaken as required using water sprays, water carts or other media on: ○ Unpaved work areas subject to traffic or wind. ○ Sand, spoil and aggregate stockpiles. ○ During the loading and unloading of dust generating materials.	
Indirect impacts on adjacent habitat or vegetation along the banks of the Nepean River system.	• Ensure treated water outflows occur within specified parameters assessed as part of this assessment and other technical studies. • Monitor the health of, and potential future impacts to, the important population of Camden White Gum between Wallacia and Bents Basin, to ensure that if more substantial impacts that expected / assessed occur, adaptive management can intervene. ○ Preparation of an adaptive management plan outlining a cycle of 'do, monitor, evaluate and respond', the foundation of adaptive management widely applied to terrestrial and aquatic ecosystem management (Kingsford et al. 2011). ○ Adaptive management plan will include an agreed monitoring, evaluation, reporting and improvement cycle (MERI), similar to the framework provided below: ▪ Monitoring – activities and programs outlined in this plan and others to measure biodiversity condition and achievement of objectives.	Mitigation measures will monitor impacts to biodiversity values along the Nepean River and allow for increased management/mitigation/offsetting should impacts occur outside the level considered acceptable by the approval authority.

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
	▪ Evaluation – collation of results by the site manager (or their agents) and assessment of trajectory towards desired objectives. ▪ Reporting – internal and external reporting cycles that document results, general observations and suggest changes or maintenance of the status quo. ▪ Improvement – the actual changes to management, and attendant monitoring programs, to ensure they remain relevant as conditions change or management challenges arise. o The management plan and the collection of baseline data will occur immediately following project approval, with monitoring of potential impacts to occur over a five year period following the commencement of AWRC operation releasing 50 ML/day into the river system, and again for another five year period if/when the AWRC capacity is increased to 1000 ML/day.	
Inadvertent impacts on adjacent habitat or vegetation opposite and surrounding the environmental flows treated water outlet near the Warragamba Dam.	• Consider biodiversity as sensitive receivers in noise and vibration management plan. • Minimise the amount of time that noise, light and vibration impacts are occurring. • Ensure the smallest machinery that can complete the required works are used to reduce potential noise and vibration impacts. • Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise. o Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied. o Avoid the use of radios or stereos outdoors. o Avoid the overuse of public address systems. o Avoid shouting and minimise talking loudly and slamming vehicle doors. o Turn off all plant and equipment when not in use. • Lighting for temporary construction camps, and where required for construction activities, will be designed in general accordance with Australian Standard 4282-1997 Control of the obtrusive effects of outdoor lighting and the good lighting design principles documented in Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring.	Mitigation measures will ensure impacts to biodiversity values along the Warragamba River are minimised and remain within the level considered acceptable by the approval authority.
Reduced viability of adjacent habitat due to edge effects.	• The impact area is to be re-profiled to original contours or to new, stable contours where not reasonably practical to re-profile to original contour. This includes compaction of the trench to an appropriate density following backfilling with subsoil. • Rehabilitate the future easement to the highest ecological condition possible, having regard to Sydney Water document 'Which trees can damage wastewater pipes?. • Include a landscaping and rehabilitation management plan as part of the CEMP and operational procedures.	Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
	• Undertake ongoing weed control within the future easement. • Re-use felled vegetation (logs ad tree-hollows) and other habitat features such as rocks/boulders to increase the habitat values of the future easement. • All revegetation / rehabilitation works within and/or contiguous with areas of native vegetation are to use locally sourced (local provenance) seed stock only. All species installed are to be locally indigenous and suitable and characteristic of the surrounding PCTs. • Where possible stockpiled vegetation should be respread over appropriate sections of the easement during rehabilitation, unless other management measures are likely to improve rehabilitation outcomes.	
Reduced viability of adjacent habitat due to noise, dust or light spill	• As per safeguards listed above for the area surrounding the environmental flows treated water outlet near the Warragamba Dam.	Mitigation measures will ensure impacts to biodiversity values along the Warragamba River are minimised and remain within the level considered acceptable by the approval authority.
Transport of weeds and pathogens to/from the site to/from adjacent vegetation	• A biosecurity management plan prepared as part of the project's CEMP is recommended and will prevent the spread of weeds and pathogens, and other biosecurity items into or out of the impact area upon implementation.	Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.
Trampling of threatened flora species.	• Ensure No-Go Zones are established early and maintained throughout the life of the construction period.	Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.
Fragmentation of movement corridors.	• Rehabilitate future easement as outline above.	Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.
Impacts of development on the habitat of threatened species	• Minimise clearing of all native vegetation at the treated water outlet at the Warragamba River, by ensuring only the minimum level of impact necessary to undertake the required works. • Avoid impacts to as much caves, crevices, cliffs, rocky habitat as is practicable. • Ensure No-Go Zones are established early and maintained throughout the life of the construction period.	Mitigation measures will ensure impacts to biodiversity associated with karst, caves, crevices, cliffs are minimised and remain within the level considered acceptable by the approval

Residual impact	Mitigation measure	Impact significance following mitigation (i.e. effectiveness of mitigation)
or ecological communities associated with karst, caves, crevices, cliffs and other features of geological significance.	• As much as is practicable do not undertake works that impact directly on potential microbat habitat at the Warragamba River during breeding season (i.e. November to February).	authority.
Impacts of development on the habitat of threatened species or ecological communities associated with human made structures.	• Install passive roost exclusion measures over the vertical (vent) shaft as follows: o Install exclusion measure well prior to site establishment for construction works. o Install exclusion measures during either spring (March to May) or autumn (September to October). ▪ This timing is required to avoid both winter hibernation period (June to August) and breeding season (November to February) for microbats potentially utilising the habitat feature. o Undertake repeated stag watching surveys prior to installation of exclusion measures to confirm the presence of microbats within the habitat, and to determine when all bats have left the potential roost. o Once all bats have exited the habitat, install a permanent cap over the opening of the shaft using material such as spray polyurethane foam or foam concrete seals (used for capping mine shafts / adits). o Undertake repeat stag watching post installation of the exclusion measures to confirm the successful exclusion of microbats.	Implementation of the detailed mitigation measures will ensure residual impact are considered of a low likelihood and severity.

11.6 Cumulative impact assessment

As part of the environmental assessment of the Upper South Creek AWRC project there is a requirement to consider the relevant cumulative impacts of the project taking into account other approved projects in the region.

Cumulative impacts are impacts that, when considered together, have different and/or greater impacts than a single impact on its own. Cumulative impacts can result from the successive, incremental and/or combined effects of a project when considered with other project/s. The extent to which another project would interact with the construction or operation of the current Upper South Creek AWRC project depends on its scale, location and/or timing of construction and/or operation. Generally, cumulative impacts would be expected to occur in situations where multiple long-duration construction activities are undertaken close to, and over a similar timescale to, construction activities for the project.

Cumulative impacts would also be expected to occur in situations where projects are operating at a similar scale and location to the project. A cumulative impact assessment has been addressed in this BDAR as there would be a cumulative impact to biodiversity from the project and other approved and proposed developments in the Western Sydney region. The projects most relevant for the cumulative biodiversity impact assessment include:

- Western Sydney Airport (GHD 2016)
- Sydney Metro Western Sydney Airport (M2A 2020)
- M12 Motorway (Roads and Maritime 2019)
- The Northern Road Upgrade – Glenmore Road to Bringelly (Jacobs 2017)
- Warragamba Dam Raising (BMT WBM 2016).

A summary of the projects relevant to this BDAR and each project's impact on; NSW PCTs, TECs and species credit species (flora and fauna) is provided in Table 52. A list of these projects, future developments and associated potential cumulative impacts to biodiversity is provided below. It is likely that the project makes only a minimal contribution to cumulative biodiversity impacts on the region.

Cumulative impacts relative to the project include:

- Removal of native vegetation and fauna habitat resources.
- Displacement of native fauna and flora species.
- Increased edge effects and habitat fragmentation.
- Increase in noise, light, vibration and other disturbance for fauna that may inhabit or use resources near the project area.
- Exacerbated Key Threatening Processes.

As the project is located within Western Sydney, an area already subject to environmental pressures which include a highly fragmented landscape with areas of agricultural, residential and commercial land use. Biodiversity loss from these projects are also likely to be restricted in area, given their location in such a highly modified environment.

The projects considered will result in cumulative impacts to native vegetation, TECs and threatened species across Western Sydney. However, if impacts are maintained at the currently proposed levels and mitigation measures are applied consistently across projects, the increase in cumulative impacts on biodiversity because of this project is not considered to be substantial.

Table 52 Cumulative impact on ecological communities and threatened flora (in non-certified lands)

Projects	Western Sydney Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Rising[1]	Upper South Creek AWRC	Cumulative impact	Percent impacted by Upper South Creek AWRC
Plant Community Type and fauna habitat (Ha) impacted								
PCT 724 Castlereagh Shale – Gravel Transition Forest	10.6	7.27	6.91		Unlikely	1.58	26.36	6%
PCT 725 Castlereagh Ironbark Forest					Unlikely	0.01	0.01	100%
PCT 781 Coastal Freshwater Wetland	35.4				Likely	0.02	35.42	0%
PCT 835 Cumberland River-flat Forest	110.7	15.93	3.23	4.29	Likely	4.56	138.71	3%
PCT 849 Cumberland Shale Plains Woodland	250.9	33.32	6.09	6.67	Possible	4.83	301.81	2%
PCT 1083 Coastal Sandstone Ridgetop Woodland					Likely	1.38	1.38	100%
PCT 1105 River Oak Open Forest					Likely	0.40	0.40	100%
PCT 1181 Hinterland Sandstone Gully Forest					Likely	0.07	0.07	100%
PCT 1800 Cumberland Swamp Oak Riparian Forest		4.11	2.53	2.53	Likely	0.92	10.09	9%

Projects	Western Sydney Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Rising[1]	Upper South Creek AWRC	Cumulative impact	Percent impacted by Upper South Creek AWRC
Threatened ecological communities (Ha) impacted - BC Act								
Cumberland Plain Woodland in the Sydney Basin Bioregion (CEEC) (Cumberland Plain Woodland).	242.8	11.67	60.16	29.14	Possible	4.37	348.14	1%
Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (EEC) (Freshwater wetlands on coastal floodplains).					Likely	0.02	0.02	100%
River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (EEC) (River-flat Eucalypt Forest).	42.1	6.64	3.23	4.29	Likely	4.39	60.65	7%
Shale Gravel Transition Forest in the Sydney Basin Bioregion (EEC) (Shale Gravel Transition Forest).	5.0	7.27	6.91		Unlikely	1.54	20.72	7%

Projects	Western Sydney Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Rising[1]	Upper South Creek AWRC	Cumulative impact	Percent impacted by Upper South Creek AWRC
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (EEC) (Swamp Oak Floodplain Forest).		4.11	2.53		Likely	0.88	7.56	12%
Threatened ecological communities (Ha) impacted - EPBC Act								
Coastal Swamp Oak Casuarina glauca Forest of New South Wales and South East Queensland ecological community (EEC) (Coastal Swamp Oak Forest).	Not listed at time of assessment	3.67	Not listed at time of assessment	Not listed at time of assessment	Likely	0.22	3.89	6%
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (CEEC).	158.4	6.12	38.48	16.37	Possible	1.88	221.25	1%
Known threatened flora impacted (Ha)								
Acacia pubescens	5.0	12.27			Possible	0.16	17.4	1%
Pultenaea parviflora		4.18		0.98	Unlikely	0.01	5.2	<1%
Callistemon linearifolius					Possible	0.46	0.5	100
Dillwynia tenuifolia	5.0	21.48	3.63		Unlikely	0.05	30.2	<1%

Projects	Western Sydney Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Rising[1]	Upper South Creek AWRC	Cumulative impact	Percent impacted by Upper South Creek AWRC
Grevillea juniperina subsp. *juniperina*	255.7	18.43			Possible	0.05	274.2	<1%
Marsdenia viridiflora subsp. *viridiflora*	255.7	14.79		0.68	N/A	0.54	271.7	<1%
Pultenaea pedunculata					Possible	0.05	0.1	100%
Pimelea spicata		8.06			Possible	2.99	11.0	27%
Known threatened fauna impacts (Ha)								
Chalinolobus dwyeri				26.25	Likely	3.48	29.7	12%
Meridolum corneovirens	141.8	1.64	1.86	16.37	Unlikely	8.95	170.6	5%
Miniopterus orianae oceanensis					Likely	1.56	1.5	100%
Myotis macropus		9.83	0.92		Likely	7.62	18.4	42%

1 – No project data was publicly available at the time of report.

12. Impact summary

12.1 Thresholds for assessment and offsetting

This section outlines the thresholds for assessment and offsetting in accordance with Section 9 of the BAM.

12.1.1 Serious and irreversible impacts

Threatened species and ecological communities, listed in the NSW BioNet Threatened Biodiversity Profile Database (DPIE 2020b) as entities potentially subject to Serious and Irreversible Impact (SAIIs) will be impacted, either directly or indirectly by the project.

Those entities include:

- Cumberland Plain Woodland TEC – direct impacts to 4.37 ha.
- Large-eared Pied Bat, Little Bent-winged Bat, and Large Bent-winged Bat– Direct impacts to low potential breeding habitats supported by natural rock cliff line habitat, and the man-made tunnel and vertical (vent) shaft at the treated water environmental flows outlet near Warragamba Dam.
- Large-eared Pied Bat, Little Bent-winged Bat, Large Bent-winged Bat and Sooty Owl – Indirect impacts associated with the removal of native vegetation from within the BAM prescribed 'breeding buffers' based on the presence for potential breeding habitat on the far side of the Warragamba River from the treated water environmental flows outlet.

In accordance with Clause 6.7 Of the BC Regulation an impact is to be regarded as serious and irreversible if it is likely to contribute significantly to the risk of a threatened species or ecological community becoming extinct because:

a) *it will cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or*

b) *it will further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or*

c) *it is an impact on the habitat of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or*

d) *the impacted species or ecological community is unlikely to respond to measures to improve its habitat and vegetation integrity and therefore its members are not replaceable.*

Assessments undertaken in accordance with Section 9.1 of the BAM for the above listed potential SAII entities are included in Appendix 5, and shown in Figure 16.

12.1.2 Impacts to native vegetation requiring offsets (ecosystem credits)

As outlined in Section 9.2.1 of the BAM, the accredited assessor is required to determine an offset for all impacts of a proposed development on PCTs that are associated with:

- A vegetation zone that has a vegetation integrity score≥15 where the PCT is representative of an endangered or critically endangered ecological community
- A vegetation zone that has a vegetation integrity score≥17 where the PCT is associated with threatened species habitat (as represented by ecosystem credits), or is representative of a vulnerable ecological community

- A vegetation zone that has a vegetation integrity score≥20 where the PCT is not representative of a TEC or associated with threatened species habitat.

On this basis, offsets are required for vegetation zone 1 as it has a vegetation integrity score greater than 20.

The offset requirement for the project was calculated using the BAM Calculator, with Table 53 providing a summary of the ecosystem credit offsets required.

Table 53 Offsets required for the project (ecosystem credits)

Vegetation zone	Area (ha)	VI score	Offset required	Biodiversity risk weighting	Credit requirement
724_Intact	0.40	68.2	Yes	2	14
724_Thinned	1.14	44.0	Yes	2	25
724_Scattered trees	0.04	33.7	Yes	2	1
725_Scattered trees	0.01	18.3	Yes	2.5	1
781_Thinned	0.02	6.3	No	2	-
835_Intact	0.58	67.5	Yes	2	20
835_Thinned	3.23	75.0	Yes	2	121
835_Scattered trees	0.75	56.0	Yes	2	21
849_Intact	0.93	60.5	Yes	2.5	35
849_Thinned	2.68	37.9	Yes	2.5	63
849_Scattered trees	1.22	24.9	Yes	2.5	19
1083_Thinned	1.38	37.1	Yes	1.5	19
1105_Thinned	0.40	23.0	Yes	1.5	3
1181_Intact	0.07	33.6	Yes	1.5	1
1800_Thinned	0.70	36.1	Yes	2	13
1800_Scattered trees	0.22	22.3	Yes	2	2

12.1.3 Impacts to threatened species requiring offsets (species credits)

As outlined in Section 9.2.2 of the BAM an offset is also required for the potential threatened species impacted by the project. The offset requirement for the project was calculated using the BAM Calculator. Table 54 provide a summary of the species credit offsets required for impacts from proposed development at the impact area.

Table 54 Offsets required for the proposed development (species credits)

Species name	Common name	Area / Count	Biodiversity risk weighting	Credits required
Threatened flora species				
Acacia pubescens	Downy Wattle	0.16 ha	2	4
Callistemon linearifolius	Netted Bottle Brush	6 individuals	1.5	9
Dillwynia tenuifolia	-	0.05 ha	2	2
Grevillea juniperina* subsp. *juniperina	Juniper-leaved Grevillea	0.05 ha	1.5	2
***Marsdenia viridiflora* subsp. *viridiflora* - endangered population**	-	0.54 ha	2	19
Pimelea spicata	Spiked Rice-flower	2.99 ha	2	75
Pultenaea parviflora	Sydney Bush-pea	0.01 ha	2	1
Pultenaea pedunculata	Mated Bush-pea	0.05 ha	2	2
Threatened fauna species				
Chalinolobus dwyeri	Large-eared Pied Bat	3.48 ha	3	137
Meridolum corneovirens	Cumberland Plain Land Snail	8.96 ha	2	259
Miniopterus orianae oceanensis	Large Bent-winged Bat	1.56 ha	3	41
Myotis macropus	Southern Myotis	7.62 ha	2	201
Pommerhelix duralensis	Dural Land Snail	1.47 ha	2	27

Species polygons for the above 11 species credit species impacted by the project are illustrated on Figure 10 and Figure 11.

12.1.4 Impacts not requiring offset and identification of areas not requiring assessment

As outlined in Section 7.2.3, impacts to vegetation zone "781_Thinned" do not require offsetting due the VI score of the vegetation zone being 6.3. There are no areas within the impact area that do not require assessment.

Figure 16a Serious and irreversible impacts - Bats and Sooty Owl

0 10 20 30 40 50

Metres

N

Scale: 1:2,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
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Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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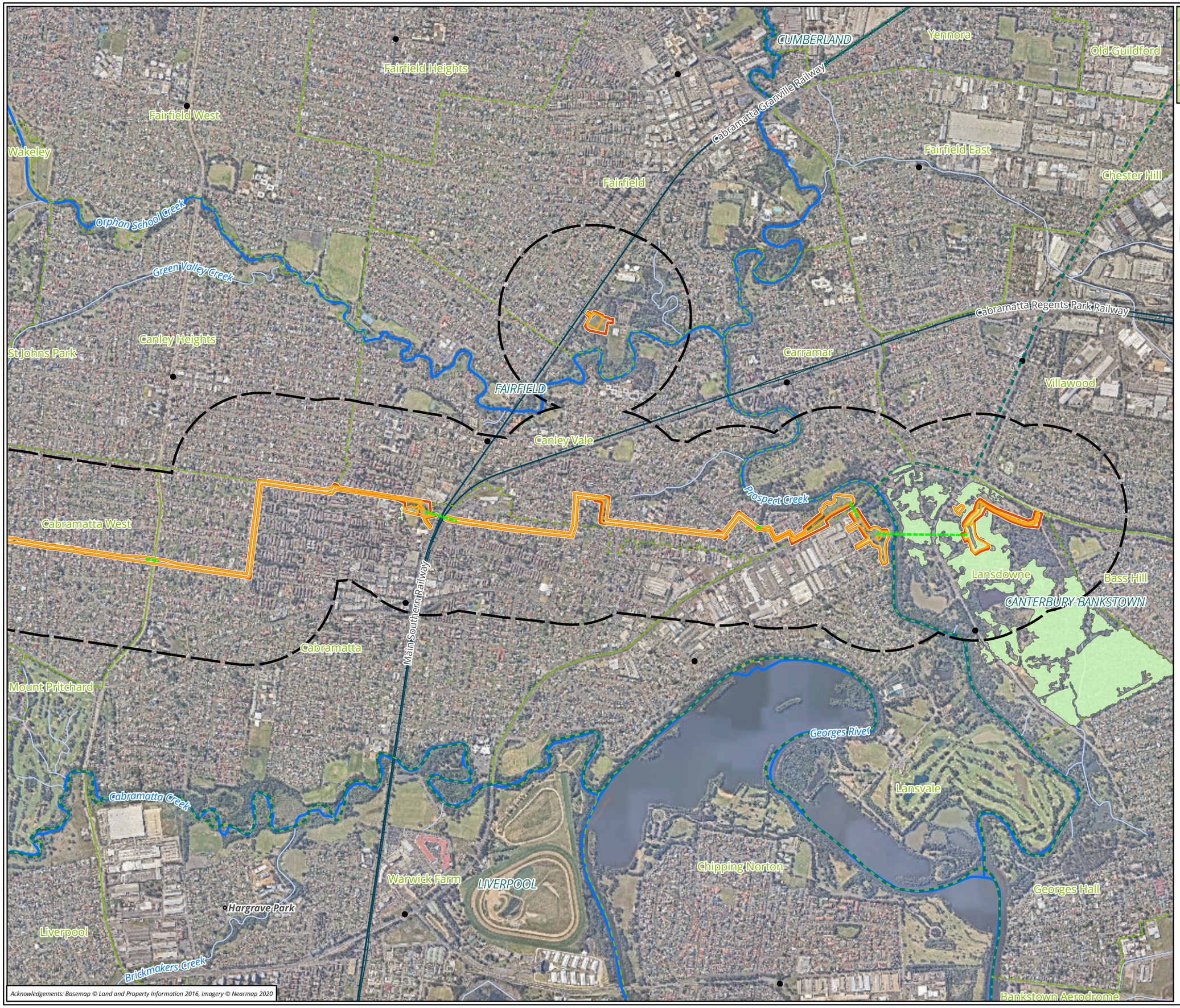

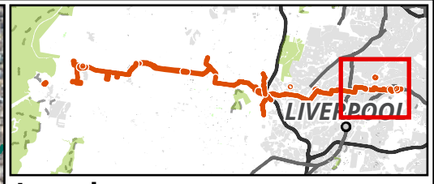

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.1 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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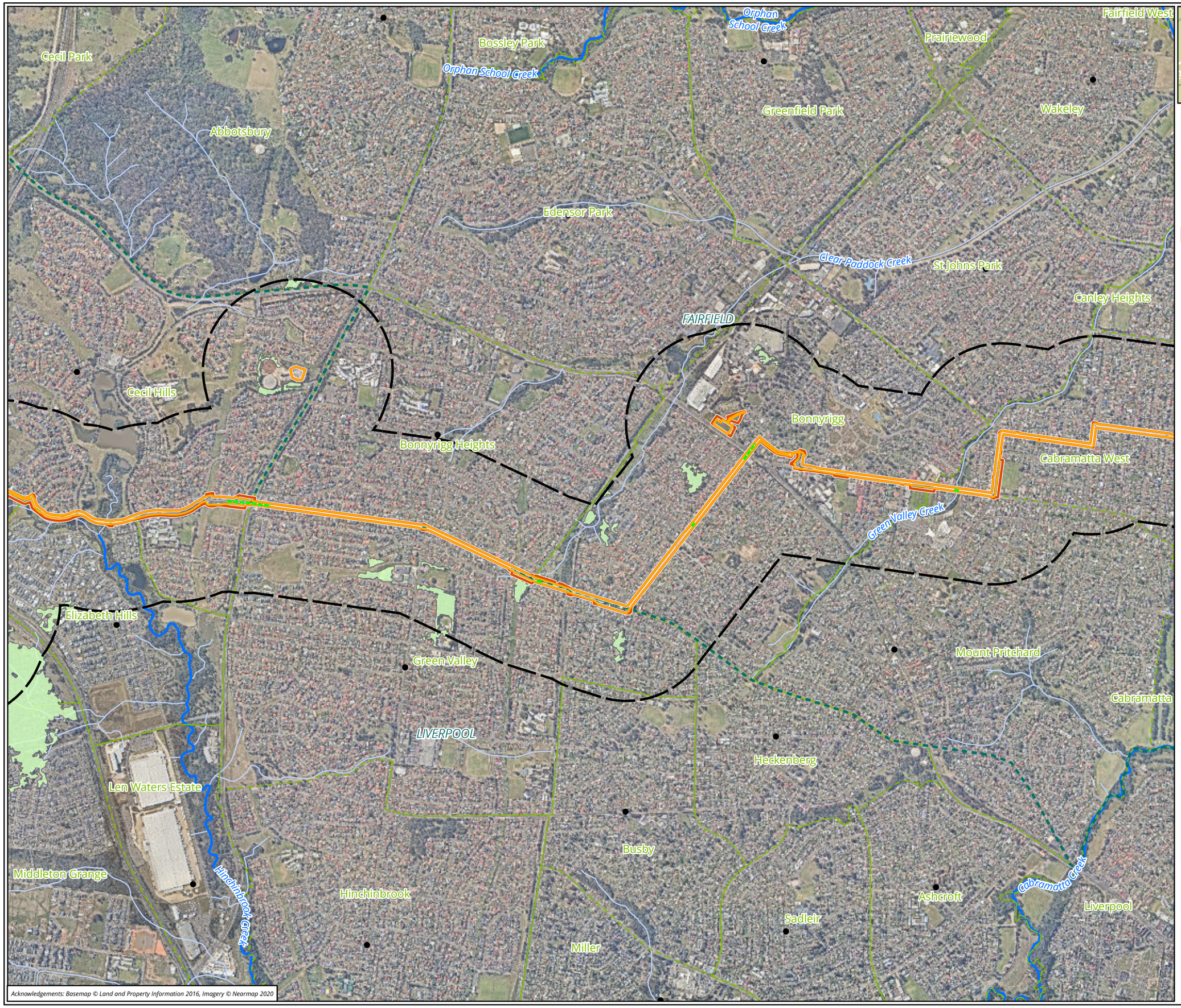

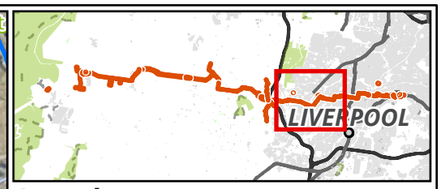

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.2 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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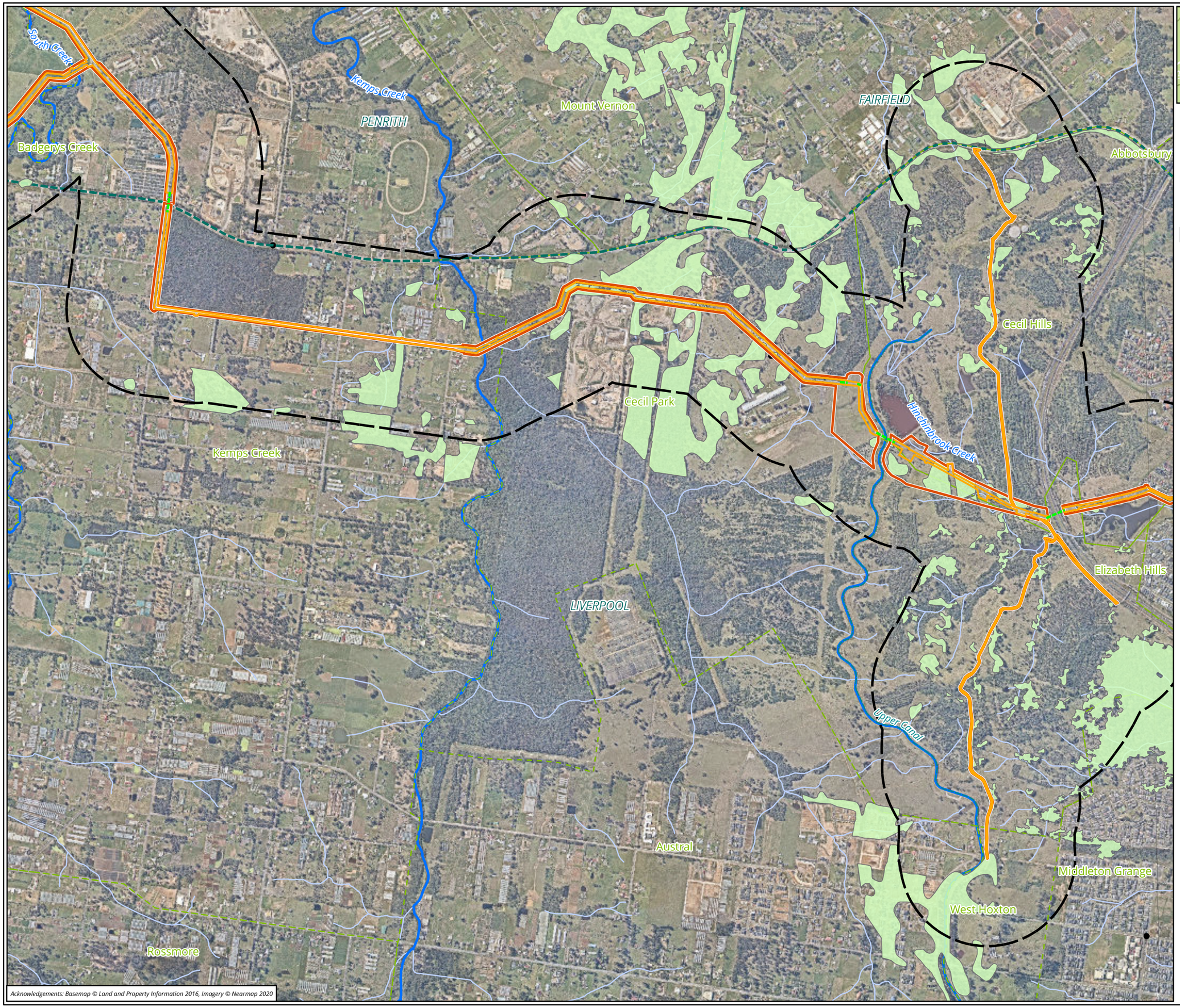

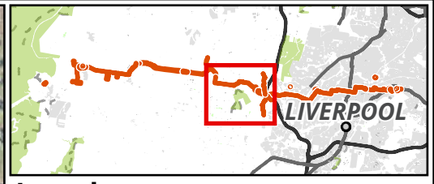

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.3 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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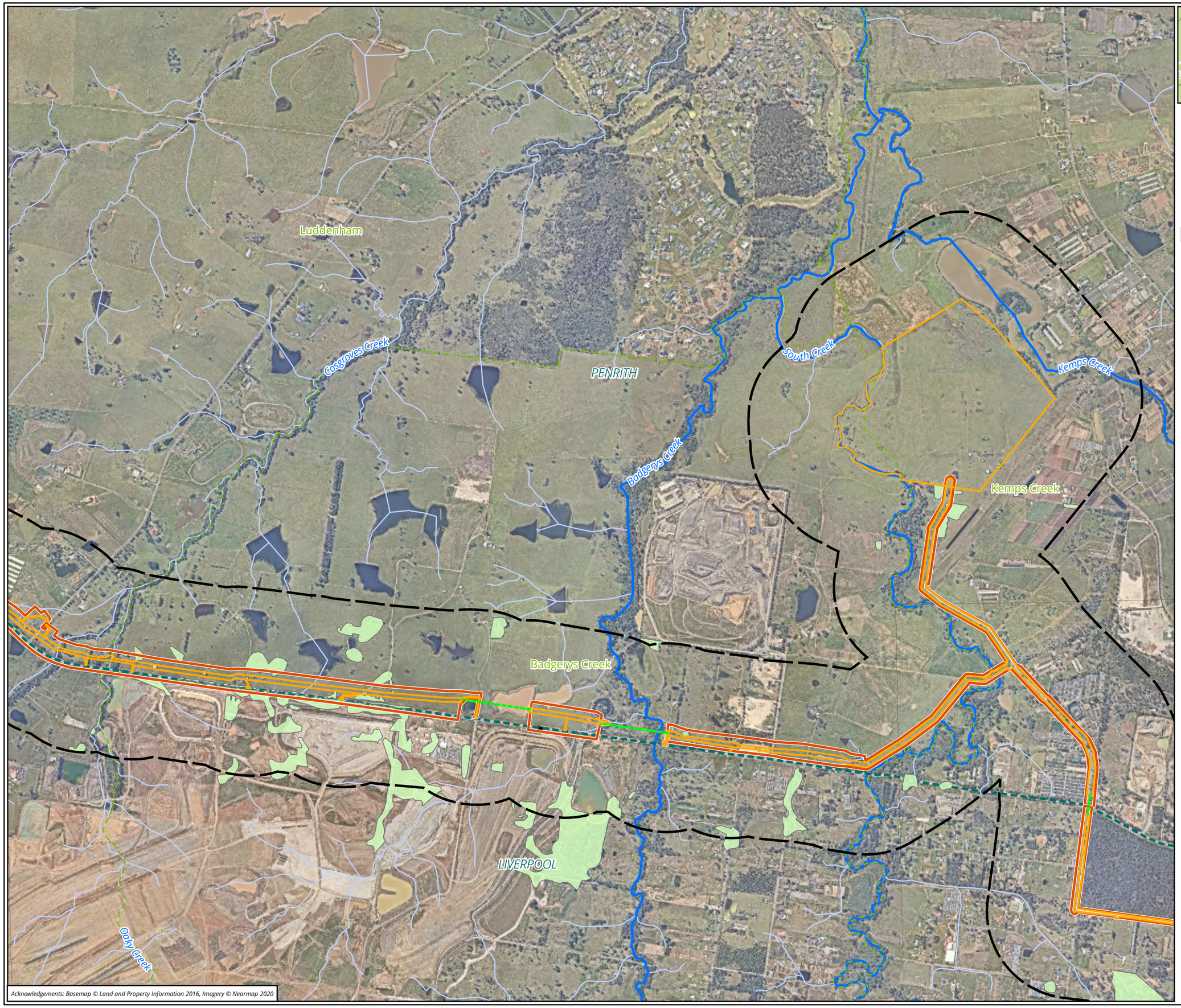

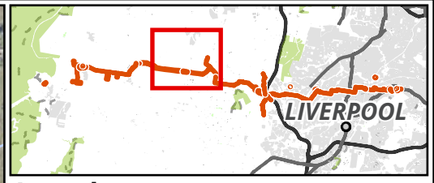

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.4 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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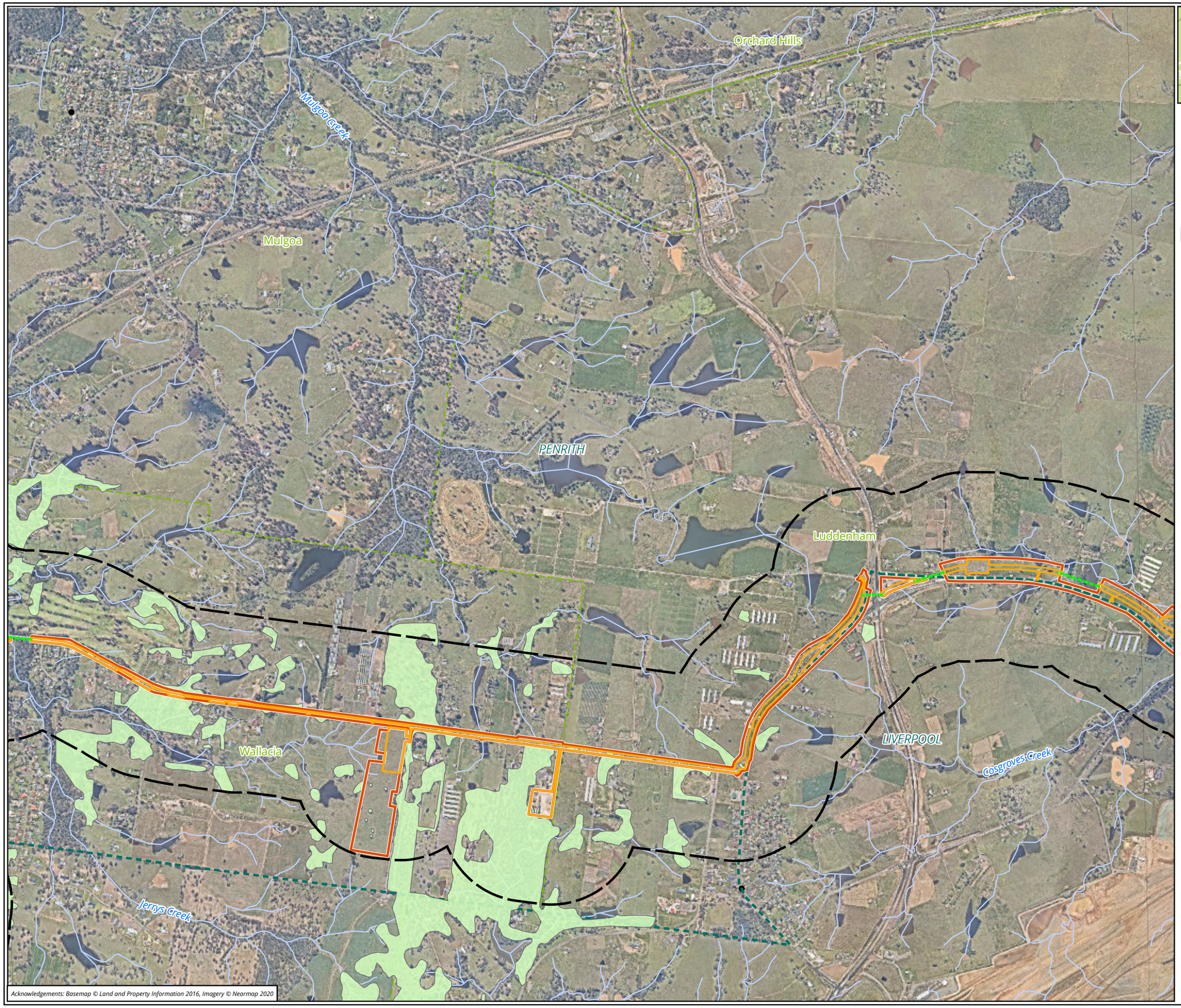

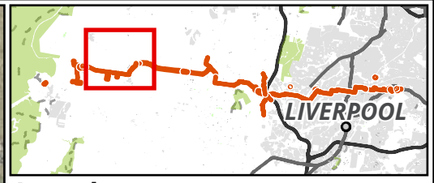

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.5 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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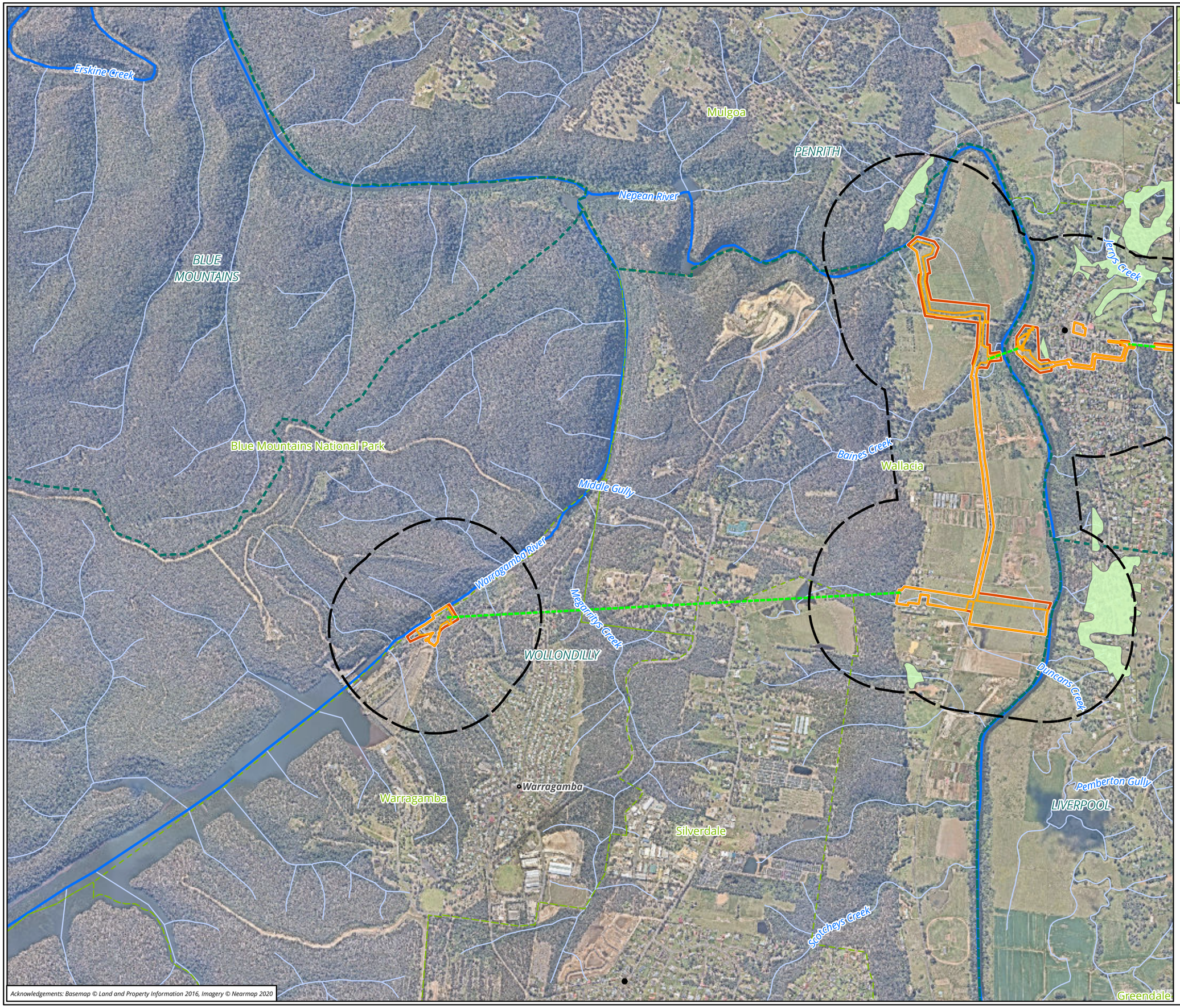

Legend

- Impact area
- Impact assessment area
- Landscape Assessment area
- Underbore
- Cumberland Plain Woodland TEC

Figure 16b.6 Serious and irreversible impacts - Cumberland Plain Woodland TEC

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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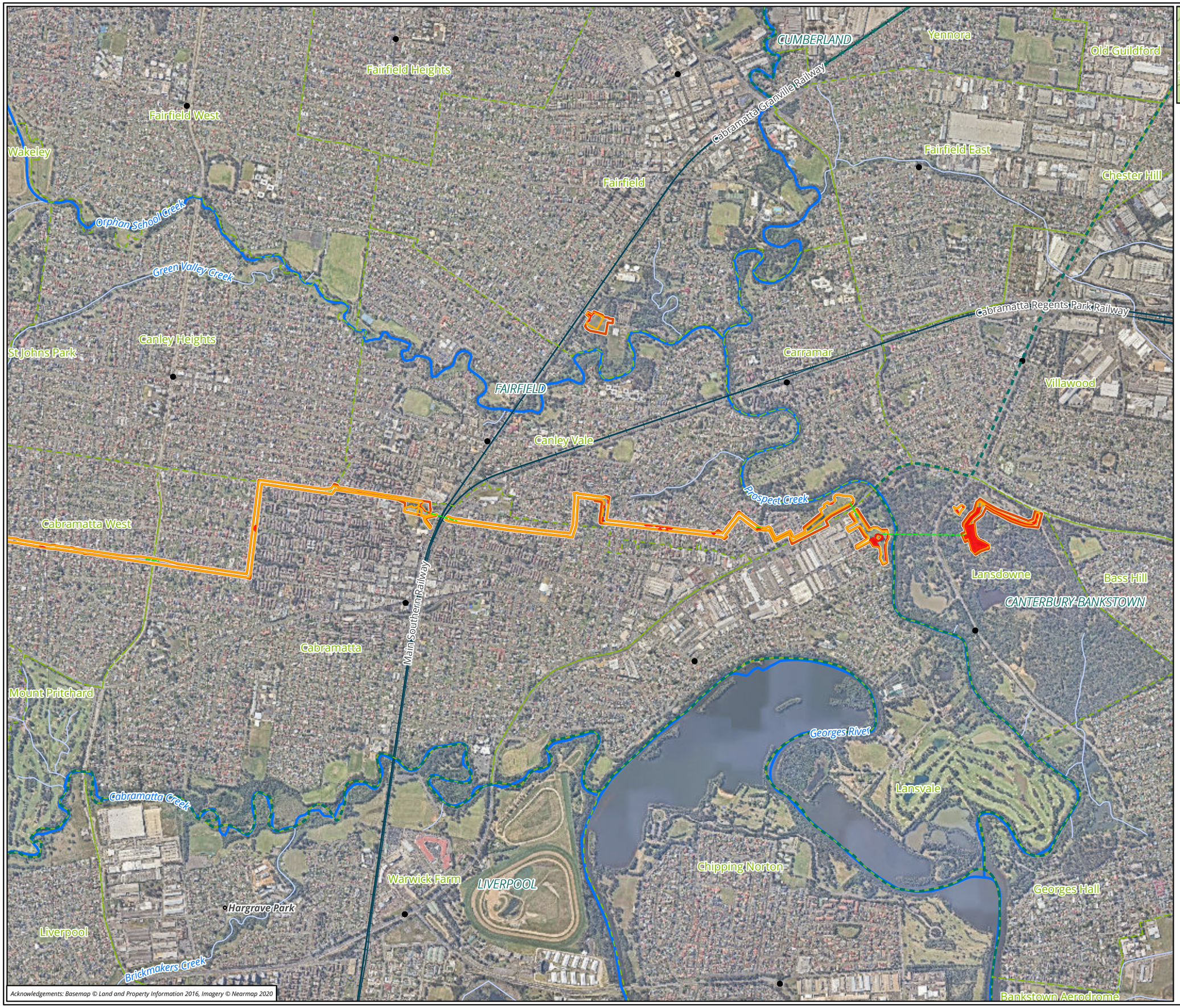

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts requiring offsets

Figure 17.1 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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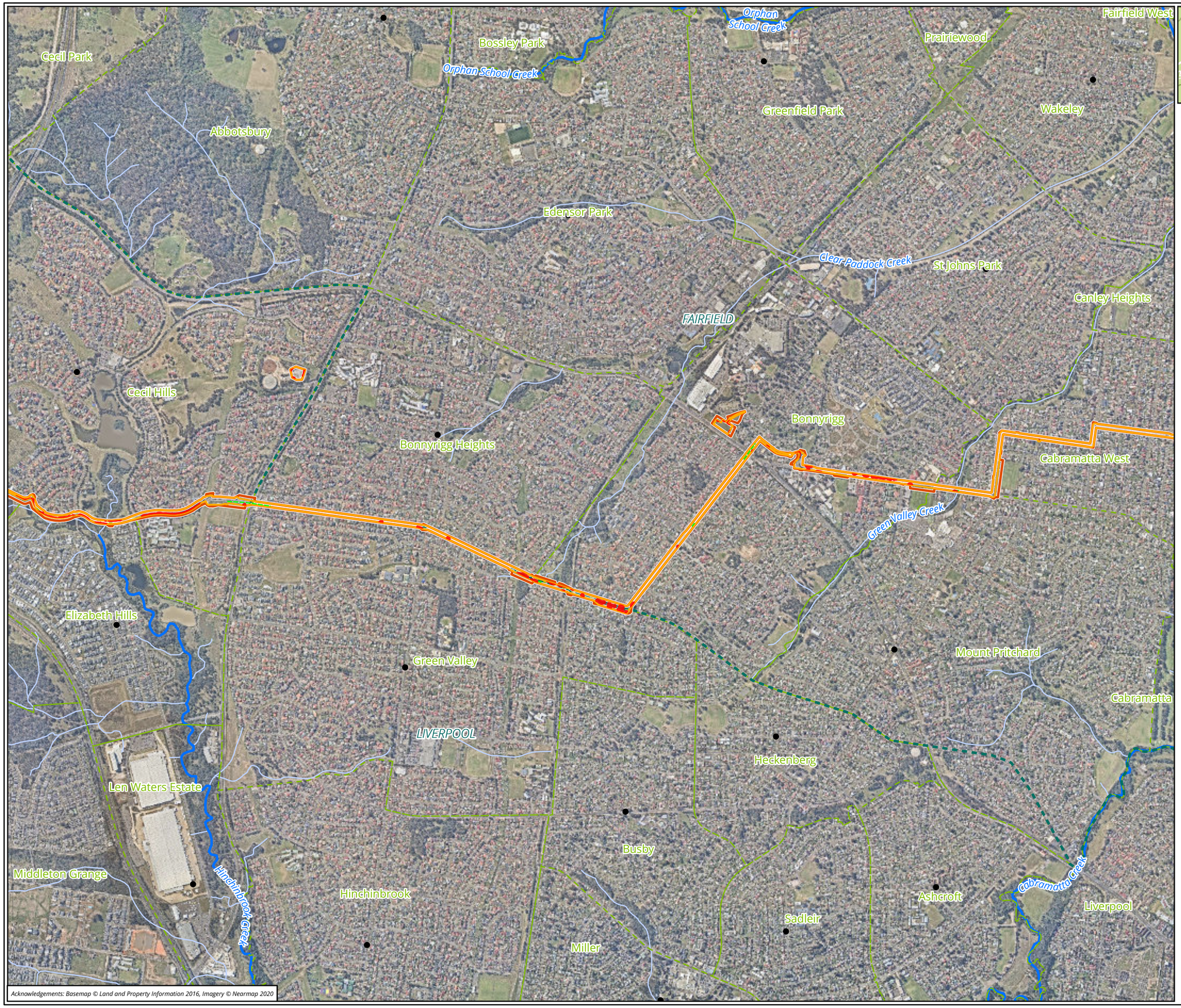

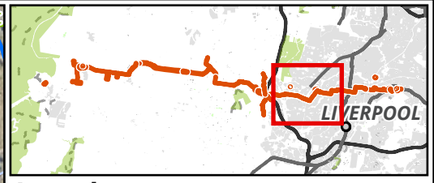

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts requiring offsets

Figure 17.2 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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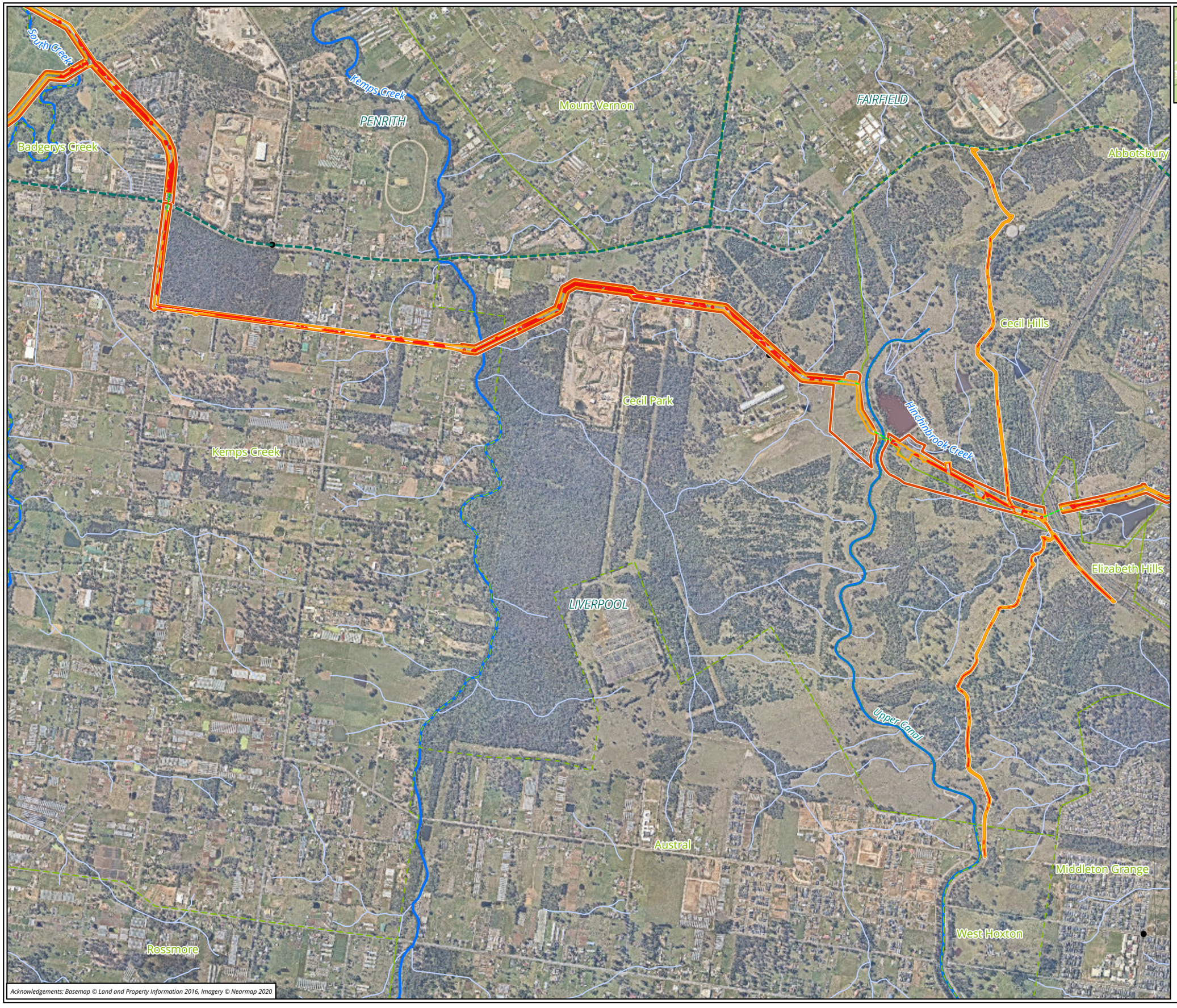

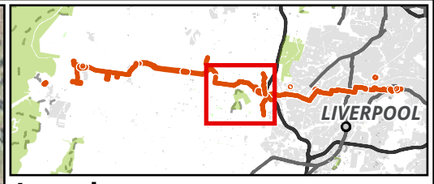

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts requiring offsets

Figure 17.3 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

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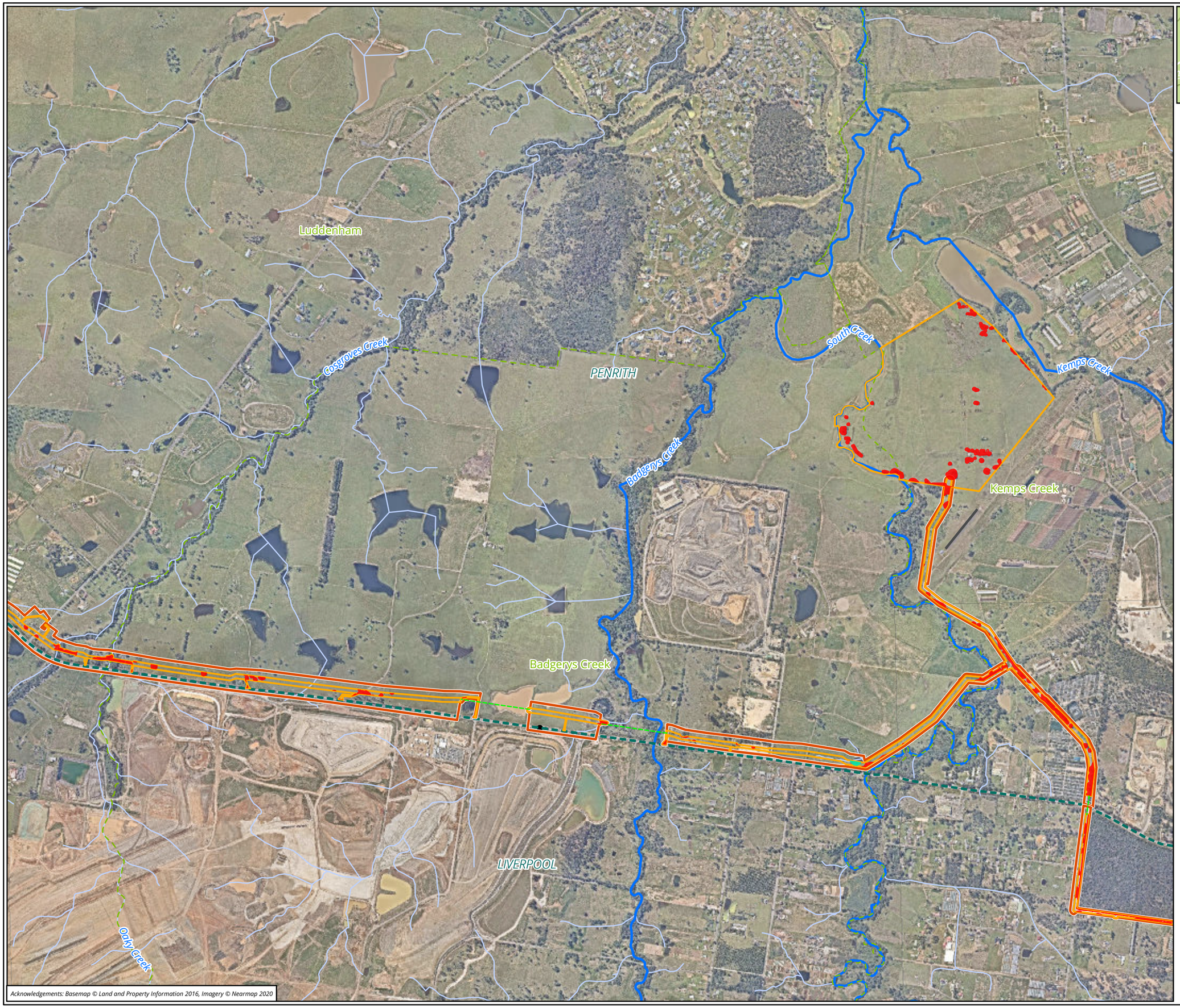

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts not requiring offsets
- Impacts requiring offsets

Figure 17.4 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
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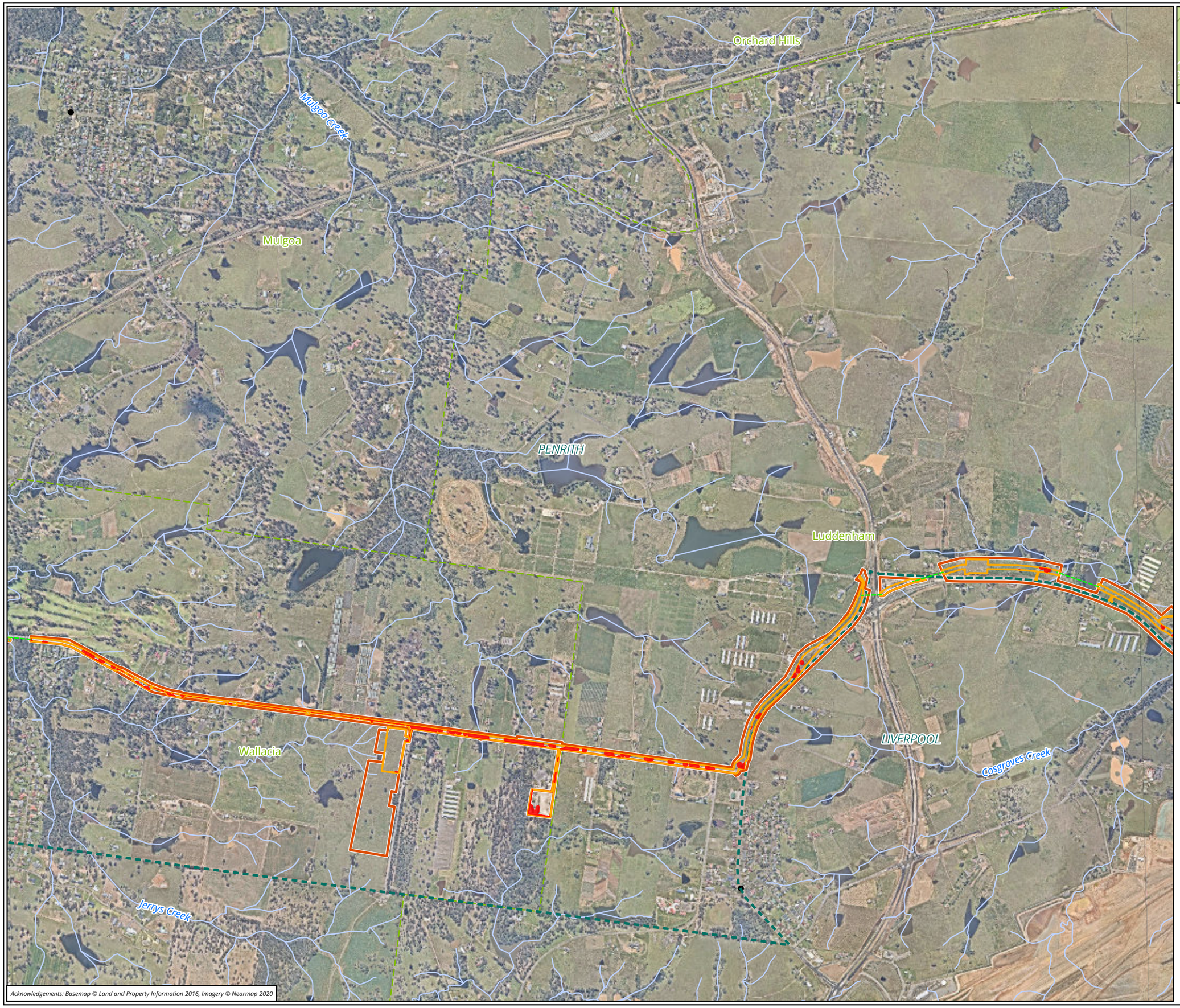

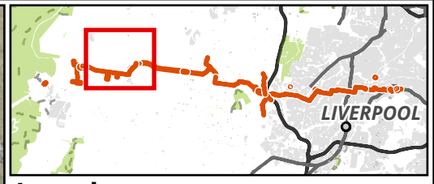

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts not requiring offsets
- Impacts requiring offsets

Figure 17.5 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: LH, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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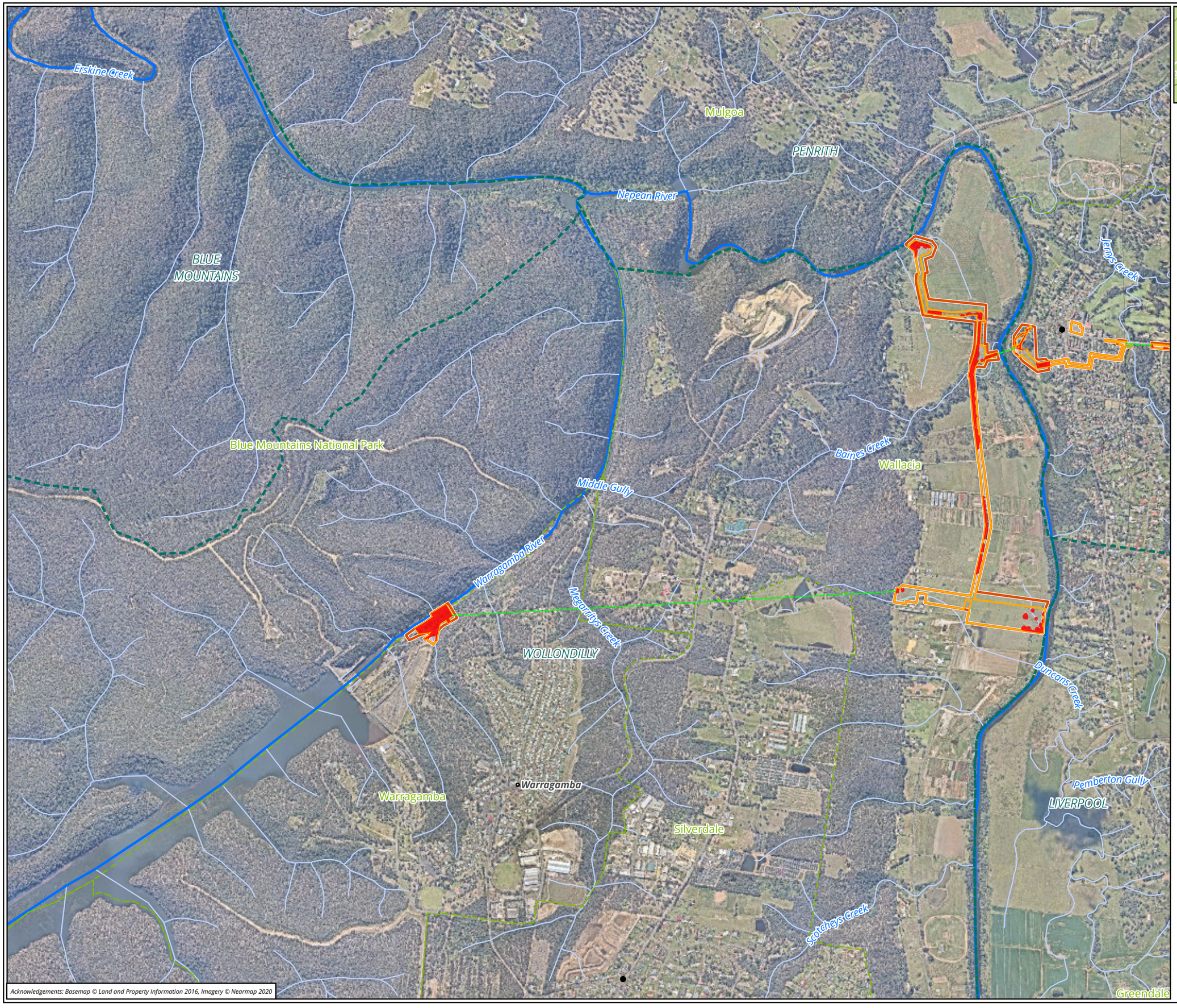

Legend

- Impact area
- Impact assessment area
- Underbore
- Impacts not requiring offsets
- Impacts requiring offsets

Figure 17.6 Impacts requiring offsets, not requiring offset, not requiring assessment

0 160 320 480 640 800

Metres

N

Scale: 1:20,000 @ A3 *Coordinate System: PCS: GDA 1994 MGA Zone 56*

biosis

Matter: 31617,
Date: 24 September 2021,
Prepared for: CW, Prepared by: LH, Last edited by: lharley
Location: P:\31600s\31617\Mapping\31617_Working\31617_BDAR2020

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13. Biodiversity credit reports

BAM Credit Summary Report

Proposal Details

Assessment Id
00019910/BAAS18138/20/00023382

Proposal Name
Upper South Creek Advanced Water Recycling Centre - Cumberland

BAM data last updated *
10/06/2021

Assessor Name
Callan Wharfe

Report Created
19/10/2021

BAM Data version *
45

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* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	BC Act Listing status	EPBC Act listing status	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Castlereagh Ironbark forest											
16	725_Scattered_trees	Not a TEC	18.3	18.3	0.01			High Sensitivity to Potential Gain	2.50		1
										Subtotal	**1**

Castlereagh shale - gravel transition forest											
1	724_Intact	Shale Gravel Transition Forest in the Sydney Basin Bioregion	68.2	68.2	0.4	Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.00		14
2	724_Thinned	Shale Gravel Transition Forest in the Sydney Basin Bioregion	44	44.0	1.1	Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.00		25
3	724_Scattered_trees	Shale Gravel Transition Forest in the Sydney Basin Bioregion	33.7	33.7	0.04	Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.00		1
										Subtotal	**40**
Coastal freshwater wetland											
4	781_Thinned	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	6.3	6.3	0.02	Endangered Ecological Community	Not Listed	High Sensitivity to Potential Gain	2.00		0
										Subtotal	**0**

Cumberland riverflat forest											
5	835_Intact	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	67.5	67.5	0.58	Endangered Ecological Community	Not Listed	High Sensitivity to Potential Gain	2.00		20
6	835_Thinned	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	75	75.0	3.2	Endangered Ecological Community	Not Listed	High Sensitivity to Potential Gain	2.00		121
7	835_Scattered_trees	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	56	56.0	0.75	Endangered Ecological Community	Not Listed	High Sensitivity to Potential Gain	2.00		21
										Subtotal	**162**

Cumberland shale plains woodland											
8	849_Intact	Cumberland Plain Woodland in the Sydney Basin Bioregion	60.5	60.5	0.93	Critically Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.50	TRUE	35
9	849_Thinned	Cumberland Plain Woodland in the Sydney Basin Bioregion	37.9	37.9	2.7	Critically Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.50	TRUE	63
10	849_Scattered_trees	Cumberland Plain Woodland in the Sydney Basin Bioregion	24.9	24.9	1.2	Critically Endangered Ecological Community	Critically Endangered	High Sensitivity to Potential Gain	2.50	TRUE	19
										Subtotal	**117**
Cumberland Swamp Oak riparian forest											
14	1800_Thinned	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	36.1	36.1	0.7	Endangered Ecological Community	Endangered	High Sensitivity to Potential Gain	2.00		13

15	1800_Scattered_trees	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	22.3	22.3	0.22	Endangered Ecological Community	Endangered	High Sensitivity to Potential Gain	2.00		2
										Subtotal	**15**
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion											
11	1083_Thinned	Not a TEC	37.1	37.1	1.4			High Sensitivity to Potential Gain	1.50		19
										Subtotal	**19**
River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion											
12	1105_Thinned	Not a TEC	23	23.0	0.4			High Sensitivity to Potential Gain	1.50		3
										Subtotal	**3**
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion											
13	1181_Intact	Not a TEC	33.6	33.6	0.07			High Sensitivity to Potential Gain	1.50		1
										Subtotal	**1**
										Total	**358**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Species credits

Acacia pubescens / Downy Wattle (Flora)								
849_Intact	60.5	60.5	0.02	Vulnerable	Vulnerable	2	False	1
849_Thinned	37.9	37.9	0.14	Vulnerable	Vulnerable	2	False	3
							Subtotal	**4**
Callistemon linearifolius / Netted Bottle Brush (Flora)								
835_Intact	N/A	N/A	4	Vulnerable	Not Listed	1.5	False	6
835_Thinned	N/A	N/A	2	Vulnerable	Not Listed	1.5	False	3
							Subtotal	**9**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)								
835_Intact	67.5	67.5	0.15	Vulnerable	Vulnerable	3	True	8
835_Thinned	75.0	75.0	1.4	Vulnerable	Vulnerable	3	True	76
835_Scattered_trees	56.0	56.0	0.06	Vulnerable	Vulnerable	3	True	3
849_Thinned	37.9	37.9	0.09	Vulnerable	Vulnerable	3	True	3
849_Scattered_trees	24.9	24.9	0.01	Vulnerable	Vulnerable	3	True	1
1083_Thinned	37.1	37.1	1.4	Vulnerable	Vulnerable	3	True	38
1105_Thinned	23.0	23.0	0.37	Vulnerable	Vulnerable	3	True	6
1181_Intact	33.6	33.6	0.07	Vulnerable	Vulnerable	3	True	2
							Subtotal	**137**
Dillwynia tenuifolia / Dillwynia tenuifolia (Flora)								
849_Thinned	37.9	37.9	0.04	Vulnerable	Not Listed	2	False	1
849_Scattered_trees	24.9	24.9	0.01	Vulnerable	Not Listed	2	False	1
							Subtotal	**2**

Grevillea juniperina subsp. juniperina / Juniper-leaved Grevillea (Flora)								
849_Thinned	37.9	37.9	0.04	Vulnerable	Not Listed	1.5	False	1
849_Scattered_trees	24.9	24.9	0.01	Vulnerable	Not Listed	1.5	False	1
							Subtotal	**2**
Marsdenia viridiflora subsp. viridiflora - endangered population / Marsdenia viridiflora R. Br. subsp. viridiflora population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas (Flora)								
835_Intact	67.5	67.5	0.28	Endangered Population	Not Listed	2	False	9
835_Thinned	75.0	75.0	0.18	Endangered Population	Not Listed	2	False	7
849_Intact	60.5	60.5	0.02	Endangered Population	Not Listed	2	False	1
849_Thinned	37.9	37.9	0.05	Endangered Population	Not Listed	2	False	1
849_Scattered_trees	24.9	24.9	0.01	Endangered Population	Not Listed	2	False	1
							Subtotal	**19**
Meridolum corneovirens / Cumberland Plain Land Snail (Fauna)								
724_Intact	68.2	68.2	0.4	Endangered	Not Listed	2	False	14
724_Thinned	44.0	44.0	1.1	Endangered	Not Listed	2	False	25
835_Intact	67.5	67.5	0.58	Endangered	Not Listed	2	False	20
835_Thinned	75.0	75.0	3.2	Endangered	Not Listed	2	False	121
849_Intact	60.5	60.5	0.93	Endangered	Not Listed	2	False	28
849_Thinned	37.9	37.9	2.7	Endangered	Not Listed	2	False	51
							Subtotal	**259**

Miniopterus orianae oceanensis / Large Bent-winged Bat (Fauna)								
1083_Thinned	37.1	37.1	1.4	Vulnerable	Not Listed	3	True	38
1105_Thinned	23.0	23.0	0.13	Vulnerable	Not Listed	3	True	2
1181_Intact	33.6	33.6	0.05	Vulnerable	Not Listed	3	True	1
							Subtotal	**41**
Myotis macropus / Southern Myotis (Fauna)								
724_Thinned	44.0	44.0	1	Vulnerable	Not Listed	2	False	22
724_Scattered_trees	33.7	33.7	0.03	Vulnerable	Not Listed	2	False	1
781_Thinned	6.3	6.3	0.02	Vulnerable	Not Listed	2	False	1
835_Intact	67.5	67.5	0.54	Vulnerable	Not Listed	2	False	18
835_Thinned	75.0	75.0	2.6	Vulnerable	Not Listed	2	False	96
835_Scattered_trees	56.0	56.0	0.43	Vulnerable	Not Listed	2	False	12
849_Intact	60.5	60.5	0.04	Vulnerable	Not Listed	2	False	1
849_Thinned	37.9	37.9	1.3	Vulnerable	Not Listed	2	False	24
849_Scattered_trees	24.9	24.9	0.5	Vulnerable	Not Listed	2	False	6
1105_Thinned	23.0	23.0	0.29	Vulnerable	Not Listed	2	False	3
1181_Intact	33.6	33.6	0.02	Vulnerable	Not Listed	2	False	1
1800_Thinned	36.1	36.1	0.7	Vulnerable	Not Listed	2	False	13
1800_Scattered_trees	22.3	22.3	0.22	Vulnerable	Not Listed	2	False	2
725_Scattered_trees	18.3	18.3	0.01	Vulnerable	Not Listed	2	False	1

							Subtotal	**201**
Pimelea spicata / Spiked Rice-flower (Flora)								
835_Intact	67.5	67.5	0.37	Endangered	Endangered	2	False	12
835_Thinned	75.0	75.0	0.17	Endangered	Endangered	2	False	6
849_Intact	60.5	60.5	0.85	Endangered	Endangered	2	False	26
849_Thinned	37.9	37.9	1.6	Endangered	Endangered	2	False	30
849_Scattered_trees	24.9	24.9	0.01	Endangered	Endangered	2	False	1
							Subtotal	**75**
Pommerhelix duralensis / Dural Land Snail (Fauna)								
1083_Thinned	37.1	37.1	1.4	Endangered	Endangered	2	False	26
1181_Intact	33.6	33.6	0.07	Endangered	Endangered	2	False	1
							Subtotal	**27**
Pultenaea parviflora / Pultenaea parviflora (Flora)								
849_Scattered_trees	24.9	24.9	0.01	Endangered	Vulnerable	2	False	1
							Subtotal	**1**
Pultenaea pedunculata / Matted Bush-pea (Flora)								
849_Thinned	37.9	37.9	0.04	Endangered	Not Listed	2	False	1
849_Scattered_trees	24.9	24.9	0.01	Endangered	Not Listed	2	False	1
							Subtotal	**2**

14. Assessment against biodiversity legislation

14.1 Environmental Planning and Assessment Act 1979

14.1.1 SEPP (Sydney Region Growth Centres) 2006

The impact area crosses directly north of the future WSAGA and extends across Existing Certified and Existing Non-Certified land associated with the South West Growth Centre (SWGC) between Luddenham and Elizabeth Hills, all of which is regulated by SEPP (Sydney Region Growth Centres) 2006. Approximately 6.7 hectares of the impact area occurs on Existing Certified land and 12.1 hectares of the impact area occurs on Existing Non-certified land within the SWGC. The project will impact upon a total of 1.31 hectares of native vegetation on Existing Certified land, and 2.38 hectares of native vegetation on Existing Non-Certified land. All Existing Certified land has already undergone assessment and offsetting against the EPBC Act and former NSW *Threatened Species Conservation Act 1994* (BC Act) and impacts are not considered any further in this BDAR. Specific Relevant Biodiversity Measures (RBMs) prescribed by the *Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Biodiversity Certification Order) are addressed below and will be addressed in more detail within the EIS.

The SEPP (Sydney Region Growth Centres) 2006 provides development controls for development impacting areas mapped within Flood prone land and Major creeks mapping as per Part 5 and Part 6 of the SEPP. Flood prone land is mapped as occurring around Kemps Creek in the location where the alignment crosses the watercourse.

Part 5 of the SEPP (Growth Centres) 2006 requires a number of consideration to be undertaken regarding the impact any development will have on mapped Flood prone land. However, Clause 19 (1) states that these controls only apply to developments requiring consent, and therefore are not applicable to the project.

Part 6 of the SEPP (Growth Centres) 2006 relates to removal of native vegetation on land that satisfies a number of conditions, including being mapped as Flood prone and Major creeks land. Clause 23 (1) (a) states that *A person must not clear native vegetation on land to which this Part applies without … approval under Part 3A* (now SSD/SSI) *of the Act.* All other considerations again relate to developments requiring consent.

The project will remove native vegetation from within both Existing Certified and Existing Non-Certified land and is therefore subject to RBMs outlined in the Biodiversity Certification Order. Further detail is provided below.

Order to confer biodiversity certification on the SEPP (Sydney Region Growth Centres) 2006

The Biodiversity Certification Order outlines 41 conditions, known as the RBMs, to ensure consistency with the biodiversity certification for the growth centres during future development. A number of these RBMs are relevant to the project including:

- RBM 8 and RBM 11 pertaining to removal of vegetation in non-certified land.
- RBM 12 pertaining to removal of vegetation within special provision area.
- RBM 17 pertaining to potential population of Downy Wattle *Acacia pubescens.*

RBM 8 and RBM 11 relate to the removal of 'existing native vegetation' from Existing Non-Certified land, and provides details on offsetting requirements for any impacts that may occur.

RBM 8 states that the clearing of any existing native vegetation in the Existing Non-Certified land will be offset by:

a) the protection of an equal or greater area of existing native vegetation elsewhere in the Growth Centres; and/or

b) the revegetation and/or restoration of an area of land elsewhere in the Growth Centres, subject to a number of additional conditions relating to the protection, size, ongoing management, and any potential additionallity of proposed revegetation/restoration.

RBM 11 states that for essential infrastructure proposals, such as the current project, clearing of existing native vegetation in Non-certified areas, will be subject to the offsetting requirements outlined in RBM 8.

RBM 12 states that within lands marked by a red hatching on the biodiversity certification maps (including the land surrounding Kemps Creek) existing native vegetation must not be cleared unless it is in accordance with a plan of management or unless such clearance has been agreed to by the DECC (now DPIE).

The project will impacts upon 0.33 hectares of existing native vegetation subject to RBM 8, RBM 11 and RBM 12, where the impact area crosses Kemps Creek. Impacts to this vegetation will occur as a result of a need to open trench the watercourse. Underboring the watercourse was considered as a crossing option however geotechnical field investigations identified a fault line under Kemps Creek. The fault line increases the risk of frac-out during underboring. A frac-out could have a high impact to vegetation and water quality in Kemps Creek. For this reason, trenching has been identified as the preferred construction method. To reduce impacts to existing native vegetation in this location, the impact area has been narrowed to 15 metres wide, from the standard 25 metres wide over the majority of the alignment. This has reduced the potential impacts in this location by 0.21 hectares, or almost 40 %.

Sydney Water is committed to securing offsets for this residual impact to existing native vegetation as defined in the Biodiversity Certification Order, in accordance with RBM 8 and RBM 11, with further details provided in Section 15.

The impact area also occurs along the boundary of an area identified by RBM 17 as holding a potential population of Downy Wattle, along Cross St, Kemps Creek, the vegetation was surveyed as per the BAM guidelines *Surveying threatened plants and their habitats* (DPIE 2020e), therefore addressing the requirements of this RBM.

14.1.2 SEPP (Western Sydney Aerotropolis) 2020

The impact area and impact assessment area occur on land zoned as the following under SEPP (Western Sydney Aerotropolis) 2020:

- Agribusiness (AGB)
- Enterprise Zone (ENT)
- Environment and Recreation Zone (ENZ)
- Infrastructure (SP2)

The water recycling centre site and a number of locations along the treated water pipelines occur in areas mapped as supporting 'high biodiversity values' under the SEPP. These areas of mapped high biodiversity values generally occur along the watercourses and on the associated floodplains of the creeks running through the SEPP's Land Application Area, and co-occur with flood planning areas. The entire project area (relevant to the SEPP's Land Application Area) also occurs within the '13 kilometre wildlife buffer zone', and the majority of the treated water pipeline from Elizabeth Drive to Park Road occurs within the '3 kilometre wildlife buffer zone'.

Clause 27 of the SEPP applies to land in the Environment and Recreation Zone, and land shown as "high biodiversity value" on the High Biodiversity Value Areas Map.

(1) The objectives of this clause are—

(a) to preserve the amenity of the Western Sydney Aerotropolis through the preservation of trees and vegetation, and

(b) to promote the conservation of, and minimise the impact of development on, native vegetation.

(2) This clause applies to— land as outlined above.

(3) A person must not clear native vegetation on land to which this clause applies without development consent.

(4) Development consent under subclause (3) must not be granted unless the consent authority is satisfied that, in relation to the disturbance of native vegetation caused by the clearing—

(a) there is no reasonable alternative available to the disturbance of the native vegetation, and

(b) any impact of the proposed clearing on biodiversity values is avoided or minimised, and

(c) the disturbance of the native vegetation will not increase salinity, and

(d) native vegetation inadvertently disturbed for the purposes of construction will be re-instated where possible on completion of construction, and

(e) the loss of remnant native vegetation caused by the disturbance will be compensated by revegetation on or near the land to avoid a net loss of remnant native vegetation, and

(f) the clearing of the vegetation is unlikely to cause or increase soil erosion, salination, land slip, flooding, pollution or other adverse land or water impacts.

(5) Development for the following purposes is prohibited on land shown as "high biodiversity value" on the High Biodiversity Value Areas Map—

(a) environmental facilities,

(b) information and education facilities,

(c) kiosks,

(d) recreation areas,

(e) recreation facilities (outdoor),

(f) roads,

(g) water recreation structures.

(6) State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017 does not apply to land to which this clause applies.

(7) This clause does not authorise the clearing of existing native vegetation within the meaning of the relevant biodiversity measures under Part 7 of Schedule 7 to the repealed Threatened Species Conservation Act 1995.

This BDAR, the mitigation strategies contained herein, and the EIS as a whole are considered sufficient to meet the objects of the clause.

Flood planning in areas mapped as within the 1 in 100 exceedance probability (AEP) flood extent for Kemps Creek, South Creek, Badgerys Creek and Cosgrove / Oakey Creeks, is required to consider the following.

(1) The objectives of this clause are—

(a) to minimise the flood risk to life and property associated with the use of land, and

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change, and

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to—

(a) land shown as the "flood planning area" on the Flood Planning Map, and

(b) other land that is at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the development—

(a) is compatible with the flood hazard of the land, taking into account projected changes as a result of climate change, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will enable safe occupation of and evacuation from flood prone land, and

(e) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(f) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding, and

(g) is consistent with any relevant floodplain risk management plan adopted by the council for the land in accordance with the Floodplain Development Manual.

(4) Development consent may be granted to development on land below the flood planning level only if the development—

(a) does not involve earthworks that will affect flood storage capacity or flood behaviour, and

(b) is not located on a floodway area or flood storage area.

(5) Words and expressions used in this clause have the same meaning as in the Floodplain Development Manual.

(6) In this clause—

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

Floodplain Development Manual means the NSW Government's Floodplain Development Manual published in 2005.

The project is not considered to be adverse to the objective of this clause from a biodiversity perspective. Further detail is provided in the projects hydrology assessment and EIS chapter

Planning controls relevant to potential wildlife hazards relating to the project include the following.

(1) The objective of this clause is to regulate development on land surrounding the Airport where wildlife may present a risk to the operation of the Airport.

(2) Development consent must not be granted to relevant development on land in the 13 kilometre wildlife buffer zone unless the consent authority—

(a) has consulted the relevant Commonwealth body, and

(b) has considered a written assessment of the wildlife that is likely to be present on the land and the risk of the wildlife to the operation of the Airport provided by the applicant, which includes—

(i) species, size, quantity, flock behaviour and the particular times of day or year when the wildlife is likely to be present, and

(ii) whether any of the wildlife is a threatened species, and

(iii) a description of how the assessment was carried out, and

(c) is satisfied that the development will mitigate the risk of wildlife to the operation of the Airport, including, for example, measures relating to—

(i) waste management, landscaping, grass, fencing, stormwater or water areas, or

(ii) the dispersal of wildlife from the land by the removal of food or the use of spikes, wire or nets.

(3) Despite subclause (2), development for the following purposes is prohibited on land in the 3 kilometre wildlife buffer zone—

(a) livestock processing industries,

(b) turf farming,

(c) waste or resource management facilities that consist of outdoor processing, storage or handling of organic or putrescible waste.

(4) In this clause—

3 kilometre wildlife buffer zone means the land shown as the "3 kilometre wildlife buffer zone" on the Wildlife Buffer Zone Map.

13 kilometre wildlife buffer zone means the land shown as the "13 kilometre wildlife buffer zone" on the Wildlife Buffer Zone Map and includes the 3 kilometre wildlife buffer zone.

Sydney Water has undertaken an assessment of the project to ensure any risk associated with potential wildlife hazards ca be effectively managed. More information is available in *Sydney Water Wildlife Hazard Assessment Western Sydney Water Treatment Plant* (Avisure 2020).

It should be ensured that the project meets the requirements outlined above, including during the rehabilitation of areas of ground disturbance resulting from construction activities, and during the development of operational procedures.

14.1.3 SEPP No 19 – Bushland in Urban Areas 1986

The majority of the study area is subject to SEPP No 19 – Bushland in Urban Areas 1986 with the exception of Western Sydney Parklands.

Under Part 6 Subclause 2 (c)(i) development consent is not required for the disturbance of bushland is being disturbed for the purposing of constructing, operating or maintaining sewerage pipelines.

14.1.4 SEPP (Vegetation in non-rural areas) 2017

The proposed development occurs on land mapped under *SEPP (Vegetation in Non-Rural Areas) 2017* based on occurrence with the Canterbury-Bankstown, Fairfield, Liverpool and Penrith LGA's as per Part 1, Section 5 of the SEPP. This SEPP is not relevant to the project within the Wollondilly LGA.

Under Part 2, Section 8(1) of *SEPP (Vegetation in Non-Rural Areas) 2017*, the proposed vegetation clearance does not require an authority under the SEPP as it is authorised under Section 60O(b)(iii) of the NSW *Local Land Services Act 2013* via assessment and approval under Part 5 of the EP&A Act.

14.1.5 SEPP (Coastal Management) 2018

The proposed development is located on land mapped as Coastal Wetlands and Proximity Area for Coastal Wetlands as defined by the Coastal Management SEPP. The current project design will result in the removal of vegetation and disturbance to soil within the proximity area for Coastal Wetlands.

Section 11 of SEPP Coastal Management states that consent must not be granted for developments in the Proximity Area for Coastal Wetlands unless the consent authority is satisfied that the project will not significantly impact on the biophysical, hydrological or ecological integrity of the adjacent Coastal Wetlands or the quantity or quality of flows to the adjacent Coastal Wetland.

The following components of the proposed development occur within proximity to Coastal wetlands:

- The pipeline installation within area cleared of vegetation approximately 50 metres from wetlands associated with Prospect Creek.
- The pipeline installation and vegetation removal adjacent to wetlands associated with Clear Paddock Creek.
- The pipeline installation and vegetation removal 15 metre from wetlands associated with Hinchinbrook Creek tributary.

The works proposed to occur within proximity to Coastal wetlands will be subject to the mitigation measures and safeguards outlined in Section 11.5, and as such indirect impacts are not expected to occur.

Based on the above, the proposed development is not expected to result in significant impacts to the biophysical, hydrological or ecological integrity of Coastal Wetlands nor will they alter the quantity or quality of flows to adjacent Coastal Wetlands.

14.2 Biosecurity Act 2015

The Biosecurity Act provides for the identification, classification and control of priority weeds with the purpose of determining if a biosecurity risk is likely to occur. A biosecurity risk is defined as the risk of a biosecurity impact occurring, which for weeds includes the introduction, presence, spread or increase of a pest into or within NSW or any part of the State. A pest plant has the potential to; harm or reduce biodiversity or out-compete other organisms for resources, including food, water, nutrients, habitat and sunlight.

Thirteen priority weeds for the Greater Sydney LLS Region have been recorded in the impact area and impact assessment area and are listed in Table 55, along with their associated Duty.

Table 55 Priority weeds within the impact area and impact assessment area

Scientific name	Common name	General biosecurity duty
Alternanthera philoxeroides	Alligator Weed	***Prohibition on dealings*** *Must not be imported into the State or sold.* ***Regional Recommended Measure*** *Exclusion zone: Blue Mountains City Council area. Core infestation area: the remainder of the region.* *Whole region: Land managers prevent spread from their land where feasible. Exclusion zone: The plant is eradicated from the land and the land kept free of the plant. Core infestation area: Land managers mitigate the risk of new weeds being introduced to their land. Land managers reduce the impact on priority assets.*
Anredera cordifolia	Madeira Vine	***Prohibition on dealings*** *Must not be imported into the State or sold.*
Asparagus aethiopicus	Ground Asparagus	***Prohibition on dealings*** *Must not be imported into the State or sold.*
Asparagus asparagoides	Bridal Creeper	***Prohibition on dealings*** *Must not be imported into the State or sold.* ****this requirement also applies to the Western Cape form of bridal creeper***
Cestrum parqui	Green Cestrum	***Regional Recommended Measure*** *Land managers should mitigate the risk of new weeds being introduced to land used for grazing livestock. Land managers should mitigate spread from their land. Plant should not be bought, sold, grown, carried or released into the environment.*
Lantana camara	Lantana	***Prohibition on dealings*** *Must not be imported into the State or sold.*
Lycium ferocissimum	African Boxthorn	***Prohibition on dealings*** *Must not be imported into the State or sold.*
Nassella neesiana	Chilean Needle Grass	***Prohibition on dealings*** *Must not be imported into the State or sold.*
Olea europaea* subsp. *cuspidata	African Olive	***Regional Recommended Measure*** *An exclusion zone is established for all lands in Blue Mountains City Council local government area and in Penrith local government area west of the Nepean River. The remainder of the region is classified as the core infestation area.* *Whole region: The plant or parts of the plant are not traded, carried, grown or released into the environment. Exclusion zone: The plant is eradicated from the land and the land kept free of the plant. Core infestation area: Land managers prevent spread from their land where feasible. Land managers reduce impacts from the plant on priority assets.*
Opuntia stricta	Common Pear	***Prohibition on dealings*** *Must not be imported into the State or sold.*

Scientific name	Common name	General biosecurity duty
***Rubus fruticosus* species aggregate**	Blackberry	***Prohibition on dealings*** *Must not be imported into the State or sold.* *All species in the Rubus fruiticosus species aggregate have this requirement, except for the varietals Black Satin, Chehalem, Chester Thornless, Dirksen Thornless, Loch Ness, Murrindindi, Silvan, Smooth Stem, and Thornfree*
Salvinia molesta	Salvinia	***Prohibition on dealings*** *Must not be imported into the State or sold.* ***Regional Recommended Measure*** *Exclusion zone: whole region except for the core infestation area of the Georges and Hawkesbury-Nepean Rivers and their tributaries.* *Whole region: Land managers mitigate the risk of the plant being introduced to their land. Exclusion zone: The plant is eradicated and the land kept free of the plant. The Local Control Authority should be notified if the plant is found. Core infestation area: Land managers should prevent spread from their land where feasible.*
Senecio madagascariensis	Fireweed	***Prohibition on dealings*** *Must not be imported into the State or sold.*

Additional biosecurity risks relevant to the project have been assessed in *Land Use Conflict Risk Assessment for the Upper South Creek AWRC* (Aurecon Arup, 2021c).

A biosecurity management plan prepared as part of the project's CEMP is recommended and will prevent the spread of weeds and other biosecurity items into the impact area upon implementation.

14.3 Water Management Act 2000

The WM Act provides for the sustainable and integrated management of the state's water. Under the WM Act an approval is required to undertake controlled activities on waterfront land, unless that activity is otherwise exempt under Section 91E. Waterfront land is defined within the Act as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark.

The proposed development is exempt from the requirement to apply for a section 89 water use approval, section 90 water management work approval or a section 91 controlled activity approval as per section 5.23 of the EP&A Act. Similarly, the project is exempt from requiring approval under section 91 of the WM Act once aquifer interference provisions commence. A licence under section 56 of the WM Act for water access is likely to be required.

Watercourse crossings (temporary and permanent) shall be designed in consultation with NSW Department of Primary Industries - Natural Resources Access Regulator (NRAR), and where feasible and reasonable, be consistent with the Guidelines for controlled activities on waterfront land – riparian corridors (NRAR 2018), *Guidelines for watercourse crossing on waterfront land* (NRAR 2012) and Fisheries NSW *Policy and Guidelines for Fish Habitat Conservation and Management* (2013 update) (Fairfull 2013).

14.4 National Parks and Wildlife Act 1974

The proposed development occurs on land adjoining Blue Mountains National Park, Burragorang State Conservation Area, Kemps Creek Nature Reserve and Western Sydney Regional Park. These parks form part of land managed by the National Park and Wildlife Service and have been conserved under the *National Parks and Wildlife Act 1974* (NPWS Act).

The proposed development occurs on land adjoining land conserved under the NPWS Act and therefore must adhere to guidelines produced by the Office of Environment and Heritage (now the Office of Environmental, Energy and Science (EES)) (OEH 2013). These guidelines outline approaches and key risks that development can have on values within the reserve, including:

- Erosion and sediment control.
- Stormwater runoff.
- Wastewater.
- Management implications relating to pests, weeds and edge effects.
- Fire and the location of asset protection zones.
- Boundary encroachments and access through EES lands.
- Visual, odour, noise, vibration, air quality and amenity impacts.
- Threats to ecological connectivity and groundwater dependent ecosystems.
- Cultural heritage.

It is recommended that proposed activity is undertaken in consultation with EES and National Parks and Wildlife Service.

15. Biodiversity offset strategy

As outlined in the sections above the residual impact to biodiversity values as a result of the project will require biodiversity offsets to be secured in accordance with the NSW BOS. This assessment has concluded that there will not be residual significant impacts to MNES listed under the Commonwealth EPBC Act, and therefore biodiversity offsets are not required to meet the criteria outlined in *EPBC Act Environmental Offsets Policy* (CoA 2012). Residual impacts to MNES, detailed in Section 9 will however be offset in accordance with the requirements of the NSW BOS.

Under the BOS Sydney Water has three main avenues for securing biodiversity offsets for the project, those being:

- Payment to the Biodiversity Conservation Fund managed by the Biodiversity Conservation Trust.
- Purchase (transfer) and retire credits from existing credit holders.
- Establish a Biodiversity Stewardship Site to generate credits required by the project.

Table 56 provides details of the projects biodiversity credit requirement (as previously presented in Sections 12.1 and 13 above), as well as like for like credit trading options for ecosystem credits. Table 57 provides details of the species credit requirement resulting from the project.

Sydney Water is committed to securing the required number and type biodiversity credit to offset residual impact of the project, either through retirement of like for like credits via a combination of the above listed options, or if unavailable though implementation of the variation rules.

Impacts associated with the clearing of 0.33 hectares of existing native vegetation on Existing Non-certified land, subject to RBM 8, RBM 11 and RBM 12 at Kemps Creek (see Section 14.1.1) are subject to specific offsetting requirements as outlined in the Biodiversity Certification Order. Sydney Water is committed to securing these offsets within the Growth Centres as required by the Biodiversity Certification Order. Offsets will be secured though either revegetation / restoration at an offsetting ratio of 3:1 (in accordance with the requirements of RBM 8), or through the transfer and retirement of biodiversity credits under the BOS, generated from a Biodiversity Stewardship Site within the Growth Centres.

Table 56 Upper South Creek AWRC ecosystem credit requirement and like for like trading options

PCT	Name of offset trading group	Trading group	Vegetation zone	HBT	Credits	IBRA region
724-Castlereagh shale - gravel transition forest	Shale Gravel Transition Forest in the Sydney Basin Bioregion This includes PCT's: 724, 808	-	724_Intact	No	14	Cumberland, Burragorang, Pittwater, Sydney Cataract, Wollemi and Yengo. Or, any IBRA subregion that is within 100 kilometres of the outer edge of the impacted site.
			724_Thinned	No	25	
			724_Scattered_trees	No	1	
725-Castlereagh Ironbark forest	Cumberland Dry Sclerophyll Forests This includes PCT's: 725	Cumberland Dry Sclerophyll Forests >=90%	725_Scattered_trees	No	1	
781-Coastal freshwater wetland	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions This includes PCT's: 780, 781, 782, 828, 1071, 1735, 1736, 1737, 738, 1739, 1740, 1741, 1742, 1911	-	781_Thinned	No	0	
835-Cumberland riverflat forest	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions This includes PCT's: 686, 828, 835, 839, 941, 971, 1064, 1108, 1109, 1212, 1228, 1232, 1293, 1318, 1326, 386, 1504, 1522, 1556, 1594, 1618, 1646, 1648, 720, 1794	-	835_Intact	No	20	
			835_Thinned	No	121	
			835_Scattered_trees	No	21	
849-Cumberland shale plains woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion This includes PCT's: 849, 850	-	849_Intact	No	35	
			849_Thinned	No	63	
			849_Scattered_trees	No	19	
1083-Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Sydney Coastal Dry Sclerophyll Forests This includes PCT's: 1083, 1138, 1156, 1181, 1183, 1250, 1253, 1619, 1620, 1621, 1623, 1624, 1625, 1627, 1632, 1636, 1638, 1642, 1643, 1681, 1776, 1777, 1778, 1780, 1782, 1783, 1785, 1786, 1787	Sydney Coastal Dry Sclerophyll Forests <50%	1083_Thinned	No	19	

PCT	Name of offset trading group	Trading group	Vegetation zone	HBT	Credits	IBRA region
1105-River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Eastern Riverine Forests This includes PCT's: 42, 84, 85, 485, 486, 1105, 1106, 1108, 1127, 1270, 1271, 1292, 1293, 1318, 1713, 1714, 1761	Eastern Riverine Forests <50%	1105_Thinned	No	3	
1181-Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Sydney Coastal Dry Sclerophyll Forests This includes PCT's: 1083, 1138, 1156, 1181, 1183, 1250, 1253, 1619, 1620, 1621, 1623, 1624, 1625, 1627, 1632, 1636, 1638, 1642, 1643, 1681, 1776, 1777, 1778, 1780, 1782, 1783, 1785, 1786, 1787	Sydney Coastal Dry Sclerophyll Forests <50%	1181_Intact	No	1	
1800-Cumberland Swamp Oak riparian forest	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions This includes PCT's: 915, 916, 917, 918, 919, 1125, 1230, 1232, 1234, 1235, 1236, 1726, 1727, 1728, 1729, 1731, 1800, 1808	-	1800_Thinned	No	13	
			1800_Scattered trees	No	2	

Table 57 AWRC species credit requirement and like for like trading options

Species credit	Credits required	Like for like credit retirement options	IBRA subregion
***Acacia pubescens* - Downy Wattle**	4	*Acacia pubescens* - Downy Wattle	Any in NSW
***Callistemon linearifolius* - Netted Bottle Brush**	9	*Callistemon linearifolius* - Netted Bottle Brush	Any in NSW
Dillwynia tenuifolia	2	*Dillwynia tenuifolia*	Any in NSW
***Grevillea juniperina* subsp. *juniperina* - Juniper-leaved Grevillea**	2	*Grevillea juniperina* subsp. *juniperina* - Juniper-leaved Grevillea	Any in NSW
***Marsdenia viridiflora* subsp. *viridiflora* - endangered population**	19	*Marsdenia viridiflora* subsp. *viridiflora* - endangered population	Any in NSW
***Pimelea spicata* - Spiked Rice-flower**	75	*Pimelea spicata* - Spiked Rice-flower	Any in NSW
***Pultenaea parviflora* - Sydney Bush-pea**	1	*Pultenaea parviflora* - Sydney Bush-pea	Any in NSW
***Pultenaea pedunculata* - Mated Bush-pea**	2	*Pultenaea pedunculata* - Mated Bush-pea	Any in NSW
***Chalinolobus dwyeri* - Large-eared Pied Bat**	137	*Chalinolobus dwyeri* - Large-eared Pied Bat	Any in NSW
***Meridolum corneovirens* - Cumberland Plain Land Snail**	259	*Meridolum corneovirens* - Cumberland Plain Land Snail	Any in NSW
***Miniopterus orianae oceanensis* - Large Bent-winged Bat**	41	*Miniopterus orianae oceanensis* - Large Bent-winged Bat	Any in NSW
***Myotis macropus* - Southern Myotis**	201	*Myotis macropus* - Southern Myotis	Any in NSW
***Pommerhelix duralensis* – Dural Land Snail**	27	*Pommerhelix duralensis* – Dural Land Snail	Any in NSW

16. Conclusion

The Upper South Creek AWRC project has been assessed in accordance with the NSW BAM and the Commonwealth EPBC Act requirements as detailed in the project SEARs.

Following efforts undertaken to avoid and minimise impact to biodiversity during the design phases of the project, residual unavoidable impacts to BC Act and EPBC Act listed biodiversity values, and PCTs providing habitat to listed threatened species, were reduced to the following, as outlined in Table 58 and Table 59.

Table 58 Biodiversity values impacted by the project and total credit requirement

Biodiversity value	Area (ha) / Count (indiv.)	Credit requirement
Native vegetation (PCTs) – Ecosystem credits		
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion (Shale Gravel Transition Forest TEC)	1.58	40
725: Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain	0.01	1
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion (Freshwater wetlands on coastal floodplains TEC)	0.02	0
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (River-flat Eucalypt Forest TEC)	4.56	162
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (Cumberland Plain Woodland TEC)	4.83	117
1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	1.38	19
1105: River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	0.40	3
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	0.07	1
1800: Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley (Swamp Oak Floodplain Forest TEC)	0.92	15
Threatened species – Species credits		
Dillwynia tenuifolia	0.05	2
Downy Wattle *Acacia pubescens*	0.16	4
Juniper-leaved *Grevillea Grevillea juniperina* subsp. *juniperina*	0.05	2

Biodiversity value	Area (ha) / Count (indiv.)	Credit requirement
***Marsdenia viridiflora* subsp. *viridiflora* - endangered population**	0.54	19
Netted Bottle Brush *Callistemon linearifolius*	6 (assumed)	9
Spiked Rice-flower *Pimelea spicata*	2.99	75
Sydney Bush-pea *Pultenaea parviflora*	0.01	1
Matted Bush-pea *Pultenaea pedunculata*	0.05	2
Cumberland Plain Land Snail *Meridolum corneovirens*	8.96	259
Dural Land Snail *Pommerhelix duralensis*	1.45	27
Large Bent-winged Bat *Miniopterus orianae oceanensis*	1.56	41
Large-eared Pied Bat *Chalinolobus dwyeri*	3.48	137
Southern Myotis *Myotis macropus*	7.62	201

Table 59 TECs impacted by the project

TEC name	Listing status	Area impacted (Ha)
BC Act TECs		
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	Endangered	0.00
Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	4.37
River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	4.39
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered	1.54
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	0.88
Sydney Freshwater Wetlands in the Sydney Basin Bioregion	Endangered	0.02
EPBC Act TECs		
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	0.22
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered	0.00
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	1.88

Impacts to Large-eared Pied Bat, Large Bent-winged Bat, Little Bent-winged Bat *Miniopterus australis* and Sooty Owl *Tyto tenebricosa* have seen conservatively assessed as potential SAIIs, due to direct impacts to low potential breeding habitat, and vegetation removal with the BAM prescribed breeding buffer of potential breeding habitat outside the project area.

An assessment of impacts to EPBC Act listed MNES was undertaken for a suite of species and communities known of considered likely to occur within the project area. It was concluded that a significant residual impact was unlikely to occur to any MNES as a result of the project.

Direct and indirect impacts have been assessed and are considered to have been reduced to an acceptable level for a project of this scale. Mitigation measures have been prescribed and Sydney Water is committed to their implementation to continue to reduce impacts to biodiversity values, and to the securing of the required biodiversity offsets (Table 58) in accordance with the NSW Biodiversity Offset Scheme (BOS).

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Appendices

Appendix 1 Survey information and limitations

Appendix 1.1 Nomenclature

The flora taxonomy (classification) used in this report follows the most recent Flora of NSW (Harden 1992, Harden 1993, Harden 2002). All doubtful species names were verified with the on-line Australian Plant Name Index (Australian National Botanic Gardens 2007). Flora species, including threatened species and introduced flora species, are referred to by both their common and then scientific names when first mentioned. Subsequent references to flora species cite the common names only, unless there is no common name, for which scientific name will be used. Common names, where available, have been included in threatened species tables and the complete flora list in Appendix 3.

Names of vertebrates follow the Census of Australian Vertebrates (CAVs) maintained by the DEE (CoA 2009). In the body of this report vertebrates are referred to by both their common and scientific names when first mentioned. Subsequent references to these species cite the common name only.

Appendix 1.2 Permits and licences

The flora and fauna assessment was conducted under the terms of Biosis' Scientific Licence issued by EES (SL100758, expiry date 31 March 2022). The BAM Assessment and quality review of the BDAR was carried out by Accredited Assessors Callan Wharfe (BAAS18138), Jane Raithby-Veall (BAAS18134) and Mitch Palmer (BAAS17051).

Appendix 1.3 Limitations

Field surveys were undertaken in accordance with the BAM (DPIE 2020a). Ecological surveys provide a sampling effort of flora and fauna present within a study area at a given time and season. Factors influencing detectability of species during survey include species dormancy, seasonal conditions, ephemeral status of waterbodies, and migration and breeding behaviours of some fauna. In many cases, these factors do not present a significant limitation to assessing the overall biodiversity values of a site.

The field survey was conducted from autumn 2020 through until summer 2021, generally in fine weather, and during the most appropriate season for the biodiversity values targeted. Suitable time to determine the presence of most threatened species coincides with reproductive activities (calling, displaying, flowering, fruiting) allowing optimal chance of detection. Surveys undertaken, combined with habitat assessments and desktop analysis are considered sufficient to reach the conclusions herein in regards to this and all other species' likelihood of occurrence within the study area. Database searches, and associated conclusions on the likelihood of species to occur within the study area, are reliant upon external data sources and information managed by third parties.

Specific limitation to the assessment contained herein include:

- Five of the total 21 BAM plots forming part of the vegetation integrity assessment undertaken the project occur outside the final impact area / impact assessment area. These include plots USCWF_05, USCWF_11, USCWF_13, USCWF_29, and USCWF_43 (refer Figure 7). These BAM plots are located outside the project footprint due to either ongoing design changes including underboring of sections, realignment of access options, or the most suitable sampling location being adjacent to (but within

the same vegetation patch) of the final footprint. The locations of all of these plots are considered suitable for sampling the floristics and condition of the relevant vegetation within the project's impact area, and are considered to conform the requirements of the BAM.

- Due to site access constraints an approximately 650 metre section of the impact area and impact assessment could not be surveyed at Kemps Creek. This has resulted in the need to assume presence of a number of threatened flora species in this location.
- Data relating to Camden White Gum individuals along the Nepean River between Bents Basin and Wallacia was not collected by Biosis staff. However, the accuracy of the data has been verified by Carl Tippler of CTE.
- Impacts associated with altered hydrological patterns along the Nepean River are largely based on desktop analysis of existing aerial vegetation mapping only. No ground validation of mapping has occurred outside the project impact area and impact assessment area.
- A small number of threatened flora species were surveyed outside their BioNet specified survey period, all relevant justifications and assumption are provided in Appendix 2.
- Despite multiple attempts to arrange access for field surveys as part of the species expert report for Cumberland Plain Land Snail and Dural Land Snail, limited field survey was able to be undertaken. As such, those assessments are largely desktop based, with more information provided in Appendix 7.

Appendix 2 BAM Candidate species assessment

All targeted flora surveys completed for this project were undertaken in accordance with the BAM (DPIE 2020a) and *NSW Guide to Surveying Threatened Plants* (OEH 2016a) and *Surveying Threatened Plants and Their Habitats* (DPIE 2020e).

Table A. 1 Threatened flora species assessment

Species	Conservation status		BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
	EPBC Act	BC Act							
Acacia baueri* subsp. *aspera -	-	V	Yes	*Acacia bauera* subsp. *aspera* is a low growing, spreading shrub between 0.1 - 1 m tall. Key ID characteristics include hairy and warty branches and cylindrical, warty phyllodes. This species is restricted to the Sydney region, specifically the Kings Tableland in the Blue Mountains in addition to the Woronora Plateau. This species occurs in low, damp heathlands associated with rocky outcrops exposed to sunlight with a suspected preference for early successional habitats. This species is associated with PCT 1083 in the Wollemi IBRA subregion. Survey is best during the peak flowering period in March; however, the survey period extends from September to April.	Low	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. PCTs associated with this species are present within the study area comprising patches of thinned PCT 1083 adjacent to Warragamba River, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted surveys undertaken within the impact area in October 2020 during the approved survey period for the species. No individuals of this species was detected. Based on the absence of this species within the impact area; *Acacia baueri* subsp. *aspera* does not require any further consideration.
***Acacia bynoeana* Bynoe's Wattle**	V	E	Yes	Bynoe's Wattle is a semi-prostrate shrub growing up to 1 m tall with shiny stiff narrow phyllodes (1.5-5 cm long, 1-3 mm wide) and single flower heads.	Low	Yes	Yes – targeted survey undertaken between April	No	This species has been previously recorded on 21 occasions within 10 kilometre of the study area with closest record being 7 kilometre from the study area.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				This species occurs in central; eastern NSW from the Hunter District to the Southern Highlands and west to the Blue Mountains. It occurs in heath or dry sclerophyll forest on sandy soils and prefers open or disturbed sites. Bynoe's Wattle is associated with Red Bloodwood *Corymbia gummifera*, Scribbly Gum, Parramatta Red Gum, Saw Banksia *Banksia serrata* and Narrow-leaved Apple. Associated PCTs relevant to the study area include 724, 725, 849, 883, 1083 and 1181 in the Cumberland and Wollemi IBRA subregions. The survey period is year round.			and October 2020.		Potential habitat for this species within the study area occurs within patches of thinned and intact PCTs 724, 725, 849, 883, 1083 and 1181 between Western Sydney Parkland and Warragamba. Targeted surveys for this species were undertaken within the impact area between May and October 2020 during the approved survey period for the species. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The small patch of PCT 849 in this location is too degraded to support this species. No individuals of this species was detected. Based on the absence of this species within the impact area; *Acacia bynoena* does not require any further consideration.
Acacia gordonii -	E	E	Yes	*Acacia gordonii* is an erect or spreading shrub growing between 0.5-1.5 m tall with alternate straight or sickle shaped phyllodes (5-15 mm long, 1 mm wide) and produces single golden yellow flower heads on a hairy peduncle (flowering August to September). This species is restricted to the north-west of	Low	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. PCTs associated with this species are present within the study area comprising patches of thinned and intact PCTs 1083 and 1181 between Bents Basin Road and Warragamba Dam, however the study area occurs outside

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Sydney occurring in the Blue Mountains as well as around the Maroota/Glenorie area. It occurs in dry sclerophyll forest and heathlands in association with rock platforms or sandstone outcrops on sandy soils. Associated PCTs relevant to the study area include 1083 and 1181 in the Cumberland and Wollemi IBRA subregions. The survey period is year round.					the species' known area of occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals of this species was detected. Based on the absence of this species within the impact area; *Acacia gordonii* does not require any further consideration.
Acacia prominens* – *endangered population **Gosford Wattle**	-	E2	Yes	The Gosford Wattle is an erect or spreading tree growing between 4-18 m tall with straight or sickle shaped phyllodes (3-5 cm long, 8-12 mm wide) and produces an inflorescence containing 8-15 pale to golden yellow flower heads (flowering July to September) (DPIE 2020b). The endangered population listing covers the Hurstville and Kogarah LGA's where it is restricted to a few sites along the railway line at Penshurst, at Carss Bush Park, Carss Park and possibly at Oatley. The endangered population is disjunct from the population occurring between the Hunter Valley and Gosford region. It occurs in Cumberland Dry Sclerophyll Forests, Sydney Coastal Dry Sclerophyll Forests, Eastern Riverine Forests and Northern Hinterland Wet Sclerophyll Forests on clay or sandy soils. This species is	Nil	No – the E2 population is not relevant to the study area or project.	No	No	The impact area does not occur within the region covered by the endangered population listing (Hurstville or Kogarah LGAs); therefore, this species does not require any further consideration.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				associated with PCT 725 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.					
Acacia pubescens **Downy Wattle**	V	V	Yes	The Downy Wattle is a spreading shrub growing between 1-5 m tall with bipinnate leaves borne on hairy branchlets and produces brilliant yellow flower heads (flowering August to October) (DPIE 2020b). This species is restricted to the Bansktown-Fairfield-Rookwood and Pitt Town areas with outliers at Barden Ridge, Oakdale and Mountain Lagoon. It occurs in Cumberland Dry Sclerophyll Forests on alluvium, shale or shale-sandstone derived soils containing gravels and ironstone. This species is associated with PCTs 724, 725, 849, 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	High	Yes	Yes – targeted survey undertaken between April and October 2020.	Yes	This species has been previously recorded on 5315 occasions within 10 kilometre of the study area with closest record being wihtin the study area. Potential habitat for this species in the impact area is present as patches of thinned and intact PCTs 724, 725, 849, 883, 1083 and 1181 between Lansdowne and Warragamba in the Liverpool and Penrith LGA's. Targeted threatened species surveys have been undertaken between June and October 2020 throughout the impact area for this species. A total of 7 individuals were detected within the impact area and a total of 12 individuals were detected within the impact assessment area. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The small patch of PCT 849 in this location is too degraded to support this species. Downy Wattle is considered within Section s8, 9 and 11 of this report.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
Acrophyllum australe -	V	V	Yes	*Acrophyllum australe* is a hairless small shrub growing between 1-2 m tall with either whorled leaves in groups of 3-4 or opposite leaves (3-10 cm long and 10-45 mm wide) with toothed margins and discolorous. This species produces sessile white to pink tinged flower heads (flowering November to December) (DPIE 2020b). This species is restricted to the Blue Mountains from Faulconbridge to Lawson, south of Bilpin and near Kings Tableland. It grows in sheltered gullies beneath waterfalls and drip zones or rock overhangs and cliff faces all with a south-east to south-west aspect on sandstone substrates. This species is associated with PCTs 1083 and 1181 in the Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	Low	No	Yes – incidental survey undertaken in October 2020.	No	There are no records of this species within 10 kilometre of the study area. PCTs associated with this species are present within the study area comprising patches of thinned PCT 1083 adjacent to Warragamba River, however the microhabitat requirements needed to support this species are not present within the study area. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals were detected within the impact area. Based on the absence of this species within the impact area; *Acrophyllum australe* does not require any further consideration.
Allocasuarina glareicola -	E	E	Yes	*Allocasuarina glareicola* is an erect, depauperate shrub growing between 1-2 m tall with ascending branchlets up to 20 cm and cones 10-13 mm long and 7-8 mm wide (DPIE 2020b). This species is restricted to the Richmond district with outliers at Voyager Point in Liverpool. It grows in Castlereagh Woodland on lateritic soils. This species is associated with PCTs 724, 725 and 883 in the	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and October 2020.	No	This species has been previously recorded on 2 occasions within 10 kilometre of the study area with closest record being 8.4 kilometre from the study area. Potential habitat for this species in the impact area is present as patches of thinned and intact PCTs 724, 725 and 883 between Kemps Creek and Wallacia. Targeted threatened species surveys have been undertaken (May – June 2020 and October

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.					2020) throughout the impact area for this species and no individuals have been recorded. Based on the absence of this species within the impact area; *Allocasuarina glareicola* does not require any further consideration.
Ancistrachne maidenii -	-	V	Yes	*Ancistrachne maidenii* is a scrambling perennial grass with slender ascending branches and distinguishable from similar looking grasses by the hairy glume and lemma on the seeds (DPIE 2020b). This species is restricted to Northern Sydney around St Albans, Mt White, Maroota and Berowra areas in addition to the vicinity of Shannon Creek near Grafton. It grows in Dry Sclerophyll Forests on transitions between the Hawkesbury and Watagan soil landscapes. This species is associated with PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is December to April.	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	This species has been previously recorded on 2 occasions within 10 kilometre of the study area with closest record being 3.5 kilometre from the study area. The western extent of the impact area in the vicinity of Warragamba is situated on the Hawkesbury soil landscape; however there are no areas containing Watagan soil landscape nearby. Based on this fact, potential habitat in the impact area is restricted to patches of PCTs 1083 and 1181 near Warragamba. Targeted threatened species surveys were undertaken (October 2020) for this species throughout the impact area for this species and no have been recorded. Whilst it is acknowledged these surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit and/or foliage were recorded.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									Based on the absence of this species within the impact area; *Ancistrachne maidenii* does not require any further consideration.
Astrotricha crassifolia **Thick-leaf Star-hair**	V	V	Yes	Thick-leaf Star-hair is a root suckering shrub growing 2-4 m tall with stiff linear leaves (2-6 cm long and 0.25-0.4 mm wide) with hairy undersides. Inflorescence is up to 10 cm long and contains small, 5 petalled, white or cream with mauve anthers (flowering in Spring) (DPIE 2020b). This species is restricted to Patonga, the Woronora Plateau and Glen Davis. It grows in Dry Sclerophyll Forests on sandstone substrates. This species is associated with PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is July to December.	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. PCTs associated with this species occur within the western extent of the study area in the vicinity of Warragamba in the form of patches of thinned and intact PCT 1083 and 1181 on sandstone substrates, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted surveys undertaken (October 2020) throughout the impact area. No individuals have been recorded. Based on the absence of this species within the impact area; Thick-leaf Star-hair does not require any further consideration.
Caesia parviflora **var. *minor*** **Small Pale Grass-lily**	-	E	Yes	Small Pale Grass-lily is an inconspicuous herb growing up to 20 cm tall with 2 mm wide leaves arranged in a basal rosette. This herb produces multiple branched flowering shoots containing small, white starry flowers tinged with blue or purple, and when fertilised, green three lobed fruits (flowering in Spring) (DPIE	Low	No	Yes – incidental survey undertaken in October 2020.	No	This species has been previously recorded on 1 occasion within 10 kilometre of the study area with closest record being 9 kilometre from the study area. However this record is associated with the Holsworthy military area, which does not support habitats commensurate with those found in

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				2020b). This species occurs in Tasmania, southern Victoria and south-east South Australia with outlying populations in NSW between Grafton and Coffs Harbour. It grows in damp places in Sydney Coastal Dry Sclerophyll Forests, Sydney Montane Dry Sclerophyll Forests, Coastal Valley Grassy Woodlands and Southern Escarpment Wet Sclerophyll Forests on sandstone substrates. This species is associated with PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is October to February.					the eastern portion of the study area. The next nearest record of the species ours over 40kilometres north-west of the western end of the study area and dates from 1904. There are no other records in proximity to the study area. PCTs associated with this species occur within the western extent of the study area in the vicinity of Warragamba in the form of a patch of thinned PCT 1083 on sandstone substrates. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been recorded. Based on the absence of this species within the impact area; Small Pale Grass-lily does not require any further consideration.
Caladenia tessellata **Thick Lip Spider Orchid**	V	E	Yes	Thick Lip Spider Orchid is small orchid characterised by a long, sparsely hairy narrow leaf up to 6 cm long and 5 mm wide and two prominent yellow glands on the base of the column. The flower contains five long spreading cream coloured petals and sepals with reddish stripes surrounding a broad down-curved yellow labellum (flowering between September to November) (DPIE	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	There are no previous records within 10 kilometre of the study area. This species known within NSW from two disjunct areas; one population near Braidwood on the Southern Tablelands and three populations in the Wyong area on the Central Coast (NSW Scientific Committee, 2002a). Habitat comprises grassy sclerophyll woodland in clay loam or quartz-rich sandier soil (OEH,

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				2020b). In NSW, this species occurs in Sydney, Wyong and Ulladulla areas with populations in Kiama and Queanbeyan presumed extinct. It grows in damp places in Central Gorge Dry Sclerophyll Forests, Cumberland Dry Sclerophyll Forests, Coastal Floodplain Woodlands and Subalpine Woodlands on clay loam, sandy or stony soils. This species is associated with PCTs 724, 725, 849 and 883 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is September to October.					2019). The total population size is estimated to be less than 50 individuals. Old records occur in the Penshurst (recorded 1901) and Como (recorded 1930) areas. PCTs associated with this species are present within the study area comprising patches of intact 724, 725, 849 and 883 spanning from Lansdowne to Wallacia. Targeted threatened species surveys have been undertaken in October 2020 throughout the impact area for this species and no individuals have been recorded. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The small patch of PCT 849 in this location is too degraded to support this species. Based on the absence of this species within the impact area; Thick Lip Spider Orchid does not require any further consideration.
Callistemon linearifolius **Netted Bottle Brush**	-	V	Yes	Netted Bottle Brush is a shrub up to 3-4 m tall with linear, sharp tipped, lance shaped leaves (8-10 cm long and 5-7 mm wide). The inflorescence is bottlebrush shaped and formed from red filaments (9-10 cm long and 0.5 cm diameter) on a hairy stem (flowering	Medium	Yes	Yes – targeted survey undertaken between May-June 2020 and October 2020.	Yes – Species assumed present in areas unable to	This species has been previously recorded on 40 occasions within 10 kilometre of the study area with closest record being 2.8 kilometre from the study area. Potential habitat for this species in the study area occurs in patches of thinned and intact

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				between Spring and Summer) (DPIE 2020b). This species occurs from the Georges River to the Hawkesbury River and the Hornsby Plateau in Sydney, north of Nelson Bay and at Coalcliff in the Illawarra. It grows in Dry Sclerophyll Forest. This species is associated with PCTs 724, 725, 835, 849 and 1083 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is October to January.				accessed for targeted survey.	724, 725, 835 and 849 spanning from Lansdowne to Wallacia. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout the impact area for this species and no individuals have been recorded. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The presence of Netted Bottle Brush has been assumed within PCT 835 vegetation in this location. Whilst it is acknowledged that a portion of targeted surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit and/or foliage were recorded.
Camarophyllopsis kearneyi	-	E	Yes	Its occurrence appears to be limited to the Lane Cove Bushland Park. Surveys in potentially suitable habitats elsewhere in the Sydney Basin Bioregion have failed to find *Camarophyllopsis kearneyi*. Does not produce basidiomes (above-ground fruiting structures) all year, but may be present only as non-reproductive hyphal structures below ground.	Nil	No	No	No	Species only occurs within Lane Cove Bushland Park, and as such outside the project's study area.
Cynanchum	E	E	Yes	White-flowered Wax Plant is a variable climber	Low	Yes	Yes – targeted	No	This species has been previously recorded

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
elegans **White-flowered Wax Plant**				with fissured corky stems up to 10 m long and 3.5 cm thick with paired ovate leaves (1.5-10.5 cm long and 1.5-7.5 cm wide). The flowers are white, tubular (4 mm long and 12 mm wide) and fruit is a dry pod containing silky haired seeds (flowering between August and May) (DPIE 2020b). This species is restricted to eastern NSW from Brunswick Heads to Gerroa growing adjacent to dry rainforest vegetation communities. This species is associated with PCTs 835 and 849 in the Cumberland IBRA subregion (DPIE 2020b). White-flowered Wax Plant occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities (NPWS 2002). The survey period is all year round.			survey undertaken between May-June 2020 and October 2020.		on 3 occasions within 10 kilometre of the study area with closest record being 2.5 kilometre from the study area. Potential habitat for this species in the impact area occurs in patches of thinned and intact 835 and 849. However, White-flowered Wax Plant occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities (NPWS 2002). Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout the impact area for this species and no individuals have been recorded. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. However, due to the lack of the required ecotonal microhabitat the presence of White-flowered Wax Plant was discounted from this area.
Darwinia biflora **-**	V	V	Yes	*Darwinia biflora* is an erect to spreading shrub growing up to 80 cm tall with paired green flowers surrounded by two red bracteoles (flowering throughout the year but concentrated in Autumn) (DPIE 2020b).	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records within 10 kilometre of the study area. PCTs associated with this species occur within the study area in the Wollemi IBRA subregion in patches of thinned 1083 and

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				This species is restricted to the Ku-ring-gai, Hornsby, Baulkham Hill and Ryde LGAs growing on the edges of weathered shale-capped ridges near intergrades with Hawkesbury sandstone. This species is associated with PCTs 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is all year round.					intact 1181 between Wallacia and Warragamba, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been recorded. Based on the absence of this species within the impact area; *Darwinia biflora* does not require any further consideration.
Darwinia peduncularis -	-	V	Yes	*Darwinia peduncularis* is a broadly spreading shrub growing up to 1.5 m tall with laterally compressed hairless leaves (7-12 mm long). The flowers are paired with downwards curved peduncles and purplish red bracts (flowering in Winter to early Spring) (DPIE 2020b). This species is restricted to coastal NSW with isolated populations in the Blue Mountains growing on or near rocky outcrops on sandy well drained soils over sandstone. This species is associated with PCTs 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records within 10 kilometre of the study area. PCTs associated with this species occur within the study area in the Wollemi IBRA subregion in patches of thinned 1083 and intact 1181 between Wallacia and Warragamba, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been recorded. Based on the absence of this species within the impact area; *Darwinia peduncularis* does not require any further consideration.

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Deyeuxia appressa -	E	E	Yes	*Deyeuxia appressa* is an erect perennial grass growing up to 0.9 m tall with deeply grooved leaves with a hairy upper surface (2-4 mm wide). The inflorescence is a dense panicle between 20-30 cm long (flowering in Spring to Summer) (DPIE 2020b). This species is known from two pre 1942 records in the Sydney area at Saltpan Creek near Bankstown and Killara near Hornsby. This species is associated with PCTs 1083, 1181 and 1800 in the Cumberland IBRA subregions (DPIE 2020b). The survey period is December.	Negligible	No	Yes – incidental survey undertaken in May-June 2020 and in October 2020.	No	This species has been previously recorded on 2 occasions within 10 kilometre of the study area with closest record being 7.2 kilometre from the study area. However the species has not been recorded in any location since 1941. PlanNet outlines habitat as comprising wet ground in the Hornsby area, with the species primarily found east of the study area with records from Salt Pan Creek and Killara, and questionable records from Kellyville. The species is considered to be extinct in the wild as the areas confirmed to be formerly occupied are now well developed and the species has not been otherwise reliably recorded since 1942 PCTs associated with this species are present within the study area comprising patches of thinned PCT 1800 along Prospect Creek. There is one previous record from 1930 located approximately 7.2 kilometre from the eastern end of the impact area. This species was considered during targeted threatened species surveys undertaken between May and October 2020 throughout the impact area. No individuals have been recorded.

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									Based on the absence of this species within the impact area; *Deyeuxia appressa* does not require any further consideration.
Dillwynia tenuifolia -	-	V	Yes	*Dillwynia tenuifolia* is a low spreading shrub growing up to 1 m tall with small, narrow leaves (4-12 mm long) and single orange-yellow and red pea flowers issuing from the tips of branches (flowering throughout the year with peak flowering between August to March) (DPIE 2020b). This species occurs in the Cumberland Plain from Windsor to Penrith and east to Dean Park with outlying populations from Voyagers Point to Kemps Creek, Luddenham and South Maroota. This species is also known to occur in the Bulga Mountains, Kurrajong Heights and Woodford. This species is associated with PCTs 724, 725, 849, 883 and 1083 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is August to October.	High	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	Yes – Species assumed present in areas unable to accessed for targeted survey.	This species has been previously recorded on over 500 occasions within 10 kilometre of the study area with closest record being within the impact area. Potential habitat for this species in the impact area occurs as patches of thinned and intact condition PCT 724, 725, 849 and 883 at Kemps Creek and thinned condition PCT 1083 at Warragamba. There are 671 previous records within 10 kilometre of Lansdowne, 691 records within10 kilometre of Kemps Creek and Luddenham and 6 records within 10 kilometre of Warragamba. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout the impact area for this species and 47 individuals have been recorded in the impact area and another 48 individuals recorded in the impact assessment area. However, all records occur within Existing Certified land and are therefore not considered further. Targeted surveys were unable to be completed within the section of the impact

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									area and impact assessment area that crosses Kemps Creek. The presence of *Dillwynia tenuifolia* has been assumed within PCT 849 vegetation in this location. *Dillwynia tenuifolia* is considered within Section 8.2.1 and Sections 12 to 16 of this report.
***Dillwynia tenuifolia* – endangered population** -	-	E2	Yes	*Dillwynia tenuifolia* is a low spreading shrub growing up to 1 m tall with small, narrow leaves (4-12 mm long) and single orange-yellow and red pea flowers issuing from the tips of branches (flowering throughout the year with peak flowering between August to March) (DPIE 2020b). The endangered population occurs between Western Road, Elizabeth Drive, Devonshire Road and Cross Street in Kemps Creek. This species is associated with PCTs 724, 725, 849, and 883 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is August to October.	High	No	No	No	This endangered population was recorded during targeted surveys however, the impact area and impact assessment area occur completely within 'Existing Certified' land in the locality of the endangered population.
Epacris purpurascens* var. *purpurascens -	-	V	Yes	*Epacris purpurascens* var. *purpurascens* is a low spreading shrub growing between 0.5-1.8 m tall with spreading, recurved ovate to heart shaped leaves with sharply pointed tips (7-21 mm long and 4.4-9 mm wide) and white or pink tinged flowers (7-10 mm diameter) (DPIE	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October	No	This species has been previously recorded on 32 occasions within 10 kilometre of the study area with closest record being 4.9 kilometre from the impact area. Potential habitat for this species in the impact area occurs as patches of high

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				2020b). This species occurs between Gosford, Narrabeen, Silverdale and Avon Dam in a range of habitats with a strong shale influence. This species is associated with PCTs 725, 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is September to October.			2020.		condition PCT 725 at Kemps Creek. There are 2 previous records within10 kilometre of Kemps Creek. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout the impact area for this species and no individuals or species with similar ID characteristics have been detected. Based on the presence of this species within the impact area; *Epacris purpurascens* var. *purpurascens* does not require further consideration.
***Eucalyptus benthamii* Camden White Gum**	V	V	Yes	Camden White Gum is a tall tree up to 40 m tall with rounded sessile immature leaves and long, lanceolate, concolorous mature leaves with irregular lateral venation. The bark is smooth and white with long loose bark ribbons and a flaky bark stockinged base. Flowers are white and capsules are small and bell shaped (flowering between Summer and Autumn) (DPIE 2020b). This species occurs on the banks of the Nepean River and associated tributaries in the vicinity of Kedumba Valley, Bents Basin, Camden, Cobbity, The Oaks and Nattai National Park. This species occurs on alluvial flats in deep alluvial sands subject to a	High	Yes	Yes – targeted survey undertaken in October 2020.	No direct impacts will occur. Indirect impacts may occur.	This species has been previously recorded on 76 occasions within 10 kilometre of the study area with closest record being within the impact assessment area. Potential habitat for this species in the impact area occurs along the banks of the Hawkesbury-Nepean River between Wallacia and Warragamba in PCTs 835 and 1105. Targeted threatened species surveys have been undertaken (October 2020) throughout the impact area for this species. No Camden White Gum were detected within the impact area, with five individuals detected within the impact assessment area. A total of 713

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				flooding regime at elevations between 30 m asl to 750 m asl. This species is associated with PCTs 835, 849 and 1105 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.					individuals have been along the Nepean River (CTE 2021) within the area subject to altered hydrological regimes as a result of the project. Impacts to Camden White Gum as further assessed in Sections 9 and 11 and Appendix 6.
Eucalyptus camfieldii **Camfield's Stringybark**	V	V	Yes	Camfield's Stringybark is a mallee tree growing between 4-9 m tall with hairy heart-shaped immature leaves and long, lanceolate, glossy green mature leaves (10 x 3 cm). The bark is rough, fibrous and stringy and red or dark grey-brown in colour. Flowers are creamy white and capsules are flattened and globe shaped with enclosed valves (9 mm diameter) (flowering between Summer and Autumn) (DPIE 2020b). This species has a restricted distribution forming a narrow band between Raymond Terrace to south of Waterfall including scattered occurrences between Norah Head and the Royal National Park. This species occurs in coastal regions in coastal heath on exposed ridges in shallow sandy soils overlying Hawkesbury sandstone. This species is associated with PCT 1083 in the Cumberland IBRA subregion (DPIE 2020b) However, PCT 1083 only occurs within the	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records within 10 kilometre of the study area. PCTs associated with this species occur within the impact area in the Wollemi IBRA subregion in the vicinity of Warragamba Dam formed from patches of thinned PCT 1083, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Camfield's Stringybark does not require further consideration.

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				portion of the impact area within the Wollemi IBRA subregion. The survey period is year round.					
Eucalyptus sp. **Cattai**	CE	CE	Yes	*Eucalyptus* sp. Cattai is a small mallee tree up to 4.5 m tall with lance shaped leaves (4-12 cm long and 1-4 cm wide). The bark is thick, fibrous or furrowed and loose on the lower trunk. Flowers are white and capsules are hemispherical to cup shaped with exerted valves (9 mm diameter) (flowering between Summer and Autumn) (DPIE 2020b). This species has a distribution restricted to The Hills LGA between Kellyville, Maraylya and Glenorie in scrub, low woodland or heath on flats or ridge tops containing sandy soils or laterised clays over sandstone. This species is associated with PCT 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records within 10 kilometre of the study area. PCTs associated with this species occur within the impact area in the Wollemi IBRA subregion in the vicinity of Warragamba Dam formed from patches of thinned PCT 1083 and intact PCT 1181, however the study area occurs outside the species' known area of occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been detected. Based on the absence of this species within the impact area; *Eucalyptus* sp. Cattai does not require further consideration.
Genoplesium baueri **Bauer's Midge Orchid**	E	E	No	*Genoplesium baueri* is a terrestrial orchid up to 6-15 cm tall fleshy, brittle and coloured yellowish green to red. The inflorescence contains 1-6 green, red or red tinged flowers (15 mm diameter) (flowering between February to March) (DPIE 2020b). This species has a distribution ranging from	Negligible	No	No	No	There are no previous records within 10 kilometre of the study area. PCTs associated with this species within the impact area occurs in the Wollemi IBRA subregion only. This potential habitat occurs in the vicinity of Warragamba Dam formed from patches of moderate and high

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				Ulladulla to Port Stephens in Dry Sclerophyll Forest and moss gardens over sandstone. This species is associated with PCT 1083 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between February and March.					condition PCT 1083. However the species is not known to occur within the Wollemi subregion, and then closest record of the species, to PCT 1083 within the impact area is approximately 30kilometres south-east and over 50 years old. Based on the above, *Genoplesium baueri* does not require further consideration.
***Grammitis stenophylla* Narrow-leaf Finger Fern**	-	E	Yes	Narrow-leaf Finger Fern is a small fern with hanging or erect dark green, leathery fronds (1-5 cm long and 1-4 mm wide) which grows in small colonies. Spores appear as dark circular patches on the underside of the fronds and the base of the frond stem is hairless (flowering between February to March) (DPIE 2020b). This species occurs from eastern Queensland to eastern NSW in Wet Sclerophyll Forest or Rainforest preferring moist places, particularly near streams, on rocks and in trees. This species is associated with PCT 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	Negligible	Yes	Yes – targeted survey undertaken in October 2020.	No	This are no records of this species within 10 kilometre of the study area, with the nearest record to potential habitat located over 30kilometres to the north. Potential habitat for this species in the impact area occurs in the Wollemi IBRA subregion only. Potential habitat occurs in the vicinity of Bents Basin Road formed from a patch of intact PCT 1181, however suitablen microhabitat types are absent from the impact area in that location Targeted threatened species surveys have been undertaken (October 2020) throughout patches of PCT 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Narrow-leaf Finger Fern does not require further consideration.

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Grevillea evansiana **Evans Grevillea**	V	V	Yes	Evans Grevillea is a dense spreading shrub up to 0.5 m -1.5 m tall with white hairy stems and discolorous leaves, glossy green above and silvery grey beneath (40 mm x 8 mm). Flowers are dark red or sometimes white and the fruit is a hairless follicle (flowering between August to December) (DPIE 2020b). This species is restricted to a small area east of Rylstone on the Central Tablelands in dry sclerophyll forest or swampy heath in sandy soils over Hawkesbury sandstone. This species is associated with PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is year round.	Negligible	Yes	No	No	There are no previous records of this species within 10 kilometre of the study area, with the species restricted to an area between 80 to 120 kilometres to the niort-west. PCTs associated with this species occur in the vicinity of Warragamba Dam, however the study area occurs outside the species' known area of occurrence . Based on the absence of this species within the impact area; Evans Grevillea does not require further consideration.
Grevillea juniperina **subsp.** ***Juniperina*** **Juniper-leaved Grevillea**	-	V	Yes	Juniper-leaved Grevillea is a broadly spreading to erect shrub up to 2.5 m tall with narrow, prickly, bright green leaves clustered along lateral branches (up to 22 mm). Flowers are spider like and red, pink, yellow, pale orange or green (2.5 cm – 3.5 cm) (flowering all year, peaking between July to October) (DPIE 2020b). This species is endemic to Western Sydney between Blacktown, Erskine Park, Londonderry and Windsor with outliers at Kemps Creek and Pitt Town. This species occurs in dry sclerophyll forests and grassy woodlands in clay to sandy soils over	High	Yes	Yes – targeted survey undertaken between May and October 2020.	Yes – Species assumed present in areas unable to accessed for targeted survey.	This species has been previously recorded on 641 occasions within 10 kilometre of the study area with closest record being 33 m from the impact area. Potential habitat for this species occurs between Kemps Creek and Luddenham formed from patches of moderate and high condition PCT 724, 725, 849 and 883. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCT 724, 725, 849 and 883 in the impact area for this species and no individuals have been

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				Wianamatta Shale and Tertiary alluvium containing lateritic gravels. This species is associated with PCT 724, 725, 849 and 883 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.					detected. The species was recorded in Western Sydney Parkland, however the proposed access track that would have impacted upon the plants has been removed from the project design. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The presence of Juniper-leaved Grevillea has been assumed within PCT 849 vegetation in this location. Based on the absence of this species within the impact area; Juniper-leaved Grevillea will require no further consideration.
***Grevillea parviflora* subsp. *parviflora* Small-flower Grevillea**	V	V	Yes	Small-flower Grevillea is a low spreading to erect shrub up to 1 m tall with erect narrow leaves with a hairy under surface and recurved margins (2-3.5 mm long and <1.3 mm wide). Flowers are spider like, clustered in groups of 6-12 and white aging to pinkish-red with rusty brown hairs on the outside of the corolla (flowering between July to December and April to May) (DPIE 2020b). This species is scattered throughout the Sydney Basin, Picton, Appin, Bargo, between Cessnock and Kurri Kurri, Putty to Wyong and	High	Yes	Yes – targeted survey undertaken between May and October 2020.	No	This species has been previously recorded on 1051 occasions within 10 kilometre of the study area with closest record being within the impact area at Kemps Creek within Existing Certified land. Potential habitat for this species in the impact area occurs between Kemps Creek and Warragamba formed from patches of moderate and high condition PCTs 724, 725, 883 and 1083. Targeted threatened species surveys have been undertaken (May – June 2020 and

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				at Lake Macquarie. This species occurs in dry sclerophyll forests and swamp woodlands in sandy or light clay soils or tertiary sands and alluvium or derived from the Mittagong Formation at elevations between 30 – 300 m asl. This species is associated with PCTs 724, 725, 883 and 1083 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is August to November.					October 2020) throughout patches of PCTs 724, 725, 883 and 1083 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; Small-flower Grevillea will not require further consideration.
Grevillea parviflora* subsp. *supplicans -	-	E	No	*Grevillea parviflora* subsp. *supplicans* is an erect to semi-prostrate shrub up to 1 m tall with arching branches and skywards facing leaves with recurved margins (15-60 mm long and 0.6-2 mm wide). Flowers are spider like and white, purple or pink (flowering between August to November) (DPIE 2020b). This species is restricted to north-west Sydney near Arcadia and Maroota-Marramarra Creek areas in the Hornsby and Hills Shire LGAs in heathy woodland on skeletal soils over sandstone substrates. This species is associated with PCTs 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). It is not known to occur in the Wollemi IBRA subregion. The survey period is July to November.	Negligible	No	No	No	There are no previous records of this species within 10 kilometre of the study area. The impact area and impact assessment rea occur outside the known geographic extant of this species. Associated PCTs for this species occur in the impact area and impact assessment area between Wallacia and Warragamba, comprising patches of thinned PCT 1083 and intact PCT 1181; however, this is located in the Wollemi IBRA region, where the species is not known to occur, and approximately 45 kilometres south-west of the nearest record of the species. Based on the above, *Grevillea parviflora* subsp. *supplicans* will not require further consideration.
Gyrostemon thesioides	-	E	Yes	*Gyrostemon thesioides* is a multi-stemmed shrub up to 0.7 m tall with narrow linear	Low	Yes	Yes – targeted survey	No	This species has been previously recorded on 16 occasions within 10 kilometre of the

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
-				leaves (5-35 mm long) and angular stems. Flowers are a whirl of 9-12 stamens and fruit is red-brown (2-2.5 mm long) (DPIE 2020b). This species is restricted to three sites to the west of Sydney near the Colo, Georges and Nepean Rivers in heathy woodland on skeletal soils over sandstone substrates. This species is associated with PCTs 724, 725, 1105, 1181 and 1800 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.			undertaken between May-June 2020 and in October 2020.		study area with closest record being 7.2 kilometre from the impact area. Potential habitat for this species in the impact area occurs along the Hawkesbury-Nepean and Warragamba Rivers between Wallacia and Warragamba formed from patches of moderate and high condition PCTs 1105 and 1181. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs1105 and 1181 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; *Gyrostemon thesioides* will not require further consideration.
***Haloragis exalata* subsp. *exalata* Square Raspwort**	V	V	Yes	Square Raspwort is a shrub up to 1.5 m tall with leaves bearing coarsely toothed margins (60-100 mm long and 13-25 mm wide). Flowers are tiny (3 mm long) and are yellowish-green to red (flowering between November to January) (DPIE 2020b). This species is restricted to four widely scattered localities in the Central Coast, South Coast and North Western Slopes regions in protected and shaded damp locations in	Negligible	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area, with the closest record being over 40kilometres north of the study area, and being historic in nature. Potential habitat for this species in the impact area occurs between Luddenham and Wallacia in patches of moderate condition PCTs 781 and 1105. Targeted threatened species surveys have

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				riparian habitats. This species is associated with PCTs 781 and 1105 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.					been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 781 and 1105 in the impact area for this species and no individuals have been detected. PCT 781 occurs within the study area only in a highly degraded state with a VI score of 6.3. Based on the absence of this species within the impact area; Square Raspwort will not require further consideration.
Haloragodendron lucasii -	E	E	Yes	*Haloragodendron lucasii* is an erect hairless shrub up to 1.5 m tall with decussate oblong leaves bearing toothed margins. Flowers are near stalkless with four sepals and are creamy white. The fruit is a winged nut (flowering between August to November) (DPIE 2020b). This species is restricted to the north shore of Sydney in dry sclerophyll forest on gentle slopes below cliff lines or sheltered aspects on moist sandy loam soils. This species is associated with PCTs 1083 and 1181 in the Cumberland IBRA subregions (DPIE 2020b). The survey period is year round.	Negligible	No	No	No	This species is associated with PCT 1083 ad 1181 in the Cumberland and Pittwater IBRA subregions. These PCTs occur within the study area, but only within the western portion of the study area in the Wollemi IBRA subregion, and over 50kilometres from the species' known area of occurrence. Based on the absence of this species within the impact area; *Haloragodendron lucasii* will not require further consideration.
Hibbertia fumana -	-	CE	Yes	*Hibbertia fumana* is a low shrub or sub-shrub branched at the base with small slender, hairy, decurrent leaves with revolute margins (~3 mm). Flowers are pedunculated, terminal	High	Yes	Yes – targeted survey undertaken between May-	No	This species has been previously recorded on 885 occasions within 10 kilometre of the study area with closest record being 2.7 kilometre from the impact area.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				on stems and comprise bilobed yellow petals with 5-7 stamens clustered on one side of twinned hairy ovaries (10-12 mm diameter) (flowering between October to December) (DPIE 2020b). This species occurs across a band in greater Sydney stretching from Mittagong to Richmond in dry sclerophyll forest and grassy woodland on alluvial habitats rich in sands and laterite deposits. This species is associated with PCTs 724, 725 and 883 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between October to December.			June 2020 and in October 2020.		Potential habitat for this species in the impact area occurs between Kemps Creek and Wallacia in patches of high and moderate condition PCTs 724, 725 and 883. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 724, 725 and 883 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; *Hibbertia fumana* will not require further consideration.
Hibbertia puberula -	-	E	Yes	*Hibbertia puberula* is a low shrub with pubescent wiry branches up to 30 cm long, oblong-lanceolate to almost linear (3-6 mm long and 0.8-1.4 mm wide). Flowers are yellow, single or sometimes in clusters of three (flowering between October to December, sometimes January) (DPIE 2020b). This species is widespread but uncommon, occurring along a band from Wollemi National Park to Morton National Park and in the south coast near Nowra in dry sclerophyll woodland, upland swamp or low heath on sandy soils or clay loams over rocky substrates. This species is associated with PCTs 883, 1083 and 1181 in	Medium	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 956 occasions within 10 kilometre of the study area with closest record being 6.6 kilometre from the impact area. Potential habitat for this species in the impact area occurs in patches of intact PCT 883 at Kemps Creek and between Wallacia and Warragamba in patches of intact and thinned PCTs 1083 and 1181. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 883, 1083 and 1181 in the impact area for this species and no individuals have been

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is between October to December.					detected. Based on the absence of this species within the impact area; *Hibbertia puberula* will not require further consideration.
***Hibbertia sp.* Bankstown** **-**	CE	CE	Yes	*Hibbertia* sp. Bankstown is a prostrate shrub with spreading hairy branches up to 40 cm long and lance shaped, oblong or linear leaves (3-6 mm long and 0.8-1.4 mm wide). Flowers are yellow with notched petals (flowering between October to December) (DPIE 2020b). This species is endemic to NSW where it is restricted to one population at Bankstown Airport in the Bankstown LGA in modified riparian forest and dry sclerophyll forest on sandy alluvium with a high silt content. This species is associated with PCT 725 and 835 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between September to December.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 217 occasions within 10 kilometre of the study area with closest record being 2.5 kilometre from the impact area. Potential habitat for this species in the impact area occurs in moderate and high condition patches of PCT 835 at Lansdowne. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 835 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; *Hibbertia* sp. Bankstown will not require further consideration.
Hibbertia superans **-**	-	E	Yes	*Hibbertia superans* is a low spreading shrub up to 30 cm tall with multiple twisted stems and branches covered in long shaggy hairs. Leaves are linear (7.5-10 mm long) and flowers are terminal on main branches and coloured yellow (flowering between July to December) (DPIE 2020b).	Negligible	No	No	No	This species is associated with PCT 1083 ad 1181 in the Cumberland IBRA subregions. These PCTs occur within the study area, but only within the western portion of the study area near Wallacia, and over 35kilometres south-west of the species' known area of occurrence.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				This species occurs on 16 sites spanning from Baulkham Hills to South Maroota and one site at Mount Boss near Kempsey in open woodland and heathland on sandstone ridgetops near shale-sandstone transition zones. This species is associated with PCT 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between July to December.					Based on the absence of this species within the impact area; *Hibbertia superans* will not require further consideration.
Hygrocybe anomala var. ianthinomarginata	-	V	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
Hygrocybe aurantipes	-	V	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such, the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.
Hygrocybe austropratensis	-	E	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.					
Hygrocybe collucera	-	E	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.
Hygrocybe griseoramosa	-	E	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.					As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.
Hygrocybe lanecovensis	-	E	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.

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Hygrocybe reesiae	-	V	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.
Hygrocybe rubronivea	-	V	Yes	Occurs in gallery warm temperate forests dominated by Lilly Pilly *Acmena smithii*, Grey Myrtle *Backhousia myrtifolia*, Cheese Tree *Glochidion ferdinandi* and Sweet Pittosporum *Pittosporum undulatum*. Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. Does not produce above ground fruiting bodies (fungus) all year round.	Negligible	No	No	No	The species is known to occur in one location in Lane Cove Bushland Park, over 18 kilometres from the eastern extent of the study area, and over 50 kilometres from the occurrence of soils derived from the Hawkesbury Soil Landscape. As such the study areas is considered to be outside the species area of occurrence and as such no further assessment has been undertaken.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Fruiting bodies begin appearing mid May to mid July sometimes to August. Associated PCTs include 1083 present in the Wollemi IBRA subregion. The survey period is May to June.					
Lasiopetalum joyceae -	V	V	Yes	*Lasiopetalum joyceae* is an erect shrub up to 2 m tall with linear leaves with revolute margins, a smooth dark green upper surface and hairy underneath (3-9 cm long and 3-6 mm wide). Flowers hairy, pinkish to reddish brown and borne in clusters (8-12 mm long) (flowering between July to December) (DPIE 2020b). This species is restricted to the shale ridgetops of the Hornsby Plateau at 34 sites between Berrilee and Duffys Forest in heathland on sandstone. This species is associated with PCT 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between September to November.	Negligible	No	No	No	This species is associated with PCT 1083 ad 1181 in the Cumberland IBRA subregions. These PCTs occur within the study area, but only within the western portion of the study area near Wallacia, between 35 to 50 kilometres south-west of the species' known area of occurrence.. Based on the absence of this species within the impact area; *Lasiopetalum joyceae* will not require further consideration.
Leionema lamprophyllum* subsp. *fractum -	-	CE	Yes	*Leionema lamprophyllum* subsp. *fractum* is a shrub up to 1.5 m tall with rhomboidal leaves with crenate to bluntly dentate margins (6-9 mm long). Flowers are yellow to yellowish-green (flowering between May to September) (DPIE 2020b). This species is restricted to Broken Back	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area, with the species known from a single population at Broken Back Range near Cessnock. PCTs associated with the species occur within the impact area occurs in patches of thinned PCT 1083 in the vicinity of

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				Range near Cessnock and a historical collection from Munghorn Gap Nature Reserve near Wollar in sparse heathland or low open woodland in skeletal soils on exposed rocky terrain and cliffs. This species is associated with PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to November.					Warragamba Dam, however the study area occurs over 135kilometres to the south-west of the known area of the species' occurrence. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. Based on the absence of this species within the impact area; *Leionema lamprophyllum* subsp. *fractum* will not require further consideration.
Leucopogon exolasius **Woronora Beard-heath**	V	V	Yes	Woronora Beard-heath is an erect shrub up to 1 m tall with hairy branchlets and sharp-pointed leaves with a convex upper surface and striated lower surface (15 mm long and 2.5 mm wide) and an inflorescence containing up to three drooping white tubular flowers growing from the leaf axils. Flowers are hairy on the inside and outside of the corolla (flowering between August to September) (DPIE 2020b). This species occurs along the upper Georges River area, Heathcote National Park and the Woronora Plateau in woodland on sandstone substrates. This species is associated with PCT 883, 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is between August to	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 5.9 kilometre from the impact area. Potential habitat for this species in the impact area occurs in patches of thinned PCT 1083 and intact PCTs 883 and 1181 between Kemps Creek and Warragamba. Targeted threatened species surveys have been undertaken (May-June 2020 and October 2020) throughout patches of PCTs 883, 1083 and 1181 in the impact area for this species and no individuals have been detected. Whilst it is acknowledged these surveys occurred outside the BioNet survey period,

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				September.					no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; Woronora Beard-heath will not require further consideration.
Leucopogon fletcheri* subsp. *fletcheri -	-	E	Yes	*Leucopogon fletcheri* subsp. *fletcheri* is an erect densely branched shrub up to 1 m tall with narrow pungent pointed leaves (3.7-8 mm long) and white pendant like solitary tubular flowers (4-5 mm long) which are hairy inside the corolla and fruit is a ridged, hairless drupe (flowering between August to September) (DPIE 2020b). This species is restricted to north-western Sydney between St Albans and Annangrove in dry sclerophyll woodland or shrubland on clayey lateritic soils on flat or sloping terrain along ridges and spurs. This species is associated with PCT 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is between August to September.	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	This species has been previously recorded on 1 occasion within 10 kilometre of the study area with closest record being 7.8 kilometre from the impact area. Potential habitat for this species in the impact area occurs in patches of thinned PCT 1083 and intact PCT 1181 between Wallacia and Warragamba. Targeted threatened species surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area for this species and no individuals have been detected. Whilst it is acknowledged these surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; *Leucopogon fletcheri* subsp. *fletcheri* will not require further consideration.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
***Marsdenia viridiflora* subsp. *viridiflora* – endangered population** -	-	E2	Yes	*Marsdenia viridiflora* subsp. *viridflora* is a climber with twining stems up to 4 m tall and narrow leaves with a prominent midvein (2-12 mm long and 1-18 mm wide). Young stems are hairy whilst aged stems are glabrous and sap is a milky latex. Flowers are bell-shaped, in clusters of 3-10 and coloured greenish or yellow (3-4 mm diameter) and fruit is pear shaped (flowering between late Spring and Summer) (DPIE 2020b). The endangered population occurs in Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys in vine thickets and open shale woodland. This species is associated with PCTs 724, 725, 835, 849 and 1800 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is between November to February.	High	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	Yes	This species has been previously recorded on 1345 occasions within 10 kilometre of the study area with closest record being within the impact area. Potential habitat for this species in the impact area occurs in patches of thinned and intact PCTs 724, 725, 835, 849 and 1800 between Lansdowne and Warragamba. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 724, 725, 835, 849 and 1800 in the impact area for this species and no individuals have been recorded in the impact area. However, 4 individuals have been recorded within the impact assessment area (one along Park Road near Wallacia and three along Tillet Parade in the Lansdowne BioBank site), and within habitat contiguous with the impact area. Whilst it is acknowledged these surveys occurred outside the BioNet survey period, this species is easily recognisable at all time of year. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									crosses Kemps Creek. The presence of Marsdenia viridiflora subsp. viridiflora has been assumed within PCT 835 and 849 vegetation in this location. Based on the presence of this species within the impact area; *Marsdenia viridiflora* subsp. *viridflora* will require further consideration.
Maundia triglochinoides -	-	V	Yes	*Maundia triglochinoides* is a perennial herb with rhizomes up to 5 mm thick and emergent tufts arising from their length. Leaves are spongy, triangular in cross section (up to 80 cm long and 5-10 mm wide) and the inflorescence is 10 cm long and 2.5 cm wide (flowering between November and January) (DPIE 2020b). This species is restricted to coastal NSW extending into southern Queensland and extending south to Wyong with Sydney populations believed to be extinct. This species grows in swamps, lagoons, dams, channels, creeks or shallow freshwater (30-60 cm deep) on heavy clay soils. This species is associated with PCTs 781 and 1800 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between November to March.	Negligible	No	Yes – incidental survey undertaken between May-June 2020 and in October 2020.	No	The species has only been recorded within the Cumberland IBRA subregion on two occasions with both records dating from 1903 with an accuracy of 1000m and a location noted as 'Kogarah swamp'. The species has never been recorded in the Wollemi IBRA subregion. The only other records in proximity of the study area are also historic (from 1902), as noted as being located at San Souci. Numerous recent records of the species exist from between the NSW Central and North Coasts with the majority of records within 20kilometres of the coast. Based on these recent records it can reasonably be concluded that if the species still occurred within the vicinity of the study area to would have been recorded within the last 115 years. PCTs associated with the species occur within the impact area in patches of thinned

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									PCT 781 and 1800 between Lansdowne and Wallacia. PCT 781 occurs within the study area only in a highly degraded state with a VI score of 6.3. This species was considered during targeted threatened species surveys undertaken between May – June 2020 and October 2020 throughout patches of PCTs 781 and 1800 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; *Maundia triglochinoides* will not require further consideration.
Melaleuca deanei **Deane's Paperbark**	V	V	Yes	Deane's Paperbark is a shrub up to 5 m tall with fibrous flaky bark and furry white new stems. Leaves are narrow, smooth and alternate (25 mm long and 6 mm wide) and the inflorescence is a white spike up to 6 cm long containing flowers with five petals on a furry stem. Fruit is barrel shaped and up to 7 mm in diameter (flowering between November and January) (DPIE 2020b). This species occurs in two areas, the Ku-ring-gai/Berowra and Holsworthy/Wedderburn as well as isolated occurrences at Springwood, Wollemi National Park at Nowra and on the Central Coast in ridgetop woodland or heath	Low	Yes	Yes – targeted survey undertaken in October 2020.		This species has been previously recorded on 8 occasions within 10 kilometre of the study area with closest record being 4.8 kilometre from the impact area. Potential habitat for this species in the impact area occurs in patches of thinned PCT 1083 and intact PCT 1181 between Wallacia and Warragamba. Targeted threatened species surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area for this species and no individuals have been detected. Based on the absence of this species within

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				on sandstone substrates. This species is associated with PCTs 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.					the impact area; Deane's Paperbark will not require further consideration.
Melaleuca groveana **Grove's Paperbark**	-	V	Yes	Grove's Paperbark is a shrub or small tree from 2-5 m tall, rarely 10 m with fibrous flaky bark. Leaves are narrow, curved and alternate (20-55 mm long and 3-8 mm wide) and the inflorescence is a short spike of fluffy white flowers. Fruit is barrel shaped and between 4-7 mm in diameter (flowering between November and January) (DPIE 2020b). This species is widespread as scattered populations in coastal districts north of Yengo National Park to south-east Queensland and at Torrington on the northern tablelands in open forest, woodlands, heath and shrubland on exposed sites, low coastal hills, escarpment ranges and tablelands on outcropping granite, rhyolite and sandstone. This species is associated with PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is year round.	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	This species has never been recorded with the Cumberland IBRA subregion, and the nearest record within the Wollemi IBRA subregion occurs over 120kilometres north of the study area. Other records of the species occur between 70 and 130kilometres to the north in the Pittwater and Yengo IBRA subregions. PCTs associated with the species occur within the impact area in patches of thinned PCT 1083 in the vicinity of Warragamba. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Grove's Paperbark will not require further consideration.
Micromyrtus minutiflora **-**	V	E	Yes	*Micromyrtus minutiflora* is a slender spreading shrub up to 2 m tall with oblong to ovate leaves and white solitary flowers (flowering between June and March) (DPIE 2020b).	Low	Yes	Yes – targeted survey undertaken between May-	No	This species has been previously recorded on 4 occasions within 10 kilometre of the study area with closest record being 2.5 kilometre from the impact area.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				This species is restricted to Western Sydney between Richmond and Penrith in dry sclerophyll forest and grassy woodland on tertiary alluvium and consolidated river sediments. This species is associated with PCTs 724, 725 and 883 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.			June 2020 and in October 2020.		Potential habitat for this species in the impact area occurs in high and moderate condition patches of PCTs 724, 725 and 883 from Kemps Creek to Wallacia. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 724, 725 and 883 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; *Micromyrtus minutiflora* will not require further consideration.
Olearia cordata -	V	V	Yes	*Olearia cordata* is a slender aromatic shrub up to 2 m tall with daisy like flowers coloured mauve or blue with a yellow centre and leaves with a heart shaped base (flowering between November and May) (DPIE 2020b). This species occurs on the south-western Hunter Plateau, eastern Colo Plateau and the Hornsby Plateau near Wiseman's Ferry in dry sclerophyll forest and open shrubland on sandstone ridges. This species is associated with PCTs, 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is year round.	Negligible	No	Yes – incidental survey undertaken in October 2020.	No	This species has never been recorded with the Cumberland IBRA subregion, and the nearest record within the Wollemi IBRA subregion occurs over 50kilometres north of the study area. Other records of the species over 35kilometres to the north in the Yengo IBRA subregion. PCTs associated with the species occur within the impact area in patches of thinned PCT 1083 and intact PCT 1181 in the vicinity of Warragamba. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									No individuals have been detected. Based on the absence of this species within the impact area; *Olearia cordata* will not require further consideration.
Persicaria elatior **Tall Knotweed**	V	V	Yes	Tall Knotweed is an erect herb up to 0.9 m tall with stalked glandular hairs, sheathed leaves and pink flowers (DPIE 2020b). This species occurs in Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon Catchment north of Robertson, Bermagui, Picton Lakes, Raymond Terrace and Grafton in riparian and swamp forest in damp places. This species is associated with PCTs 781, 835 and 1800 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between December to May.	Negligible	No	Yes – incidental survey undertaken between May-June 2020 and in October 2020.	No	The species has never been recorded within the Cumberland IBRA subregion. The 1949 record from 'Picton Lakes' refers to Thirlmere Lakes (at that time being called Picton Lakes), and more recent (2010) records occur there. No records of the species occur within the Wollemi IBRA subregion. PCTS associated with the species occur within the impact area occurs in patches of thinned and intact PCTs 781, 835 and 1800 from Lansdowne to Wallacia. This species was considered during targeted threatened species surveys undertaken in May – June 2020 and October 2020, throughout patches of PCTs 781, 835 and 1800 in the impact area. PCT 781 occurs within the study area only in a highly degraded state with a VI score of 6.3. No individuals have been detected. Whilst it is acknowledged these surveys occurred outside the BioNet survey period,

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									no species/individuals closely resembling this species' habit/foliage were recorded. Furthermore, it is noted in BioNet that the species "*can be identified from its leaves without flowers by a skilled botanist*". Based on the absence of this species within the impact area; Tall Knotweed will not require further consideration.
Persoonia acerosa **Needle Geebung**	V	V	Yes	Needle Geebung is small erect to spreading shrub up to 1-2 m tall with bright green pine-like foliage, yellow tubular flowers and pear shaped yellowish green fruit with brownish red markings (DPIE 2020b). This species occurs on the central coast and in the Blue Mountains from Mt Tomah to Hilltop and the Katoomba/Wentworth Falls/Springwood area in dry sclerophyll forest, low woodland and heath on low fertility soils. This species is associated with PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is year round.	Lowe	Yes	Yes – targeted survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species in the impact area occurs in patches of thinned PCT 1083 and intact PCT 1181 in the vicinity of Warragamba. Targeted threatened species surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; Needle Geebung will not require further consideration.
Persoonia bargoensis **Bargo Geebung**	V	E	Yes	Bargo Geebung is an erect bushy shrub between 0.6-2.5 m tall slender hairy branches, small thin discolorous leaves, yellow tubular flowers and pear shaped green fruit (DPIE 2020b).	Negligible	No	Yes – incidental survey undertaken between May-	No	There are no previous records of this species within 10 kilometre of the study area, with the known extent of the species occurring over 30 kilometres south of the study area, with PlantNet noting the species is

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				This species is restricted to south-west Sydney on the western edge of the Woronora Plateau and the northern edge of the Southern Highlands in dry sclerophyll forest and grassy woodland on well drained loamy or gravelly soils on the interface of Wianamatta Shale and Hawkesbury Sandstone. This species is associated with PCTs 849, 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). Species records show a clear association with sandstone geologies. The survey period is year round.			June 2020 and in October 2020.		"restricted to the Bargo area". PCTs associated with the species in the impact area occur as intact and thinned condition patches of PCTs 849, 1083 and 1181 between Wallacia and Warragamba. Habitat is considered absent at Kemps Creek. This species was considered during targeted threatened species surveys undertaken in May – June 2020 and October 2020 throughout patches of PCTs 849, 1083 and 1181 in the impact area for this species. No individuals have been detected. Based on the absence of this species within the impact area; Bargo Geebung will not require further consideration.
***Persoonia glaucescens* Mittagong Geebung**	V	E	Yes	Mittagong Geebung is an erect shrub up to 3 m tall with a mottled stem, brownish-red branches, glaucous erect leaves, yellow flowers and a fruit like a small plum (DPIE 2020b). This species is restricted to the area between Buxton and Berrima in dry sclerophyll forest and grassy woodland on ridgetops, plateaux and upper slopes in clayey or gravelly laterite. This species is associated with PCTs 1083 and 1181 in the Cumberland IBRA subregion (DPIE	Negligible	No	Yes – Incidental surveys undertaken in relevant PCTs in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area, which occurs over 35 kilometre north of the known geographic extent of the species (noted in PlantNet as Picton to Berrima). Associated PCTs for this species in the impact area comprise patches of intact PCT 1083 and intact PCT 1181 between Wallacia and Warragamba, only a very small area of which occurs on the boundary of the Cumberland IBRA subregion. The species is

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				2020b). The survey period is between January and March.					not known from the Wollemi IBRA subregion. Incidental surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area for this species and no individuals have been detected. Whilst it is acknowledged these surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; Mittagong Geebung will not require further consideration.
Persoonia hirsuta **Hairy Geebung**	E	E	Yes	Hairy Geebung is a spreading hairy shrub with small variable leaves and tubular yellow or orange flowers (DPIE 2020b). This species has a scattered distribution around Sydney between Singleton, Bargo and the Blue Mountains in dry sclerophyll forest, grassy woodland and heaths in sandy soils on sandstone substrates. This species is associated with PCTs 835, 1083 and 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 7.7 kilometre from the impact area. Potential habitat for this species in the impact area occurs in patches of thinned and intact PCTs 1083 and 1181 between Wallacia and Warragamba. Habitat is considered absent at Kemps Creek as the species has only ever been recorded around the periphery of the Cumberland IBRA subregion. Targeted threatened species surveys have

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									been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 1083 and 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Hairy Geebung will not require further consideration.
***Persoonia marginata* Clandulla Geebung**	V	V	Yes	Clandulla Geebung is a spreading shrub up to 0.5 m tall with hairy new branches, elliptic to obovate leaves and yellow flowers with brownish hairs (DPIE 2020b). This species occurs between Kandos and Clarence in dry sclerophyll forest and grassy woodland on sandstone substrates. This species is associated with PCT 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between January to March.	Negligible	No	Yes – Incidental surveys undertaken in relevant PCTs in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area, which occurs nearly 80 kilometres south-west of the main geographic extent of the species (noted in PlantNet as the Capertee district). Associated PCTs for this species in the impact area comprise patches of intact PCT 1181 between Wallacia and Warragamba. Incidental surveys have been undertaken (October 2020) throughout the patch of PCT 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Clandulla Geebung will not require further consideration.
***Persoonia mollis* subsp. *maxima* -**	E	E	Yes	*Persoonia mollis* subsp. *maxima* is a tall, branching, spreading shrub up to 2-6 m tall with hairy new branches and green fruit, purpling with age, resembling a small plum	Negligible	No	Yes – Incidental surveys undertaken in	No	There are no previous records of this species within 10 kilometre of the study area, which occurs over 20 kilometres south-east of the known geographic extent of the species

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				(DPIE 2020b). This species is restricted to the Hornsby Heights to Mt Colah area in sheltered aspects of wet sclerophyll forest and temperate rainforest. This species is associated with PCTs 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.			relevant PCTs in October 2020.		(noted in PlantNet as he Cowan–Hornsby area). Associated PCTs for the species occur in the impact area as patches of thinned PCT 1083 and intact PCT 1181 from Wallacia to Warragamba. Incidental surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; *Persoonia mollis* subsp. *maxima* will not require further consideration.
Persoonia nutans **Nodding Geebung**	E	E	Yes	Nodding Geebung is an erect to spreading shrub up to 2.5 m tall with hairy new branches, flat linear leaves with recurved margins and yellow drooping flowers (DPIE 2020b). This species is restricted to the Cumberland Plain between Richmond and Macquarie Fields in dry sclerophyll forest and woodlands on aeolian or alluvial sediments or shale-sandstone transition soils. PCT associations relevant to the project include PCTs 724, 725 and 883 in the Cumberland IBRA subregion (DPIE 2020b).	High	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 351 occasions within 10 kilometre of the study area with closest record being within the impact area, within Existing Certified land at Kemps Creek. Potential habitat for this species in the impact area occurs in patches of thinned and intact PCTs 724, 725 and 883 between Kemps Creek and Wallacia. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs

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				The survey period is year round.					724, 725 and 883 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; Nodding Geebung will not require further consideration.
Pilularia novae-hollandiae **Austral Pillwort**	-	E	Yes	Austral Pillwort is a semi-aquatic fern which resembles a small fine grass and fruit consisting of small hairy capsules at the base of fronds (DPIE 2020b). This species is has a scattered distribution throughout the southern half of Australia including a single historical record in suburban Sydney (Doonside) in shallow swamps, waterways and table drains particularly in drying mud. PCT associations relevant to the project include PCTs 835 and 1800 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between October and December.	Negligible	No	Yes – Incidental surveys undertaken between May-June 2020 and in October 2020.	No	Despite the high occurrence and coverage of botanical surveys across the Cumberland IBRA subregion the species has not been recorded since a single record from 1966 in Doonside. It is expected that more recent records would exist if the species current natural range included the Cumberland subregion. The species has never been recorded in the Wollemi IBRA subregion, with more recent records of the species located between 300 and 500kilometres south-west of the study area Associated PCTs for the species in the impact area comprise patches of thinned and intact PCTs 835 and 1800 between Lansdowne and Wallacia. Incidental surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 835 and 1800 in the impact area for this species and no individuals have been detected.

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									Based on the absence of this species within the impact area; Austral Pillwort will not require further consideration.
Pimelea curviflora* var. *curviflora -	V	V	Yes	*Pimelea curviflora* var. *curviflora* is a much-branched shrub up to 0.2-1.2 m tall with hairy stems, leaves that have hairy undersides and red to yellow hairy flowers (DPIE 2020b). This species is confined to the coastal areas of Sydney and the Illawarra on ridgetops and upper slopes of grassy woodlands in shale-sandstone transition soils. PCT associations relevant to the project include PCTs 724, 849, 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between October and March.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. With the BioNet distribution description stating the species is "confined to the coastal area of the Sydney and Illawarra regions. Populations are known between northern Sydney and Maroota in the north-west. New population discovered at Croom Reserve near Albion Park in Shellharbour LGA in August 2011. Formerly recorded around the Parramatta River and Port Jackson region including Five Dock, Bellevue Hill and Manly". Potential habitat for this species in the impact area occurs in patches of thinned and intact PCTs 724, 849 between Lansdowne and Wallacia. Potential habitat within patches of PCTs 1083 and 1181 between Wallacia and Warragamba are located outside the Cumberland IBRA subregion. Habitat is considered absent within the small and highly degraded patch of PCT 849 at Kemps Creek. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs

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									724, 849, 1083 and 1181 in the impact area for this species and no individuals have been detected. Whilst it is acknowledged that May – June surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; *Pimelea curviflora* var. *curviflora* will not require further consideration.
Pimelea spicata **Spiked Rice-flower**	E	E	Yes	Spiked Rice-flower is an erect to spreading shrub up to 0.5 m tall with opposite leaves and white, pink tinged tubular flowers which usually appear after rainfall (DPIE 2020b). This species occurs in two disjunct areas on the Cumberland Plain in grassy woodlands and in the Illawarra in open woodland and grasslands. This species occurs on well-structured clay soils. PCT associations relevant to the project include PCT 849 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.	High	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	Yes	This species has been previously recorded on 596 occasions within 10 kilometre of the study area with closest record being 100m from the impact area at Lansdowne Reserve. Potential habitat for this species in the impact area occurs in patches of scattered, thinned and intact PCT 849 between Lansdowne and Wallacia. With a the patch of PCT 835 at Kemps Creek also considered potential habitat by the expert report (Norris 2021) Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCT 849 in the impact area for this species.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									No individuals have been detected. Despite the absence of this species within the impact area during targeted surveys, the potential for the species to survive as rootstock, and the intensive BioNet survey requirements, have resulted in an expert report being sought to address the species. The species if further addressed in Sections 9, 9 and 11 of this report.
***Pomaderris brunnea* Brown Pomaderris**	-	E2	Yes	Brown Pomaderris is a shrub up to 3 m tall with hairy stems, leaves with toothed margins and a densely hairy underside and dense clusters of small yellowish flowers with no petals (DPIE 2020b). This species occurs in the vicinity of the Colo, Nepean and Hawkesbury Rivers as well as near Walcha on the New England tablelands and in far eastern Gippsland in Victoria in moist woodland or forest on clay and alluvial soils of flood plains and creek lines. PCT associations relevant to the project include PCTs 835, 1105, 1181, and 1800 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period between August and October.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species in the impact area occurs in patches of thinned and intact PCTs 835, 1105, 1181 and 1800 within the vicinity of the Hawkesbury-Nepean River and along other major waterways between Lansdowne and Wallacia. Habitats are considered absent at Kemps Creek. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 835, 1105, 1181 and 1800 in the impact area for this species and no individuals have been detected.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									Whilst it is acknowledged that May – June surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; Brown Pomaderris will not require further consideration.
***Pomaderris prunifolia* – endangered population** -	V	E	Yes	*Pomaderris prunifolia* is a shrub between 1-3 m tall with hairy stems, oblong to ovate leaves with a wrinkled upper surface and hairy lower surface and yellow flowers and hairy capsules (DPIE 2020b). The endangered population occurs in the Parramatta, Auburn, Strathfield and Bankstown LGA's where it is known from three sites, a roadside remnant near Rydalmere, within Rookwood Cemetery and at The Crest at Bankstown in degraded forest remnants on sandstone or shale soils. PCT associations relevant to the project include PCTs 725 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is October.	Low	No	No	No	This species has been previously recorded on 19 occasions within 10 kilometre of the study area with closest record being 2.1 kilometre from the impact area. There is no habitat for *Pomaderris prunifolia* in or adjacent to the impact area within the LGA's relevant to the endangered population in the Cumberland IBRA subregion. Therefore *Pomaderris prunifolia* will not require further consideration.
***Pomaderris sericea* Silky Pomaderris**	V	E	Yes	Silky Pomaderris is a low shrub less than 2 m tall with shining golden brown hairs on new growth, elliptical leaves with hairy undersides	Negligible	No	Yes – Incidental surveys	No	This species has never been recorded within the Cumberland IBRA subregion, with the only record from the Wollemi IBRA

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				and clusters of cream-coloured flowers (DPIE 2020b). This species is known only from Morton National Park near Bundanoon, Wollemi National Park and north-eastern Victoria in open forest on sandstone. PCT associations relevant to the project include PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September and November.			undertaken in October 2020.		subregion occurring over 150kilometres to the north-west of the study area. Additional records of the species occur between 70 to 90kilometres south of the study area. PCTs associated with this species occurs within the study area in the form of patches of thinned PCT 1083 in the vicinity of Warragamba. This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Silky Pomaderris will not require further consideration.
Prasophyllum fuscum **Slaty Leek Orchid**	V	CE	No	Slaty Leek Orchid is a terrestrial orchid with a single leaf up to 40 cm long with an inflorescence containing 10-30 greenish brown to reddish brown, lightly scented flowers (DPIE 2020b). The type specimen is from "moist meadows towards the Georges River" in the Sydney area. The species is likely to be extinct from this area. Harden (1993) states that it is confined to the Blue Mountains area. However, some authorities believe *Prasophyllum* species from this area are not *P.*	Negligible	No	No	No	There are no previous records of this species within the Cumberland IBRA subregion, with the nearest records from thw Wollemi subregion occurring over 30 to 50kilometres to the north-west, north from Wentworth Falls and Leura (both being historical records). PCTs associated with the species occur in the form of a patch of intact PCT 1181 near Bents Basin Road, Wallacia. However, the required microhabitat of moist heath, often along seepage lines, and moist sandy soil

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				fuscum, but an undescribed species. In addition, some authorities believe it is identical to *P. uroglossum* which occurs in the Wingecarribee area. The species occurs in moist grasslands or heath along seepage lines in sandy soil over sandstone substrates. PCT associations relevant to the project include PCTs 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between November and December.					over sandstone amongst sedges and grasses, are not present within the impact area or impact assessment area. Based on the absence of this species' microhabitats within the impact area and impact assessment area; Slaty Leek Orchid will not require further consideration.
***Pterostylis saxicola* Sydney Plains Greenhood**	E	E	Yes	Sydney Plains Greenhood is a terrestrial orchid occurring as a rosette of 5-8 leaves and 2-4 closely sheathing stem leaves and an inflorescence containing reddish brown to green translucent flowers (DPIE 2020b). This species is restricted to western Sydney between Freemans Reach and Picton in depressions on sandstone rock shelves above cliff lines in dry sclerophyll forest or woodland on shale sandstone transition soils or shale soils. PCT associations relevant to the project include PCTs 849, 1083 and 1181 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is October.	Low	Yes	Yes – targeted survey undertaken in May – June and October 2020.	No	This species has been previously recorded on 2 occasions within 10 kilometre of the study area with closest record being 8.7 kilometre from the impact area. Potential habitat for this species occurs in the form of patches of thinned and intact PCTs 849 between Lansdown and Warragamba. Patches of 1083 and 1181 within the impact area occur outside the Cumberland IBRA subregion. A reference population of this species existing at Simmo's Beach in Maquarie Fields was visited on the initial day of the October surveys to ascertain whether the species was flowering. Multiple individuals were observed to be flowering during this visit.

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									Targeted threatened species surveys have been undertaken (May – June 2020 (searches for rosettes in PCT 849 only) and October 2020 (all PCTs) throughout patches of PCTs 849, 1083 and 1181 in the impact area. No individuals have been detected (either flowering or as potential emergent leaves). Based on the absence of this species within the impact area; Sydney Plains Greenhood will not require further consideration.
Pultenaea glabra **Smooth Bush-Pea**	V	V	Yes	Smooth Bush-Pea is an erect shrub up to 1.5 m tall with smooth hairless stems and leaves and yellow/orange pea-like flowers (DPIE 2020b). This species is restricted to the Blue Mountains in the Katoomba-Hazelbrook and Mount Victoria areas in dry sclerophyll forest and tall damp heath on sandstone. PCT associations relevant to the project include PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to November.	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area, with the species known area of occurrence centred around the Blue Mountains townships of Woodford to Katoomba Potential habitat for this species occurs in the form of patches of thinned PCT 1083 and intact PCT 1181 in the between Wallacia and Warragamba. Targeted threatened species surveys have been undertaken (October 2020) throughout patches of PCTs 1083 and 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; Smooth Bush-Pea will not

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									require further consideration.
Pultenaea parviflora -	V	E	Yes	*Pultenaea parviflora* is a small erect branching shrub up to 1 m to 1.8 m tall with narrow broad to obovate leaves and yellow pea-like flowers with reddish markings (DPIE 2020b). This species is endemic to the Cumberland Plain from Windsor to Penrith and Dean Park with outliers at Kemps Creek and Wilberforce in dry sclerophyll forest on tertiary alluvium or laterised clays. PCT associations relevant to the project include PCTs 724, 725, 883 and 1083 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between September to November.	High	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	Yes	This species has been previously recorded on 830 occasions within 10 kilometre of the study area with closest record being within the impact area within Existing Certified land at Kemps Creek. Potential habitat for this species occurs in the form of patches of thinned and intact PCTs 724, 725, 883 between Kemps Creek and Wallacia and patches of thinned PCT 1083 in the vicinity of Warragamba (outside the Cumberland IBRA subregion). Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 724, 725, 883 and 1083 in the impact area for this species. A total of 35 individuals have been detected within the impact area and a further 65 individuals were detected within the impact assessment area at Kemps Creek, all of which occur within Existing Certified land and are therefore not considered further. A further 4 individuals were recorded along Elizabeth Drive, Luddenham within the Impact Assessment Area, immediately adjacent to the Impact Area. These records

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
									are not within Existing Certified land and thus have been addressed further in Sections 8, 9 and 11 of this report.
Pultenaea pedunculata **Matted Bush-pea**	-	E	Yes	Matted Bush-pea is a mat forming shrub with branches up to 3 m long and a height of up to 0.2 m tall with stems containing appressed white hairs, small flat discolorous leaves with a recurved point and yellow, apricot or orange pea-like flowers (DPIE 2020b). This species occurs as three disjunct populations in NSW in the Cumberland Plain, the coast between Tathra and Bermagui and the Windellama area south of Goulburn in grassy woodland in a variety of soils all of which have a lateritic influence with ironstone gravels. PCT associations relevant to the project include PCTs 724, 725 and 849 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between September to November.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	Yes – Species assumed present in areas unable to accessed for targeted survey.	This species has been previously recorded on 28 occasions within 10 kilometre of the study area with closest record being 1.6 kilometre from the impact area. Potential habitat for this species occurs in the form of patches of scattered, thinned and intact PCTs 724, 725 and 849 between Lansdowne and Wallacia. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 724, 725 and 849 in the impact area for this species and no individuals have been detected. Targeted surveys were unable to be completed within the section of the impact area and impact assessment area that crosses Kemps Creek. The presence of Mated Bush-pea has been assumed within PCT 849 vegetation in this location.
Pultenaea **sp. Olinda** -	-	E	Yes	*Pultenaea* sp. Olinda is an erect to procumbent shrub with spreading hairy stems, alternate cylindrical leaves and yellow pea-like flowers (DPIE 2020b).	Negligible	No	No	No	Records of this species occur approximately 120kilometres to the north-west of the study area east of Rylstone. PCTs associated with the species occur

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				This species occurs at Currant Mountain Gap east of Rylstone in Wollemi National Park on a pagoda rock formation. PCT associations relevant to the project include PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to October.					within the study area in the form of patches of thinned PCT 1083 in the vicinity of Warragamba. Based on the study area occurring outside the known area of occurrence of the species, *Pultenaea* sp. Olinda will not require further consideration.
***Pultenaea villifera* – endangered population** -	-	E2	Yes	*Pultenaea villifera* is an erect to up to 1 m tall with moderately hairy stems, alternate lance-shaped hairy leaves and yellow to orange pea-like flowers (DPIE 2020b). The endangered population occurs in the Blue Mountains LGA in the Springwood – Woodford area in dry sclerophyll forest and woodlands on sandy soils. PCT associations relevant to the project include PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to December.	Nil	No	No	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species occurs in the form of patches of thinned PCT 1083 and intact PCT 1181 in the vicinity of Warragamba, which is located outside the Blue Mountains LGA which defines the E2 population boundaries. Therefore *Pultenaea villifera* will not require further consideration.
***Seringia denticulata* – endangered population** -	-	E2	Yes	*Seringia denticulata* is a densely haired shrub up to 1-2 m tall with ovate strongly wrinkled leaves and white to pinkish flowers and hairy fruit (DPIE 2020b). The endangered population occurs in the Hawkesbury LGA at the Colo River area between Lower Portland and Morans Rock in	Nil	No	No	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species occurs in the form of patches of thinned and intact PCTs 835 and 1083 between Wallacia and Warragamba, which lay outside the Hawkesbury LGA which defines the

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				wet sclerophyll forest on sandy soils. PCT associations relevant to the project include PCTs 835 and 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is year round.					boundary of the E2 population. Therefore *Seringia denticulata* will not require further consideration.
Tetratheca glandulosa -	-	V	Yes	*Tetratheca glandulosa* is a small spreading shrub between 0.2-0.5 m tall with opposite leaves with recurved margins, flower stalks and sepals covered in dark-red gland tipped hairs and dark pink to pale pink flowers with four petals (DPIE 2020b). This species is restricted to the Baulkham Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah and Wyong LGAs in dry sclerophyll forests, grassy woodlands and heaths in shale-sandstone transitional soils. PCT associations relevant to the project include PCTs 835 and 1083 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.	Low	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 6 kilometre from the impact area. Potential habitat for this species occurs in the form of patches of intact and thinned PCTs 835 and 1083 between Lansdowne and Warragamba. Targeted threatened species surveys have been undertaken (May – June 2020 and October 2020) throughout patches of PCTs 835 and 1083 in the impact area for this species and no individuals have been detected. Whilst it is acknowledged May-June surveys occurred outside the BioNet survey period, no species/individuals closely resembling this species' habit/foliage were recorded. Based on the absence of this species within the impact area; *Tetratheca glandulosa* will not require further consideration.
Thesium australe	V	V	No	Austral Toadflax is a small straggling herb up	Negligible	No	No	No	Despite this species being recorded 460 time

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
Austral Toadflax				to 0.4 m tall with pale green to yellow-green slightly succulent leaves (1-4 cm long and 0.5-1.5 mm wide), This species flowers in Spring, producing minute white flowers located in the leaf axils and the nut-like fruit is produced in Summer (DPIE 2020b). This species is cryptic and is often difficult to detect as it is hidden amongst grasses and herbs. Austral Toadflax has a scattered distribution across eastern NSW, predominantly along the coast from the Northern to Southern Tablelands. This species occurs in grasslands on coastal headlands or grassland and grassy dry sclerophyll woodlands inland. Austral Toadflax is a root parasite often associated with tussock grasses, particularly Kangaroo Grass. PCT associations relevant to the project include PCTs 849 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between November to February.					in BioNet, with a large portion of the records occurring from the last 20 years, the species has not been recorded within the Cumberland IBRA subregion since 1803 (from a single record noted as from Cowpasture Plains, Camden). Records from the Capertee Uplands IBRA subregion, on the boundary of the Wollemi IBRA subregion from 2013, occur over 75 kilometres to the north-west of the impact area and impact assessment area. As such, the project is considered to occur outside the geographic range of the species and no reliable records of the species occur within the vicinity. Therefore, Austral Toadflax will not require further consideration.
Velleia perfoliata -	V	V	Yes	*Velleia perfoliata* is a small herb with light green spoon shaped leaves rising from its base (10-12 cm long and 3-4 cm wide), This species has leaf-like bracteoles which are fused and form a funnel below the flowering stalk. Flowers are yellow with five petals (12	Negligible	No	Yes – incidental surveys undertaken in October 2020.	No	There are no previous records of this species within 40 kilometre of the study area. PCTs associated with the species occur within the study area in the form of patches of thinned PCT 1083 and intact PCT 1181 between Wallacia and Warragamba.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				mm long), two of which point up and three point down (DPIE 2020b). This species has a restricted distribution within the Hawkesbury district and upper Hunter Valley. It is found in heath and dry sclerophyll forest in shallow depressions, rocky hill sides, under cliffs or along tracks and trails in sandy soils atop sandstone substrates. *Velleia perfoliata* often occurs amongst moss and lichens on rocks. PCT associations relevant to the project include PCTs 1083 and 1181 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to November.					This species was considered during targeted threatened species surveys undertaken in October 2020 throughout the impact area. Based on the absence of this species within the impact area; *Velleia perfoliata* will not require further consideration.
***Wahlenbergia multicaulis* – endangered population local government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield.** **Tadgell's Bluebell**	-	E2	No	Tadgell's Bluebell is a perennial tufted herb between 10-75 cm tall and long thin leaves bearing smooth or serrated margins. Flowers are blue with petals forming a tube, each petal being between 2-10 mm long. The styles are constricted less than a third of the way down the corolla (DPIE 2020b). This species has a confined distribution within the E2 population area, restricted to 13 known sites, two in north Sydney and the remainder in western Sydney between Rookwood and Greenacre. Tadgell's Bluebell occurs in sandstone gully forest or Castlereagh Ironbark	Medium	Yes	Yes – targeted survey undertaken between May-June 2020 and in October 2020.	No	This species has been previously recorded on 86 occasions within 10 kilometre of the study area with closest record being 2.3 kilometre from the impact area. Potential habitat for this species occurs in the form of patches of thinned and intact PCT 835 between Lansdowne and Cabramatta. Targeted threatened species surveys have been undertaken (May-June 2020 and October 2020) throughout patches of PCT 835 in the impact area for this species and no individuals have been detected.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				Forest as well as wetland or grassland adjacent to watercourses on Villawood or Hawkesbury soil landscapes but also occurring in disturbed areas. PCT associations relevant to the project include PCTs 725 and 835 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is year round.					Based on the absence of this species within the impact area; Tadgell's Bluebell will not require further consideration.
Zannichellia palustris -	-	E	Yes	*Zannichellia palustris* is a submerged aquatic plant with thin leaves between 2-7 cm long and less than 1 mm wide (DPIE 2020b). This species has a restricted distribution in NSW and is only known from the lower Hunter and within Sydney Olympic Park. *Zannichellia palustris* occurs in slightly saline stationary or slow flowing water and flowers during the warmer months. This species can be difficult to detect as it completely dies back in summer after flowering. PCT associations relevant to the project include PCT 781 in the Cumberland IBRA subregion (DPIE 2020b). The survey period is between October to January.	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species occurs in the form of patches of thinned PCT 781 between Western Sydney Parklands and Wallacia. Targeted threatened species surveys have been undertaken in October 2020 throughout patches of PCT 781 in the impact area, although habitats were generally considered highly degraded and unlikely to support the species, with PCT 781 found to have a VI score of just 6.3. No individuals have been detected. Based on the absence of this species within the impact area; *Zannichellia palustris* will not require further consideration.
Zieria involucrata -	V	E	Yes	*Zieria involucrata* is a small erect shrub growing up to 1-2 m tall. It has sparse	Low	Yes	Yes – targeted survey	No	There are no previous records of this species within 10 kilometre of the study area.

Species	Conservation status EPBC Act	BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
				branches and leaves which are densely covered in soft velvety hairs which appear star shaped under a microscope. Leaves are arranged opposite in groups of 1-3 leaflets. Leaflets are discolorous, dark green above and grey-green below, oblong to lance shaped and 3-6 cm long and 6-15 mm wide. The inflorescence is a cluster of 3-21 white, pink tinged slightly hairy flowers with small leaf-like bracts (7-12 mm long) (DPIE 2020b). This species has a disjunct distribution in the north and west of Sydney, predominantly in the Baulkham Hills, Hawkesbury, Hornsby and Blue Mountains LGA's. *Zieria involucrata* occurs in dry and wet sclerophyll forest on Hawkesbury or Narrabeen sandstone or on Quaternary alluvium. PCT associations relevant to the project include PCT 1181 in the Cumberland and Wollemi IBRA subregions (DPIE 2020b). The survey period is year round.			undertaken in October 2020.		Potential habitat for this species occurs in the form of a patch of intact PCT 1181 near Bents Basin Road in Wallacia. Targeted threatened species surveys have been undertaken (October 2020) throughout patch of PCT 1181 in the impact area. No individuals have been detected. Based on the absence of this species within the impact area; *Zieria involucrata* will not require further consideration.
Zieria murphyi **Velvet Zieria**	V	V	Yes	*Zieria murphyi* is a velvety shrub growing up to 2 m tall and differs from other Zieria species in that it sometimes has a leaves with only one leaflet instead of the usual three leaflets. The leaflets are discolorous, dark green and hairy above whilst greyish-green and velvety below (50 mm long and 10 mm wide). The	Low	Yes	Yes – targeted survey undertaken in October 2020.	No	There are no previous records of this species within 10 kilometre of the study area. Potential habitat for this species occurs in the form of a patch of thinned PCT 1083 adjacent to Warragamba Dam. Targeted threatened species surveys have been undertaken (October 2020) throughout

Species	Conservation status EPBC Act BC Act	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Conclusion and rationale
			inflorescence is a cluster of 3-9 flowers with white to pale pink petals up to 5.5 mm long (DPIE 2020b). This species has a distribution restricted to the Blue Mountains at Mt Tomah and in the southern Highlands at Morton National Park and at Penrose . *Zieria involucrata* occurs in sheltered areas of moist gullies in wet sclerophyll forest on sandy soils. PCT associations relevant to the project include PCT 1083 in the Wollemi IBRA subregion (DPIE 2020b). The survey period is between September to November.					patch of PCT 1083 in the impact area for this species and no individuals have been detected. Based on the absence of this species within the impact area; *Zieria murphyi* will not require further consideration.

Table A. 2 Threatened fauna species assessment

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
Anthochaera Phrygia **Regent Honeyeater (Breeding and Foraging)**	CE	CE	Yes	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests. The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks. Also nest in mistletoe haustoria (DPIE 2020b). This species is relevant to the Cumberland	Medium	No	No	Breeding – No Foraging – Low level impacts	The impact area and impact assessment area are not located within an area mapped by DPIE as important habitat for this species. However this species is considered as potentially significantly impacted by the project as part of the Controlled Action determination. This species has been previously recorded on 30 occasions within 10 kilometre of the study area with closest record being 1.5 kilometre from the study area. Vegetation within the study area is not suitable for nesting/breeding habitat. Furthermore, there are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region (EES 2017). The study area is not located within an area mapped by DPIE as important habitat for the species. Moderate quality foraging habitat for this species occurs within intact and thinned condition PCTs 724, 725, 835, 849, 883, 1083 and 1181 from Lansdowne to Warragamba. Impacts to this species are considered further in Sections 9 and 11, and Appendix 7

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				and Wollemi IBRA subregions.					of this report.
Burhinus grallarius **Bush Stone-curlew**	-	E	Yes	The Bush Stone-curlew is a medium sized grey to light brown bird with large bright yellow eyes. This species is found throughout Australia except for the central southern coast, inland, the far south-eastern corner and Tasmania. In the South-east it is considered rare or extinct throughout its former range. The Bush Stone-curlew inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber where it feeds on insects, frogs, lizards and snakes. The species is largely nocturnal and is highly active on moonlit nights. Bush Stone-curlew breeds in Spring to early Summer where it builds a nest on the ground in a scrape or bare patch, usually laying two eggs in a clutch (DPIE 2020b). This species is relevant to the Cumberland IBRA subregion.	Negligible	No	No	No	This species has been previously recorded on 17 occasions within 10 kilometre of the study area with closest record being 4.3 kilometre from the impact area. Records within 5 kilometre of the impact area are prior to 1996 from within the RAAF base at Orchard Hills. As no new BioNet records of the species exist in that location for over 23 years, more than a generation's length for this species, the birds are considered no longer to be present based on lack of sightings/records. The remaining records in proximity to the impact area are no more recent than 1950 and include specimen records form the Australian Museum, dated as 1884 and 1895. More recent records are associated with the Holsworthy military area and a single record in East Hills. Neither of these locations are considered to have connectivity to the impact area and as such do not indicate the species' presence. A single record occurs from within the Cumberland subregion since 1996, noted as being from 2012 in Greystanes and associated with WIRES. No more information is provided in BioNet. Due to the isolated

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
									nature of this record, both temporally and spatially, it is considered a vagrant record, and not evidence of the species persistence in the subregion. The species was removed as a candidate species because suitable micro-habitats have undergone a long history of degradation and are now considered scarce in the impact area, and the substantial lack of recent records within the subregion. Considerable survey effort has been undertaken for the species across the Cumberland subregion since 1996 and if present, it is considered likely that the species would have been positively recorded in that time.
Calidris ferruginea **Curlew Sandpiper**	CE	E	Yes	Curlew Sandpiper is a small mottled grey to chestnut brown shorebird with long black legs and a medium length down-curved bill. This species is distributed around the coastline of Australia and occurs along the entire coast of NSW with some outlying inland records. Curlew Sandpiper occupies littoral and estuarine habitats, predominantly frequenting intertidal mudflats but also occurring in swamps, lakes and lagoons where it forages for worms, molluscs, crustaceans, insects and seeds on the edge of	Negligible	No	No	No	The impact area and impact assessment area are not located in a migratory shorebird important habitat area for this species. This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 9.4 kilometre from the study area. No wetlands that would be considered of National or International Importance in accordance with EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				shallow water. Curlew Sandpiper breeds in Siberia between April to August and returns to Australia during the non-breeding season (DPIE 2020b). This species is relevant to the Cumberland IBRA subregion.					Act listed migratory shorebird species (CoA 2017) occur within the vicinity of the impact area or impact assessment area.
Callocephalon fimbriatum **Gang-gang Cockatoo**	-	V	Yes	Gang-gang Cockatoo is a medium sized cockatoo coloured slate grey with males sporting a scarlet head and crest and females have a grey head and crest with salmon pink edged feathers on their undersides. Gang-gang Cockatoo is distributed from southern Victoria to central eastern NSW. In Spring and Summer, this species is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests, in winter often move to lower altitudes in drier more open eucalypt forests. In Autumn and Winter, the species moves to lower altitudes, inhabiting dry sclerophyll forests and woodlands. Gang-gang Cockatoo favours old growth forest and woodland for breeding where it nests in hollows over 10 cm in diameter and above 9 m from the ground (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.	Medium	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken between Aug and Oct 2020 within impact area and impact assessment area.	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) – Potential Foraging habitat – Low level impacts	This species has been previously recorded on 61 occasions within 10 kilometre of the study area with closest record being 121 m from the study area. No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>10 cm diameter and at least 9 m above the ground) that occur within patches of vegetation suitable for the species to utilise as breeding habitat was detected within the impact area. Moderate quality foraging habitat for this species was detected throughout the study area in the form of intact and thinned PCTs 724,835, 849, 883, 1083, 1105 and 1181. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 of this report.
Callocephalon	-	E2	Yes	Gang-gang Cockatoo is a medium sized	Nil	No	No	No	The impact area and impact assessment

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
***fimbriatum* Gang-gang Cockatoo – endangered population in the Hornsby and Ku-ring-gai Local Government Areas**				cockatoo coloured slate grey with males sporting a scarlet head and crest and females have a grey head and crest with salmon pink edged feathers on their undersides. Gang-gang Cockatoo is distributed from southern Victoria to central eastern NSW. In Spring and Summer, this species is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests, in winter often move to lower altitudes in drier more open eucalypt forests. In Autumn and Winter, the species moves to lower altitudes, inhabiting dry sclerophyll forests and woodlands. Gang-gang Cockatoo favours old growth forest and woodland for breeding where it nests in hollows over 10 cm in diameter and above 9 m from the ground (DPIE 2020b). This endangered population is relevant to the Cumberland IBRA subregion.					area do not occur in the LGA's that contain the E2 population of this species.
***Calyptorhynchus lathami* Glossy Black-Cockatoo (Breeding)**	-	V	Yes	Glossy Black-Cockatoo has a distribution spanning from central Queensland to East Gippsland Victoria with a small population in the Riverina region and on Kangaroo Island in South Australia. This species inhabits open forests and woodlands which contain Black Sheoak *Allocasuarina littoralis* and Forest Sheoak *Allocasuarina torulosa.* Breeding	Medium	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken between Aug and Oct 2020	Breeding habitat (direct impacts) – No Breeding habitat	This species has been previously recorded on 73 occasions within 10 kilometre of the study area with closest record being 29 m from the impact area. No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>15 cm diameter in stems at least 30 cm diameter and at least 8 m above the

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				habitat consists of living or dead tree with hollows greater than 15cm diameter and greater than 5m above ground. Glossy Black-Cockatoo forages exclusively on *Casuarina* and *Allocasuarina* species (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			within impact area and impact assessment area.	(indirect impacts) – Potential Foraging habitat – Low level impacts	ground) that occur within patches of vegetation suitable for the species to utilise as breeding habitat was detected within the impact area. Moderate to high quality foraging habitat for this species was detected throughout the study area in the form of intact and thinned PCTs 724, 835, 883, 1105 and 1800. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 of this report.
Cercartetus nanus **Eastern Pygmy-possum**	-	V	Yes	The Eastern Pygmy-possum is a tiny arboreal light brown mammal with a white belly and prehensile tail. This species is found throughout south-eastern Australia from southern Queensland to Tasmania. In NSW its range extends from the coast to the Pilliga, Dubbo, Parkes and Wagga Wagga. This species occupies rainforest, dry sclerophyll forests and woodlands as well as heaths where it forages on nectar and pollen from *Banksia, Eucalyptus* and *Callistemon* species and supplements this diet with invertebrates. Eastern Pygmy-possum predominantly shelters in tree hollows but also uses rotten stumps, holes in the ground, abandoned bird	Negligible	No	No	No	Relevant to the current project, Eastern Pygmy-possum occurs in areas of sandstone geology to the north-eat and south-east of Sydney, and within the Blue Mountains area west of Sydney, with the species only ever being recorded 21 times within the Cumberland IBRA subregion. This species has been previously recorded on 5 occasions within 10 kilometre of the study area with closest record being 1.6 kilometre from the impact area. However this record is over 20 years old and associated with very low potential connectivity to the impact area. The record it noted in BioNet as being from DeFreitas

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				nests, possum dreys or dense vegetation. This species reproduces in late Spring to early Autumn dependant on food availability and will spend Winter in torpor (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					Wetland, Fairfield, which occurs adjacent to Prospect Creek and Orphan School Creek. However for animals present in that location to occur within the study area, they would need to traverse through over 3.5 kilometres of degraded urbanised riparian habitat, which is considered highly unlikely for a species known to have very small home ranges. Next closest records to the study area occur within/adjacent to the Holsworthy military area, over 15 kilometres away along the Georges River and Prospect Creek riparian zones, which are often thin and degraded, through Moorebank, Warwick Farm, and around Chipping Norton Lake. The only relevant records of the species within the Wollemi subregion occur over 10 kilometres from the project alignment within the Blue Mountains National Park and Warragamba Dam Special Area, and occur on the western side of the Nepean/Warragamba Rivers. Whilst it is acknowledged the species can feed on eucalypt blossom, the key food resources of Banksia and Bottlebrush nectar are highly limited within the project alignment, and the vegetation within the impact area and impact assessment area is

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
									generally fragmented and edge effected in nature. The degraded nature of the habitat, the lack of connectivity between areas of known habitat (existing records) and the impact area, and the very low number of records proximal to the project alignment have led to the conclusion that the species is not considered a candidate species credit species.
Chalinolobus dwyeri **Large-eared Pied Bat**	V	V	Yes	Large-eared Pied Bat is a small to medium sized bat with long ears, wattled mouth and glossy black fur. This species is distributed from Rockhampton in Queensland to Bungonia in the Southern Highlands of NSW with sporadic records from New England Tablelands and the North West Slopes. Large-eared Pied Bat is found in areas with extensive cliffs and caves near intact forests containing gullies. The species roosts in the day in caves, old mines and disused Fairy Martin nests and will hibernate between Autumn and Spring. Large-eared Pied Bat breeds in maternity roosts formed from large domed caves from November to January (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.	High	Yes	Yes – targeted survey using acoustic detectors has been undertaken in areas identified as potential roosting habitat in Oct 2020 and Dec 2020 to Jan 2021.	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) – Potential Foraging habitat – Low level impacts	This species has been previously recorded on 32 occasions within 10 kilometre of the study area with closest record being 117 m from the impact area. Potential roosting habitat for this species occurs on the western end of the impact area adjacent to Warragamba River. This area contains multiple small caves and deep overhangs in addition to a disused tunnel and a deep open shaft. No potential maternity caves occurs within or adjacent to the impact area. Potential foraging habitat for this species is formed from scattered trees, thinned and intact PCT's which occur within a 2 kilometre radius of identified potential roosting habitat. Impacts to this species are considered

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
									further in Sections 8, 9 and 11 and Appendix 6 of this report.
Haliaeetus leucogaster **White-bellied Sea-Eagle**	-	V	Yes	White-bellied Sea-Eagle has a distribution which spans the Australian coastline, including Tasmania, and ranges inland along major rivers and waterways. This species occurs in the vicinity of the sea, near bays and inlets, beaches, reefs, lagoons, estuaries in addition to freshwater swamps, lakes, reservoirs, billabongs and waterways. Terrestrial habitat consists of coastal dunes, tidal flats, grassland, heathland, woodland and forest. White-bellied Sea-Eagle is highly selective in choice of breeding habitat and maintains high site fidelity. Preferred Breeding habitat is live large old trees within 1 kilometre of rivers, lakes, large dams or creeks, wetlands and coastlines. Breeding individuals will build a large stick nest within tree canopy which is built up over successive years. This species forages within proximity to waterways where it preys upon fish and freshwater turtles, occasionally supplementing their diet with waterbirds, reptiles, mammals and carrion (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.	High	Yes	Yes – surveys for stick nests and habitat assessment undertaken to detect suitable breeding trees.	Breeding – No Foraging - Negligible	This species has been previously recorded on 208 occasions within 10 kilometre of the study area with closest record being within the impact area. One juvenile White-bellied Sea-Eagle was detected flying adjacent to the impact area along Warragamba River during surveys. No potential breeding habitat in the form of stick nests or suitable breeding trees were recorded within the study area. Potential foraging habitat for this species occurs throughout the entire length of the study area in the form of waterways which harbour prey fish species in addition to native PCTs and Urban Exotic/Native communities which harbour supplementary prey species suitable for this species. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11, with EPBC Act considerations outlined in Section 9 of this report.
Heleioporus	V	V	Yes	Giant Burrowing Frog is a long-lived (10	Low	Yes	Yes – habitat	No	This species has been previously recorded

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
australiacus **Giant Burrowing Frog**				years), large, round and cumbersome frog that grows to about 10 cm in length. This species is blue-grey to black on its limbs and back, pale on its sides and a white belly, sometimes with pale marbling. Giant Burrowing Frog has tubercules on its feet and males have enlarged forearms with a conical black spine and smaller spines on their first finger. This species has two known populations; a northern population which occurs from Sydney to Ulladulla and a southern population which occurs from Narooma, NSW to Walhalla in Victoria. Terrestrial habitat consists of open dry sclerophyll forest on a variety of soil types except for clay based soils. Breeding habitat consists of soaks or pools within first and second order streams or hanging swamp seepage lines. Giant Burrowing Frog will spend more than 95% of its life in non-breeding habitat approximately 300 m from breeding sites. When not breeding, this species will burrow below the soil surface or within leaf litter and inhabit non-overlapping home ranges approximately 0.04 ha in area. Giant Burrowing Frog breeds in Autumn during which time it will lay 500-800 eggs in			assessment and targeted survey has been undertaken for this species at the western end of the impact area.		on 10 occasions within 10 kilometre of the study area with closest record being 6.2 kilometre from the impact area. Habitat assessments of areas of potential Giant Burrowing Frog habitat found the majority of areas associated with non-clay based soils and lower order tributaries of the Nepean and Warragamba Rivers to be too degraded to support the species. Areas of highest potential habitat were considered to occur along the Warragamba River, immediately downstream of the dam, and these areas were subject to targeted survey. Targeted survey over two separate nights using call playback over a 500 m transect was undertaken for this species in areas identified as containing potential breeding and foraging habitat. No Giant Burrowing Frog individuals were detected during either survey. The species was not recorded during targeted survey and no areas of potential breeding habitat were found to occur within or adjacent to the impact area or impact assessment area. With the outlet point itself occurring on steep rocky ground above the Warragamba River, and therefore not suitable for the species.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				burrows or under vegetation in small pools. This species forages on invertebrates including arthropods (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					Based on the above, this species is considered absent from the study area and no further consideration is required under BAM, however further assessment in accordance with the EPBC Act is included in Section 9 of this report.
Hieraaetus morphnoides **Little Eagle**	-	V	Yes	Little Eagle is a medium-sized raptor that is either pale brown or dark brown with a pale underside. This species is distributed throughout the Australian mainland except for densely forested sections of the Great Dividing Range. Little Eagle occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. This species breeds in Spring in tall living trees within a remnant patch, where pairs build a large stick nest in winter (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.	High	Yes	Yes – surveys for stick nests and habitat assessment undertaken to detect suitable breeding trees.	Breeding – No Foraging - Negligible	This species has been previously recorded on 218 occasions within 10 kilometre of the study area with closest record being within the impact area. No potential breeding habitat in the form of stick nests or suitable breeding trees were recorded within the study area. Potential foraging habitat for this species occurs throughout the entire length of the study area in the form of patches of native PCTs and Urban Exotic/ Native communities which harbour prey species suitable for this species. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 of this report.
Hoplocephalus bungaroides	V	E	Yes	Broad-headed Snake is a venomous snake distinguished by a black upper body with	Low	Yes	Yes – habitat assessment	No	This species has been previously recorded on 1 occasion within 10 kilometre of the

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
Broad-headed Snake				yellow spots forming straight or zigzagged narrow cross-bands. This species looks superficially similar to the non-venomous juvenile diamond python. Broad-headed Snake is restricted to Triassic and Permian sandstone geology within the coast and ranges within a 250 kilometre radius of Sydney. This species shelters in rock crevices or under flat sandstone rocks around exposed cliff edges for the majority of the year and moves to sandstone crevices and hollows of large trees within 500 m of escarpments during the summer months. Broad-headed Snake forages on geckos and small skins and supplements this diet with frogs and small mammals. Breeding occurs from January to March during which, females will birth a clutch of 4-12 live young (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			undertaken to detect presence of suitable resting or breeding habitat. Targeted survey undertaken to detect presence of individuals in suitable habitat identified within the study area.		study area with closest record being 9.7 kilometre from the impact area. Potential habitat in the form of sandstone geology containing small cliffs with sandstone boulders and rocks was recorded within the study area in the vicinity of Warragamba Dam. Targeted survey for this species was undertaken in areas of potential habitat involving the overturning of sandstone rocks and inspection of sandstone crevices during September 2020. No individuals or traces of this species were detected. Based on the above, this species is considered absent from the study area and no further consideration is required under BAM, however further assessment in accordance with the EPBC Act is included in Section 9 of this report.
***Isoodon obesulus obesulus* Southern Brown Bandicoot (eastern)**	E	E	Yes	Southern Brown Bandicoots are a small marsupial approximately 30 cm long, weighing between 400-1600 grams with a thin tail with a pointed up to 12 cm long. This species has a short nose and ears, has a dark grey to yellowish brown upper body and a creamy white underbelly.	Negligible	No	Yes – habitat assessment undertaken to determine suitability of potential habitat	No	There are no previous records of this species within 10 kilometre of the study area, with the nearest records are 25-30 kilometres from the alignment. PCTs associated with this species occur between Wallacia and Warragamba in the

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				Southern Brown Bandicoot has a patchy distribution from the northern tip of Queensland, south-east NSW, southern coastal Victoria and the Grampian Ranges, south-east South Australia and south-west Western Australia. This species occurs in heath or open forest with a heathy understorey on sandy or friable soils. Southern Brown Bandicoot is mostly active between dusk and dawn where it forages on terrestrial invertebrates and the fruit of fungi. During daylight hours, the species will nest in a shallow depression (usually covered by shrubs, Blackberry or other understorey plants. in the ground covered by leaf litter and plant material but is also known to shelter in rabbit warrens. Male Southern Brown Bandicoot inhabit a home range of between 5-20 has whereas the female has a home range between 2-3 has. Mating occurs throughout the year, usually following periods of heavy rain, with two or three litters of 2-4 young produced annually (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.			within the impact area and impact assessment area.		form of patches of intact PCT 1181 and thinned PCT 1083. Habitat assessment undertaken in areas of potential habitat did not detect the presence of this species and no characteristic conical depressions made by this species (during foraging) were detected. Furthermore, PCTs 1181 and 1083 within the study area did not contain a heathy and dense understorey suitable for occupancy of this species. Based on the above, this species is considered absent from the study area and no further consideration is required.
Lathamus discolor	CE	E	Yes	Swift Parrot is a small bright green parrot	Medium	No	No	Breeding –	The impact area and impact assessment

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
Swift Parrot				with red around the bill, throat and forehead. Swift Parrot migrates to the Australian south-east mainland between February and October. On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Forest Red Gum *E. tereticornis*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens*. This species breeds in Tasmania between September to January and returns to the mainland during the winter months (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.				No Foraging – Low level impacts	area are not located within an area mapped by DPIE as important habitat for this species. However this species is considered as potentially significantly impacted by the project as part of the Controlled Action determination. This species has been previously recorded on 124 occasions within 10 kilometre of the study area with closest record being within the study area. Moderate quality foraging habitat for this species occurs within intact and thinned condition PCTs 725, 883, 724, 835, 849, 1800, 1083, 1105 and 1181 from Lansdowne to Warragamba. Impacts to this species are considered further in Sections 9 and 11, and Appendix 7 of this report.
***Limicola falcinellus* Broad-billed Sandpiper**	-	V	Yes	Broad-billed Sandpiper is a small, stint like sandpiper with a distinctive heavy bill with pale-grey-brown plumage with black streaks and white underparts. This species is migratory, breeding in northern Siberia and returning to Australia during Winter where it predominantly inhabits the Hunter River estuary. Broad-billed Sandpiper occupies sheltered coastal areas in estuarine sandflats and mudflats, harbours, embayments,	Negligible	No	No	No	There are no previous records of this species within 10 kilometre of the study area. The impact area and impact assessment area are not located in a migratory shorebird important habitat area for this species. No wetlands that would be considered of National or International Importance in accordance with EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				lagoons, saltmarshes and reefs. This species roosts on banks of sand, shell or shingle beaches and forages on invertebrates, crustaceans, molluscs, worms and seeds (DPIE 2020b). This species is relevant to the Cumberland IBRA subregion.					Act listed migratory shorebird species (CoA 2017) occur within the vicinity of the impact area or impact assessment area. Map-based preliminary assessment of the study area determined potential foraging habitat for this species occurs within patches of thinned PCT 781. Subsequent survey and assessment of potential foraging habitat within the study area determined that they were of low quality due to degradation, modification and nutrient enrichment. Specifically, patches of PCT 781 within the impact area were either modified (concrete lined) or in the case of the patch at Wallacia, choked with Salvinia Salvinia molesta, and were unlikely to contain large quantities of suitable foraging resources for this species.
***Limosa limosa* Black-tailed Godwit**	-	V	Yes	Black-tailed Godwit is a large sandpiper with a long straight pink bill with a black tip, dark flight feathers, a white wing bar and white underwing coverts, white rump, black tail and long greenish-black legs. This species is migratory, breeding in Mongolia and Eastern Siberia and returning to Australia during Summer where it predominantly inhabits sheltered bays, estuaries and lagoons with intertidal mudflats or sandflats or swamps, muddy lakes and sewerage treatment works.	Negligible	No	No	No	This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 3.3 kilometre from the impact area. The impact area and impact assessment area are not located in a migratory shorebird important habitat area for this species. No wetlands that would be considered of National or International Importance in accordance with EPBC Act Policy Statement 3.21 Industry guidelines for avoiding,

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				This species roosts on low banks of mud, sand and shell bars and forages on invertebrates, crustaceans, molluscs, fish and frog eggs, worms and seeds (DPIE 2020b). This species is relevant to the Cumberland IBRA subregion.					assessing and mitigating impacts on EPBC Act listed migratory shorebird species (CoA 2017) occur within the vicinity of the impact area or impact assessment area. Map-based preliminary assessment of the study area determined potential foraging habitat for this species occurs within patches of thinned PCT 781. Subsequent survey and assessment of potential foraging habitat within the study area determined that they were of low quality due to degradation, modification and nutrient enrichment. Specifically, patches of PCT 781 within the impact area were either modified (concrete lined) or in the case of the patch at Wallacia, choked with Salvinia Salvinia molesta, and were unlikely to contain large quantities of suitable foraging resources for this species.
Litoria aurea **Green and Golden Bell Frog**	V	E	Yes	Green and Golden Bell Frog is a large green frog with a gold or creamy stripe running along the side from the upper eyelids to the groin and a brown strip from the nostril to the eye. This species occurs in 50 known populations within NSW, the majority of which are small coastal or near coastal populations. Green and Golden Bell Frog predominantly inhabits marshes, dams and streamsides containing *Typha* and *Eleocharis*	Medium	Yes	No – presence determined by species expert report.	No	This species has been previously recorded on 157 occasions within 10 kilometre of the study area with closest record being within 150 m of the impact area. Map-based preliminary assessment of the study area determined potential habitat for this species occurs between Lansdowne and Wallacia within patches of intact and thinned PCTs 724, 725, 781, 835, 849, 1800 and 1105 within 200 metres of waterways and

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				spp. and is known to inhabit disturbed sites around Sydney. This species prefers habitats which are open to sunlight, free of predatory fish and close to grassy areas. Green and Golden Bell Frog breeds in Summer and is diurnal. Tadpoles forage on algae whereas adults forage on invertebrates and other frogs (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					waterbodies. The presence of this species within or adjacent to the study area has been determined as unlikely by species expert report (Lemckert 2021). Based on the above, this species is considered absent from the study area and no further consideration is required under BAM, however further assessment in accordance with the EPBC Act is included in Section 9 of this report.
Litoria booroolongensis **Booroolong Frog**	E	E	Yes	Booroolong Frog is a medium sized tree frog growing up to 5 cm. Booroolong Frog has a grey, olive or brown body with indistinct black markings and a white body. The skin of this species has a slightly warty appearance and their toes are strongly webbed with both fingers and toes displaying well-developed discs. Booroolong Frog has a distribution spanning throughout NSW to north-east Victoria, predominantly occurring along west-flowing streams along the Great Dividing Range. Booroolong Frog inhabits permanent streams with fringing vegetation such as ferns, sedges or grasses with adults preferring cobble banks and rock structures	Negligible	No	No – habitat assessment determined that suitable habitat was not present.	No	The species is considered a potential candidate due to the portion of the impact area that occurs within the Wollemi IBRA subregion only, however the nearest record, being a historical record from 1908, is located east of Katoomba, over 30kilometres from the project alignment. The species has therefore not been recorded within the vicinity of the impact area for over 100 years, with its relevant area of occurrence centred on the eastern side of the Blue Mountains. Map-based preliminary assessment of the study area determined potential habitat for this species occurs along Warragamba River adjacent to a patch of thinned PCT 1083. However habitats were found to be

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				along stream margins. Booroolong Frogs will shelter under rocks or amid vegetation on the edges of streams and in Summer, will sometimes bask in the sun on exposed rocks near flowing water. Booroolong Frog breeds in Spring and Summer during which they lay their eggs in submerged rock crevices. Tadpoles shelter in slow-moving connected or isolated pools and metamorphose in late Summer to early Autumn (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.					unsuitable along the Warragamba River in the vicinity of the impact area, due to historic disturbances and apparent evidence of chlorination (white powdery remnants of previous chlorinated releases on riverside boulders) and therefore highly unsuitable to provide habitat for this species. Based on the above, this species is considered absent from the study area and no further consideration is required.
Litoria littlejohni **Littlejohn's Tree Frog**	V	V	Yes	Littlejohn's Tree Frog is a pale brown frog with dark speckles and a broad stripe down its back. Other characteristic markings include a white or cream underbelly, large orange patches on the groin, armpit and backs of thighs and a brown bar from the tip of its snout to the top of its arm. Littlejohn's Tree Frog is distributed along the plateaus and eastern slopes of the Great Dividing Range from the Watagan State Forest in NSW southwards to Buchan in Victoria. The majority of records of this species tend to be at high altitudes. Littlejohn's Tree Frog inhabits the upper	Negligible	No	No – habitat assessment determined that suitable habitat was not present.	No	The species is considered a potential candidate due to the portion of the impact area that occurs within the Wollemi IBRA subregion only, with the nearest record of the species over 15 kilometres from the impact areas within intact vegetation forming part of the Blue Mountains National Park. Map-based preliminary assessment of the study area determined potential habitat for this species occurs along Warragamba River adjacent to a patch of thinned PCT 1083. Subsequent field assessment determined that the species' breeding habitat, upper reaches of permanent streams and in

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				reaches of permanent streams and in perched swamps. Non-breeding habitat consists of heathy forests and woodlands where it spends its time sheltering under leaf litter and understorey vegetation where it forages on invertebrates. Breeding habitat consists of still or slow flowing pools that receive extended exposure to sunlight. Breeding can occur throughout the year although usually from late Summer to early Spring and is triggered by heavy rain. During the breeding period, eggs are laid in loose gelatinous masses on small submerged twigs (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.					perched swamps (BioNet 2020), was not found to be present within the impact area in this location. The minor watercourses that feed the Warragamba River were found to be heavily modified and degraded. Furthermore, apparent evidence of chlorination (white powdery remnants of previous chlorinated releases on riverside boulders) was recorded in this area and therefore highly unsuitable to provide habitat for this species. Based on the above, this species is considered absent from the study area and no further consideration is required.
Lophoictinia isura **Square-tailed Kite**	-	V	Yes	Square-tailed Kite is a medium sized raptor with reddish plumage, white face with thick black streaks on the crown, blackish saddle, rump and central upper tail coverts with grey-brown barring. Square-tailed Kite is distributed along coastal and subcoastal areas from south-western to northern Australia and in NSW, has a scattered distribution throughout the state. Square-tailed Kite is found in a variety of timbered habitats including dry woodlands and open forests. This species shows a particular	High	Yes	Yes – surveys for stick nests and habitat assessment undertaken to detect suitable breeding trees.	Breeding – No Foraging - Negligible	This species has been previously recorded on 67 occasions within 10 kilometre of the study area with closest record being within the impact area. Two Square Kite individuals were identified foraging above the impact assessment area along Park Road at Wallacia. No potential breeding habitat in the form of stick nests or suitable breeding trees were recorded within the study area. Potential medium to high quality foraging

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				preference for timbered watercourses and forages on passerines and invertebrates. Breeding is from July to February, with nest sites generally located along or near watercourses, in a fork or on large horizontal limbs (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					habitat for this species occurs throughout the entire length of the study area in the form of patches of native PCTs 724, 725, 781, 835, 849, 883, 1800, 1083, 1105 and 1181 and Urban Exotic/ Native communities which harbour prey species suitable for this species. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 of this report.
***Meridolum corneovirens* Cumberland Plain Land Snail**	-	E	Yes	Cumberland Plain Land Snail is a native snail, superficially similar in size and shape to the Garden Snail *Helix aspera* but with a shell 25-30 mm in diameter. This species has a grey body with a slightly flattened shell that is a uniform light to dark brown in colour. Juvenile individuals will have a shell with an open umbilicus whereas adults will have a partial to wholly covered umbilicus. Cumberland Plain Land Snail is restricted to the Cumberland Plain in western Sydney between Richmond to Windsor, south to Picton and from Liverpool westward to the Hawkesbury and Nepean Rivers to the base of the Blue Mountains. This species	High	Yes	No – presence to be determined by species expert report.	Yes	This species has been previously recorded on 1427 occasions within 10 kilometre of the study area with closest record being within the impact area. Four Cumberland Plain Land Snail shells were detected in bushland located on the interface of Cross Street at Kemps Creek. Potential medium to high quality habitat for this species occurs throughout the entire length of the study area in the form of patches of native PCTs 724, 725, 835, 849 and 888. Targeted survey for Cumberland Plain Land Snail has not been undertaken as a species expert report has been prepared for this

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				predominantly occurs in PCTs 724, 725, 849 and the margins of PCTs 835 and 883 where it shelters under the litter of bark, leaves and logs or in loose soil in inter-tussock spaces of grasses and is also known to shelter under rubbish. Cumberland Plain Land Snail is known to dig several centimetres under the ground to aestivate in times of drought. This species forages on fungus and is active at night. Cumberland Plain Land Snail is believed to be hermaphroditic, breeding throughout the year when suitable conditions arise, laying clutch of 20-25 eggs in moist, dark areas (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					species.
Miniopterus australis **Little Bent-winged Bat**	-	V	Yes	Little Bent-winged Bat is a dark chocolate brown bat with a distinctive bent aspect to the wing formed from the long joint of the third finger. This species is distributed along the east coast from Cape York in Queensland to Wollongong in NSW. Eastern Coastal Free-tailed Bat inhabits wet, dry and moist sclerophyll forest, Melaleuca swamps, coastal forests and Banksia scrub. This species is insectivorous	Medium	Yes	Yes – targeted survey using acoustic devices (passive survey) has been undertaken near	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) –	This species has been previously recorded on 25 occasions within 10 kilometre of the study area with closest record being within the impact area. Potential roosting habitat for this species occurs at the western end of the study area in the vicinity of Warragamba Dam. Land within the impact area contains rocky overhangs and small caves as well as a disused tunnel and large shaft which may

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				and roosts caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and buildings. Little Bent-winged Bat breeds in Spring where they form large maternity colonies centred on five known nursery sites in Australia (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			Warragamba Dam in Oct 2020 and Dec 2020 to Jan 2021.	Potential Foraging habitat – Low level impacts	form potential roosting habitat for this species. Adjacent land across the Warragamba River in the Blue Mountains National Park contains an extensive cliff line with multiple caves and overhangs forming roosting habitat for this species. This area is within 100 m of the impact area and therefore project impacts are considered to indirectly impact upon potential breeding habitat for the species. Further potential roosting habitat for this species occurs at the proposed AWRC site at Kemps Creek formed from disused farm buildings in addition to numerous hollow-bearing trees which occur sporadically along the impact area from Lansdowne to Warragamba. These areas are not suitable for breeding. Potential foraging habitat occurs throughout the study area formed from native PCT's and Exotic/Native vegetation. Impacts to Little Bent-winged Bat foraging habitat is considered further in Sections 8 and 11 and Appendix 6 of this report.
Miniopterus orianae oceanensis **Large Bent-winged Bat**	-	V	Yes	Eastern Bent-winged Bat population distribution spans the east and north-west coasts of Australia. This species hunts in vegetated/forested areas, preying on invertebrates above the canopy. Caves are the primary roosting and breeding habitat for	High	Yes	Yes – targeted survey using acoustic devices (passive	Breeding habitat (direct impacts) – Potential	This species has been previously recorded on 234 occasions within 10 kilometre of the study area with closest record being within the impact area. Potential roosting and breeding habitat for

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				this species; however, it is also known to roost in derelict mines, storm-water tunnels, culverts and man-made structures. Populations are usually centred on a maternity cave which is used during the breeding season between spring and summer. Outside of breeding season, this species usually disperses within 300 kilometre of maternity caves (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			survey) has been undertaken near Warragamba Dam in Oct 2020 and Dec 2020 to Jan 2021.	Breeding habitat (indirect impacts) – Potential Foraging habitat – Low level impacts	this species occurs at the western end of the study area in the vicinity of Warragamba Dam. Land within the impact area contains rocky overhangs and small caves as well as a disused tunnel and large shaft which may form potential roosting and breeding habitat for this species. Adjacent land across the Warragamba River in the Blue Mountains National Park contains an extensive cliff line with multiple caves and overhangs forming breeding and roosting habitat for this species. This area is within 100 m of the impact area and therefore project impacts are considered to indirectly impact upon potential breeding habitat for the species. Additional potential roosting habitat occurs at the proposed AWRC site at Kemps Creek formed from disused farm buildings. Potential foraging habitat occurs throughout the study area formed from native PCT's and Exotic/Native vegetation. Impacts to Large Bent-winged Bat foraging habitat is considered further in Sections 8 and 11 and Appendix 6 of this report.
Mixophyes balbus **Stuttering Frog**	V	E	Yes	Stuttering Frog is a large, muscular frog (up to 8 cm long) characterised by large black eyes with vertical pupils, webbed feet, barred hind legs and a black line stretching from the snout to the ear. Stuttering Frog has an olive-	Negligible	No	No – habitat assessment determined that suitable habitat was	No	The species is considered a potential candidate due to the portion of the impact area that occurs within the Wollemi IBRA subregion only, with the nearest record of the species, since the 1970s being between

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				green body with a creamy white underbelly and adults will exhibit a pale blue crescent above the upper half of the eye. Stuttering Frog has a distribution the east coast of Australia from southern Queensland to north-east Victoria. In NSW, Stuttering Frog range has contracted with recent records concentrated at 3 sites south of Sydney. Stuttering Frog preferred habitat occurs in rainforest and wet sclerophyll forest in the foothills and escarpments on the eastern side of the Great Dividing Range. Non-breeding habitat consists of deep leaf litter and thick understorey vegetation on the forest floor. Breeding habitat consists of small, flowing streams. Breeding occurs in Summer and is stimulated by heavy rains. Stuttering Frog will lay their eggs on rock shelves and shallow riffles from which the tadpoles will move to deep permanent pools as they grow before metamorphosing by 12 months (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.			not present.		45 kilometres and 75 kilometres away from the project alignment. The species is associated in BioNet with PCT 1105, however BioNet also notes the species' habitat as rainforest and wet sclerophyll forest, which is not present in the impact area or impact assessment area. The species' habitat is considered not to occur within the impact area or impact assessment area. Based on the above, this species is considered absent from the study area and no further consideration is required.
Mixophyes iteratus **Giant Barred Frog**	E	E	Yes	Giant Barred Frog is a very large, powerfully built frog (up to 11.5 cm long) characterised by eyes with a golden iris, blotched light and dark brown upperparts, limbs with crossbars	Negligible	No	No – habitat assessment determined that suitable	No	The species is considered a potential candidate due to the portion of the impact area that occurs within the Wollemi IBRA subregion only, with the nearest record of

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				and black hind sides of the thighs with yellow spots. Giant Barred Frog has a distribution spanning from Eumundi in south-east Queensland to Warimoo in the Blue Mountains, NSW. Giant Barred Frog preferred habitat is along freshwater streams with permanent or semi-permanent water at lower elevations and containing rainforest or wet sclerophyll forest. This species will also occur in less ideal habitats such as drier forests, degraded riparian remnants and dams. Breeding habitat occurs within streams where individuals will lay eggs from late Spring to Summer whereupon the female will kick them out of the water onto a nearby bank. The life cycle from hatching to maturity can take up to 14 months to complete. Giant Barred Frog forages on invertebrates, molluscs, arthropods and other frogs (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.			habitat was not present.		the species, since the 1970s being over 50 kilometres to the north-east of the project alignment. Furthermore, BioNet notes that declines appear to have occurred at the margins of the species' range, with no recent records south of the Hawkesbury River. The species is associated in BioNet with PCT 1105, however this PCT within the impact area occurs in a degraded condition state, impacted by weeds and physical disturbances, and is not considered to support potential habitat for the species. Based on the above, this species is considered absent from the study area and no further consideration is required.
Myotis macropus **Southern Myotis**	-	V	Yes	Southern Myotis is a dark grey to reddish brown bat with disproportionately large feet. This species is distributed along a coastal band from the north-west of	High	Yes	Yes – targeted survey using acoustic	Yes – Assumed present in areas	This species has been previously recorded on 503 occasions within 10 kilometre of the study area with closest record being within the impact area.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				Australia, across the top end and south to western Victoria and is rarely found inland. Southern Myotis is known to roost in groups of 10 to 15 within close proximity to water in caves, mine shafts, houses, hollow-bearing trees, stormwater channels, bridges. The species has a unique foraging strategy to other microbat species as it forages on aquatic macroinvertebrates and larval fish (Campbell 2009). The species has been classes as a species credit species because it is highly dependent on waterbodies for foraging, roosting and breeding (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			devices (passive survey) has been undertaken near Warragamba Dam in Oct 2020 and Dec 2020 to Jan 2021.	where survey was not undertaken	Potential foraging habitat occurs throughout the study area formed from native PCT's and Exotic/Native vegetation, and waterbodies. Due to the common presence of Southern Myotis records and the common occurrence of potential forage habitat thought and within 200m of the impact area and impact assessment area, the species has been assumed to be present. Impacts to Southern Myotis habitat is considered further in Sections 8 and 11 of this report.
Ninox connivens **Barking Owl**	-	V	Yes	Barking Owl is a medium sized owl (to 42 cm) and is characterised by large yellow eyes, brown or greyish brown upperparts and a white breast vertically streaked with brown. This species is found throughout Australia except for the central arid regions and has a wide but sparsely distributed population in NSW, predominantly on the western slopes and plains as well as the northeast coastal and escarpment forests. Barking Owl preferred habitat ranges from woodland to open sclerophyll forest including	Medium	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken within impact area and impact assessment area.	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) – Potential	This species has been previously recorded on 20 occasions within 10 kilometre of the study area with closest record being 985 m from the impact area. Potential moderate to high quality foraging habitat for this species occurs as patches of PCT's 724, 725, 835, 849, 883, 1083, 1181 and 1800 within the study area from Lansdowne to Warragamba. No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>20 cm diameter) that occur within

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				fragmented remnants and partially cleared farmland. Barking Owl breeding habitat is defined as patches of vegetation (including riparian forests) which contains large living or dead trees (80-240 DBH) with hollows greater than 20cm diameter and more than 4 m above ground. Breeding trees are usually situated in an area containing dense mid-storey vegetation. Breeding occurs during mid-Winter to Spring wherein three eggs are laid in a clutch. Favoured prey species are arboreal mammals; however, Barking Owl is known to supplement their diet with avifauna, flying mammals and terrestrial mammals (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.				Foraging habitat – Low level impacts	patches of vegetation or topographic situations suitable for the species to utilise as breeding habitat was detected within the impact area during field surveys which were undertaken for this species between April and May 2020 and August and October 2020. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11.
Ninox strenua **Powerful Owl**	-	V	Yes	Powerful Owl is the largest owl in Australia and is characterised by dark greyish-brown with whitish underparts and feathers with dark grey-brown V markings. This species is endemic to eastern and south-eastern Australia; east of the Great Dividing Range from Mackay to south-western Victoria. Powerful Owl preferred habitat ranges from woodland, open sclerophyll forest, wet sclerophyll forest and rainforest. Powerful	High	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken within impact area and impact assessment	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) –	This species has been previously recorded on 91 occasions within 10 kilometre of the study area with closest record being 1 kilometre from the impact area. Potential moderate to high quality foraging habitat for this species occurs as patches of PCT's 724, 725, 835, 849, 1083, 1105 and 1181 within the study area from Lansdowne to Warragamba.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				Owl breeding habitat is defined as patches of vegetation which contains large living or dead trees (80-240 DBH) with hollow greater than 20cm diameter and 50 cm depth. Breeding trees are usually situated in an area containing dense mid-storey vegetation. Favoured prey species are arboreal mammals; however, Powerful Owl is known to supplement their diet with avifauna, flying mammals and terrestrial mammals (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			area.	Potential Foraging habitat – Low level impacts	No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>20 cm diameter) that occur within patches of vegetation or topographic situations suitable for the species to utilise as breeding habitat was detected within the impact area during field surveys which were undertaken for this species between April and May 2020 and August and October 2020. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11.
Pandion cristatus **Eastern Osprey**	-	V	Yes	Eastern Osprey is a large water dependant raptor with dark brown plumage above, white underparts and distinctly bowed wings when in flight. This species has a global distribution and in Australia, ranges along the coastline with the exception of Victoria and Tasmania. This species is uncommon around closely settled sections of south-east Australia. Eastern Osprey preferred habitat consist of the mouths of large rivers, lagoons and lakes where it forages for fish over clear, open water. This species breeds from July to September, building stick nests high up in dead crowns of live trees within 1 kilometre	Medium	Yes	Yes – surveys for stick nests and habitat assessment undertaken to detect suitable breeding trees.	Breeding – No Foraging - Negligible	This species has been previously recorded on 8 occasions within 10 kilometre of the study area with closest record being 986 m from the impact area. No potential breeding habitat in the form of stick nests or suitable breeding trees were recorded within the study area. Potential medium to high quality foraging habitat for this species occurs throughout the entire length of the study area in the form of patches of native PCTs 724, 781, 835, 1105 and 1800 which line the waterways containing habitat suitable for the prey of

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				of the sea where it lays a clutch of 2-3 eggs (DPIE 2020b). This species is relevant to the Cumberland IBRA subregion.					this species. Impacts to the foraging habitat of this species are considered further in Section 11 of this report.
Petaurus norfolcensis **Squirrel Glider**	-	V	No	Squirrel Glider populations are sparse and widely distributed throughout eastern Australia, spanning from northern Queensland to western Victoria. Squirrel Glider preferred habitat is found in mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range where the impact area is located. Squirrel Glider prefers mixed stands with a shrub or Acacia understorey containing abundant tree hollows for refuge and breeding. Forages on Eucalypt sap, Acacia gum, nectar, honeydew and manna with supplemented with invertebrates and pollen (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.	Negligible	No	No	No	This species has been previously recorded on 1 occasion within 10 kilometre of the study area with closest record being 8.1 kilometre from the impact area. Very few records of Squirrel Gliders occur within the central portion of the Cumberland IBRA subregion, through which the project alignment occurs. The species occurs around the fringes of the subregion in association with areas of intact vegetation and/or areas connected to those larger tracts of vegetation. BioNet notes habitat requires for the species as comprising Blackbutt-Bloodwood with heathy understorey, east of the diving range, that the species prefers mixed stands with a shrub or Acacia midstorey, and as requiring abundant tree hollows for refuge and nest sites. These habitat types are highly limited in the context of the impact area and impact assessment area. patches of habitat are generally small, fragmented, degraded, edge-effected and comprise re-growth with few hollows.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
									Whilst PCTs 1083 and 1181 within the impact area broadly support Blackbutt-Bloodwood canopy and Acacias in the midstorey, hollows are limited in both locations, and species records in areas of connected habitats are highly limited. Three records occur within the Burragorang State Forest Conservation Area (1996, 27 kilometres to the south-west), and Blue Mountains National Park (1997, 21 kilometres to the west), with a further two records from 1994 and 2009 in the Llandilo area with no habitat connectivity to the project alignment. At the eastern end of the alignment two records occur from 2006 and 2010 within the Holsworthy military area. However, these records are considered to have highly limited connectivity to the impact area due to the habitat comprising 15 kilometres of Georges River and Prospect Creek riparian zones, that often occur as thin and degraded strips through Moorebank, Warwick Farm, and around Chipping Norton Lake. It is highly unlikely that animals in Holsworthy would ever occur in the vicinity of the project alignment. Based on the above, this species is considered absent from the study area and

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
									no further consideration is required.
Petrogale penicillata **Brush-tailed Rock-wallaby**	V	E	No	Brush-tailed Rock-wallaby is a medium sized agile marsupial with a long, bushy, dark rufous brown tail and thick brown body fur with grey shoulders and a pale chest and belly. Brush-tailed Rock-wallaby has a distribution which spans from south-east Queensland to the Grampians in west Victoria. In NSW, the population bounds are he Queensland border in the north, Shoalhaven in the south and the Warrumbungles in the west. This species occurs on rocky outcrops, escarpments, cliffs and prefers landscapes with a complex structure of fissures, caves and ledges which face north. This species shelters or basks (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.	Low	Yes	Yes – Active searches of potential habitat were undertaken within the areas adjacent to Warragamba River, and remote cameras were deployed in Dec 2020 to Jan 2021	No	This species has been previously recorded on 3 occasions within 10 kilometre of the study area with closest record being 560 m from the study area. Potential habitat for this species occurs in the vicinity of the Warragamba River where steep rocky areas occur, that support large boulders and crevices within patches of intact PCT 1181 and thinned PCT 1083. Targeted survey for the species was undertaken using baited remote sensing cameras within areas of potential habitat between December 2010 and January 2021. The species was not recorded. Based on the above, this species is considered absent from the study area and no further consideration is required under BAM, however further assessment in accordance with the EPBC Act is included in Section 9 of this report.
Phascogale tapoatafa **Brush-tailed Phascogale**	-	V	No	Brush-tailed Phascogale is an arboreal marsupial with grey fur above, a pale cream underbelly and a large black, bushy, bottlebrush like tail. Brush-tailed Phascogale has naked ears, a body length of up to 20 cm and an equivalent tail length.	Negligible	No	No	No	There are no previous records of this species within 10 kilometre of the study area, with the species not having been recorded within the Cumberland IBRA subregion since pre-1900, and only within the Wollemi IBRA subregion once in 1982, and over 45

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				Brush-tailed Phascogale has a patchy distribution throughout coastal Australia; however, in NSW it predominantly occurs to the east of the Great Dividing Range and only occasional occurrences further inland, This species preferred habitat is dry sclerophyll forest with a sparse groundcover of herbs, grasses, shrubs or leaf litter but it will also inhabit swamps, rainforest or wet sclerophyll forest. Brush-tailed Phascogale feeds on arthropods but will occasionally eat other invertebrates and supplement its diet with small vertebrates or nectar. Brush-tailed Phascogale is a short-lived species (up to 3 years) and breeds exclusively in tree hollows with entrances between 2.5-4 cm wide and mate during May-July, usually only producing one litter (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.					kilometres north of the impact area. PCTs associated with the species occur as intact condition PCT 1181 adjacent to Bents Basin Road at Wallacia, and thinned condition PCT 1083 adjacent to the Warragamba Dam. Neither impacted patch of vegetation contain hollow-bearing trees, with the area of PCT 1083 consisting of secondary regrowth subsequent to historical clearing. The species is considered highly unlikely to occur within the impact area or impact assessment area, and as such is not considered a candidate species credit species. Based on the above, this species is considered absent from the study area and no further consideration is required.
Phascolarctos cinereus **Koala**	V	V	Yes	Koala is an arboreal marsupial with grey to brown fur with white underparts. Koala has a fragmented distribution throughout eastern Australia and in NSW, Koala populations occur on the central and north coasts, southern highlands, southern and northern tablelands, the Blue Mountains, southern coastal forests and on plains west	Medium	Yes	Yes – Koala SAT surveys were undertaken within the western and central portions of	No	This species has been previously recorded on 202 occasions within 10 kilometre of the study area with closest record being less than 1 kilometre from the study area. Potential foraging habitat for this species occurs throughout the study area from Lansdowne to Warragamba in the form of thinned and intact PCTs 724, 725, 835, 849,

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				of the Great Dividing Range. This species primarily Inhabits eucalypt woodlands and forests. Koala feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			the project alignment.		883, 1083, 1105, 1181 and 1800. Koala SAT surveys were undertaken in the areas of highest potential habitat with proximal and relatively recent records of the species. This included four locations at the western end of the project alignment, around Wallacia, and another five were undertaken within the Western Sydney Parklands. No scats or scratches that could be confirmed as Koala were detected during the surveys. Based on the above, this species is considered absent from the study area however the species is further address in Section 9 and 11 of this report.
Pommerhelix duralensis **Dural Land Snail**	E	E	No	Dural Land Snail is a medium sized snail with a dark brown to black semi-translucent subglobose to spherical shell (10-23 mm high and 14-23 mm wide), grey body and bright yellow mucosum. This species known distribution is on the western and northwest fringes of the Cumberland IBRA subregion on shale sandstone transitional landscape. However, recent discovery of an extensive population within City of Parramatta Council may	Medium	Yes	No – presence to be determined by species expert report.	Yes	This species has been previously recorded on 2 occasions within 10 kilometre of the study area with closest record being 4.4 kilometre from the study area. Potential habitat for this species within the study area occurs in patches of thinned PCT 1083 near Warragamba Dam and in intact PCT 1181 near Bents Basin Road. As it is difficult to detect this species outside of evenings after rain, a species expert report is to be prepared.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				indicate the species distribution is more widespread than previously known. Dural Land Snail occurs in dry and wet sclerophyll forest, usually in association with Turpentine and shelters amongst rocks, leaf litter, curled up bark and within the inter-tussock spaces of grasses. This species is predominantly nocturnal, foraging on fungus and occasionally centipedes and dispersing up to 1 m per evening (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					
Pseudophryne australis **Red-crowned Toadlet**	-	V	No	Red-crowned Toadlet is a small brown to black frog with reddish-orange patches between the eyes and on the rump, measuring less than 30 mm long. This species has a white marbled black and white belly and a short, squelchy call which can be heard year round. This species has a restricted distribution within the Sydney Basin from Pokolbin in the north, Nowra in the south and Mt Victoria in the west. Red-crowned Toadlet inhabits open forests on Hawkesbury or Narrabeen sandstone substrates where it occurs in periodically wet drainage lines below sandstone ridges. This species will shelter under rocks or thick leaf litter and will breed	Low	Yes	Yes	No	This species has been previously recorded on 34 occasions within 10 kilometre of the study area with closest record being 155 m from the study area. Habitat assessments of areas of potential Red-crowned Toadlet habitat found the majority of areas associated with non-clay based soils and lower order tributaries of the Nepean and Warragamba Rivers to be too degraded to support the species. Areas of highest potential habitat were considered to occur along the Warragamba River, immediately downstream of the dam, and these areas were subject to targeted survey. Targeted survey over two separate nights using call playback over a 500 m transect

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				in dense vegetation and debris beside ephemeral creeks and gullies. Red-crowned Toadlet will not breed in waters that are polluted (even mildly) or with a PH range outside of 5.5 to 6.5 (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					was undertaken for this species in areas identified as containing potential breeding and foraging habitat. No Red-crowned Toadlet individuals were detected during either survey. The species was not recorded during targeted survey and no areas of potential breeding habitat were found to occur within or adjacent to the impact area or impact assessment area. With the outlet point itself occurring on steep rocky ground above the Warragamba River, and therefore not suitable for the species. Based on the above, this species requires no further consideration.
Pteropus poliocephalus **Grey-headed Flying-fox**	V	V	Yes	Grey-headed Flying-fox are distributed throughout the eastern coast of Australia from Rockhampton in Queensland to Adelaide in South Australia, within 200 kilometre of the coast. Grey-headed Flying-fox preferred habitat ranges from subtropical and temperate rainforest, tall sclerophyll forests and woodlands, heaths and swamps in addition to cultivated gardens and orchards. Roost camps are generally located in gullies, near water in vegetation with a dense canopy and are within 20 kilometre of a sustainable foraging resource. Grey-headed	High	Yes	Yes	Breeding – No Foraging – Low level impacts	This species has been previously recorded on 1492 occasions within 10 kilometre of the study area with closest record being from withn the study area. Potential high and moderate quality foraging habitat occurs along the entire length of the study area from Lansdowne to Warragamba in all patches of PCT's. A Grey-headed Flying-fox camp containing up to 2,500 individuals has been recorded immediately adjacent to the study area at Blaxland's Crossing Reserve in Wallacia. The

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				Flying-fox generally travel up to 50 kilometre per evening to forage on the nectar, pollen and fruit of native trees such as *Eucalyptus, Melaleuca, Banksia* species (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.					camp is not a nationally important flying-fox camp and was observed to contain only males when investigated between May – June 2020. Due to the absence of breeding females, the camp is not considered 'species credit' habitat for the species. Based on the above, this species is considered absent from the study area and no further consideration is required under BAM, however further assessment in accordance with the EPBC Act is included in Section 9 of this report.
Tyto novaehollandiae **Masked Owl**	-	V	Yes	Masked Owl is a medium sized raptor with grey to dark brown upper, barred wings and tail, white to rufous-brown underparts, dark set eyes and a heart-shaped facial disc. This species is distributed from the coast to the western plains where it inhabits dry sclerophyll forests and woodlands from sea level to 1100 m in elevation. Masked Owl is known to occasionally utilise forest margins and roadsides. Pairs have a home range of between 500 to 1000 has and will roost and breed in moist gullies utilising large tree hollows or caves for nesting. This species forages for small arboreal and terrestrial mammals (DPIE 2020b). This species is relevant to the Cumberland	Medium	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken within impact area and impact assessment area.	Breeding habitat (direct impacts) – No Breeding habitat (indirect impacts) – Potential Foraging habitat – Low level impacts	This species has been previously recorded on 45 occasions within 10 kilometre of the study area with closest record being 1.9 kilometre from the study area. Potential moderate to high quality foraging habitat for this species occurs as patches of PCT's 724, 725, 835, 849, 883, 1083, 1105, 1181 and 1800 within the study area from Lansdowne to Warragamba. No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>20 cm diameter) that occur within patches of vegetation or topographic locations suitable for the species to utilise as breeding habitat was detected within the

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				and Wollemi IBRA subregions.					impact area during field surveys which were undertaken for this species between April and May 2020 and August and October 2020. Potential breeding habitat has been dismissed within the impact area adjacent to Warragamba Dam. The majority of the caves in this area consists of small shallow overhangs exposed to sunlight which are unsuitable for the species. Surveys undertaken during September and October 2020 did not detect the presence of this species, any juveniles or presence of nests or traces. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 of this report.
Tyto tenebricosa **Sooty Owl**	-	V	Yes	Sooty Owl is a medium sized owl up to 45 cm long, with a prominent heart shaped facial disc and dark eyes. Sooty Owl is dark grey with fine white spotting on its plumage and a pale underbelly. Sooty Owl has a distinctive call akin to a high pitched human scream. This species is distributed along the easternmost sections of NSW, predominantly	Medium	Yes	Yes – Habitat assessment and hollow-bearing tree survey undertaken within impact area and impact	Breeding habitat (direct impacts) – No Breeding habitat (indirect	This species has been previously recorded on 13 occasions within 10 kilometre of the study area with closest record being 1.1 kilometre from the study area. Potential foraging habitat for this species occurs in patches of thinned condition PCT 1105 and marginal foraging habitat within thinned PCT 1083 within the study area

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
				along the coast, escarpment and eastern tablelands. Sooty Owl preferred habitat occurs in rainforest (dry, subtropical and warm temperate rainforest) as well as wet sclerophyll forest. This species roosts diurnally in the hollow of a very large and tall forest tree or in dense vegetation and is predominantly nocturnal, foraging for small terrestrial and arboreal mammals (DPIE 2020b). This species is relevant to the Cumberland and Wollemi IBRA subregions.			assessment area.	impacts) – Potential Foraging habitat – Low level impacts	between Wallacia and Warragamba. No breeding habitat in the form of hollow-bearing trees containing suitably sized hollows (>20 cm diameter) that occur within patches of vegetation or topographic locations suitable for the species to utilise as breeding habitat was detected within the impact area during field surveys which were undertaken for this species between April and May 2020 and August and October 2020. Potential breeding habitat has been dismissed within the impact area adjacent to Warragamba Dam. The majority of the rocky overhangs in this area are shallow and exposed to sunlight which are unsuitable for the species. Surveys undertaken during September and October 2020 did not detect the presence of this species, any juveniles or presence of nests or traces. Potential breeding habitat on the western bank of the Warragamba River could not be excluded and as such potential indirect impacts are assessed in Section 11 and Appendix 6 of this report.
Vespadelus troughtoni	-	V	No	Eastern Cave Bat is a chestnut brown bat with a rufous brown head and dark wings. This	Low	Yes	Yes – targeted	No	There are no previous records of this species within 10 kilometre of the study area.

Species	Conservation status EPBC	BC	BAM Predicted SCS	Habitat description	Potential occurrence in impact area	BAM Candidate species	Survey required/ undertaken	Impacted by project	Candidate species rationale
Eastern Cave Bat				species is distributed along a broad band across both sides of the Great Dividing Range between Cape York to just east of the ACT. Eastern Cave Bat is a cave roosting bat with preferred habitat being dry open forest and woodlands usually near cliffs or rocky overhangs. This species will also utilise disused mines and can occasionally be found along cliff lines in moist gully vegetation. Very little is currently known regarding this species foraging or breeding behaviours (DPIE 2020b). This species is relevant to the Wollemi IBRA subregion.			survey using acoustic devices (passive survey) has been undertaken near Warragamba Dam in Oct 2020 and Dec 2020 to Jan 2021.		Potential habitat for this species occurs within the western end of the study area in the vicinity of Warragamba Dam. Land within the impact area contains rocky overhangs and small caves as well as a disused tunnel and large shaft which may form potential roosting and breeding habitat for this species. Adjacent land across the Warragamba River in the Blue Mountains National Park contains an extensive cliff line with multiple caves and overhangs forming breeding and roosting habitat for this species. The species was not recorded during targeted survey and is therefore not addressed further in this report.

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Native species																															
Acanthaceae	Brunoniella australis	Blue Trumpet							0.1	10	1	50			0.5	40	1	100	0.5	20			0.1	1	0.1	6						
Acanthaceae	Pseuderanthemum variabile	Pastel Flower													0.1	10																
Adiantaceae	Cheilanthes sieberi	Rock Fern																	2	80	0.5	30									0.1	8
Adiantaceae	Cheilanthes sieberi subsp. sieberi	Rock Fern									0.1	2																				
Amaranthaceae	Alternanthera denticulata	Lesser Joyweed																														
Amaranthaceae	Alternanthera nana	Hairy Joyweed					0.1	9	0.1	2			0.1	1							0.1	1					0.1	1				
Amaranthaceae	Dysphania pumilio	Small Crumbweed																													0.1	1
Anthericaceae	Arthropodium milleflorum	Pale Vanilla-lily																			0.1	2										
Anthericaceae	Caesia parviflora	Pale Grass-lily																														
Anthericaceae	Laxmannia gracilis	Slender Wire Lily																	0.1	2											0.1	2
Anthericaceae	Tricoryne elatior	Yellow Autumn-lily					0.1	1																								
Apiaceae	Centella asiatica	Indian Pennywort							0.5	40							0.2	50					0.1	10								
Apiaceae	Hydrocotyle sibthorpioides																				0.1	3										
Apiaceae	Hydrocotyle tripartita	Pennywort											0.1	10																		
Asphodelaceae	Bulbine bulbosa	Bulbine Lily													0.1	1																
Asteraceae	Brachyscome graminea																															
Asteraceae	Calotis lappulacea	Yellow Burr-daisy			0.1	1																										
Asteraceae	Cotula australis	Common Cotula					0.1	10													0.1	6	1	100	0.1	20	0.2	50	0.1	8		
Asteraceae	Euchiton japonicus																															
Asteraceae	Euchiton sphaericus	Star Cudweed																			0.1	10										
Asteraceae	Lagenifera stipitata	Blue Bottle-daisy																													0.3	50
Asteraceae	Ozothamnus diosmifolius	White Dogwood									0.3	2									0.3	2									0.2	9
Asteraceae	Sigesbeckia orientalis subsp. orientalis	Indian Weed																							3	200	0.2	20			0.1	10
Asteraceae	Vernonia cinerea																															
Asteraceae	Vittadinia cuneata	A Fuzzweed							0.1	2																						
Bignoniaceae	Pandorea pandorana	Wonga Wonga Vine									0.6	2																				

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Native species																																
Acanthaceae	Brunoniella australis	Blue Trumpet													0.2	7	0.3	6					0.1	3	0.2	10						
Acanthaceae	Pseuderanthemum variabile	Pastel Flower																														
Adiantaceae	Cheilanthes sieberi	Rock Fern			10	###													0.8	100			0.4	30								
Adiantaceae	Cheilanthes sieberi subsp. sieberi	Rock Fern																											0.1	2		
Amaranthaceae	Alternanthera denticulata	Lesser Joyweed																							0.1	1						
Amaranthaceae	Alternanthera nana	Hairy Joyweed																											0.2	10		
Amaranthaceae	Dysphania pumilio	Small Crumbweed					0.1	2																	0.3	20						
Anthericaceae	Arthropodium milleflorum	Pale Vanilla-lily			0.3	10																										
Anthericaceae	Caesia parviflora	Pale Grass-lily																	0.1	8												
Anthericaceae	Laxmannia gracilis	Slender Wire Lily					0.1	1											0.2	40												
Anthericaceae	Tricoryne elatior	Yellow Autumn-lily																														
Apiaceae	Centella asiatica	Indian Pennywort																			0.5	100					0.5	50				
Apiaceae	Hydrocotyle sibthorpioides																															
Apiaceae	Hydrocotyle tripartita	Pennywort																														
Asphodelaceae	Bulbine bulbosa	Bulbine Lily																														
Asteraceae	Brachyscome graminea																						0.3	20								
Asteraceae	Calotis lappulacea	Yellow Burr-daisy																														
Asteraceae	Cotula australis	Common Cotula					0.1	5							0.1	10									1	200	0.1	70			0.2	50
Asteraceae	Euchiton japonicus																												0.1	10		
Asteraceae	Euchiton sphaericus	Star Cudweed																														
Asteraceae	Lagenifera stipitata	Blue Bottle-daisy																														
Asteraceae	Ozothamnus diosmifolius	White Dogwood			0.5	4																	0.2	2								
Asteraceae	Sigesbeckia orientalis subsp. orientalis	Indian Weed																														
Asteraceae	Vernonia cinerea																						0.2	40								
Asteraceae	Vittadinia cuneata	A Fuzzweed																														
Bignoniaceae	Pandorea pandorana	Wonga Wonga Vine	2	40																												

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Blechnaceae	Blechnum ambiguum		0.1	2																											
Campanulaceae	Wahlenbergia communis	Tufted Bluebell																													
Campanulaceae	Wahlenbergia gracilis	Sprawling Bluebell					0.1	1													0.1	20	0.1	10			0.1	10			0.1	10
Campanulaceae	Wahlenbergia stricta	Tall Bluebell																													
Casuarinaceae	Allocasuarina littoralis	Black She-Oak	1	2															25	30	3	4									
Casuarinaceae	Casuarina cunninghamiana subsp. cunninghamiana	River Oak											3	1																	
Casuarinaceae	Casuarina glauca	Swamp Oak																							75	50					
Chenopodiaceae	Atriplex semibaccata	Creeping Saltbush																											0.1	1		
Chenopodiaceae	Einadia hastata	Berry Saltbush							0.2	2											2	20	0.6	10			0.1	1			0.1	1
Chenopodiaceae	Einadia nutans	Climbing Saltbush					0.4	30															0.1	10	0.2	8	0.3	20	0.4	30	0.2	10
Chenopodiaceae	Einadia nutans subsp. linifolia	Climbing Saltbush					0.8	70																							0.1	1
Chenopodiaceae	Einadia nutans subsp. nutans	Climbing Saltbush															0.5	8			0.1	1										
Chenopodiaceae	Einadia polygonoides	Knotweed Goosefoot																														
Chenopodiaceae	Einadia trigonos	Fishweed																														
Chenopodiaceae	Einadia trigonos subsp. trigonos						0.6	20			0.1	3									0.1	1	0.1	1			0.1	1				
Clusiaceae	Hypericum gramineum	Small St John's Wort																														
Commelinaceae	Commelina cyanea	Native Wandering Jew			0.1	1							0.2	20							1	50	0.1	10			0.2	10	0.1	10		
Convolvulaceae	Convolvulus erubescens	Pink Bindweed	0.1	1																			0.1	1	0.1	1						
Convolvulaceae	Dichondra repens	Kidney Weed							0.3	30	0.5	50			15	500	0.1	30					2	100					0.4	40		
Convolvulaceae	Polymeria calycina																														0.1	20
Cyperaceae	Carex appressa	Tall Sedge																														
Cyperaceae	Carex breviculmis																															
Cyperaceae	Carex inversa	Knob Sedge													0.2	20	0.1	30			0.1	2	0.1	10			0.1	20				
Cyperaceae	Cyperus difformis	Dirty Dora																														
Cyperaceae	Cyperus gracilis	Slender Flat-sedge					0.1	8					0.1	10							0.1	10	0.2	70			0.2	100	0.1	20		
Cyperaceae	Eleocharis pusilla								0.3	4																						
Cyperaceae	Fimbristylis dichotoma	Common Fringe-sedge																			0.2	30					0.1	20				

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Blechnaceae	Blechnum ambiguum																													
Campanulaceae	Wahlenbergia communis	Tufted Bluebell			0.1	1																								
Campanulaceae	Wahlenbergia gracilis	Sprawling Bluebell					0.1	4							0.2	80									0.1	2	0.1	10				
Campanulaceae	Wahlenbergia stricta	Tall Bluebell																	0.2	100												
Casuarinaceae	Allocasuarina littoralis	Black She-Oak			7	5	0.7	1									3	20	0.8	4			2	3								
Casuarinaceae	Casuarina cunninghamiana subsp. cunninghamiana	River Oak																			15	8										
Casuarinaceae	Casuarina glauca	Swamp Oak	20	50																												
Chenopodiaceae	Atriplex semibaccata	Creeping Saltbush																														
Chenopodiaceae	Einadia hastata	Berry Saltbush	0.9	20	0.2	4	0.4	7									1	10			0.1	2	0.2	4	0.1	1						
Chenopodiaceae	Einadia nutans	Climbing Saltbush													0.1	3									0.2	20			0.1	2		
Chenopodiaceae	Einadia nutans subsp. linifolia	Climbing Saltbush																														
Chenopodiaceae	Einadia nutans subsp. nutans	Climbing Saltbush																											0.1	1		
Chenopodiaceae	Einadia polygonoides	Knotweed Goosefoot	0.3	10																												
Chenopodiaceae	Einadia trigonos	Fishweed															0.6	10														
Chenopodiaceae	Einadia trigonos subsp. trigonos												0.1	1											1	80	0.1	4				
Clusiaceae	Hypericum gramineum	Small St John's Wort																	0.2	100							0.1	4				
Commelinaceae	Commelina cyanea	Native Wandering Jew	0.4	30																					0.1	10			0.1	1		
Convolvulaceae	Convolvulus erubescens	Pink Bindweed																									1	40				
Convolvulaceae	Dichondra repens	Kidney Weed			0.4	50							0.4	50	0.1	10	0.1	10					0.1	10	0.1	10			2	200		
Convolvulaceae	Polymeria calycina																												0.2	2		
Cyperaceae	Carex appressa	Tall Sedge																									4	50				
Cyperaceae	Carex breviculmis																														0.1	10
Cyperaceae	Carex inversa	Knob Sedge											0.1	10											0.1	30	0.1	2	0.1	20	0.1	20
Cyperaceae	Cyperus difformis	Dirty Dora																													0.3	30
Cyperaceae	Cyperus gracilis	Slender Flat-sedge											0.1	30											0.7	100	0.1	1	0.1	40		
Cyperaceae	Eleocharis pusilla																															
Cyperaceae	Fimbristylis dichotoma	Common Fringe-sedge																														

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Cyperaceae	Gahnia aspera	Rough Saw-sedge	2.7	17																												
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge	0.1	1															2	40											0.1	2
Cyperaceae	Lepidosperma urophorum		0.3	2																												
Cyperaceae	Ptilothrix deusta																		0.5	10												
Dawsoniaceae	Dawsonia spp.																															
Dilleniaceae	Hibbertia acicularis																		0.1	10												
Dilleniaceae	Hibbertia aspera	Rough Guinea Flower																													0.1	1
Ericaceae	Astroloma humifusum	Native Cranberry																														
Ericaceae	Leucopogon juniperinus	Prickly Beard-heath									0.6	3			0.3	3																
Ericaceae	Leucopogon muticus	Blunt Beard-heath																														
Ericaceae	Lissanthe strigosa	Peach Heath																														
Ericaceae	Lissanthe strigosa subsp. strigosa																		0.3	3												
Euphorbiaceae	Chamaesyce drummondii	Caustic Weed																														
Fabaceae (Faboideae)	Daviesia ulicifolia	Gorse Bitter Pea																														
Fabaceae (Faboideae)	Desmodium rhytidophyllum																0.4	30														
Fabaceae (Faboideae)	Desmodium varians	Slender Tick-trefoil							0.1	1							0.1	4							0.2	20	0.1	7			0.1	5
Fabaceae (Faboideae)	Dillwynia sieberi										0.3	4																				
Fabaceae (Faboideae)	Glycine clandestina	Twining glycine							0.4	20	0.1	1			0.5	10					0.1	4										
Fabaceae (Faboideae)	Glycine microphylla	Small-leaf Glycine					0.2	5	0.1	1	0.1	1			0.7	60	0.2	50			0.1	10	0.1	4	0.2	30			0.1	2		
Fabaceae (Faboideae)	Glycine tabacina	Variable Glycine	0.1	1	0.3	100	1	60			0.1	10			0.1	10	0.3	50			0.2	20	0.1	10	0.2	20	0.1	4			0.2	10
Fabaceae (Faboideae)	Hardenbergia violacea	False Sarsaparilla									0.4	2			0.3	3																
Fabaceae (Faboideae)	Kennedia rubicunda	Dusky Coral Pea																														
Fabaceae (Faboideae)	Podolobium ilicifolium	Prickly Shaggy Pea																														

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Cyperaceae	Gahnia aspera	Rough Saw-sedge																														
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge			1	30													0.3	2			1	30								
Cyperaceae	Lepidosperma urophorum																															
Cyperaceae	Ptilothrix deusta																															
Dawsoniaceae	Dawsonia spp.																						0.5	200								
Dilleniaceae	Hibbertia acicularis																															
Dilleniaceae	Hibbertia aspera	Rough Guinea Flower																					0.1	1								
Ericaceae	Astroloma humifusum	Native Cranberry																					0.2	6								
Ericaceae	Leucopogon juniperinus	Prickly Beard-heath																														
Ericaceae	Leucopogon muticus	Blunt Beard-heath																	0.7	1												
Ericaceae	Lissanthe strigosa	Peach Heath					0.2	1																								
Ericaceae	Lissanthe strigosa subsp. strigosa				0.1	1																	0.5	5								
Euphorbiaceae	Chamaesyce drummondii	Caustic Weed							0.4	50																						
Fabaceae (Faboideae)	Daviesia ulicifolia	Gorse Bitter Pea					0.6	2											0.3	4												
Fabaceae (Faboideae)	Desmodium rhytidophyllum																												0.1	1		
Fabaceae (Faboideae)	Desmodium varians	Slender Tick-trefoil			0.2	20							1	80											0.1	3						
Fabaceae (Faboideae)	Dillwynia sieberi				1	7																										
Fabaceae (Faboideae)	Glycine clandestina	Twining glycine											0.3	20																		
Fabaceae (Faboideae)	Glycine microphylla	Small-leaf Glycine			0.4	70	0.1	1																	0.1	4	0.1	1	0.1	10		
Fabaceae (Faboideae)	Glycine tabacina	Variable Glycine													0.1	4	0.3	10	0.1	10			0.1	3	0.3	50			0.1	4		
Fabaceae (Faboideae)	Hardenbergia violacea	False Sarsaparilla											0.1	4					0.1	2												
Fabaceae (Faboideae)	Kennedia rubicunda	Dusky Coral Pea																	0.2	10												
Fabaceae (Faboideae)	Podolobium ilicifolium	Prickly Shaggy Pea																	1	20												

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Fabaceae (Faboideae)	Pultenaea villosa	Hairy Bush-pea																	0.3	9												
Fabaceae (Mimosoideae)	Acacia binervia	Coast Myall	3	4									10	5																		
Fabaceae (Mimosoideae)	Acacia decurrens	Black Wattle									3	8			5	10					2	6										
Fabaceae (Mimosoideae)	Acacia echinula	Hedgehog Wattle																														
Fabaceae (Mimosoideae)	Acacia falcata																2	20														
Fabaceae (Mimosoideae)	Acacia floribunda	White Sally																														
Fabaceae (Mimosoideae)	Acacia implexa	Hickory Wattle							0.5	3																						
Fabaceae (Mimosoideae)	Acacia longissima	Long-leaf Wattle	0.3	2																												
Fabaceae (Mimosoideae)	Acacia parramattensis	Parramatta Wattle															0.1	1					0.1	4								
Fabaceae (Mimosoideae)	Acacia parvipinnula	Silver-stemmed Wattle	0.3	1																												
Fabaceae (Mimosoideae)	Acacia podalyriifolia	Queensland Silver Wattle																														
Geraniaceae	Geranium homeanum														0.1	1																
Goodeniaceae	Goodenia bellidifolia																															
Goodeniaceae	Goodenia hederacea	Ivy Goodenia																														
Goodeniaceae	Goodenia hederacea subsp. hederacea										0.2	6																			0.1	2
Hypoxidaceae	Hypoxis hygrometrica var. villosisepala																				0.2	20										
Juncaceae	Juncus flavidus																															
Juncaceae	Juncus usitatus								0.1	1																						
Lamiaceae	Plectranthus parviflorus																								0.1	10						
Lamiaceae	Scutellaria humilis	Dwarf Skullcap																			0.1	6										
Lauraceae	Cassytha glabella																		0.1	1												
Linaceae	Linum marginale	Native Flax																							0.1	2	0.1	10				

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Fabaceae (Faboideae)	Pultenaea villosa	Hairy Bush-pea																					0.1	2								
Fabaceae (Mimosoideae)	Acacia binervia	Coast Myall																														
Fabaceae (Mimosoideae)	Acacia decurrens	Black Wattle																														
Fabaceae (Mimosoideae)	Acacia echinula	Hedgehog Wattle																	2	20												
Fabaceae (Mimosoideae)	Acacia falcata																															
Fabaceae (Mimosoideae)	Acacia floribunda	White Sally	0.5	1																												
Fabaceae (Mimosoideae)	Acacia implexa	Hickory Wattle											0.6	10					0.1	1												
Fabaceae (Mimosoideae)	Acacia longissima	Long-leaf Wattle																	0.1	1												
Fabaceae (Mimosoideae)	Acacia parramattensis	Parramatta Wattle															0.1	1														
Fabaceae (Mimosoideae)	Acacia parvipinnula	Silver-stemmed Wattle																														
Fabaceae (Mimosoideae)	Acacia podalyriifolia	Queensland Silver Wattle													0.5	1																
Geraniaceae	Geranium homeanum																															
Goodeniaceae	Goodenia bellidifolia				0.3	50																										
Goodeniaceae	Goodenia hederacea	Ivy Goodenia																	0.1	5												
Goodeniaceae	Goodenia hederacea subsp. hederacea				0.2	10																										
Hypoxidaceae	Hypoxis hygrometrica var. villosisepala												0.1	1																		
Juncaceae	Juncus flavidus																														0.2	5
Juncaceae	Juncus usitatus										0.5	4									0.3	20					0.1	10			4	70
Lamiaceae	Plectranthus parviflorus		4	20																												
Lamiaceae	Scutellaria humilis	Dwarf Skullcap																														
Lauraceae	Cassytha glabella																															
Linaceae	Linum marginale	Native Flax																														

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Lobeliaceae	Lobelia purpurascens	Whiteroot			0.1	20													1	30	0.3	50	0.4	50	0.1	7					0.4	50
Lomandraceae	Lomandra filiformis	Wattle Matt-rush																					0.1	5								
Lomandraceae	Lomandra filiformis subsp. filiformis								0.6	30					0.3	100			0.1	5												
Lomandraceae	Lomandra longifolia	Spiny-headed Mat																														
Lomandraceae	Lomandra multiflora subsp. multiflora	Many-flowered Mat			0.1	2					1	20			0.3	4			1	8												
Lomandraceae	Lomandra obliqua																															
Loranthaceae	Amyema gaudichaudii				0.1	1																										
Luzuriagaceae	Geitonoplesium cymosum	Scrambling Lily	0.4	9																												
Meliaceae	Melia azedarach	White Cedar													0.1	2																
Menispermaceae	Stephania japonica	Snake vine	0.2	2																												
Moraceae	Ficus rubiginosa	Port Jackson Fig																														
Myoporaceae	Eremophila debilis	Amulla									0.3	3																				
Myrtaceae	Angophora floribunda	Rough-barked Apple																					8	2								
Myrtaceae	Austromyrtus tenuifolia																															
Myrtaceae	Callistemon citrinus	Crimson Bottlebrush																														
Myrtaceae	Callistemon pinifolius	Pine-leaved Bottlebrush																	0.1	1												
Myrtaceae	Callistemon salignus	Willow Bottlebrush																														
Myrtaceae	Corymbia eximia	Yellow Bloodwood	8	7																												
Myrtaceae	Corymbia maculata	Spotted Gum					10	1	20	6																						
Myrtaceae	Eucalyptus amplifolia	Cabbage Gum							65	30	25	5											15	6			45	5				
Myrtaceae	Eucalyptus crebra	Narrow-leaved Ironbark																														
Myrtaceae	Eucalyptus eugenioides	Thin-leaved Stringybark																														
Myrtaceae	Eucalyptus fibrosa	Red Ironbark			60	40																									80	20
Myrtaceae	Eucalyptus globoidea	White Stringybark	3	1																												
Myrtaceae	Eucalyptus longifolia	Woollybutt																														
Myrtaceae	Eucalyptus moluccana	Grey Box			0.2	1					8	1			3	5	30	7											5	2		
Myrtaceae	Eucalyptus pilularis	Blackbutt																														

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Lobeliaceae	Lobelia purpurascens	Whiteroot			0.1	20	0.2	10									0.3	20	0.1	1			0.5	30	0.1	7						
Lomandraceae	Lomandra filiformis	Wattle Matt-rush																	0.4	60												
Lomandraceae	Lomandra filiformis subsp. filiformis				0.3	100	0.2	50															0.2	20					0.2	20		
Lomandraceae	Lomandra longifolia	Spiny-headed Mat	0.9	10																					1	4						
Lomandraceae	Lomandra multiflora subsp. multiflora	Many-flowered Mat			0.2	2													0.1	1			0.5	6								
Lomandraceae	Lomandra obliqua																		0.4	10												
Loranthaceae	Amyema gaudichaudii																															
Luzuriagaceae	Geitonoplesium cymosum	Scrambling Lily																														
Meliaceae	Melia azedarach	White Cedar																														
Menispermaceae	Stephania japonica	Snake vine																														
Moraceae	Ficus rubiginosa	Port Jackson Fig							0.4	1																						
Myoporaceae	Eremophila debilis	Amulla															0.6	10														
Myrtaceae	Angophora floribunda	Rough-barked Apple	3	2			7	5					6	6																		
Myrtaceae	Austromyrtus tenuifolia																		1	20												
Myrtaceae	Callistemon citrinus	Crimson Bottlebrush	1	1																												
Myrtaceae	Callistemon pinifolius	Pine-leaved Bottlebrush																														
Myrtaceae	Callistemon salignus	Willow Bottlebrush											4	2																		
Myrtaceae	Corymbia eximia	Yellow Bloodwood																														
Myrtaceae	Corymbia maculata	Spotted Gum	1	1					5	3			8	3																		
Myrtaceae	Eucalyptus amplifolia	Cabbage Gum	15	6	2	2							9	3											60	8						
Myrtaceae	Eucalyptus crebra	Narrow-leaved Ironbark											25	8									10	3								
Myrtaceae	Eucalyptus eugenioides	Thin-leaved Stringybark											15	3																		
Myrtaceae	Eucalyptus fibrosa	Red Ironbark																					65	20					20	4		
Myrtaceae	Eucalyptus globoidea	White Stringybark																														
Myrtaceae	Eucalyptus longifolia	Woollybutt																					7	2								
Myrtaceae	Eucalyptus moluccana	Grey Box							3	2					15	10	8	10														
Myrtaceae	Eucalyptus pilularis	Blackbutt																	20	7												

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Myrtaceae	Eucalyptus punctata	Grey Gum	15	20																												
Myrtaceae	Eucalyptus racemosa	Narrow-leaved Scribbly Gum																	15	4												
Myrtaceae	Eucalyptus tereticornis	Forest Red Gum					4	2							55	20					7	10							15	5		
Myrtaceae	Kunzea ambigua	Tick Bush			0.2	20													5	6	8	10										
Myrtaceae	Leptospermum arachnoides																															
Myrtaceae	Leptospermum polygalifolium	Tantoon																														
Myrtaceae	Melaleuca decora				60	100													40	30	10	20									5	3
Myrtaceae	Melaleuca nodosa				0.1	1													15	20											2	10
Myrtaceae	Melaleuca styphelioides	Prickly-leaved Tea Tree																														
Myrtaceae	Tristaniopsis laurina	Kanooka	2	2																												
Oleaceae	Notelaea venosa	Veined Mock-olive							1	1																						
Oxalidaceae	Oxalis perennans						0.1	20			0.1	2			0.1	20	0.1	6	0.1	2	0.2	40	0.7	100	0.1	30			0.1	2	0.1	20
Philydraceae	Philydrum lanuginosum	Frogsmouth													0.1	3																
Phormiaceae	Dianella caerulea var. producta		0.5	5																												
Phormiaceae	Dianella longifolia	Blueberry Lily													0.2	10	0.1	2														
Phormiaceae	Dianella revoluta	Blueberry Lily																	0.1	3												
Phyllanthaceae	Breynia oblongifolia	Coffee Bush	0.1	1																												
Phyllanthaceae	Glochidion ferdinandi	Cheese Tree	2	9																												
Phyllanthaceae	Phyllanthus hirtellus	Thyme Spurge																	0.1	4												
Phyllanthaceae	Poranthera microphylla	Small Poranthera																			0.1	10									0.1	50
Pittosporaceae	Billardiera scandens	Hairy Apple Berry																	0.1	1											0.1	2
Pittosporaceae	Bursaria spinosa	Native Blackthorn			0.2	20			6	20	60	50			45	50					30	40	6	20	0.3	1	0.4	1				
Plantaginaceae	Plantago gaudichaudii	Narrow Plantain																														
Plantaginaceae	Plantago varia						0.8	40																								
Plantaginaceae	Veronica plebeia	Trailing Speedwell																													0.2	20
Poaceae	Aristida ramosa	Purple Wiregrass															30	400														
Poaceae	Aristida vagans	Threeawn Speargrass																													0.5	50

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Myrtaceae	Eucalyptus punctata	Grey Gum	3	1																												
Myrtaceae	Eucalyptus racemosa	Narrow-leaved Scribbly Gum					10	4																								
Myrtaceae	Eucalyptus tereticornis	Forest Red Gum							8	4			3	1																		
Myrtaceae	Kunzea ambigua	Tick Bush																	1	1												
Myrtaceae	Leptospermum arachnoides																		0.7	1												
Myrtaceae	Leptospermum polygalifolium	Tantoon	0.4	1																												
Myrtaceae	Melaleuca decora				30	20			4	2			1	1			6	1					25	50	4	2					7	10
Myrtaceae	Melaleuca nodosa		1	5	5	4	1	2															2	2								
Myrtaceae	Melaleuca styphelioides	Prickly-leaved Tea Tree	10	20																												
Myrtaceae	Tristaniopsis laurina	Kanooka																														
Oleaceae	Notelaea venosa	Veined Mock-olive																														
Oxalidaceae	Oxalis perennans				0.1	10	0.1	7					0.1	7	0.1	20							0.1	20	0.2	60	0.1	4	0.1	10		
Philydraceae	Philydrum lanuginosum	Frogsmouth																														
Phormiaceae	Dianella caerulea var. producta																															
Phormiaceae	Dianella longifolia	Blueberry Lily																							0.2	5						
Phormiaceae	Dianella revoluta	Blueberry Lily					1	70											0.2	2			0.7	20					0.2	10		
Phyllanthaceae	Breynia oblongifolia	Coffee Bush																	0.1	1												
Phyllanthaceae	Glochidion ferdinandi	Cheese Tree																														
Phyllanthaceae	Phyllanthus hirtellus	Thyme Spurge			0.1	2																	0.1	1								
Phyllanthaceae	Poranthera microphylla	Small Poranthera			0.1	50													0.2	50			0.1	20								
Pittosporaceae	Billardiera scandens	Hairy Apple Berry																	0.1	4			0.1	6								
Pittosporaceae	Bursaria spinosa	Native Blackthorn	1	3	75	200									1	4	0.5	3	0.1	1			0.3	5			2	20	0.5	2		
Plantaginaceae	Plantago gaudichaudii	Narrow Plantain																									0.1	6				
Plantaginaceae	Plantago varia																															
Plantaginaceae	Veronica plebeia	Trailing Speedwell			0.2	10																	0.2	10								
Poaceae	Aristida ramosa	Purple Wiregrass			0.1	4																										
Poaceae	Aristida vagans	Threeawn Speargrass			3	300													0.3	20			1	70					0.2	10		

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Austrostipa pubescens																													
Poaceae	Austrostipa ramosissima	Stout Bamboo Grass									0.6	10																		
Poaceae	Bothriochloa macra	Red Grass															0.1	10												
Poaceae	Chloris truncata	Windmill Grass																							0.1	10			0.2	10		
Poaceae	Chloris ventricosa	Tall Chloris															0.4	50												
Poaceae	Cymbopogon refractus	Barbed Wire Grass	0.1	1																	0.1	1								
Poaceae	Cynodon dactylon	Common Couch			0.1	10	0.6	5	0.8	50											4	50	0.1	1	0.1	10	0.5	30	0.5	10	0.3	20
Poaceae	Dichelachne crinita	Longhair Plumegrass													0.1	1														
Poaceae	Dichelachne micrantha	Shorthair Plumegrass																												
Poaceae	Echinopogon caespitosus	Bushy Hedgehog-grass																	0.2	7										0.1	10
Poaceae	Entolasia marginata	Bordered Panic	0.1	10					0.2	10	0.5	50			0.1	20			2	70	0.8	50			0.5	60				0.1	10
Poaceae	Entolasia stricta	Wiry Panic	0.1	10																										
Poaceae	Eragrostis brownii	Brown's Lovegrass																	0.1	10	0.1	10								
Poaceae	Eragrostis leptostachya	Paddock Lovegrass																			0.1	10					1	70				
Poaceae	Eriochloa pseudoacrotricha	Early Spring Grass																												
Poaceae	Lachnagrostis aemula	Blowngrass							0.3	20																				
Poaceae	Microlaena stipoides	Weeping Grass	0.1	4	0.1	10	10	700	0.5	30	10	700			20	###	40	###	0.7	40	45	###	75	###	20	600	55	###	2	200	65	###
Poaceae	Oplismenus aemulus												0.3	30	0.2	30					0.2	30			0.2	30					
Poaceae	Panicum effusum	Hairy Panic																												
Poaceae	Panicum simile	Two-colour Panic																			0.7	70								
Poaceae	Paspalidium distans						0.3	10											1	40	1	50					15	600				
Poaceae	Poa labillardierei var. labillardierei	Common Tussock-grass																												
Poaceae	Rytidosperma caespitosum	Ringed Wallaby Grass													0.2	30	0.1	2									0.2	20				
Poaceae	Sporobolus creber	Slender Rat's Tail Grass					0.1	1									0.1	1														
Poaceae	Themeda triandra		0.2	3							0.7	20			0.5	10			0.2	3												
Polygonaceae	Persicaria decipiens	Slender Knotweed																												
Polygonaceae	Persicaria hydropiper	Water Pepper											0.2	10																		
Polygonaceae	Rumex brownii	Swamp Dock							0.2	2													0.1	3								

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Austrostipa pubescens																		0.1	1												
Poaceae	Austrostipa ramosissima	Stout Bamboo Grass															0.1	1														
Poaceae	Bothriochloa macra	Red Grass											0.1	1																		
Poaceae	Chloris truncata	Windmill Grass																														
Poaceae	Chloris ventricosa	Tall Chloris																														
Poaceae	Cymbopogon refractus	Barbed Wire Grass																	0.6	10												
Poaceae	Cynodon dactylon	Common Couch	0.2	3			15	50					4	50	0.5	20					70	500			1	30	0.3	10	0.1	6	35	300
Poaceae	Dichelachne crinita	Longhair Plumegrass																														
Poaceae	Dichelachne micrantha	Shorthair Plumegrass																	0.1	2												
Poaceae	Echinopogon caespitosus	Bushy Hedgehog-grass															0.5	50	0.1	10			0.6	50			0.2	30				
Poaceae	Entolasia marginata	Bordered Panic	0.1	2	0.1	10																	0.7	70								
Poaceae	Entolasia stricta	Wiry Panic			4	200													0.5	30												
Poaceae	Eragrostis brownii	Brown's Lovegrass			0.2	30																										
Poaceae	Eragrostis leptostachya	Paddock Lovegrass			0.1	10																			0.4	60	2	200	0.5	50		
Poaceae	Eriochloa pseudoacrotricha	Early Spring Grass																											0.1	10		
Poaceae	Lachnagrostis aemula	Blowngrass																													0.1	10
Poaceae	Microlaena stipoides	Weeping Grass	0.2	20	35	700	10	500					40	###	1	100	55	###	0.5	100			1	200	40	###	1	100	1	100		
Poaceae	Oplismenus aemulus																															
Poaceae	Panicum effusum	Hairy Panic																											0.1	10		
Poaceae	Panicum simile	Two-colour Panic																														
Poaceae	Paspalidium distans				4	200																										
Poaceae	Poa labillardierei var. labillardierei	Common Tussock-grass	0.8	30																												
Poaceae	Rytidosperma caespitosum	Ringed Wallaby Grass			0.5	40											0.1	10					0.1	3			0.1	10			0.1	10
Poaceae	Sporobolus creber	Slender Rat's Tail Grass																							0.1	10						
Poaceae	Themeda triandra				0.2	10																	0.1	1								
Polygonaceae	Persicaria decipiens	Slender Knotweed																									0.1	1				
Polygonaceae	Persicaria hydropiper	Water Pepper																														
Polygonaceae	Rumex brownii	Swamp Dock	0.1	1																												

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Portulacaceae	Portulaca oleracea	Pigweed																												0.1	3
Proteaceae	Grevillea juniperina subsp. juniperina	Juniper-leaved Grevillea																													
Proteaceae	Hakea dactyloides	Finger Hakea	0.5	1																											
Proteaceae	Macadamia integrifolia	Macadamia Nut																													
Proteaceae	Persoonia linearis	Narrow-leaved Geebung																	0.1	2											
Ranunculaceae	Clematis glycinoides	Headache Vine									0.5	1													0.1	1					
Rubiaceae	Asperula conferta	Common Woodruff															0.1	20													
Rubiaceae	Opercularia varia	Variable Stinkweed															0.2	30	0.3	20										0.1	2
Rubiaceae	Pomax umbellata	Pomax																												0.1	2
Rutaceae	Philotheca myoporoides	Long-leaf Wax Flower	2	9																											
Santalaceae	Exocarpos cupressiformis	Cherry Ballart							3	1	3	1			2	1															
Sapindaceae	Dodonaea triquetra	Large-leaf Hop	0.4	4																											
Sapindaceae	Dodonaea viscosa subsp. cuneata	Wedge-leaf Hop																													
Solanaceae	Solanum americanum	Glossy Nightshade																												0.1	2
Solanaceae	Solanum campanulatum																0.1	1													
Solanaceae	Solanum prinophyllum	Forest Nightshade			0.1	1											0.1	1			0.6	4			0.1	6				0.1	1
Stackhousiaceae	Stackhousia viminea	Slender Stackhousia																													
Typhaceae	Typha orientalis	Broad-leaved Cumbungi																													
Xanthorrhoeaceae	Xanthorrhoea minor																		0.3	2											
Introduced Species																															
Agavaceae	Yucca aloifolia	Spanish Bayonet																													
Alliaceae	Agapanthus praecox subsp. orientalis																														
Alliaceae	Nothoscordum borbonicum	Onion Weed																			0.1	1							0.1	1	
Amaranthaceae	Alternanthera philoxeroides	Alligator Weed																													
Amaranthaceae	Alternanthera pungens	Khaki Weed																												0.1	1
Amaranthaceae	Amaranthus retroflexus	Redroot Amaranth							0.1	1													0.1	1							
Amaranthaceae	Amaranthus viridis	Green Amaranth																													

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Portulacaceae	Portulaca oleracea	Pigweed					0.1	10																	0.1	20	0.1	3				
Proteaceae	Grevillea juniperina subsp. juniperina	Juniper-leaved Grevillea			0.2	1																										
Proteaceae	Hakea dactyloides	Finger Hakea																														
Proteaceae	Macadamia integrifolia	Macadamia Nut	0.1	1																												
Proteaceae	Persoonia linearis	Narrow-leaved Geebung																	1	30												
Ranunculaceae	Clematis glycinoides	Headache Vine	1	20																							0.1	2				
Rubiaceae	Asperula conferta	Common Woodruff																														
Rubiaceae	Opercularia varia	Variable Stinkweed			0.5	40													0.1	6			0.1	10								
Rubiaceae	Pomax umbellata	Pomax																	0.3	100												
Rutaceae	Philotheca myoporoides	Long-leaf Wax Flower																														
Santalaceae	Exocarpos cupressiformis	Cherry Ballart																					4	8								
Sapindaceae	Dodonaea triquetra	Large-leaf Hop																														
Sapindaceae	Dodonaea viscosa subsp. cuneata	Wedge-leaf Hop											0.3	3																		
Solanaceae	Solanum americanum	Glossy Nightshade																														
Solanaceae	Solanum campanulatum																															
Solanaceae	Solanum prinophyllum	Forest Nightshade															0.5	5					0.5	8								
Stackhousiaceae	Stackhousia viminea	Slender Stackhousia			0.1	2																	0.1	2								
Typhaceae	Typha orientalis	Broad-leaved Cumbungi									15	100																				
Xanthorrhoeaceae	Xanthorrhoea minor																															
Introduced Species																																
Agavaceae	Yucca aloifolia	Spanish Bayonet							0.2	1																						
Alliaceae	Agapanthus praecox subsp. orientalis		0.1	4																												
Alliaceae	Nothoscordum borbonicum	Onion Weed					0.2	50													0.2	50							0.1	2	0.1	1
Amaranthaceae	Alternanthera philoxeroides	Alligator Weed																			0.1	7										
Amaranthaceae	Alternanthera pungens	Khaki Weed					0.2	4																	0.1	1						
Amaranthaceae	Amaranthus retroflexus	Redroot Amaranth																														
Amaranthaceae	Amaranthus viridis	Green Amaranth																							0.1	2						

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Amaranthaceae	Gomphrena celosioides	Gomphrena Weed					0.1	9																			0.1	2	0.1	4	0.1	2
Amygdalaceae	Prunus cerasifera	Cherry Plum																														
Anacardiaceae	Schinus areira	Pepper Tree																														
Anthericaceae	Chlorophytum comosum	Spider Plant																														
Apiaceae	Cyclospermum leptophyllum	Slender Celery			0.1	30	0.1	4	0.1	1			0.1	1							0.1	20			0.1	6			0.1	3		
Apiaceae	Foeniculum vulgare	Fennel																														
Apiaceae	Hydrocotyle bonariensis												0.1	2																		
Apocynaceae	Araujia sericifera	Moth Vine			0.1	20			0.8	30			0.1	2	0.3	30					0.1	1			0.1	1			0.1	9		
Apocynaceae	Gomphocarpus physocarpus	Balloon Cotton Bush																			0.1	2										
Asparagaceae	Asparagus aethiopicus	Asparagus Fern													0.4	10																
Asparagaceae	Asparagus asparagoides	Bridal Creeper			0.5	100			1	30	0.6	30	0.1	1	1	50	0.1	1	0.1	1	0.9	10			0.1	1						
Asparagaceae	Asparagus officinalis	Asparagus													0.2	10																
Asparagaceae	Sansevieria trifasciata	Mother-in-law																														
Asphodelaceae	Asphodelus fistulosus	Onion Weed			0.1	20																										
Asteraceae	Ageratina adenophora	Crofton Weed	1	40																												
Asteraceae	Aster subulatus	Wild Aster							0.1	10																						
Asteraceae	Bidens pilosa	Cobbler's Pegs	0.1	1	0.2	100			35	500	0.8	60	0.1	2	0.7	50	0.1	5	0.1	6	0.2	20	0.1	6	0.1	5	0.1	3	0.1	20		
Asteraceae	Bidens subalternans	Greater Beggar's Ticks																					0.1	10	0.1	7						
Asteraceae	Bidens tripartita	Burr Marigold											0.1	1							0.2	20										
Asteraceae	Cirsium vulgare	Spear Thistle	0.1	1	0.1	1			0.5	10			0.1	1	0.1	2	0.1	4	0.1	3	0.1	10	0.1	2	0.1	1						
Asteraceae	Conyza bonariensis	Flaxleaf Fleabane							0.8	30	0.1	1	0.7	80							0.2	20	0.2	20	0.1	10						
Asteraceae	Dimorphotheca ecklonis	Cape Daisy																											0.1	1		
Asteraceae	Facelis retusa						0.1	2													0.1	1	0.1	1	0.1	1			0.1	1		
Asteraceae	Gamochaeta purpurea	Purple Cudweed					0.1	10	0.1	1	0.1	1											0.1	10	0.1	10					0.1	10
Asteraceae	Hypochaeris microcephala var. albiflora	White Flatweed					0.1	10	0.4	10											0.1	1	0.8	50	0.2	20	0.1	10				
Asteraceae	Hypochaeris radicata	Catsear			0.1	50							0.2	10					0.1	1	0.1	10	0.1	4	0.1	10	0.2	20	0.1	2	0.1	10
Asteraceae	Lactuca serriola	Prickly Lettuce			0.1	20																										
Asteraceae	Senecio madagascariensis	Fireweed			0.2	50	50	200			0.1	1					0.1	1			0.1	10	0.2	20	0.1	9	1	100	0.1	10	0.1	4
Asteraceae	Senecio pterophorus														0.1	2					0.2	10										

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Amaranthaceae	Gomphrena celosioides	Gomphrena Weed																												
Amygdalaceae	Prunus cerasifera	Cherry Plum							0.6	2																				
Anacardiaceae	Schinus areira	Pepper Tree																											3	1
Anthericaceae	Chlorophytum comosum	Spider Plant	0.2	10																										
Apiaceae	Cyclospermum leptophyllum	Slender Celery							0.1	1											0.1	10					0.1	10			0.3	200
Apiaceae	Foeniculum vulgare	Fennel																									0.2	2				
Apiaceae	Hydrocotyle bonariensis																															
Apocynaceae	Araujia sericifera	Moth Vine					0.4	1	0.3	10			0.1	4	0.5	30	0.5	20					0.1	1			0.2	6	0.1	1		
Apocynaceae	Gomphocarpus physocarpus	Balloon Cotton Bush																														
Asparagaceae	Asparagus aethiopicus	Asparagus Fern																														
Asparagaceae	Asparagus asparagoides	Bridal Creeper	0.1	1											0.2	1	0.5	6					0.1	4								
Asparagaceae	Asparagus officinalis	Asparagus																									0.3	5				
Asparagaceae	Sansevieria trifasciata	Mother-in-law							0.1	1																						
Asphodelaceae	Asphodelus fistulosus	Onion Weed																														
Asteraceae	Ageratina adenophora	Crofton Weed																														
Asteraceae	Aster subulatus	Wild Aster																			0.1	2									0.1	2
Asteraceae	Bidens pilosa	Cobbler's Pegs	1	50	0.2	20	0.2	2					0.1	4	0.4	30	0.6	40									0.5	50	0.1	3		
Asteraceae	Bidens subalternans	Greater Beggar's Ticks									0.2	10															0.2	20				
Asteraceae	Bidens tripartita	Burr Marigold			0.1	1	0.1	1	0.5	20							0.5	30			0.3	30										
Asteraceae	Cirsium vulgare	Spear Thistle													0.1	1	0.5	10			0.1	10					0.1	4			0.3	10
Asteraceae	Conyza bonariensis	Flaxleaf Fleabane	0.1	1											0.1	8					0.1	1					0.1	1				
Asteraceae	Dimorphotheca ecklonis	Cape Daisy					1	100																								
Asteraceae	Facelis retusa						0.1	10																			0.1	30				
Asteraceae	Gamochaeta purpurea	Purple Cudweed					0.1	10													0.1	5			0.1	6	0.3	70				
Asteraceae	Hypochaeris microcephala var. albiflora	White Flatweed			0.1	2									0.1	10									0.1	10	0.1	10	0.1	1	0.1	10
Asteraceae	Hypochaeris radicata	Catsear			0.1	1	0.5	30							0.2	50	0.1	10	0.2	40	0.1	20	0.3	30	0.1	1	0.2	30	0.3	40	0.3	80
Asteraceae	Lactuca serriola	Prickly Lettuce	0.1	1																											0.1	2
Asteraceae	Senecio madagascariensis	Fireweed			0.1	4	0.2	10					0.1	6	0.1	10			0.1	4	0.3	50			1	50	0.1	4	0.5	20		
Asteraceae	Senecio pterophorus																1	5														

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Soliva sessilis	Bindyi					0.1	40																					0.1	3		
Asteraceae	Sonchus oleraceus	Common Sowthistle					0.1	10	0.3	10	0.1	1	0.3	20	0.1	2	0.1	3	0.1	10	0.2	40	0.2	30	0.2	20	0.1	10	0.1	10	0.1	6
Asteraceae	Tagetes minuta	Stinking Roger											0.1	2																		
Asteraceae	Tanacetum parthenium	Feverfew							0.3	2																						
Asteraceae	Taraxacum officinale	Dandelion																					0.1	1	0.1	1			0.1	10		
Basellaceae	Anredera cordifolia	Madeira Vine																														
Bignoniaceae	Jacaranda mimosifolia	Jacaranda																														
Boraginaceae	Heliotropium amplexicaule	Blue Heliotrope											0.1	1																		
Brassicaceae	Brassica fruticulosa	Twiggy Turnip																														
Brassicaceae	Cardamine flexuosa	Wood Bittercress																					0.1	1								
Brassicaceae	Cardamine hirsuta	Common Bittercress											0.1	10															0.1	6		
Brassicaceae	Lepidium africanum	Common Peppercress					0.7	200															0.1	5			0.1	10	0.1	5		
Brassicaceae	Lepidium bonariense	Argentine Peppercress					0.1	10																								
Brassicaceae	Raphanus raphanistrum	Wild Radish																			0.1	10										
Cactaceae	Hylocereus undatus	Night-blooming Cactus																														
Cactaceae	Opuntia stricta	Common Prickly Pear																													0.1	2
Capparaceae	Capsella bursa	Shepherd's Purse					0.1	10															0.1	10					0.1	1		
Caryophyllaceae	Cerastium vulgare	Mouse-ear Chickweed																			0.1	1	0.3	60	0.1	10	0.1	1	0.1	2		
Caryophyllaceae	Paronychia brasiliana	Chilean Whitlow Wort, Brazilian Whitlow					0.5	100																	0.1	3	0.1	3				
Caryophyllaceae	Polycarpon tetraphyllum	Four-leaved Allseed																									0.1	6				
Commelinaceae	Tradescantia fluminensis	Wandering Jew											35	300																		
Convolvulaceae	Ipomoea indica	Morning Glory							0.5	10																						
Crassulaceae	Bryophyllum delagoense	Mother of millions																													0.5	100
Cyperaceae	Cyperus brevifolius																															
Cyperaceae	Cyperus eragrostis	Umbrella Sedge			0.1	10			0.3	20			0.1	4							0.2	20										
Cyperaceae	Cyperus papyrus				0.1	20																										
Euphorbiaceae	Acalypha australis																															
Euphorbiaceae	Euphorbia peplus	Petty Spurge																														

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Soliva sessilis	Bindyi	0.1	50			1	200																								
Asteraceae	Sonchus oleraceus	Common Sowthistle	0.1	10	0.1	20	1	70	10	500	0.2	10	0.1	4	0.1	20	0.8	60			0.1	10	0.1	10	0.1	3	0.3	60	0.2	20	0.8	100
Asteraceae	Tagetes minuta	Stinking Roger																							0.6	20						
Asteraceae	Tanacetum parthenium	Feverfew	0.1	6																												
Asteraceae	Taraxacum officinale	Dandelion																											0.1	7	0.1	7
Basellaceae	Anredera cordifolia	Madeira Vine	2	10			0.4	1																								
Bignoniaceae	Jacaranda mimosifolia	Jacaranda					0.5	1																								
Boraginaceae	Heliotropium amplexicaule	Blue Heliotrope																														
Brassicaceae	Brassica fruticulosa	Twiggy Turnip	0.2	10			0.1	1									0.1	2														
Brassicaceae	Cardamine flexuosa	Wood Bittercress																														
Brassicaceae	Cardamine hirsuta	Common Bittercress																														
Brassicaceae	Lepidium africanum	Common Peppercress					0.1	10																			0.1	3				
Brassicaceae	Lepidium bonariense	Argentine Peppercress																														
Brassicaceae	Raphanus raphanistrum	Wild Radish																														
Cactaceae	Hylocereus undatus	Night-blooming Cactus	0.3	5																												
Cactaceae	Opuntia stricta	Common Prickly Pear																											0.2	9		
Capparaceae	Capsella bursa	Shepherd's Purse																							0.1	10						
Caryophyllaceae	Cerastium vulgare	Mouse-ear Chickweed	0.1	30			0.1	2									0.4	10			0.1	40							0.2	10		
Caryophyllaceae	Paronychia brasiliana	Chilean Whitlow Wort, Brazilian Whitlow					0.1	20																	0.1	10			0.1	1		
Caryophyllaceae	Polycarpon tetraphyllum	Four-leaved Allseed					0.1	1																	0.1	10						
Commelinaceae	Tradescantia fluminensis	Wandering Jew	3	60																					2	60						
Convolvulaceae	Ipomoea indica	Morning Glory																														
Crassulaceae	Bryophyllum delagoense	Mother of millions																														
Cyperaceae	Cyperus brevifolius																										0.1	10				
Cyperaceae	Cyperus eragrostis	Umbrella Sedge																													0.5	20
Cyperaceae	Cyperus papyrus																															
Euphorbiaceae	Acalypha australis		0.1	1																												
Euphorbiaceae	Euphorbia peplus	Petty Spurge	0.1	1																												

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Euphorbiaceae	Triadica sebifera	Chinese Tallowood																												
Fabaceae (Caesalpinioideae)	Senna pendula var. glabrata														0.6	3														
Fabaceae (Faboideae)	Lotus angustissimus	Slender Birds-foot Trefoil																			0.1	1	0.1	2	0.1	10			0.1	3		
Fabaceae (Faboideae)	Lotus subbiflorus	Hairy Birds-foot Trefoil					0.2	20																						
Fabaceae (Faboideae)	Medicago polymorpha	Burr Medic					0.1	10																					0.1	5		
Fabaceae (Faboideae)	Trifolium repens	White Clover					0.2	20															0.2	30								
Fabaceae (Faboideae)	Vicia sativa	Common vetch																							0.1	1						
Juncaceae	Juncus acutus subsp. acutus	Sharp Rush																												
Lamiaceae	Lamium amplexicaule	Dead Nettle																												
Lauraceae	Cinnamomum camphora	Camphor Laurel									0.1	1																		
Liliaceae	Lilium formosanum	Formosan Lily													0.1	2														
Malaceae	Crataegus monogyna	Hawthorn																												
Malvaceae	Malva neglecta	Dwarf Mallow					0.2	10															0.1	5						
Malvaceae	Modiola caroliniana	Red-flowered Mallow					0.5	40									0.1	2					0.1	3					0.1	10		
Malvaceae	Pavonia hastata										0.4	20																		
Malvaceae	Sida rhombifolia	Paddy's Lucerne			0.1	20	0.7	80	0.3	20	0.5	50	0.1	10	0.1	1	2	200			0.1	10	2	200	2	200	0.5	100	0.1	2	0.1	3
Ochnaceae	Ochna serrulata	Mickey Mouse Plant	0.3	4							0.1	1			2	10														
Oleaceae	Fraxinus excelsior	European ash																												
Oleaceae	Ligustrum lucidum	Large-leaved Privet			0.1	1							15	200							0.1	1								
Oleaceae	Ligustrum sinense	Small-leaved Privet			0.1	1			3	6			10	200	1	4														
Oleaceae	Olea europaea subsp. cuspidata	African Olive											3	3	0.1	1	0.1	1	0.1	1					2	8				
Onagraceae	Oenothera curtiflora	Clockweed																												
Oxalidaceae	Oxalis corniculata	Creeping Oxalis											0.2	4			0.1	10					0.2	30			0.1	7				
Oxalidaceae	Oxalis debilis var. corymbosa																								0.1	1						
Oxalidaceae	Oxalis latifolia																															

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Euphorbiaceae	Triadica sebifera	Chinese Tallowood					0.8	1	2	1																						
Fabaceae (Caesalpinioideae)	Senna pendula var. glabrata																															
Fabaceae (Faboideae)	Lotus angustissimus	Slender Birds-foot Trefoil											0.1	3							0.1	10					0.1	1	0.2	50	0.1	40
Fabaceae (Faboideae)	Lotus subbiflorus	Hairy Birds-foot Trefoil																														
Fabaceae (Faboideae)	Medicago polymorpha	Burr Medic	0.1	3			0.2	10															0.1	1							0.1	1
Fabaceae (Faboideae)	Trifolium repens	White Clover																			0.1	1							0.1	10		
Fabaceae (Faboideae)	Vicia sativa	Common vetch																			0.1	5					0.1	10				
Juncaceae	Juncus acutus subsp. acutus	Sharp Rush																			0.5	6										
Lamiaceae	Lamium amplexicaule	Dead Nettle					0.1	5																								
Lauraceae	Cinnamomum camphora	Camphor Laurel																	0.1	1												
Liliaceae	Lilium formosanum	Formosan Lily																														
Malaceae	Crataegus monogyna	Hawthorn							4	2																						
Malvaceae	Malva neglecta	Dwarf Mallow																							0.1	1						
Malvaceae	Modiola caroliniana	Red-flowered Mallow	0.1	2			0.1	2																	0.1	20	0.1	1			0.1	4
Malvaceae	Pavonia hastata																															
Malvaceae	Sida rhombifolia	Paddy's Lucerne	0.1	3			0.1	10					0.8	70	0.2	30	5	100							1	100	0.1	10	0.5	20	0.1	20
Ochnaceae	Ochna serrulata	Mickey Mouse Plant																														
Oleaceae	Fraxinus excelsior	European ash							3	2																						
Oleaceae	Ligustrum lucidum	Large-leaved Privet																														
Oleaceae	Ligustrum sinense	Small-leaved Privet																									25	100				
Oleaceae	Olea europaea subsp. cuspidata	African Olive					0.2	1					0.1	1									0.1	1					0.1	2		
Onagraceae	Oenothera curtiflora	Clockweed																													0.1	2
Oxalidaceae	Oxalis corniculata	Creeping Oxalis															0.2	20	0.1	10							0.1	2			1	100
Oxalidaceae	Oxalis debilis var. corymbosa																															
Oxalidaceae	Oxalis latifolia		0.3	1			0.1	10																								

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Passifloraceae	Passiflora suberosa	Cork Passionfruit													0.3	10																
Phytolaccaceae	Phytolacca octandra	Inkweed																	0.1	1	1	20										
Plantaginaceae	Plantago lanceolata	Lamb's Tongues					35	500	0.3	5					0.2	20	0.3	40					0.1	2			0.2	20	0.2	20	0.1	5
Poaceae	Aira caryophyllea	Silvery Hairgrass																					0.1	10								
Poaceae	Axonopus compressus	Broad																														
Poaceae	Briza subaristata																															
Poaceae	Bromus catharticus	Praire Grass			0.2	50	1	80	0.1	5			0.2	10																		
Poaceae	Cenchrus clandestinus	Kikuyu Grass			10	500	0.2	1	6	50																			1	30	0.2	10
Poaceae	Chloris gayana	Rhodes Grass					0.3	10									0.1	1											5	200		
Poaceae	Chloris virgata	Feathertop Rhodes Grass							4	70																						
Poaceae	Digitaria sanguinalis	Crab Grass																			0.5	30							0.5	20		
Poaceae	Echinochloa crus	Barnyard Grass																														
Poaceae	Ehrharta erecta	Panic Veldtgrass							10	200	6	400	0.8	70	3	80							0.5	50	0.2	50			0.2	20		
Poaceae	Ehrharta longiflora	Annual Veldtgrass									0.5	30																				
Poaceae	Eleusine indica	Crowsfoot Grass																					0.2	10			0.2	20				
Poaceae	Eleusine tristachya	Goose Grass																							0.1	10						
Poaceae	Eragrostis curvula	African Lovegrass	0.4	10	50	500									0.4	3			0.2	2	0.3	2							5	200	10	300
Poaceae	Eragrostis pilosa	Soft Lovegrass																											0.1	10		
Poaceae	Lolium multiflorum	Italian Ryegrass																							0.2	30			30	###		
Poaceae	Lolium perenne	Perennial Ryegrass					0.5	20																								
Poaceae	Megathyrsus maximus																															
Poaceae	Melinis repens	Red Natal Grass	0.2	20																												
Poaceae	Paspalum dilatatum	Paspalum					0.1	2	0.7	10							40	300			0.1	2	0.3	10			0.5	20	1	40	0.5	20
Poaceae	Paspalum urvillei	Vasey Grass																														
Poaceae	Setaria parviflora								0.5	30							0.5	50			5	200	0.5	30			0.1	5	0.5	30		
Poaceae	Sporobolus indicus	Parramatta Grass																					0.1	1			0.1	10				
Poaceae	Stenotaphrum secundatum	Buffalo Grass																														
Polygalaceae	Polygala paniculata		0.1	1																												
Polygonaceae	Acetosa sagittata	Rambling Dock			0.2	1							0.7	4																		

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Passifloraceae	Passiflora suberosa	Cork Passionfruit																												
Phytolaccaceae	Phytolacca octandra	Inkweed																											0.1	1
Plantaginaceae	Plantago lanceolata	Lamb's Tongues					0.1	10							0.3	30	0.5	30			0.2	40					0.1	2	0.2	10	1	80
Poaceae	Aira caryophyllea	Silvery Hairgrass																							0.1	10	0.2	50				
Poaceae	Axonopus compressus	Broad																											0.1	2		
Poaceae	Briza subaristata																												0.1	10		
Poaceae	Bromus catharticus	Praire Grass	0.2	40																											1	60
Poaceae	Cenchrus clandestinus	Kikuyu Grass					1	50							4	50											0.2	4	20	100		
Poaceae	Chloris gayana	Rhodes Grass							0.2	2					10	300											0.5	10	0.1	1		
Poaceae	Chloris virgata	Feathertop Rhodes Grass					5	200																			0.2	20				
Poaceae	Digitaria sanguinalis	Crab Grass																													0.5	60
Poaceae	Echinochloa crus	Barnyard Grass																													0.6	30
Poaceae	Ehrharta erecta	Panic Veldtgrass	40	500													4	200									0.1	10	0.1	10		
Poaceae	Ehrharta longiflora	Annual Veldtgrass																														
Poaceae	Eleusine indica	Crowsfoot Grass					3	100																								
Poaceae	Eleusine tristachya	Goose Grass																														
Poaceae	Eragrostis curvula	African Lovegrass			0.4	5	10	100							15	###			0.4	9			0.1	1			0.2	2			0.3	6
Poaceae	Eragrostis pilosa	Soft Lovegrass																														
Poaceae	Lolium multiflorum	Italian Ryegrass																														
Poaceae	Lolium perenne	Perennial Ryegrass																														
Poaceae	Megathyrsus maximus		0.1	1																												
Poaceae	Melinis repens	Red Natal Grass																													0.1	1
Poaceae	Paspalum dilatatum	Paspalum			0.2	10	0.5	30					0.5	20			1	30			10	300			0.5	40	4	80	15	300	0.2	20
Poaceae	Paspalum urvillei	Vasey Grass	0.5	6																							1	20			0.5	10
Poaceae	Setaria parviflora						0.5	20									7	300			0.5	60			0.5	40	2	200	10	200	55	###
Poaceae	Sporobolus indicus	Parramatta Grass					0.2	20																	0.2	3	0.1	1				
Poaceae	Stenotaphrum secundatum	Buffalo Grass																	0.1	3												
Polygalaceae	Polygala paniculata																															
Polygonaceae	Acetosa sagittata	Rambling Dock																														

Family	Scientific name	Common name	USCWF_01		USCWF_02		USCWF_03		USCWF_04		USCWF_05		USCWF_11		USCWF_13		USCWF_14		USCWF_16		USCWF_17		USCWF_18		USCWF_19		USCWF_20		USCWF_22		USCWF_23	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Polygonaceae	Rumex crispus	Curled Dock											0.3	20																		
Polygonaceae	Rumex obtusifolius	Broadleaf Dock							0.1	1											0.1	2	0.1	2								
Portulacaceae	Talinum paniculatum																															
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel																					0.1	10								
Rosaceae	Rubus fruticosus sp. agg.	Blackberry complex	0.1	1					0.3	1					0.1	2																
Rubiaceae	Galium aparine	Goosegrass																							0.1	2						
Rubiaceae	Richardia stellaris																															
Salviniaceae	Salvinia molesta																															
Sapindaceae	Cardiospermum grandiflorum	Balloon Vine									2	4	55	100																		
Scrophulariaceae	Verbascum virgatum	Twiggy Mullein																									0.5	40				
Solanaceae	Cestrum parqui	Green Cestrum																					2	6								
Solanaceae	Lycium ferocissimum	African Boxthorn																							0.1	4	1	6				
Solanaceae	Solanum mauritianum	Wild Tobacco Bush											1	30																		
Solanaceae	Solanum nigrum	Black-berry Nightshade			0.1	20	0.1	1	0.3	6	0.1	1	2	50	0.1	5	0.1	3	0.1	3	1	20	0.3	20	0.1	5	0.1	1	0.1	2		
Solanaceae	Solanum pseudocapsicum	Madeira Winter Cherry																														
Solanaceae	Solanum seaforthianum	Climbing Nightshade											0.1	2	0.1	2																
Solanaceae	Solanum sisymbriifolium						1	10					0.2	3					0.1	4			1	10	0.4	6	0.8	10	0.1	2	0.1	1
Ulmaceae	Celtis occidentalis	Hackberry											0.2	2																		
Ulmaceae	Ulmus parvifolia	Chinese Elm											0.1	2																		
Verbenaceae	Lantana camara	Lantana	3	10							2	20	50	100											0.3	3						
Verbenaceae	Verbena bonariensis	Purpletop			0.1	30			0.4	30							0.1	1					0.2	30	0.1	4			0.1	2		
Verbenaceae	Verbena caracasana	Shore Verbain																														
Verbenaceae	Verbena hispida	Rough Verbena															0.1	5														
Violaceae	Viola odorata	Sweet Violet																														

Family	Scientific name	Common name	USCWF_24		USCWF_25		USCWF_26		USCWF_27		USCWF_29		USCWF_31		USCWF_32		USCWF_33		USCWF_36		USCWF_38		USCWF_39		USCWF_40		USCWF_41		USCWF_42		USCWF_43	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Polygonaceae	Rumex crispus	Curled Dock																														
Polygonaceae	Rumex obtusifolius	Broadleaf Dock									0.1	2									0.2	10									0.7	30
Portulacaceae	Talinum paniculatum		0.1	2																												
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel																			0.1	30					0.1	20			0.1	30
Rosaceae	Rubus fruticosus sp. agg.	Blackberry complex							0.4	2																	0.2	10				
Rubiaceae	Galium aparine	Goosegrass															0.1	1														
Rubiaceae	Richardia stellaris						0.1	4																					0.1	10		
Salviniaceae	Salvinia molesta										75	###																				
Sapindaceae	Cardiospermum grandiflorum	Balloon Vine															0.5	1														
Scrophulariaceae	Verbascum virgatum	Twiggy Mullein																														
Solanaceae	Cestrum parqui	Green Cestrum																									7	50				
Solanaceae	Lycium ferocissimum	African Boxthorn													0.9	4	1	7														
Solanaceae	Solanum mauritianum	Wild Tobacco Bush																														
Solanaceae	Solanum nigrum	Black-berry Nightshade	0.3	20			0.1	1					0.1	1			0.5	4			0.1	6			0.2	5			0.1	2		
Solanaceae	Solanum pseudocapsicum	Madeira Winter Cherry																									0.2	4				
Solanaceae	Solanum seaforthianum	Climbing Nightshade																														
Solanaceae	Solanum sisymbriifolium				0.1	4			1	20					0.3	6	0.3	2			0.1	1	0.1	4	1	20	0.1	5	0.1	10	0.2	5
Ulmaceae	Celtis occidentalis	Hackberry																														
Ulmaceae	Ulmus parvifolia	Chinese Elm																														
Verbenaceae	Lantana camara	Lantana																	2	6												
Verbenaceae	Verbena bonariensis	Purpletop													0.2	10					0.1	10					0.2	20			0.1	10
Verbenaceae	Verbena caracasana	Shore Verbain																			0.2	2					0.1	10				
Verbenaceae	Verbena hispida	Rough Verbena																													0.1	10
Violaceae	Viola odorata	Sweet Violet	0.2	20																												

Plot ID	PCT	Area (Ha)	Patch size	Condition	Zone	Easting	Northing	Bearing	Comp. Tree	Comp. Shrub	Comp. Grass	Comp. Forbs	Comp. Ferns	Comp. Other	Struc. Tree	Struc. Shrub	Struc. Grass	Struc. Forbs	Struc. Ferns	Struc. Other
USCWF_17	724	0.4	101	Intact	56	294840	6249306	164	3	4	12	16	1	3	12.0	48.3	52.4	5.3	0.5	0.4
USCWF_23	724	1.14	101	Thinned	56	284971.2	6249572	100	1	4	6	18	1	4	80.0	7.3	66.1	2.5	0.1	0.5
USCWF_27	724	1.14	101	Thinned	56	294587.8	6249801	114	4	1	0	1	0	0	16.4	4.0	0.0	0.4	0.0	0.0
USCWF_42	724	0.04	101	Scattered_trees	56	292763.9	6249592	240	1	1	9	9	1	3	20.0	0.5	2.4	3.0	0.1	0.4
USCWF_29	781	0.02	101	Thinned	56	282120.5	6250100	270	0	0	2	0	0	0	0.0	0.0	15.5	0.0	0.0	0.0
USCWF_05	835	0.58	101	Intact	56	312172.9	6247871	120	3	6	5	5	1	6	36.0	64.5	12.8	1.9	0.1	1.8
USCWF_18	835	3.23	101	Thinned	56	294265.5	6249949	332	3	1	5	12	0	3	23.1	6.0	75.5	5.4	0.0	0.3
USCWF_31	835	3.23	101	Thinned	56	299543.5	6247490	112	6	4	5	4	0	3	66.0	5.9	44.3	0.7	0.0	1.4
USCWF_04	835	3.23	101	Thinned	56	303630.2	6247011	21	2	4	7	7	0	3	85.0	10.5	2.8	1.5	0.0	0.6
USCWF_20	835	0.75	101	Scattered_trees	56	288958.5	6250077	90	1	1	8	9	0	2	45.0	0.4	72.1	1.4	0.0	0.2
USCWF_13	849	0.93	101	Intact	56	312508.2	6247876	221	4	3	9	8	0	4	63.1	47.3	21.9	16.2	0.0	1.6
USCWF_32	849	2.68	101	Thinned	56	285315.4	6249522	85	1	2	2	6	0	1	15.0	1.5	1.5	0.8	0.0	0.1
USCWF_14	849	2.68	101	Thinned	56	299207.9	6247704	93	2	2	7	10	0	3	30.1	2.1	70.8	2.8	0.0	0.6
USCWF_22	849	1.22	101	Scattered_trees	56	285539	6249494	85	2	1	4	5	0	1	20.0	0.1	2.8	1.1	0.0	0.1
USCWF_03	849	1.22	101	Scattered_trees	56	290092.2	6249935	280	2	0	5	9	0	2	14.0	0.0	11.1	3.1	0.0	1.2
USCWF_01	1083	1.38	101	Thinned	56	278216.2	6248596	37	7	6	8	1	1	4	34.0	3.6	3.0	0.5	0.1	0.8
USCWF_11	1105	0.4	101	Thinned	56	281452.6	6250220	200	2	0	2	4	0	0	13.0	0.0	0.4	0.6	0.0	0.0
USCWF_36	1181	0.07	101	Intact	56	280776.6	6248750	108	2	12	11	10	1	4	20.8	8.1	3.4	1.7	0.8	0.5
USCWF_19	1800	0.7	101	Thinned	56	289219.5	6250006	5	1	2	5	8	0	5	75.0	0.4	20.9	3.8	0.0	0.8
USCWF_38	1800	0.22	101	Scattered_trees	56	294175.8	6252018	268	1	0	2	2	0	0	15.0	0.0	70.3	0.6	0.0	0.0

Plot ID	PCT	Area (Ha)	Patch size	Condition	Zone	Easting	Northing	Bearing	Fun. Large Trees	Fun. Hollow Trees	Fun. Litter Cover	Fun. Len. Fallen Logs	Fun. Tree Stem 5to9	Fun. Tree Stem 10to19	Fun. Tree Stem 20to29	Fun. Tree Stem 30to49	Fun. Tree Stem 50to79	Fun. Tree Regen	Fun. High Threat Exotic
USCWF_17	724	0.4	101	Intact	56	294840	6249306	164	1	0	69.0	156.0	1	1	1	1	0	0	1.7
USCWF_23	724	1.14	101	Thinned	56	284971.2	6249572	100	3	0	8.0	0.0	0	1	1	1	0	0	11.3
USCWF_27	724	1.14	101	Thinned	56	294587.8	6249801	114	0	0	6.0	16.0	1	1	1	1	0	0	6.5
USCWF_42	724	0.04	101	Scattered_trees	56	292763.9	6249592	240	4	0	9.0	0.0	0	0	0	1	0	0	35.4
USCWF_29	781	0.02	101	Thinned	56	282120.5	6250100	270	0	0	46.0	0.0	0	0	0	0	0	0	75.0
USCWF_05	835	0.58	101	Intact	56	312172.9	6247871	120	3	0	74.0	26.0	1	1	1	1	0	0	10.8
USCWF_18	835	3.23	101	Thinned	56	294265.5	6249949	332	0	0	19.0	22.0	1	1	1	1	0	0	2.8
USCWF_31	835	3.23	101	Thinned	56	299543.5	6247490	112	0	0	66.0	0.0	0	1	1	1	0	0	0.6
USCWF_04	835	3.23	101	Thinned	56	303630.2	6247011	21	2	0	62.0	8.0	1	1	1	1	0	1	22.3
USCWF_20	835	0.75	101	Scattered_trees	56	288958.5	6250077	90	0	0	72.0	7.0	0	0	1	1	0	0	1.5
USCWF_13	849	0.93	101	Intact	56	312508.2	6247876	221	1	0	46.0	14.0	1	1	1	1	0	0	8.2
USCWF_32	849	2.68	101	Thinned	56	285315.4	6249522	85	0	0	10.0	1.0	1	0	1	1	0	1	30.6
USCWF_14	849	2.68	101	Thinned	56	299207.9	6247704	93	0	0	17.0	0.0	1	1	1	1	0	0	40.2
USCWF_22	849	1.22	101	Scattered_trees	56	285539	6249494	85	4	0	14.0	0.0	0	1	1	1	0	0	12.3
USCWF_03	849	1.22	101	Scattered_trees	56	290092.2	6249935	280	2	0	5.0	0.0	0	0	0	0	0	0	0.6
USCWF_01	1083	1.38	101	Thinned	56	278216.2	6248596	37	0	0	62.0	5.0	1	1	1	1	0	1	4.7
USCWF_11	1105	0.4	101	Thinned	56	281452.6	6250220	200	0	0	43.0	2.0	1	1	1	0	0	1	167.0
USCWF_36	1181	0.07	101	Intact	56	280776.6	6248750	108	0	0	64.0	14.0	1	1	1	1	0	0	2.6
USCWF_19	1800	0.7	101	Thinned	56	289219.5	6250006	5	0	0	9.0	5.0	1	1	1	1	0	0	0.8
USCWF_38	1800	0.22	101	Scattered_trees	56	294175.8	6252018	268	0	0	16.0	0.0	0	1	1	0	0	0	10.1

Appendix 4 Fauna

Table A. 3 Fauna species recorded in the study area

Class	Common name	Scientific name	Observation type	BC Act	EPBC Act
Amphibian	Broad-palmed frog	*Litoria latopalmata*	O		
Amphibian	Brown-striped Marsh Frog	*Limnodynastes peroni*	OW		
Amphibian	Common Eastern Froglet	*Crinia signifera*	OW		
Amphibian	Peron's Tree Frog	*Litoria peroni*	W		
Aves	Australian Hobby	*Falco longipennis*	O		
Aves	Australian King-Parrot	*Alisterus scapularis*	O		
Aves	Australian Magpie	*Cracticus tibicen*	W		
Aves	Australian Pelican	*Pelecanus conspicillatus*	O		
Aves	Australian Pipit	*Anthus novaeseelandiae*	O		
Aves	Australian Raven	*Corvus coronoides*	O		
Aves	Australian White Ibis	*Threskiornis molucca*	O		
Aves	Australian Wood Duck	*Chenonetta jubata*	O		
Aves	Bell Miner	*Manorina melanophrys*	O		
Aves	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O		
Aves	Black-shouldered Kite	*Elanus axillaris*	O		
Aves	Cattle Egret	*Ardea ibis*	O		
Aves	Common Myna	*Sturnus tristis*	O		
Aves	Common Starling	*Sturnus vulgaris*	O		
Aves	Crested Pigeon	*Ocyphaps lophotes*	O		
Aves	Crimson/Eastern Rosella	*Platycercus elegans elegans x adscitus eximius*	O		
Aves	Dusky Moorhen	*Gallinula tenebrosa*	O		

Class	Common name	Scientific name	Observation type	BC Act	EPBC Act
Aves	Eastern Great Egret	*Ardea modesta*	O		
Aves	Eastern Rosella	*Platycercus eximius*	O		
Aves	Eastern Whipbird	*Psophodes olivaceus*	W		
Aves	Eastern Yellow Robin	*Eopsaltria australis*	OW		
Aves	Eurasian Coot	*Fulica atra*	O		
Aves	Galah/Pink Cockatoo	*Cacatua Hybrid*	O		
Aves	Golden Whistler	*Pachycephala pectoralis*	O		
Aves	Golden-headed Cisticola	*Cisticola exilis*	O		
Aves	Grey Butcherbird	*Cracticus torquatus*	O		
Aves	Grey Fantail	*Rhipidura albiscapa*	O		
Aves	Hardhead	*Aythya australis*	O		
Aves	Laughing Kookaburra	*Dacelo novaeguineae*	O		
Aves	Little Black Cormorant	*Phalacrocorax sulcirostris*	O		
Aves	Little Corella	*Cacatua sanguinea*	O		
Aves	Little Friarbird	*Philemon citreogularis*	O		
Aves	Magpie-lark	*Grallina cyanoleuca*	O		
Aves	Masked Lapwing	*Vanellus miles*	O		
Aves	Masked Woodswallow	*Artamus personatus*	O		
Aves	Noisy Miner	*Manorina melanocephala*	O		
Aves	Pied Butcherbird	*Cracticus nigrogularis*	O		
Aves	Pied Cormorant	*Phalacrocorax varius*	O		
Aves	Pied Currawong	*Strepera graculina*	O		
Aves	Purple Swamphen	*Porphyrio porphyrio*	O		
Aves	Rainbow Bee-eater	*Merops ornatus*	O		

Class	Common name	Scientific name	Observation type	BC Act	EPBC Act
Aves	Rainbow Lorikeet	*Trichoglossus haematodus*	O		
Aves	Red Wattlebird	*Anthochaera carunculata*	OW		
Aves	Red-browed Finch	*Neochmia temporalis*	O		
Aves	Red-rumped Parrot	*Psephotus haematonotus*	O		
Aves	Royal Spoonbill	*Platalea regia*	O		
Aves	Rufous Whistler	*Pachycephala rufiventris*	O		
Aves	Satin Bowerbird	*Ptilonorhynchus violaceus*	W		
Aves	Silvereye	*Zosterops lateralis*	O		
Aves	Spotted Pardalote	*Pardalotus punctatus*	W		
Aves	Square-tailed Kite	*Lophoictinia isura*	O		V
Aves	Sulphur-crested Cockatoo	*Cacatua galerita*	O		
Aves	Superb Fairy-wren	*Malurus cyaneus*	OW		
Aves	Tawny Frogmouth	*Podargus strigoides*	H		
Aves	Wedge-tailed Eagle	*Aquila audax*	O		
Aves	Welcome Swallow	*Hirundo neoxena*	O		
Aves	Whistling Kite	*Haliastur sphenurus*	O		
Aves	White-bellied Sea Eagle	*Haliaeetus leucogaster*	O		V
Aves	White-browed Scrubwren	*Sericornis frontalis*	O		
Aves	White-faced Heron	*Egretta novaehollandiae*	O		
Aves	White-throated Treecreeper	*Cormobates leucophaea*	OW		
Aves	White-winged Chough	*Corcorax melanorhamphos*	O		
Aves	Willie Wagtail	*Rhipidura leucophrys*	O		
Aves	Wonga Pigeon	*Leucosarcia melanoleuca*	O		
Aves	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	O		

Class	Common name	Scientific name	Observation type	BC Act	EPBC Act
Aves	Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	O		
Gastropoda	Cumberland Plain Land Snail	*Meridolum corneovirens*	O		E
Mammalia	Brown Quail	*Coturnix ypsilophora*	O		
Mammalia	Cat	*Felis catus*	Q		
Mammalia	Chocolate Wattled Bat	*Chalinolobus morio*	U		
Mammalia	East-coast Freetail Bat	*Micronomus norfolkensis*	U		
Mammalia	Eastern Broad-nosed Bat	*Scotorepens orion*	U		
Mammalia	Eastern Falsistrelle	*Falsistrellus tasmaniensis*	U		
Mammalia	Eastern Grey Kangaroo	*Macropus giganteus*	O		
Mammalia	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*	U		
Mammalia	Fox	*Vulpes vulpes*	Q		
Mammalia	Golden-tipped Bat	*Phoniscus papuensis*	U		
Mammalia	Gould's Wattled Bat	*Chalinolobus goldii*	U		
Mammalia	Greater Broad-nosed Bat	*Scoteanax rueppellii*	U		
Mammalia	Grey-headed Flying-fox	*Pteropus poliocephalus*	OW	Vu	V
Mammalia	Large Bent-winged Bat	*Miniopterus orianae oceanensis*	U		V
Mammalia	Large Forest Bat	*Vespeadelus darlingtoni*	U		
Mammalia	Large-eared Pied Bat	*Chalinolobus dwyeri*	U	Vu	V
Mammalia	Little Bent-winged Bat	*Miniopterus australis*	U		V
Mammalia	Little Forest Bat	*Vespeadelus vulturnus*	U		
Mammalia	Long-eared Bat	*Nyctophilus* sp.	U		
Mammalia	Swamp Wallaby	*Wallabia bicolor*	O		
Mammalia	White-striped Freetail Bat	*Austronomus australis*	U		
Reptile	Dark-flecked Garden Sunskink	*Lampropholis delicata*	O		

Class	Common name	Scientific name	Observation type	BC Act	EPBC Act
Reptile	Red-bellied Black Snake	*Pseudechis porphyriacus*	O		

Observation type key

O – Observed
U – Ultrasonic
OW – Observed and heard call.
Q – Camera
H – Hair, feathers or skin.

Appendix 5 Serious and Irreversible Impact assessments

SAII assessment for Cumberland Plain Woodland

The *Cumberland Plain Woodland in the Sydney Basin Bioregion* (PCT 849) is listed under the NSW BC Act as a Critically Endangered Ecological Community. The CEEC is listed in the BioNet Threatened Biodiversity Data Collection (TBDC) as an entity subject to SAII in NSW. The CEEC is considered an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 1: an ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline.
- Principle 2: an ecological community that is observed, inferred or reasonably suspected to be severely degraded or disturbed.

Given the absence of definitive impact thresholds stated for the community, the potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Table A.4 Assessment of SAII for Cumberland Plain Woodland TEC

Information required (BAM Section 9.1.1)	Response
1. Impacts to the CEEC and the action and measures taken to avoid the direct and indirect impact on the CEEC at risk of an SAII.	The project will impact upon a total of approximately 5.35 ha of PCT 849 vegetation that meets the BC Act listing requirements for Cumberland Plain Woodland CEEC. However of this 5.35 ha, 0.98 ha occurs on Existing Certified land in Kemps Creek, and as such is not subject to this assessment. Thus the total area of Cumberland Plain Woodland impacted by the project, and subject to this assessment, comprises approximately 4.37 ha (Figure 16). The vegetation to be removed occurs in the following conditions: • Intact: 0.93 hectares – VI score of 60.5. • Thinned: 2.46 hectares – VI score of 37.9. • Scattered trees: 0.98 hectares – VI score of 24.9. Measures undertaken by the proponent to avoid and minimise impacts to the CEEC (PCT 849) are provided in Section 10 of this BDAR. Specifically, substantial efforts have been made to ensure that impacts to Cumberland Plain Woodland have been avoided and minimised throughout the design phase of the project. Throughout the three major design stages of the project (50 %, 80 % and 100 % designs) ecological constraints information was developed and used to influence alignment design options, construction options, and avoidance opportunities. Ecological constraints were developed over time based on the level of ground-truthing that had been undertaken during each subsequent project design stage. Initial constraints were high level and based on existing vegetation mapping which were refined by rapid assessments to confirm PCTs and TECs, and then further developed by detailed BAM surveys to provide accurate data on vegetation (including TEC) type, extent and condition. Opportunities to avoid impacts to Cumberland Plain Woodland were a key focus at each stage of the project design, due to a desire to minimise impacts to the CEEC, minimise the potential need to refer the project to the Commonwealth, and to minimise the cost of offsets. Avoidance and minimisation of impacts were achieved at two broad scales, macro-scale avoidance achieved through alignment changes, and micro-scale avoidance achieved through measures such as minimisation of impact corridor widths, underbores, and placing open trenching in the roadway (rather than the road verge). An example of macro-scale avoidance to Cumberland Plain Woodland has been achieved at the Lansdowne Reserve Stewardship Site, where early design stages required pipe-stringing for underboring of Henry Lawson Drive and Prospect Creek, as well as open trenching between the two

Information required (BAM Section 9.1.1)	Response
	underbores, all of which would have impacted upon the TEC. This design would have resulted in impact to approximately 1.6 ha more Cumberland Plain Woodland than is impacted by the current project design. Commitments made in the development of the project design that have further minimised impacts to Cumberland Plain Woodland include: • Minimising the width of the impact area with in Western Sydney Parklands and at Cosgrove Creek. • Locating the underbore at Badgerys Creek to avoid adjacent vegetation. • Locating the open trenching within the roadway for 1.7 kilometres of Park Road, Wallacia.
2a. Evidence of reduction in geographic distribution, as the current total geographic extent of the TEC in NSW and the estimated reduction in geographic extent of the TEC since 1970 (not including impacts of the proposal). (SAII Principle 1)	Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018). To be considered under this principle, the ecological community should have been observed, estimated, inferred, or reasonably suspected to have undergone, or be projected to undergo, a very large reduction in distribution, being: • ≥80% reduction where the reduction is over a 50-year period (i.e. since 1970), either in the past, future, or any part of the past, present and future (DPIE 2019). Prior to European settlement, Cumberland Plain Woodland was extensive across the Western Sydney area, and is estimated to have covered approximately 125,446 ha (DEC 2005, NPWS 2004). Whilst formerly extensive, the community now mostly occurs as small patches within the Cumberland IBRA subregion, with some occurrences extending into neighboring subregions. It is known to occur within the following LGAs: Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly (Commonwealth of Australia 2010). Whilst there is no guidance as to the proportion of geographic distribution reduction that has occurred over the last 50 years (i.e. since 1970), the fact that the CEEC is noted in the SAII guidance document (DPIE 2019) as being subject to Principle 1, infers that it has occurred in recent times, and therefore at a rapid rate. According to *Remnant vegetation of the western Cumberland subregion, 2013 Update VIS_ID 4207* (DPIE 2015a), and *The Native Vegetation of the Sydney Metropolitan Area* (DPIE 2016a) and *Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands* (Tozer et al. 2010), the current extent of Cumberland Plain Woodland (PCT 849 and PCT 850) within NSW is approximately 22,774 ha. This is a total reduction of approximately 82 % of the geographic distribution.
2b. Extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes. (SAII Principle 2)	Reduction in ecological function relates to the IUCN principle of "very small population size" which for ecological communities means communities have very high levels of either environmental degradation or disruption of biotic processes, and interactions have an increased risk of failure to sustain their characteristic native species assemblages (Bland et al. 2016). Ecological communities that are considered to have a very large degree of environmental degradation or disruption of biotic processes or interactions are those with: • ≥90% extent and severity where the disruption or impacts are measured since 1970.

Information required (BAM Section 9.1.1)	Response
	• ≥80% extent and severity where the disruption or impacts are over a 50-year period, either in the past, future, or any part of the past, present and future (as per (Bland et al. 2016). (DPIE 2019). **i. change in community structure, ii. change in species composition and iii. disruption of ecological processes** The initial reduction in Cumberland Plain Woodland was due to tree-felling for timber and clearing for crops and pastures. This decline has accelerated since World War II, where there was a marked acceleration in urban and industrial development in the region, which continues to present day. Now, almost all of the remaining areas of the community are either regrowth forest or degraded woodland impacted by past clearing activities (OEH 2019). The final determination for Cumberland Plain Woodland notes that changes in community structure contribute to a very large reduction in the overall ecological functioning of Cumberland Plain Woodland (OEH 2019). Large trees that were once common prior to European settlement now occur very sparsely within the remaining patches of woodland, or remain as isolated individuals within paddocks or urban areas. Loss of these large trees has contributed to the decline and extinctions in native bird and mammal species, once common throughout the Cumberland Plain., and the associated ecological processes they once supported Other structural changes include the removal of fallen woody debris and standing dead trees, removal of woody understorey plants. (OEH 2019). Changes in species composition over time have occurred a result of clearing vegetation for agricultural process and the selective retention of trees. The proportion of native and characteristic understorey grasses, forbs, shrubs etc. now present within the TEC as a whole has been reduced by this process, which has been further exacerbated by the invasion of understorey weed species. **iv. invasion and establishment of exotic species, v. degradation of habitat, and vi. fragmentation of habitat.** Invasion of remnant woodland by exotic species poses a major threat to Cumberland Plain Woodland, with very large numbers of weed species invading many different areas of the community. These species degrade the community through smothering of indigenous plants, reducing both reproduction and survival, and by inhibiting the emergence and establishment of new seedlings (OEH 2019). These exotic weed species are now rapidly changing the structure and composition of Cumberland Plain Woodland remnants and pose a major problem for management (Benson & Howell 2002). Fragmentation has also resulted in a very large reduction in the ecological function of Cumberland Plain Woodland, with the remaining areas of the community being severely fragmented. The final determination for the community states that more than half of the remaining tree cover mapped by Tozer (2003) occurs in patches of less than 80 ha, with half of all mapped patches being smaller than 3 ha (OEH 2019). Whilst there is no guidance as to the proportion of this degradation has occurred in the last 50 years (i.e. since 1970), the fact that the EEC is noted in the SAII guidance document (DPIE 2019) as being subject to Principle 2, infers that it has occurred in recent times.
2c. Evidence of restricted geographic distribution, based on the TEC's geographic range in NSW.	The geographic distribution of ecological communities is defined by the area of occupancy, sensu (Bland et al. 2016). Ecological communities with a very limited geographic distribution have an area of occupancy of less than or equal to two 10 x 10 km grid cells (200 km2) or an extent of occurrence of ≤1,000 km2, sensu (Bland et al. 2016), and one of the following: • An observed or inferred continuing decline in:

Information required (BAM Section 9.1.1)	Response
(SAII Principle 3)	○ A measure of spatial extent appropriate to the ecological community. ○ A measure of environmental quality appropriate to characteristic biota of the ecological community. ○ A measure of disruption to biotic interactions appropriate to the characteristic biota of the ecological community. • Observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years. • An ecological community that exists at one location (DPIE 2019). **i. extent of occurrence, ii. area of occurrence and iii. Number of threat-define locations** According to the final determination for the CEEC, Cumberland Plain Woodland is estimated to occur within an extent of occurrence of 2,810 km2 and an area of occupancy of just under 2,100 km2 based on 2 x 2 km grid cells (OEH 2019). There are no specific threat defined locations listed in the TBDC for the community. However, whilst the community is represented within conservation reserves, much of the remaining area occurs on private land or public easements, putting it at risk from small-scale clearing associated with housing, industrial development and transport infrastructure. Given the low area of occupancy and the facts that land-clearing is likely to remain a threatening process contributing to the decline of this community over the next twenty years, the CEEC can be considered a highly geographically restricted community. Based on the available information the CEEC does not currently meet the thresholds for consideration under SAII Principle 3.
2d. Evidence that the TEC is unlikely to respond to management. (SAII Principle 4)	This principle encompasses two components, firstly whether there are any particular traits of the community which limits its' response to management, and secondly whether there are any key threatening processes affecting the community which cannot be effectively managed (DPIE 2019). Conservation management of the community in areas subjected to historical clearing and agricultural grazing has resulted in some measurable recovery, provided the soil has not been disturbed by earthworks, cultivation, fertiliser application or other means of nutrient of moisture enrichment (OEH 2019). Conversely in areas that have been exposed to these soil disturbances, restoration has been proven to be problematic, with one abandoned pasture planting site showing no evidence of convergence in species composition with nearby remnant woodland stands over a 10 year period (OEH 2019). However, several management measures are detailed within the TBDC for this community. These include: • Community and land-holder liaison/ awareness and/or education. • Habitat management: Fire. • Habitat management: Ongoing EIA - Advice to consent and planning authorities. • Habitat management: Promote regeneration by avoiding mowing or prolonged or heavy grazing. • Habitat management: Protect habitat by controlling run-off entering the site if it would change water, nutrient or sediment levels or cause erosion. • Habitat management: Weed Control. • Habitat Rehabilitation/Restoration and/or Regeneration. Generally those entities which are listed as unlikely to respond to management (and thus

Information required (BAM Section 9.1.1)	Response
	are irreplaceable) tend to include species where the ability to control key threats is negligible and known reproductive characteristics that severely limit their ability to increase the existing population (DPIE 2019). Ecological communities as a whole do not typically align well with these criteria. The response to management practices of Cumberland Plain Woodland has been demonstrated to be based on site specific conditions and therefore it is does not meet SAII Principle 4.
3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a TEC, the assessor must record this in the BDAR or BCAR.	Not applicable.
4a. The impact on the geographic extent of the TEC, by estimating the total area of the TEC to be impacted by the proposal.	As discussed above, the current extent of Cumberland Plain Woodland within NSW is approximately 22,774 ha. The CEEC is known to occur as small patches within the Cumberland IBRA subregion, with some occurrences extending into neighboring subregions. It is known to occur within the following LGAs: Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly (OEH 2019, Commonwealth of Australia 2010). **Direct impacts** The proposed development will result in the removal of approximately 4.37 ha of the CEEC from non-certified areas within the impact area. As such the total area of the CEEC to be impacted by the project equates to 0.02 % of the CEEC within NSW. The vegetation occurs in the following conditions: • Intact: 0.93 hectares – VI score of 60.5. • Thinned: 2.46 hectares – VI score of 37.9. • Scattered trees: 0.98 hectares – VI score of 24.9. The structure of these patches ranges from patches of woodland with full structural integrity across all stratum (intact condition), down to patches of scattered native trees where the middle stratum has been completely removed and there is a low level of native species in the understorey. These areas occur predominantly as roadside vegetation patches and scattered trees. However, several large patches of thinned vegetation do occur to the south of the Liverpool Offtake Reservoir in Kemps Creek, and intact vegetation occurs at the eastern end of the alignment adjacent to Boggabilla Reserve (near the intersection of Hume Highway and Henry Lawson Drive). **Indirect impacts** Indirect impacts to Cumberland Plain Woodland associated with factors such as increased edge effects, fragmentation, altered fire regimes, and transport of weeds and pathogens are not expected to be substantial or significant, largely due to the already degraded and edge effected nature of the TEC within the impact area and broader vicinity. Impacts associated with altered hydrological patterns as a result of increased water in the Nepean River system have the potential to impact upon Cumberland Plain Woodland where it occur in relatively close proximity to the river, however this is not expected to be a substantial level of impact. Where Cumberland Plain Woodland occurs within the impact assessment area (and outside Existing Certified land), and therefore most likely to suffer indirect impacts associated with

Information required (BAM Section 9.1.1)	Response
	construction and operational activities, the TEC occurs in the following condition: • Intact: 0.95 hectares – VI score of 60.5. • Thinned: 8.99 hectares – VI score of 37.9. • Scattered trees: 2.13 hectares – VI score of 24.9
4b. The extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes of the TEC.	**i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500m of the development footprint or equivalent area for other types of proposals.** Cumberland Plain Woodland present in the wider landscape surrounding the project area occurs in an already highly fragmented state. GIS was used to determine the range and average size of mapped (OEH 2013, OEH 2016, Biosis 2021) occurrences of Cumberland Plain Woodland within a 500 m buffer of the impact area along the 35 km alignment. The results of which are provided below both for those patches intersected by the impact area (i.e. subject to vegetation removal) and those patches not intersected by the impact area (i.e. not directly impact by the project). **Mapped areas within 500m not directly impacted:** • Size range: <0.001ha to 67 ha • Average size: 1.31 ha • Total no. mapped polygons: 314 **Mapped areas within 500m directly impacted:** • Size range: <0.001ha to 115 ha • Average size: 1.44 ha • Total no. mapped polygons: 167 **ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by:** • **distance between isolated areas of the TEC, presented as the average** • **distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and** • **estimated maximum dispersal distance for native flora species characteristic of the TEC, and** • **other information relevant to describing the impact on connectivity and fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development** GIS was used to undertake a nearest neighbour analysis of mapped (OEH 2013, OEH 2016, Biosis 2021) occurrences of Cumberland Plain Woodland prior to and post vegetation to determine the distance between impacted areas of the CEEC before and after the proposed vegetating removal. The average distance between mapped occurrences of Cumberland Plain Woodland within a 500 m buffer of the impact area, include: • 41.7 m before development • 46.1 m after development. Based on the above there will be an average increase of 5 m separation between retained patches of Cumberland Plain Woodland within 500 m of the impact area, with a maximum increase in separation distance of up to 20 m. Native flora species characteristic of the TEC include a range trees, shrubs, grasses, forbs and other groundcover species, the majority of which are dispersed via wind or animal vectors, with some species primary method of dispersal likely to be via non-flying insects such as ants. The increase in average separation distance by 5 m for mapped Cumberland

Information required (BAM Section 9.1.1)	Response

	Plain Woodland within 500 m of the impact area, with a maximum increase of up to 20 m, is not expected to result in a significant or substantial impediment to the dispersal of native species between retained patches, in an already highly fragmented landscape.
	Furthermore the project will not result in the creation of barrier to movement across the pipeline corridor post-construction and revegetation work will help promote connectivity across the future easement.
	It is noted in EPBC Act conservation advice documents that allowances can be made for "breaks" of up to 30 metres between areas of MNES habitat, and that such breaks, which may be the result of watercourses, tracks, paths, roads, etc., do not significantly alter the overall functionality of the ecological community, or habitat (CoA 2020). As such, breaks in connectivity caused by the future pipeline easement, of up to 20 m are not considered to be substantial in nature.
	The project will result in some vegetation removal that splits patches of Cumberland Plain Woodland vegetation into two (or more) patches, which is likely to increase the area to perimeter ratio for smaller patches, which may in turn increase edge effects for those smaller, now isolated patches. However any increase in edge effects is unlikely to be significant or substantial to the vegetation immediately adjacent to the impact area, along the majority of the project alignment, due to the already disturbed and edge effected nature of the vegetation.
	iii. describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3). The assessor must also include the relevant composition, structure and function condition scores for each vegetation zone.
	The TEC occurs in three conditions within the subject land:
	• Intact:
	  ○ Composition condition score: 70.4
	  ○ Structure condition score: 68.7
	  ○ Function condition score: 45.8
	  ○ Presence of hollow-bearing trees: No
	  ○ VI score: 60.5
	• Thinned:
	  ○ Composition condition score: 38.8
	  ○ Structure condition score: 48.1
	  ○ Function condition score: 29.1
	  ○ Presence of hollow-bearing trees: No
	  ○ VI score: 37.9
	• Scattered trees:
	  ○ Composition condition score: 32.5
	  ○ Structure condition score: 11.0
	  ○ Function condition score: 42.9
	  ○ Presence of hollow-bearing trees: No
	  ○ VI score: 24.9
	The proposed works will result in the removal of 4.37 ha of the CEEC from non-certified areas of the subject land. This includes 0.93 ha in intact condition, 2.46 in thinned condition, and 0.98 ha in scattered trees condition.

SAII assessment for Large Bent-winged Bat

Large Bent-winged Bat is listed as Vulnerable under the NSW BC Act, with the BioNet Threatened Biodiversity Data Collection (TBDC) indicating that the species is an entity subject to SAII in NSW. The species is considered an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 4: a species that is unlikely to respond to measures to improve its habitat and therefore its members are not replaceable.

The SAII threshold for the species is described in the TBDC as "*breeding habitat to be identified by survey*". As such impacts to breeding habitat are what are considered SAII for this species. These areas are described as follows:

Potential breeding habitat is caves, tunnels, mines or other structures known or suspected to be used by M. schreibersii oceanensis including species records in BioNet with microhabitat code 'IC – in cave'; observation type code 'E nest-roost'; with numbers of individuals >500; or from the scientific literature.

The potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Table A.5 Assessment of SAII for Large Bent-winged Bat

Information required (BAM Section 9.1.2)	Response
1. The action and measures taken to avoid the direct and indirect impact on the species at risk of an SAII.	Actions and measures undertaken by the proponent to avoid and minimise impacts to Large Bent-winged Bat are provided in Section 10 of this BDAR. Impacts to Large Bent-winged Bat are most likely to occur in the western areas of the project, where the location of the proposed water outlet structure is to be installed to release high-quality treated water to the Warragamba River as environmental flows (Figure 16). The potential SAIIs to the potential breeding habitat for the species in this area are minimised through the use of horizontal directional drilling which reduces the need for trenching through larger areas of habitat, and reduces the requirements for vegetation removal. The impact area is also located immediately adjacent to the footprint of the existing Warragamba dam facility where there is a history of disturbance and allows for utilisation of existing road networks for access, further reducing the need for constructing new access roads. This minimises the need for extensive clearing and development of infrastructure in pristine areas surrounding the project's impact area. The location of the proposed outlet structure has also been selected following a preliminary constraints assessment which investigated a number of pipeline design alternatives (Biosis 2020). The selected option was chosen as it represented the least impact to ecological values and features, including impacts to additional SAIIs and TECs which have been avoided. Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact. These include: • Undertaking works outside of breeding season. • Implementation of roost exclusions (i.e. blocking up potential breeding habitat outside of breeding season and over-wintering to ensure no individuals are present during works). • Undertaking pre-clearance survey immediately prior to commencement of works to ensure no individuals are present.

2a. Evidence of rapid decline. **(Principle 1)**	**i. Evidence of rapid decline in the population of the species in NSW in the past 10 years or three generations (whichever is longer), or** **ii. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer) as indicated by: an index of abundance appropriate to the species; decline in geographic distribution and/or habitat quality; exploitation; effect of introduced species, hybridisation, pathogens, pollutants, competitors or parasites.** Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018). To be considered under this principle, the species should have an observed, estimated, inferred, suspected or projected population of ≥80 % in 10 years or three generations (whichever is longer) (DPIE 2019). Large Bent-winged Bat is known to form large maternity colonies of upwards of 150,000 individuals (DPIE 2021b), with one study estimating established colonies ranging from 15,000 to 200,000 Bent-winged Bats (Dwyer & Hamilton-Smith 1965). However this was prior to the species *Miniopterus schreibersii* (former binomial name of Large Bent-winged Bat) being formally split into three sub-species, one of which being the Large Bent-winged Bat (Cardinal & Christidis 2000). There were eight such breeding caves documented for Bent-winged Bats across South Australia, Victoria, New South Wates and Southern Queensland in 1965 (Dwyer & Hamilton-Smith 1965). The Saving Our Species strategy for Large Bent-winged Bat has more recently identified seven priority management sites across NSW for the species, presumably linked to the locations of similar maternity sites. These sites are: • Kwiamble in Inverell LGA. • Mount Kaputar in Narrabri LGA. • Willi Willi Cave in Kempsey LGA. • Yessabah in Kempsey LGA. • Church Cave in Yass Valley LGA. • Drum Cave. • Dip Cave (DPIE 2015b). The Willi Willi Cave, Drum Cave and Church Cave appear in both the Dwyer & Hamilton-Smith study (1965) and the priority management site under the Saving Our Species strategy (DPIE 2015b), from which we can infer that the populations utilising these areas are still present over a significant time-period. There is nothing published within the literature that would indicate that the species is currently undergoing rapid decline in the magnitude of ≥ 80 % over a ten year period. Furthermore a comparison study on fungal skin flora between Large Bent-winged Bat and Southern Bent-wing Bat *Miniopterus orianae bassanii* states that Large Bent-winged bat is more common and widespread (than Southern Bent-wing Bat), with numbers appearing to be stable (Holz et al. 2018). However it is unclear upon what data this statement has been based. Based on the available information it is not possible to state the scale of decline in the last 10 years. However as there has been no reporting of rapid population declines of ≥80 % in the last 10 years within the scientific literature, and important maternity nesting sites continue to be utilised over a significant time period, it is unlikely that a decline in the species is being experienced that would trigger consideration of the species under SAII Principle 1.

Information required (BAM Section 9.1.2)	Response

2b. Evidence of small population size. (Principle 2)	**i. An estimate of the species' current population size in NSW, and**
	ii. An estimate of the decline in the species' population size in NSW in three years or one generation (whichever is longer), and
	iii. Where such data is available, an estimate of the number of mature individuals in each subpopulation, or the percentage of mature individuals in each subpopulation, or whether the species is likely to undergo extreme fluctuations.
	Species with small population sizes are highly vulnerable to any event which impacts and further reduces their population size due to the time-lag between developmental impacts and the realisation of ecological benefits from improvements in habitat condition at stewardship offset sites (DPIE 2019).
	To be considered under this principle a species must have a very small population size which would lead it to be considered critically endangered under the *IUCN Red List Categories and Criteria* (IUCN 2012). Specifically the species has a known population size that is either:
	• Fewer than 50 mature individuals independent of whether there are any threats.
	• Fewer than 250 mature individuals and the species has an observed, estimated or projected continuing decline:
	  ○ of at least 25% in three years or one generation (whichever is longer), or
	  ○ where the number of mature individuals in each subpopulation is <50, or
	  ○ the percentage of mature individuals in one subpopulation is 90–100%, or
	  ○ the population is subject to extreme fluctuations in the number of individuals.
	'Population' means the total number of mature individuals in New South Wales, 'Subpopulations' are geographically or otherwise distinct groups in the total population (DPIE 2019, IUCN Standards and Petitions Committee 2019). The species is not currently listed as critically endangered under the NSW BC Act.
	A population pattern study on *Miniopterus schreibersii* in north-east NSW (P.D Dwyer 1966a) (once again undertaken prior to the splitting into subspecies), estimated a population size of a single population of *M. schreibersii* as being 32,000 before birth of young and 44,000 after birth of young. The peak size of the Willi Willi cave maternity colony was also estimated as being 25,650 (P.D Dwyer 1966a). As stated above, these estimates are likely to include all three subspecies of *M. schreibersii* and do not reflect population sizes of just Large Bent-winged Bat.
	This population size is supported by the previously mentioned studies undertaken on maternity roosts for the species, with maternity colonies reportedly ranging from 100 to 150,000 individuals (DPIE 2021b, Dwyer & Hamilton-Smith 1965).
	Given the reported sizes of the individual *M. schreibersii* populations, coupled with the large breeding congregations that are reported to occur at maternity roost sites, the species does not meet the thresholds required for consideration of the species under SAII Principle 2.

2c. Evidence of limited geographic range for the threatened species. (Principle 3)	The geographic range of a species is measured by its area of occupancy, which represents the area of suitable habitat currently occupied by the taxon (IUCN Standards and Petitions Committee 2019). Species that are known to have a very limited geographic distribution are generally known to:
	• Have an area of occupancy of ≤ 10 km^2.
	• Have an extent of occurrence of ≤ 100 km^2.
	• Have at least two of the following three conditions:
	  ○ Are severely fragmented or only known from one location.
	  ○ Continuing decline.

Information required (BAM Section 9.1.2)	Response
	○ Extreme fluctuations. • Inhabit less than or equal to three locations in NSW (DPIE 2019). **i. Extent of occurrence.** The species extent of occurrence is very large as it occurs along the east coast of Australia from Cape York in northern Queensland to Castlemaine in Victoria, east of the Great Dividing Range and all along the eastern coast of NSW (Churchill 2008). This extent of occurrence is significantly larger than the threshold detailed above. **ii. Area of occupancy.** Similarly the area of occupancy is also large with the occurrence of Large Bent-winged Bat being mostly contiguous across its known extent within NSW, as evidenced by Bionet records for the species (DPIE 2015b, DPIE 2021c). This area is signification larger than the threshold detailed above. **iii. Number of threat-defined locations (geographically or ecologically distinct areas in which a single threatening event may rapidly affect all species occurrences).** The primary threat facing the species is disturbance and damage to maternity roosting sites by animals and humans. As noted above, the Saving Our Species program for the species has identified seven priority areas for Large Bent-winged Bat within NSW, presumably linked to the occurrence of some of these maternity sites. The species is understood to form discrete populations centred on such maternity caves, with individuals returning to the same cave to birth and rear young (DPIE 2021c). Impacts to these maternity caves would represent the largest threat-defined locations for the species. **iv. Whether the species' population is likely to undergo extreme fluctuations.** Based on the size of known maternity colonies (ranging from 100 to 150,000 individuals) it is unlikely that extreme fluctuations in the species' population would occur. As noted above, a comparison study on fungal skin flora between Large Bent-winged Bat and Southern Bent-wing Bat *Miniopterus orianae bassanii* has also stated that Large Bent-winged bat is more common and widespread, with numbers appearing to be stable (Holz et al. 2018). However it is unclear upon what data this statement has been based. The available information on the geographic distribution of the species indicates that the species does not meet the thresholds for consideration under SAII Principle 3.
2d. Evidence that the species is unlikely to respond to management. (Principle 4)	This principle encompasses two components, firstly whether there are any particular traits of the species which limits its' response to management, and secondly whether there are any key threatening processes affecting the species which cannot be effectively managed. Furthermore in select areas where essential habitat components cannot be readily re-created (such as caves or cliff lines used by threatened species) such impacts can be deemed irreplaceable (DPIE 2019). **i. Known reproductive characteristics severely limit the ability to increase the existing population on, or occupy new habitat on, a biodiversity stewardship site.** The species requires maternity cave sites with specific temperature and humidity regimes in order to breed successfully. The species forms discrete populations based on these structures which individuals return to annually in order to birth and rear young (DPIE 2021c). These features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **ii. The species is reliant on abiotic habitats which cannot be restored or replaced on a biodiversity stewardship site.** In addition to maternity roost sites, the species also requires specific roosting habitats in

Information required (BAM Section 9.1.2)	Response
	proximity to foraging resources in the form of caves. However the species is also known to use derelict mines, storm-water tunnels, buildings and other man-made structures (DPIE 2021c). Whilst man-made structures can be replicated, the preferred primary roosting habitat of caves is unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **iii. Life history traits and/or ecology is known but the ability to control key threatening processes at a biodiversity stewardship site is currently negligible.** The primary threat to the species is loss or degradation of roosting habitat and maternity roost sites as a result of animals and human activity. Where suitable roosting habitats occur within a biodiversity stewardship site, effective management of such features can be readily achieved. Secondary threats include loss of suitable foraging resources in proximity to roosting sites due to vegetation clearing and inappropriate fire regimes. Both of these can be effectively managed at a biodiversity stewardship site. Given the specialised breeding and roosting habitat requirements for the species, it is unlikely such habitats can be readily replicated at a biodiversity stewardship site. As such consideration of this species under SAII Principle 4 is warranted.
3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a species, the assessor must record this in the BDAR or BCAR.	The TBDC does not state that data is 'unknown' or 'data deficient' for this species.
4a. The impact on the species' population	**i. An estimate of the number of individuals (mature and immature) present in the subpopulation on the subject land (the site may intersect or encompass the subpopulation) and as a percentage of the total NSW population, and,** **ii. An estimate of the number of individuals (mature and immature) to be impacted by the proposal and as a percentage of the total NSW population.** There are four historical records based on ultrasonic recordings within two kilometres of the proposed treated water environmental flows outlet (DPIE 2021b). The species was also recorded on 29 of the 30 recorder (trap) nights undertaken as part of during targeted surveys from 14 December 2020 to 18 January 2021 across two songmeter SM4 devices. Whilst the overall size of the population is unknown, breeding or roosting colonies can number from 100 to 150,000 individuals (DPIE 2021b). The species historic records and confirmed detections as part of the targeted survey do not indicate activity levels or the presence of the species in such volumes that would indicate the presence of either a breeding or a large roosting colony. It is more likely that that the detected individuals are visiting the location to forage. This is supported by the data collected as part of the targeted survey, where the species was primarily detected more than one hour after twilight, with only seven nights out of 30 where the species was recorded within one hour of twilight. This indicates that individuals were travelling to the location from outside of the project impact area. As such, it is likely that the local population consists of foraging individuals and does not include a breeding or roosting colony. However, as the presence of breeding cannot be conclusively discounted, the habitat present within and surrounding the impact area has

Information required (BAM Section 9.1.2)	Response
	been considered low potential breeding habitat for the purposes of this SAII assessment (further information is provided in Section 8.2.3 of this BDAR). Due to access restrictions along the Warragamba River (particularly along the northern bank bordering the Blue Mountains National Park where high vertical cliff faces prevented safe access), targeted survey utilising harp trapping survey methodology in accordance with the *'Species credit' threatened bats and their habitats* (OEH 2018) BAM survey guidelines could not be undertaken. Instead a total of 92 equivalent survey nights of acoustic survey across four passive auditory detector units (Anabat Express and SM4 Bat Songmeters) was undertaken in October and December 2020 and January 2021. Two dusk cave emergence surveys were also undertaken in October 2020 in order to establish presence of the species within the locality. Given the nature of acoustic surveys, it is not possible to estimate the number of individuals present and impacted as a percentage of the total NSW population. However given maternity colonies can include up to 150,000 individuals and are likely to include at least thousands of individuals, the percentage of the overall NSW population present within the subject land is a very small percentage of the overall population.

4b. Impact on geographic range.	**i. The area of the species' geographic range to be impacted by the proposal in hectares, and a percentage of the total AOO, or EOO within NSW.**
	The impacts to available habitat for Large Bent-winged Bat as a result of the proposed works include the following:
	• Removal of approximately 1.56 hectares of native vegetation that occurs within 100 metres of habitat supporting low potential breeding habitat for Large Bent-winged Bat. This includes direct impacts to the following habitat structures:
	  ○ Removal of a vertical (vent) shaft, the opening to which is located in rocky cliff overhang habitat located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	  ○ Construction of the treated water environmental flows outlet, and associated gabion walls and HDD drilling, within an area of rocky cliff overhangs located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	• Disturbance from indirect impacts in the form of increased traffic, noise and light during the project construction. These impacts will cease once construction is completed. Passive roost exclusions and undertaking works outside of breeding season are recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of these indirect impacts. Ongoing indirect impacts are expected to be minimal, and are assessed along with indirect construction impacts in Section 11.2 above.
	The area to be impacted is likely to represent <0.001 % of the extent of occurrence for the species, along the east coast of Australia from Cape York in northern Queensland to Castlemaine in Victoria, east of the Great Dividing Range and all along the eastern coast of NSW (Churchill 2008). Similarly it is likely to represent <0.001 % of the occurrence for the species with BioNet records indicating the species is primarily contiguous across its known range.
	ii. The impact on the subpopulation as either: all individuals will be impacted (subpopulation eliminated); OR impact will affect some individuals and habitat; OR impact will affect some habitat, but no individuals of the species will be directly impacted.

Information required (BAM Section 9.1.2)	Response
	The proposed impacts are likely to affect potential habitat for the species. No direct impacts to individuals of the species are likely to occur as a result of the proposal. **iii. To determine if the persisting subpopulation that is fragmented will remain viable, estimate the habitat area required to support the remaining population, and habitat available within dispersal distance, and distance over which genetic exchange can occur and pollination distance for the species.** Vegetation within the impact area is connected to surrounding vegetation in all directions, forming a vegetation patch of more than 100,000 ha. This includes large tracts of intact native vegetation that form the Blue Mountains National Park, as well as forested riparian zones associated with the Warragamba River and later the Nepean River. These areas represent prime foraging habitat for the species which typically hunts in forest areas, catching moths and other flying insects above the tree canopy (DPIE 2021c). They are also likely to support numerous cave, cliff and escarpment habitats suitable for roosting and potentially breeding, given the underlying Hawkesbury sandstone geologies that occur throughout the Blue Mountains National Park. By comparison, the impact area contains degraded foraging habitat due to historical disturbances associated with the construction of the Warragamba Dam. The removal of 1.56 hectares of native vegetation from low potential breeding habitat buffers within a patch of more than 100,000 hectares, is considered unlikely to impact the viability of the species within the locality. **iv. To determine changes in threats affecting remaining subpopulations and habitat if the proposed impact proceeds, estimate changes in environmental factors including changes to fire regimes (frequency, severity); hydrology, pollutants; species interactions (increased competition and effects on pollinators or dispersal); fragmentation, increased edge effects, likelihood of disturbance; and disease, pathogens and parasites. Where these factors have been considered elsewhere in relation to the target species the assessor may refer to the relevant sections of the BDAR or BCAR.** **Changes to fire regimes** The risk of fire as a result of sparks from machinery during proposed works is unlikely, but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers within the project's CEMP. Upon completion of works, the proposal is unlikely to result in changes to frequency or intensity of fire regimes within the locality. **Hydrology** Changes to hydrology as a result of the proposal are discussed in Section 11.2.1 These changes are unlikely to significantly impact on the foraging or roosting behaviour of Large Bent-winged Bat. **Pollutants** The project does not involve the use of any pesticides, nor is it likely to substantially increase the levels of pesticides within the environment. **Species interactions** The impact area and surrounds likely support several pest animal species and it is highly likely that feral goats are already present within the area. The small-scale nature of works is

Information required (BAM Section 9.1.2)	Response
	unlikely to result in an increase in feral animal activity in the area, or alter the existing disturbances to roosting sites that may already be exhibited by goats within the locality. In addition to feral goats, introduced predators such as feral cats and foxes can negatively impact the species by preying on bats as they exit caves, sometimes taking significant numbers. One study reported 476 Bent-winged bats (prior to the taxonomic subspecies change) being predated (P.D Dwyer 1966b). Black Rats have also been reported in maternity caves and are likely to prey upon young (P.D Dwyer 1966b, Lumsden & Jemison 2015). Such predators were recorded during camera trap surveys, are likely to already present within the broader locality, and are unlikely to increase as a result of the proposal. **Fragmentation** Large Bent-winged Bat is a highly mobile species capable of dispersing across breaks in habitats. While it is assumed that connected vegetation is preferred by the species for movement, the existence of many records of the species within urbanised areas suggests that the species does not rely on specialised dispersal or movement habitat. Thus, the loss of approximately 1.56 hectares of native vegetation from the buffer area of low potential roosting sites is unlikely to impact the movement ecology of the local population. As such population fragmentation will not occur as a result of the proposal. **Increased edge effects** The proposed works that occur within the vicinity of the identified potential Large Bent-winged Bat habitats are occurring within a previously disturbed area of the existing Warragamba Dam footprint. As such these areas are already subject to some edge effects. Whilst transport of weeds is possible during construction, these will be mitigated through the application of appropriate weed control measures to bed detailed within the CEMP. This will ensure the existing edge effects are not exacerbated by the proposal. These edge effects are also unlikely to significantly impact the species, given the availability of foraging resources within the locality. **Likelihood of disturbance** Disturbance will occur in the form of direct impacts to native vegetation within the 100 metre buffer are of low potential breeding habitats. In additional indirect impacts during construction (i.e. light, noise and vibration) have the potential to disturb any roosting individuals that may be present. These indirect impacts will be mitigated through passive roost exclusions and undertaking works outside of breeding season. **Disease, pathogens and parasites** One of the most significant pathogens impacting bats it White-nose fungus. To date there have been no cases of White-nose fungus recorded in Australia. Given the localised nature of the proposed works, restricted to Western Sydney, it is therefore unlikely that the fungus could be spread to microbats as a result of the proposed works.
5. The assessor may also provide new information that can be used to demonstrate that the principle identifying the species as at risk of an SAII, is inaccurate.	Not applicable.

SAII assessment for Little Bent-winged Bat

Little Bent-winged is listed as Vulnerable under the NSW BC Act, with the BioNet Threatened Biodiversity Data Collection (TBDC) indicating that the species is an entity subject to SAII in NSW. The species is considered an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 4: a species that is unlikely to respond to measures to improve its habitat and therefore its members are not replaceable.

The SAII threshold for the species is described in the TBDC as "*breeding habitat to be identified by survey*". As such impacts to breeding habitat are what are considered SAII for this species. These areas are described as follows:

Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records in BioNet with microhabitat code 'IC – in cave'; observation type code 'E nest-roost'; with numbers of individuals >500; or from the scientific literature.

All breeding habitat including the cave, or other features, used for breeding and the area immediately surrounding this feature must be mapped. Species polygon boundaries should have a 100m radius buffer around an accurate GPS point location centred on the cave/feature entrance.

The potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Table A.6 Assessment of SAII for Little Bent-winged Bat

Information required (BAM Section 9.1.2)	Response
1. The action and measures taken to avoid the direct and indirect impact on the species at risk of an SAII.	Actions and measures undertaken by the proponent to avoid and minimise impacts to Little Bent-winged Bat are provided in Section 10 of this BDAR. Impacts to Little Bent-winged Bat are most likely to occur in the western areas of the project, where the location of the proposed water outlet structure is to be installed to release high-quality treated water to the Warragamba River as environmental flows (Figure 16). The potential SAIIs to the potential breeding habitat for the species in this area are minimised through the use of horizontal directional drilling which reduces the need for trenching through larger areas of habitat, and reduces the requirements for vegetation removal. The impact area is also located immediately adjacent to the footprint of the existing Warragamba dam facility where there is a history of disturbance and allows for utilisation of existing road networks for access, further reducing the need for constructing new access roads. This minimises the need for extensive clearing and development of infrastructure in pristine areas surrounding the project's impact area. The location of the proposed outlet structure has also been selected following a preliminary constraints assessment which investigated a number of pipeline design alternatives (Biosis 2020). The selected option was chosen as it represented the least impact to ecological values and features, including impacts to additional SAIIs and TECs which have been avoided. Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact. These include: • Undertaking works outside of breeding season. • Implementation of roost exclusions (i.e. blocking up potential breeding habitat outside of breeding season and over-wintering to ensure no individuals are present during works).

Information required (BAM Section 9.1.2)	Response
	• Undertaking pre-clearance survey immediately prior to commencement of works to ensure no individuals are present.
2a. Evidence of rapid decline. **(Principle 1)**	**i. Evidence of rapid decline in the population of the species in NSW in the past 10 years or three generations (whichever is longer), or** **ii. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer) as indicated by: an index of abundance appropriate to the species; decline in geographic distribution and/or habitat quality; exploitation; effect of introduced species, hybridisation, pathogens, pollutants, competitors or parasites.** Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018). To be considered under this principle, the species should have an observed, estimated, inferred, suspected or projected population of ≥80% in 10 years or three generations (whichever is longer) (DPIE 2019). Maternity roosts for Little Bent-winged Bat are rare with only five documented nursery sites within Australia (DPIE 2021b). The species maternity roosts are documented as being large, with groups of 3,000 to 4,000 individuals, with the largest known maternity colony consisting of 100,000 individuals. The largest maternity colony in NSW co-occurs with a large maternity colony of Large Bent-winged Bat. This pattern of co-occurrence is repeated across several roost sites and it is thought that the smaller species depends on the heat generated by the larger species to successfully rear its young (DPIE 2021b, Dwyer 1968, Churchill 2008). There are two priority management areas (one north of Newcastle and one in Byron Bay), as well one key management site, Willi Willi Cave in northern NSW, identified under the NSW Saving our Species strategy for Little Bent-winged Bat (DPIE 2015c). Willi Willi Cave was previously identified as an important site for the species in a biological study conducted between 1960 and 1966 (Dwyer 1968). This is evidence of a continuing population of the species in this area over a significant time-period. Based on the available information it is not possible to state the scale of decline in the last 10 years. However as there has been no reporting of rapid population declines of ≥80 % in the last 10 years within the scientific literature, and important maternity nesting sites continue to be utilised over a significant time period, it is unlikely that a decline in the species is being experienced that would trigger consideration of the species under SAII Principle 1.
2b. Evidence of small population size. **(Principle 2)**	**i. An estimate of the species' current population size in NSW, and** **ii. An estimate of the decline in the species' population size in NSW in three years or one generation (whichever is longer), and** **iii. Where such data is available, an estimate of the number of mature individuals in each subpopulation, or the percentage of mature individuals in each subpopulation, or whether the species is likely to undergo extreme fluctuations.** Species with small population sizes are highly vulnerable to any event which impacts and further reduces their population size due to the time-lag between developmental impacts and the realisation of ecological benefits from improvements in habitat condition at stewardship offset sites (DPIE 2019). To be considered under this principle a species must have a very small population size which would lead it to be considered critically endangered under the *IUCN Red List Categories and Criteria* (IUCN 2012). Specifically the species has a known population size that is either:

Information required (BAM Section 9.1.2)	Response

	• Fewer than 50 mature individuals independent of whether there are any threats.
	• Fewer than 250 mature individuals and the species has an observed, estimated or projected continuing decline:
	  ○ of at least 25% in three years or one generation (whichever is longer),. or
	  ○ where the number of mature individuals in each subpopulation is <50, or
	  ○ the percentage of mature individuals in one subpopulation is 90–100%, or
	  ○ the population is subject to extreme fluctuations in the number of individuals.
	'Population' means the total number of mature individuals in New South Wales, 'Subpopulations' are geographically or otherwise distinct groups in the total population (DPIE 2019, IUCN Standards and Petitions Committee 2019). The species is not currently listed as critically endangered under the NSW BC Act.
	The previously mentioned biological study on Little Bent-wing Bat in north-east NSW between 1960 and 1966, located a single nursery colony at Willi Willi Bat Cave, reportedly belonging to the southernmost population of the species (Dwyer 1968). This nursery colony was estimated to include 4,000 individuals (1,800 of which were estimated to be young). The study also included colony estimates at three non-breeding roosting caves (Carrai, Yessabah and Big Hill), with number tending to be around 500 to 600 individuals (Dwyer 1968).
	This population size is supported by the previously mentioned studies undertaken on maternity roosts for the species, with groups of 3,000 to 4,000 individuals being reported, and the largest known maternity colony consisting of 100,000 individuals (DPIE 2021b, Dwyer 1968, Churchill 2008). More contemporary estimates of population sizes are not available within the literature.
	Given the reported sizes of the individual colonies, coupled with the large breeding congregations that are reported to occur at maternity roost sites, the species does not meet the thresholds required for consideration of the species under SAII Principle 2.

2c. Evidence of limited geographic range for the threatened species. (Principle 3)	The geographic range of a species is measured by its area of occupancy, which represents the area of suitable habitat currently occupied by the taxon (IUCN Standards and Petitions Committee 2019). Species that are known to have a very limited geographic distribution are generally known to:
	• Have an area of occupancy of ≤ 10 km^2.
	• Have an extent of occurrence of ≤ 100 km^2.
	• Have at least two of the following three conditions:
	  ○ Are severely fragmented or only known from one location.
	  ○ Continuing decline.
	  ○ Extreme fluctuations.
	• Inhabit less than or equal to three locations in NSW (DPIE 2019).
	i. Extent of occurrence.
	The species extent of occurrence is very large as it occurs along the east coast of Australia, ranging from north of Batemans Bay up to Cape York in Queensland (DPIE 2021b).
	ii. Area of occupancy.
	Similarly the area of occupancy is also large with the occurrence of Little Bent-winged Bat being mostly contiguous across its known extent within NSW, as evidenced by Bionet records for the species (DPIE 2015b, DPIE 2021c). This area is signification larger than the threshold detailed above.
	iii. Number of threat-defined locations (geographically or ecologically distinct areas in which a single threatening event may rapidly affect all species occurrences).

Information required (BAM Section 9.1.2)	Response
	The primary threat facing the species is disturbance and damage to maternity roosting sites by animals and humans. As noted above, the Saving Our Species program for the species has identified two priority management areas (one north of Newcastle and one in Byron Bay), as well one key management site, Willi Willi Cave in northern NSW (DPIE 2015c), presumably linked to the occurrence of some of these maternity sites. With the crucial role these maternity colonies play in successful breeding, impacts to these maternity caves would represent the largest threat-defined locations for the species. **iv. Whether the species' population is likely to undergo extreme fluctuations.** Based on the size of known maternity colonies (with typical ranges of 3,000 to 4,000 individuals) it is unlikely that extreme fluctuations in the species' population would occur. Maternity roost sites also appear to be stable in time, with colonies studied in the 1960s still present to current day. Therefore the available information on the geographic distribution of the species indicates that the species does not meet the thresholds for consideration under SAII Principle 3.
2d. Evidence that the species is unlikely to respond to management. (Principle 4)	This principle encompasses two components, firstly whether there are any particular traits of the species which limits its' response to management, and secondly whether there are any key threatening processes affecting the species which cannot be effectively managed. Furthermore in select areas where essential habitat components cannot be readily re-created (such as caves or cliff lines used by threatened species) such impacts can be deemed irreplaceable (DPIE 2019). **i. Known reproductive characteristics severely limit the ability to increase the existing population on, or occupy new habitat on, a biodiversity stewardship site.** The species requires maternity cave sites with specific temperature and humidity regimes in order to breed successfully. The species forms discrete populations based on these structures which individuals return to annually in order to birth and rear young (DPIE 2021c, Dwyer 1968). Furthermore, it is believed the temperature of some caves is dependent upon the mixed breeding congregations formed with the Large Bent-winged Bat and Common Bent-winged Bat *Miniopterus schreibersii*, which are larger species which gather at maternity colonies in even greater numbers than Little Bent-winged Bat. It is thought that the colonisation of the Little Bent-winged Bat in the southern regions of its distribution has been dependent on the establishment of maternity colonies by these larger bent-winged bat species (DPIE 2021c, Dwyer 1968). These features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **ii. The species is reliant on abiotic habitats which cannot be restored or replaced on a biodiversity stewardship site.** In addition to maternity roost sites, the species also requires specific roosting habitats in proximity to foraging resources in the form of caves. However the species is also known to use derelict mines, storm-water tunnels, buildings and other man-made structures (DPIE 2021c). Whilst man-made structures can be replicated, the preferred primary roosting habitat of caves is unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **iii. Life history traits and/or ecology is known but the ability to control key threatening processes at a biodiversity stewardship site is currently negligible.** The primary threat to the species is loss or degradation of roosting habitat and maternity roost sites as a result of animals and human activity. Where suitable roosting habitats occur

Information required (BAM Section 9.1.2)	Response
	within a biodiversity stewardship site, effective management of such features can be readily achieved. Secondary threats include loss of suitable foraging resources in proximity to roosting sites due to vegetation clearing and inappropriate fire regimes. Both of these can be effectively managed at a biodiversity stewardship site. Given the specialised breeding and roosting habitat requirements for the species, it is unlikely such habitats can be readily replicated at a biodiversity stewardship site. As such consideration of this species under SAII Principle 4 is warranted.
3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a species, the assessor must record this in the BDAR or BCAR.	The TBDC does not state that data is 'unknown' or 'data deficient' for this species.
4a. The impact on the species' population	**i. An estimate of the number of individuals (mature and immature) present in the subpopulation on the subject land (the site may intersect or encompass the subpopulation) and as a percentage of the total NSW population, and,** **ii. An estimate of the number of individuals (mature and immature) to be impacted by the proposal and as a percentage of the total NSW population.** The size of the local population is unknown due to lack of adequate survey for the species in the region. Two historical records based on ultrasonic recordings occur within the vicinity of the study area, one approximately 700 metres from the proposed treated water environmental flows outlet recorded in 2017, the other approximately 2 kilometres away recorded in 2012 (DPIE 2021b). The species was detected four times during acoustic detection surveys undertaken as part of during targeted surveys from 14 December 2020 to 18 January 2021, as part of the current assessment. Whilst the overall size of the population is unknown, breeding or roosting colonies can number from 3,000 to 4,000 individuals (DPIE 2021b). The species historic records and confirmed detections as part of the targeted survey do not indicate activity levels or the presence of the species in such volumes that would indicate the presence of either a breeding or a large roosting colony. It is more likely that that the detected individuals are visiting the location to forage. However, as the presence of breeding cannot be conclusively discounted, the habitat present within and surrounding the impact area has been considered low potential breeding habitat for the purposes of this SAII assessment (further information is provided in Section 8.2.3 of this BDAR). Due to access restrictions along the Warragamba River (particularly along the northern bank bordering the Blue Mountains National Park where high vertical cliff faces prevented safe access), targeted survey utilising harp trapping survey methodology in accordance with the *'Species credit' threatened bats and their habitats* (OEH 2018) BAM survey guidelines could not be undertaken. Instead a total of 92 equivalent survey nights of acoustic survey across four passive auditory detector units (Anabat Express and SM4 Bat Songmeters) was undertaken in October and December 2020 and January 2021. Two dusk cave emergence surveys were also undertaken in October 2020 in order to establish presence of the species within the locality. Given the nature of acoustic surveys, it is not possible to estimate the number of individuals

Information required (BAM Section 9.1.2)	Response
	present and impacted as a percentage of the total NSW population. However given maternity colonies can include up to 3,000 to 4,000 individuals, the percentage of the overall NSW population present within the subject land is a very small percentage of the overall population.

4b. Impact on geographic range.	**i. The area of the species' geographic range to be impacted by the proposal in hectares, and a percentage of the total AOO, or EOO within NSW.**
	The impacts to available habitat for Little Bent-winged Bat as a result of the proposed works include the following:
	• Removal of approximately 1.56 hectares of native vegetation that occurs within 100 metres of habitat supporting low potential breeding habitat for Large-eared Pied Bat. This includes direct impacts to the following habitat structures:
	  ○ Removal of a vertical (vent) shaft, the opening to which is located in rocky cliff overhang habitat located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	  ○ Construction of the treated water environmental flows outlet, and associated gabion walls and HDD drilling, within an area of rocky cliff overhangs located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	• Disturbance from indirect impacts in the form of increased traffic, noise and light during the project construction. These impacts will cease once construction is completed. Passive roost exclusions and undertaking works outside of breeding season are recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of these indirect impacts. Ongoing indirect impacts are expected to be minimal, and are assessed along with indirect construction impacts in Section 11.2 above.
	The area to be impacted is likely to represent <0.001 % of the extent of occurrence for the species, along the east coast of Australia from Cape York in northern Queensland down along the eastern coast of NSW to Batemans Bay (Churchill 2008). Similarly it is likely to represent <0.001 % of the occurrence for the species with BioNet records indicating the species is primarily contiguous across its known range.
	ii. The impact on the subpopulation as either: all individuals will be impacted (subpopulation eliminated); OR impact will affect some individuals and habitat; OR impact will affect some habitat, but no individuals of the species will be directly impacted.
	The proposed impacts are likely to affect potential habitat for the species. No direct impacts to individuals of the species are likely to occur as a result of the proposal.
	iii. To determine if the persisting subpopulation that is fragmented will remain viable, estimate the habitat area required to support the remaining population, and habitat available within dispersal distance, and distance over which genetic exchange can occur and pollination distance for the species.
	Vegetation within the impact area is connected to surrounding vegetation in all directions, forming a vegetation patch of more than 100,000 ha. This includes large tracts of intact native vegetation that form the Blue Mountains National Park, as well as forested riparian zones associated with the Warragamba River and later the Nepean River. These areas represent prime foraging habitat for the species which typically hunts in forest areas, foraging for small insects beneath the canopy of densely vegetated habitats.(DPIE 2021c). They are also likely to support numerous cave, cliff and escarpment habitats suitable for

Information required (BAM Section 9.1.2)	Response
	roosting, given the underlying Hawkesbury sandstone geologies that occur throughout the Blue Mountains National Park. By comparison, the impact area contains degraded foraging habitat due to historical disturbances associated with the construction of the Warragamba Dam. The removal of 1.56 hectares of native vegetation from low potential breeding habitat buffers within a patch of more than 100,000 hectares, is considered unlikely to impact the viability of the species within the locality. **iv. To determine changes in threats affecting remaining subpopulations and habitat if the proposed impact proceeds, estimate changes in environmental factors including changes to fire regimes (frequency, severity); hydrology, pollutants; species interactions (increased competition and effects on pollinators or dispersal); fragmentation, increased edge effects, likelihood of disturbance; and disease, pathogens and parasites. Where these factors have been considered elsewhere in relation to the target species the assessor may refer to the relevant sections of the BDAR or BCAR.** **Changes to fire regimes** The risk of fire as a result of sparks from machinery during proposed works is unlikely, but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers within the project's CEMP. Upon completion of works, the proposal is unlikely to result in changes to frequency or intensity of fire regimes within the locality. **Hydrology** Changes to hydrology as a result of the proposal are discussed in Section 11.2.1. These changes are unlikely to significantly impact on the foraging or roosting behaviour of Little Bent-winged Bat. **Pollutants** The project does not involve the use of any pesticides, nor is it likely to substantially increase the levels of pesticides within the environment. **Species interactions** The impact area and surrounds likely support several pest animal species and it is highly likely that feral goats are already present within the area. The small-scale nature of works is unlikely to result in an increase in feral animal activity in the area, or alter the existing disturbances to roosting sites that may already be exhibited by goats within the locality. In addition to feral goats, introduced preda2tors such as feral cats and foxes can negatively impact the species by preying on bats as they exit caves. Black Rats have also been reported in Bent-winged Bat maternity caves and are likely to prey upon young (P.D Dwyer 1966b, Lumsden & Jemison 2015). Such predators were recorded during camera trap surveys, are likely to already present within the broader locality, and are unlikely to increase as a result of the proposal. **Fragmentation** Little Bent-winged Bat is a highly mobile species capable of dispersing across breaks in habitats. While it is assumed that connected vegetation is preferred by the species for movement, the existence of many records of the species within urbanised areas suggests that the species does not rely on specialised dispersal or movement habitat. Thus, the loss

Information required (BAM Section 9.1.2)	Response
	of approximately 1.56 hectares of native vegetation from the buffer area of low potential roosting sites is unlikely to impact the movement ecology of the local population. As such population fragmentation will not occur as a result of the proposal. **Increased edge effects** The proposed works that occur within the vicinity of the identified potential Little Bent-winged Bat habitats are occurring within a previously disturbed area of the existing Warragamba Dam footprint. As such these areas are already subject to some edge effects. Whilst transport of weeds is possible during construction, these will be mitigated through the application of appropriate weed control measures to bed detailed within the CEMP. This will ensure the existing edge effects are not exacerbated by the proposal. These edge effects are also unlikely to significantly impact the species, given the availability of foraging resources within the locality. **Likelihood of disturbance** Disturbance will occur in the form of direct impacts to native vegetation within the 100 metre buffer are of low potential breeding habitats. In additional indirect impacts during construction (i.e. light, noise and vibration) have the potential to disturb any roosting individuals that may be present. These indirect impacts will be mitigated through passive roost exclusions and undertaking works outside of breeding season. **Disease, pathogens and parasites** One of the most significant pathogens impacting bats it White-nose fungus. To date there have been no cases of White-nose fungus recorded in Australia. Given the localised nature of the proposed works, restricted to Western Sydney, it is therefore unlikely that the fungus could be spread to microbats as a result of the proposed works.
5. The assessor may also provide new information that can be used to demonstrate that the principle identifying the species as at risk of an SAII, is inaccurate.	Not applicable.

SAII assessment for Large-eared Pied Bat

Large-eared Pied Bat is listed as Vulnerable under the NSW BC Act, with the BioNet Threatened Biodiversity Data Collection (TBDC) indicates that the species is an entity subject to SAII in NSW. The species is considered an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 4: a species that is unlikely to respond to measures to improve its habitat and therefore its members are not replaceable.

The SAII threshold for the species is described in the TBDC as "*potential breeding habitat and presence of breeding individuals, as identified by survey*". As such impacts to breeding habitat are what are considered SAII for this species. These areas are described as follows:

Potential breeding habitat is PCTs associated with the species within 100 metres of rocky areas containing caves, or overhangs or crevices, cliffs or escarpments, or old mines, tunnels, culverts, derelict concrete buildings.

The potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Table A.7 Assessment of SAII for Large-eared Pied Bat

Information required (BAM Section 9.1.2)	Response
1. The action and measures taken to avoid the direct and indirect impact on the species at risk of an SAII.	Actions and measures undertaken by the proponent to avoid and minimise impacts to Large-eared Pied Bat are provided in Section 10 of this BDAR. Impacts to Large-eared Pied Bat are most likely to occur in the western areas of the project, where the location of the proposed water outlet structure is to be installed to release high-quality treated water to the Warragamba River as environmental flows (Figure 16). The potential SAIIs to the potential breeding habitat for the species in this area are minimised through the use of horizontal directional drilling which reduces the need for trenching through larger areas of habitat, and reduces the requirement for vegetation removal. The impact area is also located immediately adjacent to the footprint of the existing Warragamba dam facility where there is a history of disturbance and allows for utilisation of existing road networks for access, further reducing the need for constructing new access roads. This minimises the need for extensive clearing and development of infrastructure in pristine areas, surrounding the project's impact area. The location of the proposed outlet structure has also been selected following a preliminary constraints assessment which investigated a number of pipeline design alternatives (Biosis 2020). The selected option was chosen as it represented the least impact to ecological values and features, including impacts to additional SAIIs and TECs which have been avoided. Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact. These include: • Undertaking works outside of breeding season. • Implementation of roost exclusions (i.e. blocking up potential breeding habitat outside of breeding season and over-wintering to ensure no individuals are present during works). • Undertaking pre-clearance survey immediately prior to commencement of works to ensure no individuals are present.

Information required (BAM Section 9.1.2)	Response
2a. Evidence of rapid decline. **(Principle 1)**	**i. Evidence of rapid decline in the population of the species in NSW in the past 10 years or three generations (whichever is longer), or** **ii. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer) as indicated by: an index of abundance appropriate to the species; decline in geographic distribution and/or habitat quality; exploitation; effect of introduced species, hybridisation, pathogens, pollutants, competitors or parasites.** Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018). To be considered under this principle, the species should have an observed, estimated, inferred, suspected or projected population of ≥80% in 10 years or three generations (whichever is longer) (DPIE 2019). Large-eared Pied Bat is a data-deficient species (DPIE 2021d), the former distribution of which is poorly known. The Species Profile and Threats Database (SPRAT) (DAWE 2020a) indicates that whilst it has been suggested that there have been large declines in suitable habitat, it is not possible to evaluate past declines in the species extent of occurrence due for the following reasons: • It was only formally described in 1966. • Like most insectivorous bats it is nocturnal and unobtrusive so opportunistic observations are uncommon. • Targeted surveys utilising appropriate techniques to record this species have only taken place since the 1990s (DAWE 2020a). Extensive surveying has been undertaken to determine maternity roost sites for the species, however only four sites have been recorded across the specie' range, one of which was permanently flooded in 1976 and another one was abandoned in 2009 (DERM 2011, DAWE 2020a, TSSC 2012). The *National Recovery Plan for the Large-eared Pied Bat* states that it has not yet been determined whether any specific populations of the Large-eared Pied Bat are at a higher level of threat than others, and that a better understanding of distribution, population size, roost preferences and threats is required before such populations can be identified (DERM 2011). Based on the available information it is likely that the species has experienced previous large declines associated with habitat loss, primarily due to the destruction and interference of maternity and other roosts (TSSC 2012, DERM 2011). Due to the data-deficient nature of the species it is not possible to state the scale of decline in the last 10 years. However there has been no reporting of rapid population declines of ≥80 % in the last 10 years within the scientific literature, which would trigger consideration of the species under SAII Principle 1.
2b. Evidence of small population size. **(Principle 2)**	**i. An estimate of the species' current population size in NSW, and** **ii. An estimate of the decline in the species' population size in NSW in three years or one generation (whichever is longer), and** **iii. Where such data is available, an estimate of the number of mature individuals in each subpopulation, or the percentage of mature individuals in each subpopulation, or whether the species is likely to undergo extreme fluctuations.** Species with small population sizes are highly vulnerable to any event which impacts and further reduces their population size due to the time-lag between developmental impacts

Information required (BAM Section 9.1.2)	Response

	and the realisation of ecological benefits from improvements in habitat condition at stewardship offset sites (DPIE 2019).
	To be considered under this principle a species must have a very small population size which would lead it to be considered critically endangered under the *IUCN Red List Categories and Criteria* (IUCN 2012). Specifically the species has a known population size that is either:
	• Fewer than 50 mature individuals independent of whether there are any threats.
	• Fewer than 250 mature individuals and the species has an observed, estimated or projected continuing decline:
	  ○ of at least 25% in three years or one generation (whichever is longer), or
	  ○ where the number of mature individuals in each subpopulation is <50, or
	  ○ the percentage of mature individuals in one subpopulation is 90–100%, or
	  ○ the population is subject to extreme fluctuations in the number of individuals.
	'Population' means the total number of mature individuals in New South Wales, 'Subpopulations' are geographically or otherwise distinct groups in the total population (DPIE 2019, IUCN Standards and Petitions Committee 2019). The species is not currently listed as critically endangered under the NSW BC Act.
	There is currently insufficient data to estimate the abundance or population trends of the Large-eared Pied Bat (DAWE 2020a). The species appears to exist in a number of small populations throughout its known range, with colonies seldom containing more than 50 individuals (TSSC 2012, DERM 2011). The Blue Mountains National Park is known to support a population of Large-eared Pied Bat with foraging and roosting ecology studies having been done on this population (Williams & Thomson 2018), however the exact size of the local population is unknown.
	The national listing advice for the species states that there is insufficient data to accurately determine the total number of mature individuals (TSSC 2012). However, two studies have been undertaken on maternity caves, one north-west of Coonabarabran in central New South Wales (Pennay 2008), and one approximately 200 kilometres away in Copeton in 1962-1963 (Dwyer 1966). Both of these studies reported small population sizes, ranging from 14-40 mature adults with females typically supporting two pups. The displayed breeding behaviours at the two sites were broadly consistent despite the period of 39 years between observations (Dwyer 1966, Pennay 2008, TSSC 2012).
	The SPRAT profile suggests that the species is unlikely to undergo extreme natural fluctuations in population numbers or extent of occurrence or area of occupancy. However the justifications for this statement are unknown (DAWE 2020a).
	Based on the available information it is likely that the Large-eared Pied Bat population across NSW consists of more than 50 individuals. Whilst it is almost certain that more than 250 mature individuals occur within NSW, definitive data on total population numbers is not available. Whilst the total number of mature adults in each subpopulation is low (reportedly <50 individuals), this appears to be stable with similar subpopulation results being observed at two maternity caves approximately 200 kilometres apart over a 39 year period time lapse (Dwyer 1966, Pennay 2008, TSSC 2012). Given the data-deficient nature of this species, consideration of the species under SAII Principle 2 is warranted.

2c. Evidence of limited geographic range for the threatened species. (Principle 3)	The geographic range of a species is measured by its area of occupancy, which represents the area of suitable habitat currently occupied by the taxon (IUCN Standards and Petitions Committee 2019). Species that are known to have a very limited geographic distribution are generally known to:

Information required (BAM Section 9.1.2)	Response

	• Have an area of occupancy of ≤ 10 km^2.
	• Have an extent of occurrence of ≤ 100 km^2.
	• Have at least two of the following three conditions:
	  ○ Are severely fragmented or only known from one location.
	  ○ Continuing decline.
	  ○ Extreme fluctuations.
	• Inhabit less than or equal to three locations in NSW (DPIE 2019).
	i. Extent of occurrence.
	The species extent of occurrence is approximately 570,000 km^2, based on the distribution range in Hoye and Dwyer (1995, DAWE 2020b).
	ii. Area of occupancy.
	The area of occupancy is approximately 9,120 km^2. This is calculated form the extent of occurrence and the detection rate of echolocation calls of 1.6 % at 3,154 site across the range of Large-eared Pied Bat (DAWE 2020b).
	iii. Number of threat-defined locations (geographically or ecologically distinct areas in which a single threatening event may rapidly affect all species occurrences).
	The primary threat facing the species is disturbance and damage to primary nursery sites by animals and humans (DAWE 2020b). The species requires cave environments of a specific structure (arch caves with dome roofs and indentations for holding) in order to breed successfully. These physical characteristics are very uncommon and their scarcity presumably poses a limiting factor in the distribution of the species (DERM 2011, Pennay 2008). The species exhibits high fidelity to these maternity cave sites, and only four such roosting sites have been formerly recorded in NSW (DAWE 2020b)
	iv. Whether the species' population is likely to undergo extreme fluctuations.
	As noted above, it is detailed in the SPRAT profile for the species that Large-eared Pied Bat is unlikely to undergo extreme natural fluctuations in population numbers, extent of occurrence or area of occupancy, however the justification for this statement is unknown (DAWE 2020b).
	The available information on the geographic distribution of the species indicates that the species does not meet the thresholds for consideration under SAII Principle 3.

2d. Evidence that the species is unlikely to respond to management. (Principle 4)	This principle encompasses two components, firstly whether there are any particular traits of the species which limits its' response to management, and secondly whether there are any key threatening processes affecting the species which cannot be effectively managed. Furthermore in select areas where essential habitat components cannot be readily re-created (such as caves or cliff lines used by threatened species) such impacts can be deemed irreplaceable (DPIE 2019). **i. Known reproductive characteristics severely limit the ability to increase the existing population on, or occupy new habitat on, a biodiversity stewardship site.** The species requires highly specific maternity roosting sites consisting of arched cave environments with dome roofs and indentations for holding in order to breed successfully. These physical characteristics are uncommon and their scarcity presumably poses a limiting factor in the distribution of the species (DERM 2011, Pennay 2008). The species exhibits high site fidelity to these maternity cave sites, and only four such roosting sites have been formerly recorded in NSW (DAWE 2020b). These features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring.

Information required (BAM Section 9.1.2)	Response
	ii. The species is reliant on abiotic habitats which cannot be restored or replaced on a biodiversity stewardship site. In addition to maternity roost sites, the species also requires sandstone cliff/escarpments habitats (roosting habitat) in close proximity to fertile woodland valley habitats (foraging habitat), particularly box gum woodlands or river/rainforest corridors (DAWE 2020b). These features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **iii. Life history traits and/or ecology is known but the ability to control key threatening processes at a biodiversity stewardship site is currently negligible.** The primary threat to the species is loss or degradation of roosting habitat and maternity roost site as a result of animals and human activity. Where suitable roosting habitats occur within a biodiversity stewardship site, effective management of such features can be readily achieved. Secondary threats include loss of suitable foraging resources in proximity to roosting sites due to vegetation clearing and inappropriate fire regimes. Both of these can be effectively managed at a biodiversity stewardship site. Given the highly specialised breeding and roosting habitat requirements for the species, it is unlikely such habitats can be readily replicated at a biodiversity stewardship site. As such consideration of this species under SAII Principle 4 is warranted.
3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a species, the assessor must record this in the BDAR or BCAR.	The TBDC does not state that data is 'unknown' or 'data deficient' for this species. However the Saving Our Species profile for the species states that the species is data deficient (DPIE 2021d) and the SPRAT profile and National Recovery Plan for the species both note a lack of information for the species (DAWE 2020b, DERM 2011). The TBDC lists "lack of knowledge" as one of the threats to the species leading to insufficient understanding of species/community ecology and insufficient understanding of habitat requirements (DPIE 2021c).
4a. The impact on the species' population	**i. An estimate of the number of individuals (mature and immature) present in the subpopulation on the subject land (the site may intersect or encompass the subpopulation) and as a percentage of the total NSW population, and,** **ii. An estimate of the number of individuals (mature and immature) to be impacted by the proposal and as a percentage of the total NSW population.** Four known records exist within two kilometres of the proposed treated water environmental flows outlet. All of these records have occurred recently (since 2016) and two of the records are between 400 - 600 metres away from the proposed impact area (DPIE 2021b). The presence of Large-eared Pied Bat within the impact area has been confirmed via positive detection from two Anabat Express units deployed in October 2020, and on two additional SM4 Song Meter units deployed from December 2020 to January 2021 on six more occasions (out of a possible total of 30 survey nights). The historical records and acoustic detection results collected as part of this assessment indicate the presence of a small local population within the area. Studies on the foraging and roosting behaviour of Large-eared Pied Bats within the western Blue Mountains National Park found that individuals typically roosted within 700 metres of foraging habitat (Williams & Thomson 2018). Data captured for the current assessment suggest the species is present, at lower levels of activity, compared to other species of microbats recorded during the site surveys.

Information required (BAM Section 9.1.2)	Response
	As the species was recorded on just six nights out of a possible 30, this illustrates it is not commonly utilising the area and is highly unlikely to be using habitats within, or immediately surrounding the impact area, for roosting or breeding. Large-eared Pied Bat calls were first recorded no earlier than 10:03pm (on one occasion), more than one and a half hours after the end of civil twilight (c.8:40pm), with the remaining calls recorded between 11:52pm and 3:20am. Bats arriving in the area long after dark strongly suggests that the site is being utilised for foraging, and that there is no evidence to support the presence of a local roost where bats would be emerging closer to dusk (sunset being at c.8:10pm). Given the nature of acoustic surveys, and the data deficient nature of the species, it is not possible to estimate the number of individuals present and impacted as a percentage of the total NSW population.

4b. Impact on geographic range.	**i. The area of the species' geographic range to be impacted by the proposal in hectares, and a percentage of the total AOO, or EOO within NSW.**
	The impacts to available habitat for Large-eared Pied Bat as a result of the proposed works include the following:
	• Removal of approximately 1.56 hectares of native vegetation that occurs within 100 metres of habitat supporting low potential breeding habitat for Large-eared Pied Bat. This includes direct impacts to the following habitat structures:
	  ○ Removal of a vertical (vent) shaft, the opening to which is located in rocky cliff overhang habitat located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	  ○ Construction of the treated water environmental flows outlet, and associated gabion walls and HDD drilling, within an area of rocky cliff overhangs located between Core Pare Road and the Warragamba River (east of the Warragamba Dam).
	• Removal of a total of approximately 3.48 hectares of potential foraging habitat based on a 2 kilometre buffer from the presence of the potential roost habitat comprising sandstone cliffs and overhangs along the Warragamba River and Nepean River gorges.
	• Disturbance from indirect impacts in the form of increased traffic, noise and light during the project construction. These impacts will cease once construction is completed. Passive roost exclusions and undertaking works outside of breeding season are recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of these indirect impacts. Ongoing indirect impacts are expected to be minimal, and are assessed along with indirect construction impacts in Section 11.2 above.
	The area to be impacted represents <0.001 % of the 570,000 km2 extent of occurrence for the species, and <0.001 % of the 9,120 km2 area of occurrence for the species, based on the estimates provided in the species' SPRAT profile (DAWE 2020b).
	However, it should be noted that these measures do not account for the highly specialised breeding habitats required by the species, which are very uncommon across the species' area of occurrence.
	ii. The impact on the subpopulation as either: all individuals will be impacted (subpopulation eliminated); OR impact will affect some individuals and habitat; OR impact will affect some habitat, but no individuals of the species will be directly impacted.
	The proposed impacts are likely to affect potential habitat for the species. No direct impacts to individuals of the species are likely to occur as a result of the proposal.
	iii. To determine if the persisting subpopulation that is fragmented will remain viable,

Information required (BAM Section 9.1.2)	Response
	estimate the habitat area required to support the remaining population, and habitat available within dispersal distance, and distance over which genetic exchange can occur and pollination distance for the species. Vegetation within the impact area is connected to surrounding vegetation in all directions, forming a vegetation patch of more than 100,000 ha. This includes large tracts of intact native vegetation that form the Blue Mountains National Park, as well as forested riparian zones associated with the Warragamba River and later the Nepean River. These areas represent prime roosting habitat for the species given the underlying Hawkesbury sandstone geologies that occur throughout the Blue Mountains National Park which support numerous cave, cliff and escarpment habitats. By comparison, the impact area contains degraded foraging habitat due to historical disturbances associated with the construction of the Warragamba Dam. The removal of 1.56 hectares of native vegetation from low potential breeding habitat buffers and a further 3.48 ha of potential foraging habitat, within a patch of more than 100,000 hectares, is considered unlikely to impact the viability of the species within the locality. **iv. To determine changes in threats affecting remaining subpopulations and habitat if the proposed impact proceeds, estimate changes in environmental factors including changes to fire regimes (frequency, severity); hydrology, pollutants; species interactions (increased competition and effects on pollinators or dispersal); fragmentation, increased edge effects, likelihood of disturbance; and disease, pathogens and parasites. Where these factors have been considered elsewhere in relation to the target species the assessor may refer to the relevant sections of the BDAR or BCAR.** **Changes to fire regimes** The risk of fire as a result of sparks from machinery during proposed works is unlikely, but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers within the project's CEMP. Upon completion of works, the proposal is unlikely to result in changes to frequency or intensity of fire regimes within the locality. **Hydrology** Changes to hydrology as a result of the proposal are discussed in Section 11.2.1. These changes are unlikely to significantly impact on the foraging or roosting behaviour of Large-eared Pied Bat. **Pollutants** The project does not involve the use of any pesticides, nor is it likely to substantially increase the levels of pesticides within the environment. **Species interactions** The impact area and surrounds likely support several pest animal species and it is highly likely that feral goats are already present within the area. The small-scale nature of works is unlikely to result in an increase in feral animal activity in the area, or alter the existing disturbances to roosting sites that may already be exhibited by goats within the locality. In addition to feral goats, introduced predators such as feral cats and foxes can negatively impact the species. Such predators were recorded during camera trap surveys, and are likely already present within the broader locality and are unlikely to increase as a result of the

Information required (BAM Section 9.1.2)	Response
	proposal. **Fragmentation** Large-eared Pied Bat is a highly mobile species capable of dispersing across breaks in habitats. While it is assumed that connected vegetation is preferred by the species for movement, the existence of many records of the species within urbanised areas suggests that the species does not rely on specialised dispersal or movement habitat. Thus, the loss of approximately 1.56 hectares of native vegetation from the buffer area of low potential roosting sites and a further 3.48 hectares of foraging habitat is unlikely to impact the movement ecology of the local population. As such population fragmentation will not occur as a result of the proposal. **Increased edge effects** The proposed works that occur within the vicinity of the identified potential Large-eared Pied Bat habitats are occurring within a previously disturbed area of the existing Warragamba Dam footprint. As such these areas are already subject to some edge effects. Whilst transport of weeds is possible during construction, these will be mitigated through the application of appropriate weed control measures to bed detailed within the CEMP. This will ensure the existing edge effects are not exacerbated by the proposal. These edge effects are also unlikely to significantly impact the species, given the availability of foraging resources within the locality. **Likelihood of disturbance** Disturbance will occur in the form of direct impacts to native vegetation within the 100 metre buffer are of low potential breeding habitats as well as the removal of foraging habitat. In additional indirect impacts during construction (i.e. light, noise and vibration) have the potential to disturb any roosting individuals that may be present. These indirect impacts will be mitigated through passive roost exclusions and undertaking works outside of breeding season. **Disease, pathogens and parasites** One of the most significant pathogens impacting bats it White-nose fungus. To date there have been no cases of White-nose fungus recorded in Australia. Given the localised nature of the proposed works, restricted to Western Sydney, it is therefore unlikely that the fungus could be spread to microbats as a result of the proposed works.
5. The assessor may also provide new information that can be used to demonstrate that the principle identifying the species as at risk of an SAII, is inaccurate.	Not applicable.

SAII assessment for Sooty Owl

Sooty Owl is listed as Vulnerable under the NSW BC Act, with the BioNet Threatened Biodiversity Data Collection (TBDC) indicating that the species is an entity subject to SAII in NSW. The species is considered an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 4: a species that is unlikely to respond to measures to improve its habitat and therefore its members are not replaceable.

The SAII threshold for the species is described in the TBDC as "*only for cave breeding habitat to be identified by survey*". Specifically, on sites where the species is determined to be present and suitable caves are present and breeding has been detected/proven any impact could be serious and irreversible. Any other impact on the species habitat is unlikely to be a potential serious and irreversible impact.

The potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Table A.8 Assessment of SAII for Sooty Owl

Information required (BAM Section 9.1.2)	Response
1. The action and measures taken to avoid the direct and indirect impact on the species at risk of an SAII.	Actions and measures undertaken by the proponent to avoid and minimise impacts to Sooty Owl are provided in Section 10 of this BDAR. Impacts to Sooty Owl are most likely to occur in the western areas of the project, where the location of the proposed water outlet structure is to be installed to release high-quality treated water to the Warragamba River as environmental flows (Figure 16). There are no direct impacts to the potential cave and cliff line breeding habitat for Sooty Owl will occur as a result of the proposed works. Potential breeding habitat in the forms of cliffs, overhangs and caves has been conservative assumed to be present along the northern bank of the Warragamba River, on the opposite side of the river gorge from the project's impact area. Suitable habitat was found to be absent from the impact area itself. Impacts are therefore restricted to clearing of vegetation within the 100 metres radius buffer around the potentially occurring cliff / overhang /cave features, on the far (northern) side of the river, and potentially un-surveyed areas to the north-east of the impact area and impact assessment area, on the southern side of the river. The vegetation removal is located immediately adjacent to the footprint of the existing Warragamba dam facility where there is a history of disturbance within the vegetation proposed to be removed. This minimises the need for extensive clearing and development of infrastructure in pristine areas. The location of the proposed outlet structure has also been selected following a preliminary constraints assessment (Biosis 2020) which investigated a number of pipeline options. The selected option was chosen as it represented the least impact to ecological values and features, including other SAIIs and TECs. Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact. These include undertaking works outside of breeding season and undertaking pre-clearance immediately prior to commencement of works to ensure no individuals are present.

Information required (BAM Section 9.1.2)	Response
2a. Evidence of rapid decline. **(Principle 1)**	**i. Evidence of rapid decline in the population of the species in NSW in the past 10 years or three generations (whichever is longer), or** **ii. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer) as indicated by: an index of abundance appropriate to the species; decline in geographic distribution and/or habitat quality; exploitation; effect of introduced species, hybridisation, pathogens, pollutants, competitors or parasites.** Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018). To be considered under this principle, the species should have an observed, estimated, inferred, suspected or projected population of ≥80% in 10 years or three generations (whichever is longer) (DPIE 2019). The *Recovery Plan for the Large Forest Owls* (DEC 2006) estimates the minimum population size of Sooty Owl within NSW to be 2,000 pairs or at least 10,000 individuals (including non-breeding), based on systematic survey within most forested regions of NSW, concentrated in public forests. Listed within the recovery plan as the contributing reasons for listing of Sooty Owl is that the population is suspected to be declining. An eight-year PhD study by Kavanagh (1997) predicted somewhere between 100-200 breeding pairs located within the south-eastern region of NSW. A preliminary population viability assessment on this population indicated a low probability of regional extinction over a 200 year period. However these results were sensitive to a number of demographic parameters, in particular the annual adult mortality rate and the annual probability of owl pairs failing to breed (Kavanagh 1997). Similar low extinction probabilities (but high prediction uncertainty) were recorded in a population viability study into Powerful Owl (McCarthy et al. 1999, DEC 2006). Given the reported sizes of the Sooty Owl populations, coupled with the preliminary population viability assessment results, it is unlikely that the species has undergone rapid decline that would trigger consideration of the species under SAII Principle 1.
2b. Evidence of small population size. **(Principle 2)**	**i. An estimate of the species' current population size in NSW, and** **ii. An estimate of the decline in the species' population size in NSW in three years or one generation (whichever is longer), and** **iii. Where such data is available, an estimate of the number of mature individuals in each subpopulation, or the percentage of mature individuals in each subpopulation, or whether the species is likely to undergo extreme fluctuations.** As outlined above the *Recovery Plan for the Large Forest Owls* (DEC 2006) estimates the minimum population size of Sooty Owl within NSW to be 2,000 pairs or at least 10,000 individuals (including non-breeding). Species decline appears to be primarily linked with the loss of habitat, resulting from wide-scale clearing of old-growth rainforest and moist forest environments which is the key threat to the species (DEC 2006, Kavanagh & Standon 2002). Given the large area of occurrence for the species, and the lack of recent population studies in the literature, it is difficult to quantify expected species decline. However, studies have shown that Sooty Owl has a large home range with approximately one pair of Sooty Owls occurring for every 1,823 hectares of suitable native vegetation (McIntyre & Henry 2002). As such it could be estimated that a breeding pair is lost for each 1,823 ha of suitable habitat (i.e. old-growth rainforest or moist

Information required (BAM Section 9.1.2)	Response
	forest with suitably size hollow-bearing trees) cleared within the species' area of occurrence. However, these habitats are likely to already be protected as state forests, national parks and nature reserves as the species has a preference for extensively forested areas, with small (<200 ha) fragments of forest being unsuitable as a reservoir for the species (Kavanagh & Standon 2002). Given the reported sizes of the Sooty Owl populations, coupled with the preliminary population viability assessment results, it is unlikely that the species has a small population size that would meet the thresholds required for consideration of the species under SAII Principle 2.

2c. Evidence of limited geographic range for the threatened species. (Principle 3)	The geographic range of a species is measured by its area of occupancy, which represents the area of suitable habitat currently occupied by the taxon (IUCN Standards and Petitions Committee 2019). Species that are known to have a very limited geographic distribution are generally known to:
	• Have an area of occupancy of ≤ 10 km^2.
	• Have an extent of occurrence of ≤ 100 km^2.
	• Have at least two of the following three conditions:
	  ○ Are severely fragmented or only known from one location.
	  ○ Continuing decline.
	  ○ Extreme fluctuations.
	• Inhabit less than or equal to three locations in NSW (DPIE 2019).
	i. Extent of occurrence.
	One of the contributing reasons for the listing of Sooty Owl under the NSW BC Act is that the current distribution of the species is between 10,001 – 100,000 km^2, with the current distribution having declined by an unknown extent (DEC 2006).This extent of occurrence is significantly larger than the threshold detailed above.
	ii. Area of occupancy.
	Similarly the area of occupancy is also large with the occurrence of Sooty Owl being widespread throughout its range, although limited by the distribution of its specialised habitat (DEC 2006). This area is also considered to be significantly larger than the threshold detailed above.
	iii. Number of threat-defined locations (geographically or ecologically distinct areas in which a single threatening event may rapidly affect all species occurrences).
	The primary threat facing the species is habitat clearing and fragmentation, particularly in relation to riparian rainforests and moist forests with large hollow-bearing trees (DPIE 2021c, DEC 2006, Kavanagh 1997). The Saving Our Species strategy for the species notes five priority management areas for the species around Eden, Batemans Bay, Wollongong and Sydney, Port Macquarie and Coffs Harbour. These priority areas are large zones that cover much of the east coast (DPIE 2015d).
	Given the large area of occurrence of the species and the primary threat, it is unlikely that a single threatening event would rapidly affect all species occurrences.
	iv. Whether the species' population is likely to undergo extreme fluctuations.
	As highlighted above, preliminary population modelling in the south-east region of NSW has indicated that there is a low probability of regional extinction over a 200 year period (Kavanagh 1997). However there are some uncertain parameters that comprise this model, particularly annual adult mortality rate and the annual probability of owl pairs failing to breed. Sooty Owl lives in monogamous, life-long pairs with breeding occurring irregularly

Information required (BAM Section 9.1.2)	Response
	and unpredictably throughout the year, although typically peaking in autumn-winter and early spring. A single clutch of 1-2 eggs is laid a year, but sometimes (perhaps more often) there is no breeding within a year (DEC 2006). Although there is some variability in nesting, it is unlikely that all breeding pairs across the species' area of occurrence would fail to breed in the same year. It is much more likely that in any given year there is a proportion of the adult breeding population producing clutches, with others not breeding due to local environmental factors. As such extreme fluctuations across the species population are unlikely. Given the available information the species does not meet the thresholds for consideration under SAII Principle 3.
2d. Evidence that the species is unlikely to respond to management. (Principle 4)	This principle encompasses two components, firstly whether there are any particular traits of the species which limits its' response to management, and secondly whether there are any key threatening processes affecting the species which cannot be effectively managed. Furthermore in select areas where essential habitat components cannot be readily re-created (such as caves or cliff lines used by threatened species) such impacts can be deemed irreplaceable (DPIE 2019). **i. Known reproductive characteristics that severely limit the ability to increase the existing population on, or occupy new habitat on, a biodiversity stewardship site.** The species requires large old hollow-bearing trees in live or occasionally dead trees (typically Eucalyptus or rainforest tree species) for nesting. These hollows need to be greater than 40 cm wide and greater than 100 cm deep, with the height of the hollow being at least 16 m above the ground in trees of at least 120 cm diameter at breast height. Suitable nesting trees must also be situated in unlogged, unburnt gullies and lower slopes within 100 m of streams. In addition to hollow-bearing trees the species also sometime utilises caves for breeding (DEC 2006). These features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **ii. The species is reliant on abiotic habitats which cannot be restored or replaced on a biodiversity stewardship site.** As detailed above, the species requires hollow-bearing trees for nesting and roosting within dense rainforest or moist forest. The species also utilises caves, and recesses or ledges in cliffs for roosting. Such roosting sites are typically in the darkest and most secluded or sheltered position in the forest such as narrow, gloomy side-gullies near creek junctions or in vine tangles (DEC 2006). Such features are unlikely to be replicated successfully on a stewardship site, where such features are not already naturally occurring. **iii. Life history traits and/or ecology is known but the ability to control key threatening processes at a biodiversity stewardship site is currently negligible.** The primary threat to the species is habitat clearing and fragmentation for agriculture, pine plantations, mining, major infrastructure and urban developments. Intensive logging of wood-production forests also has the potential to remove important nesting and roosting sites as well as the den site of prey species. Additional threats identified for the species include inadequate fire regimes, grazing, predation of fledglings, human hazards, pest control, disease and drought (DEC 2006, Kavanagh & Standon 2002). For the most part, where suitable roosting habitats occur within a biodiversity stewardship site, effective management of such features can be readily achieved. However, given the specialised breeding and roosting habitat requirements for the species, as well as the large home range size of individuals, identifying and protecting the necessary stewardship sites to

Information required (BAM Section 9.1.2)	Response
	protect the species is likely to be challenging. Given the available information, consideration of this species under SAII Principle 4 is warranted.
3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a species, the assessor must record this in the BDAR or BCAR.	The TBDC does not state that data is 'unknown' or 'data deficient' for this species.
4a. The impact on the species' population	**i. An estimate of the number of individuals (mature and immature) present in the subpopulation on the subject land (the site may intersect or encompass the subpopulation) and as a percentage of the total NSW population, and,** **ii. An estimate of the number of individuals (mature and immature) to be impacted by the proposal and as a percentage of the total NSW population.** Sooty Owl has a large home range, with population studies for large forest owl conservation in East Gippsland in regional Victoria finding approximately one pair of Sooty Owls occurring for every 1,823 hectares of native vegetation (McIntyre & Henry 2002). Studies looking at the diet and roosting behaviour of the species at Cape Conran in Victoria also reported that some males of the species have a home range of up to 2,879 hectares (L'Hotellier & Bilney 2016). The species is also strongly associated with large forested areas with studies showing that individuals are usually recorded less than one kilometre from the boundary of state forest, national park or other area of continuous forest. They are not generally present within remnant forest and woodland fragments on private land (Kavanagh & Standon 2002). Based on these studies it is likely that the local population present within the locality includes individuals located within the continuous forested area of the Blue Mountains National Park, an area of 247,000 hectares (NPWS 2001). Assuming a similar density to that studied within East Gippsland forest (McIntyre & Henry 2002), a total of 135 breeding pairs could be present within this national park. However, given the species is strongly territorial (Lundie-Jenkins 1992) with large home-ranges (DSE 2003), it is likely that the small area of native vegetation that supports potential cave breeding habitat along the banks of the Warragamba River, adjacent to the project's impact area is capable of supporting only a single breeding pair at most. This is supported by the closest known record occurring approximately 4 kilometres north-east of the study area, from 2017 (DPIE 2021b). The remaining known records are greater than 5 kilometres from the study area.
4b. Impact on geographic range.	**i. The area of the species' geographic range to be impacted by the proposal in hectares, and a percentage of the total AOO, or EOO within NSW.** The impacts to potential habitat for Sooty Owl as a result of the proposed works include the following: • Removal of approximately 1.56 hectares of native vegetation that occurs within 100 metres of potential 'breeding habitat buffer areas' that would be required by the BAM if breeding was recorded / assumed present on the far side of the river. • Disturbance from indirect impacts in the form of increased traffic, noise and light during the project construction. These impacts will cease once construction is completed.

Information required (BAM Section 9.1.2)	Response
	Ongoing indirect impacts are expected to be minimal, and are assessed along with indirect construction impacts in Section 11.2 above. The area to be impacted is likely to represent approximately between 0.015 % to 0.0015 % of the extent of occurrence for the species, based on the values provided in the Recovery Plan for the Large Forest Owls (DEC 2006). It is likely to represent a similar are of occupancy, given its widespread occurrence across its range. **ii. The impact on the subpopulation as either: all individuals will be impacted (subpopulation eliminated); OR impact will affect some individuals and habitat; OR impact will affect some habitat, but no individuals of the species will be directly impacted.** The proposed impacts may affect potential habitat within the breeding buffer zone for the species. As detailed in the TBDC, these impacts would only constitute a SAII if the species is determined to be present and suitable caves are present and breeding has been detected. Any other impact on the species habitat is unlikely to be a potential serious and irreversible impact (DPIE 2021c). No individuals were recorded during the assessment, and no breeding was observed within the cave features. Due to the size of the area of potential breeding habitat, and access restrictions along the Warragamba River (particularly along the northern bank bordering the Blue Mountains National Park where high vertical cliff faces prevented safe access), targeted survey in accordance with the survey guidelines could not be undertaken. As such, due to the presence of potential breeding habitat and the inability to conduct targeted survey, other than hollow-bearing tree survey and cave roost assessment within the impact area, the removal of 1.56 hectares native vegetation present with the impact area has been conservative included under this SAII assessment. Cave breeding habitat was not recorded with the impact area, however numerous small caves and overhangs occur on the far side of the river. Furthermore as noted above, roosting sites are typically in the darkest and most secluded or sheltered position in the forest such as narrow, gloomy side-gullies near creek junctions or in vine tangles (DEC 2006), this does not align well with the large and steep gorge-side habitat opposite the project's impact area where the species' habitat has between conservative assumed to be present. As such actual impact to the species breeding habitat ae considered unlikely to occur. **iii. To determine if the persisting subpopulation that is fragmented will remain viable, estimate the habitat area required to support the remaining population, and habitat available within dispersal distance, and distance over which genetic exchange can occur and pollination distance for the species.** Vegetation within the impact area is connected to surrounding vegetation in all directions, forming a vegetation patch of more than 100,000 ha. This includes large tracts of intact native vegetation that form the Blue Mountains National Park, as well as forested riparian zones associated with the Warragamba River and later the Nepean River. These areas represent prime foraging and breeding habitat for the species which roosts by day in the hollow of a tall forest tree or in heavy vegetation; hunts by night for small ground mammals or tree-dwelling mammals; and breeds in hollow-bearing trees or caves (DPIE 2021c). Numerous such cave, cliff and escarpment habitats suitable for nesting have occur in the locality given the underlying Hawkesbury sandstone geologies that occurs throughout the Blue Mountains National Park.

Information required (BAM Section 9.1.2)	Response
	By comparison, the impact area contains degraded foraging habitat due to historical disturbances associated with the construction of the Warragamba Dam. The removal of 1.56 hectares of native vegetation from low potential breeding habitat buffers within a patch of more than 100,000 hectares, is considered unlikely to impact the viability of the species within the locality. **iv. To determine changes in threats affecting remaining subpopulations and habitat if the proposed impact proceeds, estimate changes in environmental factors including changes to fire regimes (frequency, severity); hydrology, pollutants; species interactions (increased competition and effects on pollinators or dispersal); fragmentation, increased edge effects, likelihood of disturbance; and disease, pathogens and parasites. Where these factors have been considered elsewhere in relation to the target species the assessor may refer to the relevant sections of the BDAR or BCAR.** **Changes to fire regimes** Sooty Owl appears to display a strong associated with long-unburnt forest, particularly when it comes to choosing nesting and roosting locations (DEC 2006, Kavanagh 1997). The risk of fire as a result of sparks from machinery during proposed works is unlikely, but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers within the project's CEMP. Upon completion of works, the proposal is unlikely to result in changes to frequency or intensity of fire regimes within the locality. **Hydrology** Changes to hydrology as a result of the proposal are discussed in Section 11.2.1. These changes are unlikely to significantly impact on the foraging or roosting behaviour of Sooty Owl. **Pollutants** The project does not involve the use of any pesticides, nor is it likely to substantially increase the levels of pesticides within the environment. **Species interactions** The impact area and surrounds likely support several pest animal species such as feral goats, feral cats, foxes and black rats. Foxes are known to predate Powerful Owl and Masked Owl fledglings and could conceivably be a threat to Sooty Owl fledglings. Black rats also potentially carry the parasitic Rat Lungworm *Angiostrongylus cantonensis* with which individuals may become infected (DEC 2006). Several such pest animals were recorded during camera trap surveys indicating that they are already present within the broader locality. Given the nature of the proposed works, the proposal is considered unlikely to increase pest numbers. **Fragmentation** Sooty Owl is a highly mobile species capable of dispersing across breaks in habitats. Studies have showing that Sooty Owl has a large home range with approximately one pair of Sooty Owls occurring for every 1,823 hectares of native vegetation (McIntyre & Henry 2002), and some males of the species have a home range of up to 2,879 hectares (L'Hotellier & Bilney 2016). Given the small scale of impacts, restricted to 1.56 hectares of native vegetation within the previously disturbed Warragamba Dam Facility footprint, this represents less than 0.1% of the available foraging habitat within a pair's home range. As such population

Information required (BAM Section 9.1.2)	Response
	fragmentation will not occur as a result of the proposal. **Increased edge effects** The proposed works that occur within the vicinity of the identified low potential cliff/cave breeding habitat buffer are occurring within a previously disturbed area of the existing Warragamba Dam footprint. As such these areas are already subject to some edge effects. Whilst transport of weeds is possible during construction, these will be mitigated through the application of appropriate weed control measures to bed detailed within the CEMP. This will ensure the existing edge effects are not exacerbated by the proposal. These edge effects are also unlikely to significantly impact the species, given the availability of foraging resources within the locality. **Likelihood of disturbance** Disturbance will occur in the form of direct impacts to native vegetation within the 100 metre buffer are of low potential breeding habitats. In additional indirect impacts during construction (i.e. light, noise and vibration) have the potential to disturb any roosting individuals that may be present. These indirect impacts will be mitigated through passive roost exclusions and undertaking works outside of breeding season. **Disease, pathogens and parasites** The *Recovery Plan for the Large Forest Owls* states that little is known of diseases in owls, with a low incidence of natural pathogens in nestling and fledgling Powerful Owls and Masked Owls, and a very low incidence of disease in adult owls. Sooty Owl may be susceptible to infection from the Rat Lungworm which is a parasitic nematode worm of introduced and native rodents (DEC 2006). Given the low incidence of pathogens known to infect Sooty Owl, along with the localised nature of the proposed works, restricted to Western Sydney, it is unlikely that the impacts of disease, pathogen and parasites would be significantly exacerbated as a result of the proposed works.
5. The assessor may also provide new information that can be used to demonstrate that the principle identifying the species as at risk of an SAII, is inaccurate.	Not applicable.

Appendix 6 Significant Impact Criteria assessments

SIC Assessment for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest – Critically Endangered Ecological Community EPBC Act

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest represents certain occurrences of the coastal plain grassy eucalypt woodlands that are endemic to the shale hills and plains of the Sydney Basin Bioregion in NSW and which occur primarily in, but not limited to, the Cumberland Sub-region. The ecological community incorporates the grassy eucalypt shale hills and plains woodlands and the shale-gravel transition forests of this region.

The Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community is limited to the Sydney Basin Bioregion with most occurrences in the Cumberland Sub-region. The community typically occurs on flat to undulating or hilly terrain, at elevations up to approximately 350 metres above sea level. Some occurrences may extend onto locally steep sites at slightly higher elevations. Most occurrences are on clay soils derived from Wianamatta Group geology, with limited to rare occurrences on other soil types.

In 2009, the ecological community occupied a maximum area of approximately 12,300 hectares but is highly fragmented into generally small remnants, mostly under 10 hectares in size (Tozer, 2003).

The main and ongoing threats to the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community as outlined in the Approved Conservation Advice (TSSC 2009) include clearing for urban, industrial or rural development, the consequent fragmentation of native vegetation remnants, inappropriate grazing and fire regimes, weed invasion and the low level of protection in reserves. Vegetation clearance was, and continues to be, the major contributor to the loss and fragmentation of native vegetation across the Cumberland Plain. The continuing decline is predominately a consequence of dispersed, small scale clearing actions associated with urban development (NSW Scientific Committee and Simpson, 2008).

A total of 1.88 hectares of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest occurs within the impact area and will be directly impacted by the project, with an additional 5.53 hectares mapped in the impact assessment area, and potentially indirectly impacted by adjacent vegetation clearing and constriction activities.

Significant impact criteria	Likelihood of significant impact	Justification
Reduce the extent of an ecological community	Unlikely	The project requires the direct removal of 1.88 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest within the impact area, with an additional 5.53 ha of the ecological community situated in the adjacent to the impact area, which has the potential to be indirectly impacted by the project. Substantial efforts have been made to ensure that impacts to Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest have been avoided and minimised throughout the design phase of the project. Avoidance and minimisation of impacts were achieved at two broad scales, macro-scale avoidance achieved through alignment changes, and micro-scale avoidance achieved through measures such as minimisation of impact corridor widths, underbores, and placing open trenching in the roadway (rather than the road verge). An estimated total of 10,726 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest remains in various conditions (DECCW 2011), within the Cumberland Plain Recovery Plan study area. Which equates broadly to the shale basin referred to as the 'Cumberland Plain' in western Sydney, and ranges from Kurrajong to Cattai in the north, Strathfield down to Campbelltown in the east, Bargo in the south, and Oakdale to Emu Plains on

Significant impact criteria	Likelihood of significant impact	Justification
		the west, comprising an area of approximately 2,200 kilometre^2. The project will result in an overall reduction of approximately 0.06 % of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest that is likely to be directly and indirectly impacted by the current proposal, and a relatively localised impact through a linear strip of the TECs extent of occurrence. This has been assessed as unlikely to be a significant reduction of the extent of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	Unlikely	The project will require the removal of 1.88 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in the impact area, which equates to the residual impact following all efforts undertaken to minimise and avoid impacts to the TEC. This direct impact is likely to lead to minor increases in localised fragmentation impacts, particularly to the patches of retained vegetation immediately adjacent to the impact area. These impacts will occur at Lansdowne Reserve and within Western Sydney Parklands where clearing for the project will increase fragmentation of larger retained patches of the TEC. These impacts are not considered substantial however as the break in connectivity will only occur over a length of approximately 450 m in Western Sydney Parklands and 120 m in Lansdowne Reserve. The increased fragmentation will not substantially reduce connectivity in either location, as the impacts in Lansdowne Reserve will be rehabilitated and thus temporary in nature, and occur within/adjacent to already fragmented patches of the TEC in Western Sydney Parklands. Edge effects may increase as a result of the project, but these are again not expected to be substantial. Generally, Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest present in the impact area exists in a highly fragmented landscape and has limited connectivity to surrounding areas of native vegetation. As the fragmentation impacts expected to occur as a result of the project, which are localised and relatively minor in nature, are not expected to increase impacts to Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest such that a significant impact to the TEC is likely to occur.
Adversely affect habitat critical to the survival of an ecological community	Unlikely	The *Matters of National Environmental Significance Significant impact guideline* (CoA 2013) state the 'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary: • for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators), • to maintain genetic diversity and long term evolutionary development, or • for the reintroduction of populations or recovery of the species or ecological community. No such habitat has been identified in a recovery plan for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest, or listed on the Register of Critical Habitat maintained by the minister under the EPBC Act. The project will directly impact upon 1.88 ha of habitat that supports the TEC, which occurs largely in a degraded, fragmented and edge effect state. The

Significant impact criteria	Likelihood of significant impact	Justification
		highest quality patch of habitat relevant to the project occurs within the Stewardship Site at Lansdowne Reserve. The project will not impact upon the Stewardship Site itself, but will impact upon the edges of the habitat present, and with a 120 m long, by 20 m wide impact for access through as area to the west of the Stewardship Site boundary. This impact will occur through a portion of the remnant vegetation in lower condition, supporting lower habitat values than the majority of the reserve. The project will not impact upon the vast majority of habitat protected within the reserve (and Stewardship Site), with <2 % of the patch of the TEC being impacted, so it cannot be said that the project is likely to substantially impact upon Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in this location. Due to the generally low quality Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest habitat impacted by the project, the project is not considered likely to result in impacts that will adversely affect habitat critical to the survival of an ecological community.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	Unlikely	Potential indirect impacts to groundwater and GDEs surrounding the impact area (ie. not directly removed by the project), associated with the construction and operational phases of the project, have been assessed by Aurecon Arup in the Upper South Creek AWRC Groundwater Impact Assessment (Aurecon Arup 20211b). The assessment report notes that construction of the proposed AWRC and pipelines have the potential to impact the groundwater systems in several ways, including: • Induced drawdowns from required dewatering activities during trenching works, temporarily reducing the availability of groundwater for GDEs and surrounding groundwater users. • Disruption of surface water and groundwater connectivity. • Furthermore, operation of the proposed AWRC and pipelines have the potential to impact the groundwater systems in several ways, including: • Induced drawdowns from any underdrainage systems employed for underground structure floatation management, reducing the availability of groundwater for GDEs and surrounding groundwater users. (Aurecon Arup 20211b) Where trenching activities would require dewatering due to inflows of groundwater, drawdowns would occur that would likely effect the surrounding GDEs. However, it is concluded by Aurecon Arup (20211b) that drawdowns would be constrained to a short period of time during construction, and therefore the predicted impacts are not expected to prevent the long-term viability of the affected ecosystems. (Aurecon Arup 20211b) To minimise impacts to groundwater systems, a range of mitigation measures would be implemented during the detailed design, construction and operational phases of the project and detailed in a project CEMP and operational procedures. The assessments concludes that following the implementation of suggested mitigation measures the severity of any residual impact to GDEs would be considered low. (Aurecon Arup 20211b)

Significant impact criteria	Likelihood of significant impact	Justification
		Based on the assessment undertaken by Aurecon Arup (2020b) the project is not expected to result in substantial or significant indirect impacts to GDEs surrounding the impact area, and thus the TEC which may represent a surface expression of a GDE. The project is not expected to result in substantial alteration to surface water patterns as the impact area will be rehabilitated following completion of construction works. The final rehabilitated form of the areas of open trenching will ensure ground levels are re-profiled to a stable landform consistent with original contours and vegetated with a self-sustaining groundcover species. Alterations to hydrological patterns surrounding the Nepean River may also occur, but the area of the TEC impacted in this is not expected to be substantial due to its occurrence further back from the riverbank and on higher parts of the floodplain. Mitigation measures would ensure that downstream indirect impacts (such as sediment and nutrient transportation) would be controlled and would not impact remaining areas of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in the locality. As such, the project is not expected to result in impacts that modify or destroy abiotic factors necessary for the survival of the TEC.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	Unlikely	The project will not result in specific impacts to characteristic and functionally important species, as neither the construction or operational impacts will result in alterations to fire or flood regimes that maintain (or would potentially impact upon) the diversity of the TEC in the impact area, or broader landscape. The project will not alter management regimes of any retained vegetation, such as increased under-scrubbing or grazing, and there is no likelihood of the project resulting in an increase in harvesting of flora species. The project will result in direct impact to a total of 1.88 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest, with an additional 5.53 ha of the TEC occurring adjacent, and potentially subject to indirect impacts. Neither of these extents support a high proportion of functionally important species, when compared to patches of the TEC that occur in the broader landscape. As such, the project is not expected to result in impacts that cause a substantial change in the species composition of an occurrence of the TEC.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: • **assisting invasive species, that are harmful to the listed ecological community, to become established, or**	Unlikely	Most locations where this TEC occurs are subject to existing weed invasion, pest animals, erosion and chemical inputs as a result of surrounding agricultural land use. Construction activities can be managed through standard practices to avoid further sedimentation and pollution.

Significant impact criteria	Likelihood of significant impact	Justification
• **causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or**		
Interfere with the recovery of an ecological community.	Unlikely	There is no Commonwealth adopted Recovery Plan for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest. However, the TEC is included in the Cumberland Plain Recovery Plan (DECCW 2011), a multi-entity recovery plan that has been prepared for 20 threatened species, populations and ecological communities that occur within the 'Cumberland Plain' region in western Sydney. The recovery plan has the following objectives: • To build a protected area network, comprising public and private lands, focused on the priority conservation lands. • To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation. • To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program. • To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner The project will directly impact upon 1.88 ha of the TEC following substantial efforts to ensure that impacts have been avoided and minimised throughout the design phase of the project. Whilst the project will impact upon Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in the priority conservation lands mapped at Lansdowne Reserve, impacts in this area have been substantially minimised through deign refinements, and are now restricted to the edges of existing roadways and temporary impact to a lower condition patch of vegetation for access required to the wastewater system connection point. This level of residual impact will not reduce the ongoing capacity of Lansdowne Reserve (and the Lansdowne Reserve Stewardship Site) to act a priority conservation area for the TEC. The project will not result in impacts likely to be adverse to any of the other objectives of the Cumberland Plain Conservation Plan, nor will it impact upon areas of high quality habitat which could support the TEC into the future, and as such it is not expected that the project will interfere with the recovery of an ecological community.

Based on the assessment provided above, it is concluded that Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest is unlikely to be significantly impacted by the project, and as such offsetting in accordance with the EPBC Act Environmental Offsets Policy (CoA 2012) and the EPBC Act is not required.

SIC Assessment for Regent Honeyeater Anthochchaera phrygia – Critically Endangered EPBC Act

Regent Honeyeater is endemic to mainland south-eastern Australia where it is now patchily distributed from 100 kilometres north of Brisbane to the Adelaide area. The species is mainly associated with woodland of the inland slopes of NSW and Victoria but also occurs at key coastal sites in NSW. The species feeds mainly on nectar from key eucalypt species and mistletoes and its movements are tied to the timing of flowering for these food tree species.

The main threat to the species is clearing, habitat fragmentation and degradation associated with agriculture and urban development. Other threats include firewood collection, invasive plants, grazing by livestock and predation by exotic predators. Woodland fragmentation has led to increased numbers of Noisy Friarbird and Red Wattlebird, which compete with Regent Honeyeaters for key nectar resources.

There are four key breeding areas for the Regent Honeyeater and a number of subsidiary areas which may be used in response to resource availability (CoA 2016).

Threats to the Regent Honeyeater as outlined in the National Recovery plan (CoA 2016) include:

- Small population size (350-400 individuals)
- Habitat loss and fragmentation (clearing of woodland and forest containing key eucalypt species)
- Habitat degradation (loss of mature trees and restriction of shrub and sapling growth)
- Competition (from other nectivorous birds)

A total of 13.77 hectares of potential foraging habitat occurs within the impact area. These areas support key tree species known to be important food resources for Regent Honeyeater, including Spotted Gum *Corymbia maculata*, Thin-leaved Stringybark *E. eugenioides*, and Red Ironbark *E. fibrosa*. Diurnal bird surveys conducted during field assessment did not detect any Regent Honeyeater activity. Previous records within the locality are sporadic with primarily singular records occurring within years spanning from 1980 to 2015, there are less than 10 total records of the species within 5 kilometres of the impact area since 1980. It is assumed the impact area may be used on occasion for foraging by the Regent Honeyeater, but that survey over any given year may be unable to detect the species given that the estimated total number of individual birds is less than 1000, their wide distribution across the south-east of Australia and the nomadic nature of the species (CoA 2016).

The impact area is considered not to support breeding habitat given the generally degraded and edge effected nature of the habitats within the impact area, no areas mapped as supporting breeding habitat by the National Recovery Plan, no EES 'Important Areas' mapping in the vicinity of the impact area, the number of records across years is low and breeding has not been identified previously in the area. The closest EES mapped Important Area for the species occurs at Mulgoa, approximately 3 kilometres north of the western extent of the project alignment.

To compare the approximate level of impact to potential Regent Honeyeater habitat, to that available to the species across the Cumberland IBRA subregion, the total sum area of the 8 habitat PCTs impacted by the project, as mapped by OEH (2013) and OEH 2016), has been calculated. This equates to a total area of 32,000 hectares of potential habitat, commensurate to that impacted by the project, currently available to the species across the subregion.

Based on the above, the project will impact upon approximately 0.04 % of potential Regent Honeyeater habitat within the Cumberland IBRA subregion. It is acknowledged that these calculations are based on aerial vegetation mapping that is at least 7 years old, however the total area of potential habitat available to the species is not expected to have changed substantially since the mapping projects were completed. As such, the above calculations are considered suitable to determine an approximate level of impact by the project.

Significant impact criteria	Likelihood of significant impact	Justification
Lead to a long-term decrease in the size of a population	Unlikely	Due to its complex movement patterns typified by migration and local nomadism, the Regent Honeyeater has what is effectively a single national population (CoA 2016). Factors that would lead to a long-term decrease in the size of this national population include direct impacts to locations considered important for the species (i.e. Important Areas – breeding habitat for Regent Honeyeater) (DPIE 2020f). The impact area does not include known Important Areas for Regent Honeyeater, or any mapped Key or Other breeding areas (CoA 2016). Furthermore, approximately 32,000 hectares of potential habitat is present within the Cumberland IBRA subregion, comprising similar PCTs to those being removed by the project. Removal of 13.77 hectares of potential habitat within the impact area is unlikely to lead to further declines in the species, given the abundance of similar foraging habitat remaining in the locality.
Reduce the area of occupancy of the species	Unlikely	As outlined above, the species is patchily distributed from 100 kilometres north of Brisbane to the Adelaide area. The species is mainly associated with woodland of the inland slopes of NSW and Victoria but also occurs at key coastal sites in NSW. Western Sydney is not one of these key sites. The impact area has not been identified within any Important Areas for the Regent Honeyeater (DPIE 2020f). One Important Area has been mapped within the Cumberland IBRA subregion for Regent Honeyeater, located approximately 3 kilometre north of the impact area, around Mulgoa. No Important Areas are mapped within the Wollemi IBRA subregion for Regent Honeyeater. Approximately 32,000 hectares of potential habitat is present within the Cumberland IBRA, comprising similar PCTs to be removed by the project. The proposal will result in the removal of 13.77 hectares of potential foraging habitat and removal at this scale is unlikely to significantly reduce the area of occupancy of the species, especially as it is not mapped as an Important Area (DPIE 2020), and does not occur near the extant of the species range. The species is highly mobile and may continue to forage in retained habitat adjacent to the impact area and the development will not represent a barrier to the movement of individuals.
Fragment an existing population into two or more populations	Unlikely	As mentioned above, the Regent Honeyeater has what is considered a single national population (CoA 2016). The species is highly mobile and individuals can move freely through areas of unsuitable and marginal habitat to seek out and exploit favourable habitat patches. The project will not impact on known critical habitat or mapped Important Areas for Regent Honeyeater, nor will it substantially change the patchy connected / fragmented nature of the landscape through which the impact area traverses. As a result, the proposal will not fragment the population into two or more populations.
Adversely affect habitat critical to the survival of a species	Unlikely	Habitat critical to the survival of this species is defined in the Regent Honeyeater National Recovery Plan (CoA 2016) as: • Any breeding or foraging habitat in areas where the species is likely to occur (as defined by the distribution map provided in Figure 2 of the National Recovery Plan); and • Any newly discovered breeding or foraging locations. One Important Area has been mapped within the Cumberland IBRA subregion for

Significant impact criteria	Likelihood of significant impact	Justification
		Regent Honeyeater, located approximately 3 kilometre north of the impact area at Mulgoa. No Important Areas are mapped within the Wollemi IBRA subregion for Regent Honeyeater. While the project will result in the removal of known feed tree species, from within areas mapped by the Recovery Plan as 'Species likely to occur', vegetation within the impact area does not constitute known or likely breeding habitat as it has not been mapped as an Important Area (DPIE 2020). As such the removal of 13.57 ha of foraging habitat, which equates to approximately 0.04 % of the similar habitat available to the species across the IBRA subregion, is not considered to be substantial enough to adversely affect habitat critical to the survival of the species. Following development, approximately 32,000 ha of habitat will remain within the IBRA subregion, which is by the same criteria, also considered habitat critical to the survival of a species.
Disrupt the breeding cycle of a population	Unlikely	In accordance with the BAM, EES has mapped locations identifying areas that are considered important for a threatened species, known as Important Areas (DPIE 2020). For Regent Honeyeater, Important Areas constitute breeding habitat. One such area is known within the Cumberland IBRA subregion, located approximately 3 kilometre north of the impact area near Mulgoa. While the project may result in the removal of vegetation utilised for foraging by the species, the project will not result in the disruption to the breeding cycle of the species, as habitat mapped as an Important Area will not be impacted by the proposal. As outlined above, the species is considered to effectively comprise a single population and as such, impacts to a very small proportion of the populations non-breeding habitat is not considered likely to result in any disruption of the breeding cycle.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	The Regent Honeyeater may utilise the impact area on occasion for foraging, however, the project will not impact on any existing breeding sites. The project will result in the removal of approximately 13.77 hectares of potential foraging habitat for the Regent Honeyeater. An approximate 32,000 hectares of potential foraging habitat remains within the Cumberland IBRA subregion. The magnitude of the impact from the current project is unlikely to impact the species to the extent that it would cause a decline. While the project will result in the removal of potential forage habitat, the level of loss is not likely to result in the decline of the species, based on the very small proportional impact to the species overall forage habitat, and the fact there will be no impact to known breeding sites for Regent honeyeater.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically	Unlikely	The project is unlikely to exacerbate the current level of invasive species threat operating within or surrounding the impact area to the point that they become harmful to the Regent Honeyeater. The project Construction Environmental Management Plan will include measures to ensure appropriate biosecurity management is undertaken during construction.

Significant impact criteria	Likelihood of significant impact	Justification
endangered species' habitat		
Introduce disease that may cause the species to decline, or	Unlikely	The proposed action is unlikely to introduce a disease that causes the Regent Honeyeater to decline. The project Construction Environmental Management Plan will include measures to ensure appropriate biosecurity management is undertaken during construction.
Interfere with the recovery of the species.	Unlikely	Key objectives of the species' recovery plan are to: • Reverse the long-term population trend of decline and increase the numbers of regent honeyeaters to a level where there is a viable, wild breeding population, even in poor breeding years; and to • Enhance the condition of habitat across the regent honeyeaters range to maximise survival and reproductive success, and provide refuge during periods of extreme environmental fluctuation. Other factors that may interfere with the recovery of the species include impacts to key breeding habitat. Although removal of 13.77 hectares of potential foraging habitat for the Regent Honeyeater may contribute to cumulative effects of habitat loss, no impacts to breeding habitat will occur from the project. One Important Area has been mapped within the Cumberland IBRA subregion for Regent Honeyeater, located approximately 3 kilometre north of the impact area. Given that the impact area is outside of any known breeding habitat (and Important Areas), and the proposed action will impact on a small proportion of foraging habitat with significantly larger areas of commensurate and comparable habitat within the locality, it is unlikely that interfere with the species' recovery.

Based on the assessment provided above, it is concluded that Regent Honeyeater is unlikely to be significantly impacted by the project, and as such offsetting in accordance with the EPBC Act Environmental Offsets Policy (CoA 2012) and the EPBC Act is not required.

SIC Assessment for Swift Parrot Lathamus discolour – Critically Endangered EPBC Act

Swift Parrot breed in Tasmania and overwinter in mainland Australia (Saunders and Tzaros 2011). Breeding occurs between September and April in Tasmania in a range of forest types (Higgins 1999). Once breeding is complete, they disperse from breeding areas, across Tasmania, and to mainland Australia (Higgins 1999). Most birds spend the winter in Victoria and New South Wales, but they are also known to extend as far north as Brisbane, although this is unusual (Higgins 1999). They disperse across broad landscapes, foraging on nectar, pollen and lerps in a variety of eucalypt species. (Saunders and Tzaros 2011). On the mainland Swift Parrot mostly occurs on the inland slopes but occasionally occurs on the coast (DoE 2018). They return to Tasmania in August and September, with the largest number of 'returning' records from September (Higgins 1999).

Swift Parrots occur as a single population that is estimated to be approximately 1000 pairs which is most likely continuing to decline (Garnett et al. 2011; Saunders and Tzaros 2011). Key factors contributing to their decline reported in the National Recovery Plan (Saunders and Tzaros 2011) include:

- Loss and alternation of habitat from forestry activities (firewood harvesting, residential clearing, agricultural and industrial developments).
- Attrition of old growth trees within agricultural landscapes.
- Suppression of forest regeneration and fire.
- Climate change.
- Food and nest competition.
- Flight collision hazards.
- Psittacine beak and feather disease.
- Illegal capture and trade.

Priority habitats are those which are used for nesting (Tasmania only), by large proportions of the swift parrot population, repeatedly between seasons (high site fidelity) or for prolonged periods of time (site persistence) (Saunders and Tzaros 2011). Habitat critical to the survival of the Swift Parrot is likely to constitute areas with high site fidelity and site persistence as well as those areas in which breeding occurs (Tasmania only).

A total of 13.77 hectares of suitable foraging habitat occurs within the impact area. These areas support key tree species known to be important food resources for Swift Parrot, including Forest Red Gum and Spotted Gum.

Diurnal bird surveys conducted during field assessment did not detect any Swift Parrot activity. The species has been previously recorded on less than 100 occasions within 10 kilometres of the study area since 1980, and has the potential to be an occasional visitor to the impact area during autumn and winter. The impact area does not constitute breeding habitat given breeding only occurs in Tasmania.

To compare the approximate level of impact to potential Swift Parrot habitat, to that available to the species across the Cumberland IBRA subregion, the total sum area of the 8 habitat PCTs impacted by the project, as mapped by OEH (2013) and OEH 2016), has been calculated. This equates to a total area of 32,000 hectares of potential habitat, commensurate to that impacted by the project, currently available to the species across the subregion.

Based on the above, the project will impact upon approximately 0.04 % of potential Swift Parrot habitat within the Cumberland IBRA subregion. It is acknowledged that these calculations are based on aerial vegetation mapping that is at least 7 years old, however the total area of potential habitat available to the species is not

expected to have changed substantially since the mapping projects were completed. As such, the above calculations are considered suitable to determine an approximate level of impact by the project.

Significant impact criteria	Likelihood of significant impact	Justification
Lead to a long-term decrease in the size of a population	Unlikely	Due to its migratory movement patterns typified by seasonal migration and local nomadism, the Swift Parrot occurs as a single migratory population (Saunders and Tzaros, 2011). Factors that may lead to a long-term decrease in the size of the species include direct impacts to locations considered important for the species (i.e. Important Areas – important migratory foraging habitat for Swift Parrot) (DPIE 2020). The impact area is not mapped as an Important Area for Swift Parrot. Further, approximately 32,000 hectares of potential foraging habitat is present within the Cumberland IBRA subregion, comprising similar PCTs to be removed by the project. Removal of 13.77 hectares of potential habitat within the impact area is unlikely to lead to declines in the population of a wide ranging species such as Swift Parrot, given the abundance of similar foraging habitat remaining in the locality, and the limited 'importance' of the habitat impacted.
Reduce the area of occupancy of the species	Unlikely	The impact area has not been identified within any Important Areas for Swift Parrot (DPIE 2020). Several Important Areas have been mapped within the Cumberland IBRA subregion for Swift Parrot, with the closest situated approximately 700 m north of the impact area, surrounding Mulgoa. Two Important Areas are mapped within the Wollemi IBRA subregion for Swift Parrot, both over 90 kilometre from the impact area. The species' area of occupancy ranges from Tasmania to Brisbane, and thus the removal of a very small percentage (0.04 %) of the 'non-important' forage habitat available to the species within the Cumberland IBRA subregion is highly unlikely to reduce the overall area of occupancy of the species. The species is highly mobile and will continue to forage in retained habitat surrounding the impact area and the development will not represent a barrier to the movement of individuals.
Fragment an existing population into two or more populations	Unlikely	As mentioned above, the Swift Parrot is considered a single migratory population (Saunders and Tzaros, 2011). The species is highly mobile and individuals can move freely through areas of unsuitable and marginal habitat to seek out and exploit favourable habitat patches. The project will not impact on known priority habitat, or mapped Important Areas for Swift Parrot, and the impact occurs across a small fraction of the species range. As such, the project will not fragment the population into two or more populations. The species may continue to utilise the vegetation surrounding the impact area.
Adversely affect habitat critical to the survival of a species	Unlikely	To date no critical habitat for Swift Parrot has been listed on the DAWE Register of Critical Habitat. The National Recovery Plan for Swift Parrot outlines priority habitats as those which are used for nesting (Tasmania only), by large proportions of the swift parrot population, repeatedly between seasons (high site fidelity) or for prolonged periods of time (site persistence) (Saunders and Tzaros 2011). Habitat critical to the survival of this species is defined in the National Recovery Plan for the Swift Parrot National Recovery Plan (Saunders and Tzaros 2011) as: • Priority habitat for which the Swift Parrot has a level of site fidelity or which possess phenological characteristics likely to be of importance to the Swift Parrot, and

Significant impact criteria	Likelihood of significant impact	Justification
		• Areas otherwise identified by the Recovery Team Database records of the species within the vicinity of the project occur sporadically, with <100 records from 1980-2019 (within 10 kilometre). Thus, the impact area is unlikely to have high site fidelity due to the low number of records spread across multiple decades within the locality. Therefore given the geographic distribution, highly mobile nature of the species and existence of a large amount of potential foraging habitat across the Cumberland and Wollemi IBRA subregions, the project is considered unlikely to impact on habitat critical to the survival of the Swift Parrot. Additionally, several Important Areas have been mapped within the Cumberland IBRA subregion for Swift Parrot, with the closest situated approximately 700 m north of the impact area surrounding Mulgoa. Two Important Areas are mapped within the Wollemi IBRA subregion for Swift Parrot, both over 90 kilometre from the impact area. While the project will result in the removal of known feed tree species for the Swift Parrot, vegetation within the impact area does not constitute known important migratory foraging habitat, as it has not been mapped as an Important Area (DPIE 2020). Thus, it is unlikely that the proposal will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	Unlikely	The Swift Parrot is seasonally migratory and breeds in Tasmania. No additional breeding sites have been identified on the mainland. The project's impact are not of a magnitude great enough to impact upon forage resources available to the species, such that disruption to the breeding cycle of the species is likely to occur.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Swift Parrot are assumed to utilise the impact area on occasion for foraging. The impact area will result in the removal of approximately 13.77 hectares of potential foraging habitat for the Swift Parrot. Approximately 32,000 hectares of potential foraging habitat is present within the Cumberland IBRA subregion, comprising similar PCTs to be removed by the project. The magnitude of the impact from the current project is unlikely to impact the species to the extent that it would cause a decline. While the project will result in the removal of potential forage habitat, the level of loss is not likely to result in the decline of the species, based on the very small proportional impact to the species overall forage habitat, and the fact there will be no impact to the species' breeding habitat.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Unlikely	The project is unlikely to exacerbate the current level of invasive species threat operating within the impact area to the point that they become harmful to the Swift Parrot. The project Construction Environmental Management Plan will include measures to ensure appropriate biosecurity management is undertaken during construction.

Significant impact criteria	Likelihood of significant impact	Justification
Introduce disease that may cause the species to decline	Unlikely	Psittacine beak and feather disease is listed as a threat to the Swift Parrot, this is a naturally occurring disease that is often fatal. This disease affects growth of feathers and the beak and may persist for long periods in tree hollows, it can be transmitted orally or through faeces and feathers (DoE 2004). The project is unlikely to introduce or increase the spread of this disease to the Swift Parrot. Further, the project Construction Environmental Management Plan will include measures to ensure appropriate biosecurity management is undertaken during construction.
Interfere with the recovery of the species	Unlikely	The Approved Conservation Advice for Swift Parrot (CoA 2016b) states that the main ongoing threats to the species include habitat loss and alteration, collision mortality (including with cars), competition with other more aggressive honeyeaters, and Psittacine Beak and Feather Disease. Although removal of potential foraging habitat may contribute to cumulative effects of habitat loss, the proposal would not lead to any impacts to Swift Parrot breeding habitat (located in Tasmania only) and would not impact any areas mapped as important migratory foraging habitat (Important Areas) (DPIE 2020). Several Important Areas have been mapped within the Cumberland IBRA subregion for Swift Parrot, with the closest situated approximately 700 m north of the impact area surrounding Mulgoa. Two Important Areas are mapped within the Wollemi IBRA subregion for Swift Parrot, both over 90 kilometre from the impact area. Given the proposed action will impact on a small area of foraging habitat with significantly larger areas of commensurate and comparable habitat within the locality, it is unlikely that habitat loss and alteration will occur at an extent that will interfere with the species' recovery. Collisions impacts are not expected to be substantially increased by the project. The project is unlikely to introduce or increase the spread of this disease to the Swift Parrot. Further, the project Construction Environmental Management Plan will include measures to ensure appropriate biosecurity management is undertaken during construction.

Based on the assessment provided above, it is concluded that Swift Parrot is unlikely to be significantly impacted by the project, and as such offsetting in accordance with the EPBC Act Environmental Offsets Policy (CoA 2012) and the EPBC Act is not required.

SIC Assessment for Camden White Gum Eucalyptus benthamii – Vulnerable EPBC Act

Camden White Gum is a tree that grows to 40 metres tall, its bark sheds to ground level and is smooth and white, with a small stocking of rough bark at the base. Immature leaves are rounded, adult leaves are long and lanceolate in shape with irregular lateral venation and evenly coloured on both sides. The tree flowers in summer and autumn, although sporadic flowering may occur throughout the year. (CoA 2014b)

Camden White Gum occurs west of Sydney on the Cumberland Plain and Blue Mountains. Populations of up to 6500 occur in Kedumba Valley in Blue Mountains National Park, while Bents Basin State Recreation Area supports up to 300 plants. Scattered trees occur along the Nepean River around Camden and Cobbitty, with a stand at Werriberri Creek in The Oaks, and at least five trees occur along the Nattai River in Nattai National Park. Remnant populations at Camden and Wallacia have a higher proportion of alleles not detected in larger populations and are an important source of genetic diversity. Historically, the species probably occurred throughout floodplains of the Nepean River and tributaries as far downstream as the Grose River junction. (CoA 2014b)

Camden White Gum occurs on alluvial flats of the Nepean River and its tributaries at altitudes of 30 metres to 750 meters above sea level. Natural habitat includes a combination of deep, fertile alluvial sands and a flooding regime that allows seedling establishment. Recruitment occurs on disturbed or depositional bare soils following flooding. (CoA 2014b)

The main identified threats to Camden White Gum are land clearing, urban development, inappropriate fire regimes, changed hydrology, weed invasion and inappropriate revegetation works (impacting genetic diversity. Populations are now isolated within fragmented habitat due to extensive pre-1840 land clearing. Regulation of flooding regimes, competition from weeds and inappropriate fire regimes limit natural regeneration. The productive nature of alluvial flats make them particularly prone to weed invasion, Other threats to the Camden white gum include habitat degradation caused by feral pigs at Kedumba and hybridisation with Manna Gum *Eucalyptus viminalis*. Raising the height of Warragamba Dam wall and the construction of smaller dams could destroy populations and potential habitat. (CoA 2014b)

The project will not result in direct removal to Camden White Gum or its habitat, with individuals only present within the impact assessment area, adjacent to the impact area at Wallacia. Key impacts of the project are associated with the effects of increased treated water being discharged into the Nepean River a t the Wallacia weir. This increase of water into the river system has been modelled to result in a maximum 30 cm (median) to 60 centimetre (maximum) increase in river depth up to 12 kilometre upstream of Wallacia weir, and a 14 centimetre increase downstream to the Penrith weir (Streamology 2021), during the 100 ML/day ultimate dry weather treatment capacity of the AWRC (planned for completion in 2036).

Camden White Gum are known to occur in the area affected by the increased water depth, and resultant inundation extent, at Wallacia and Bents Basin. Targeted survey for the species was undertaken by Biosis in mid-2020 surrounding the impact assessment area, and by CTE in late 2020 between Wallacia and Bents Basin, and a total of 713 stems were recorded. The location of each of the 713 stems recorded by CTE was captured using DGPS with an accuracy of approximately +/- 1 metre, with the species found to occur consistently along the banks of the Nepean River between Bents Basin and Wallacia (Figure 15), and as such all individuals are considered to comprise a single population.

Significant impact criteria	Likelihood of significant impact	Justification
Lead to a long-term decrease in the size of an important population of a species	Unlikely	The Approved Conservation Advice for Camden White Gum (CoA 2041b) notes that remnant populations at Camden and Wallacia have a higher proportion of alleles not detected in larger populations and are an important source of genetic diversity (Butcher et al. 2005). The population of the species present within the impact assessment area and upstream along the Nepean River to Bents Basin, is therefore considered an "Important Population", in accordance with the definition provided in the MNES Significant impact guidelines 1.1 (CoA 2013), due to the consistent occurrence of trees in this stretch of the river, and movement of genetic material downstream from Bents Basin to Wallacia. A total of 713 individual Camden White Gums were recorded by CTE using DGPS between Bents Basin and Wallacia in late-2020, 12 of which have been found likely to be present within the current and future median flow inundation extents modelled by Streamology (2021), and therefore subject to altered hydrological patterns. Mature trees with established root systems are not expected to be substantially affected by the increased frequency and duration of inundation expected to result from the proposed volumes of treated water to be released into the river system. However should negative impacts be realised as a result of the increased inundation and saturation of the trees' roots, these would only be expected to affect a small portion (up to 1.7%) of the population of Camden White Gums present within the area assessed. To account for the areas of Camden White Gum habitat potentially impacted, a 30 metre buffer was applied to all 713 GPS points representing Camden White Gum individuals, and the mapped vegetation present within each inundation extent polygon, within 30 metres of an individual tree, was selected and assessed. Up to 0.54 ha of known habitat supporting the important population was found to occur within the modelled current and future median inundation extents, with a total of 34.9 ha of habitat present and supporting the population. As such potential impacts associated with altered hydrological patterns are likely only to occur to 0.5 % of the habitat supporting the important population. The Approved Conservation Advice for *Eucalyptus benthamii* (Camden White Gum) (CoA 2014b) notes that one of the main threats to the species is 'changed hydrology, and that the species' natural habitat includes a combination of deep, fertile alluvial sands and a flooding regime that allows seedling establishment, with recruitment occurring on disturbed or depositional bare soils following flooding. The changes to hydrological patterns within the Nepean River system as a result of the project are not expected to represent substantial or significant negative pressures on the species, as the increased water released into the system will result in a minor to negligible increase in flood frequency, which will not negatively impact upon post-flood opportunities for seedling recruitment. Based on the above the project is not considered likely to lead to a long-term decrease in the size of an important population of a species.
Reduce the area of occupancy of an important population	Unlikely	As outlined above, a total of 713 individual Camden White Gums were recorded by CTE between Bents Basin and Wallacia, with up to 12 individuals and 0.54 ha of habitat expected to be located within the bands of the river bank subject to altered hydrology. Expected changes to inundation frequency as a result of the project are described as follows: • Biodiversity values present between the current low flow extent (25 ML/day) and current median flow extent (229 ML/day), are currently subject to inundation >50 % of the time. ○ With an increase of 50 ML/day into the river system the frequency with which these biodiversity values will be inundated will increase from >50 % of the time to >63% of the time.

Significant impact criteria	Likelihood of significant impact	Justification
		○ With an increase of 100 ML/day into the river system the frequency with which these biodiversity values will be inundated will increase from >50% of the time to >74% of the time. • Biodiversity values present between the current median flow extent (229 ML/day) and the future median flow extent for 50 ML/day releases (279 ML/day), are currently subject to inundation between 40-50 % of the time, which will increase to >50 % of the time. • Biodiversity values present between the current median flow extent (229 ML/day) and the future median flow extent for 100 ML/day releases (329 ML/day), are currently subject to inundation between 27-50 % of the time, which will increase to >50 % of the time. These changes will occur to a thin horizontal band along the banks of the Nepean River and as such will not reduce the area of occupancy of the important population that occurs from Bents Basin to Wallacia.
Fragment an existing important population into two or more populations	Unlikely	The proposed increase in water in the river system will not result in fragmentation of the important population of Camden White Gum.
Adversely affect habitat critical to the survival of a species	Unlikely	No habitat critical to the survival of Camden White Gum has been declared or defined. The species occurs in a number of location within the Blue Mountains and across the Cumberland Plain (see introductory text above), and the vast majority of the habitat known to support the species will not be affected by the project. As such, the project is not expected to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	Unlikely	As outlined above, seedling recruitment in Camden White Gum populations is known to occur on disturbed or depositional bare soils following flooding (CoA 2014a), and it is expected that the increased water released to the river system will result in a negligible to slight increase in the frequency of flood events, and as such it is not expected that seedling recruitment will be negatively impacted by the increased flow.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	As outlined above, increased inundation frequency is considered likely to occur to just 0.5 % of the habitat currently supporting the important population of Camden White Gum, with potential impacts to habitat available for recruitment, following flood events, considered negligible. The project is not considered likely to result in impacts of a magnitude likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species	Unlikely	Alterations to flooding regimes may provide new opportunities for exotic species to become established though increased frequency on inundation favouring more water tolerant exotic species. However, the increased frequency with which this is expected to occur is unlikely to substantially increase the likelihood of novel exotic species/populations, damaging to Camden White Gum, from becoming established. Furthermore, the vast majority of the species' habitat will not be impacted by the project, and onging monitoring and adaptive management will be

Significant impact criteria	Likelihood of significant impact	Justification
becoming established in the vulnerable species' habitat		undertaken to ensure intervention can occur if new weed infestations threatening the health of the species become apparent.
Introduce disease that may cause the species to decline	Unlikely	The project will not introduce disease that may Camden White Gum to decline.
Interfere with the recovery of the species	Unlikely	The Approved Conservation Advice for Camden White Gum (CoA 2041b) lists the following relevant recovery actions: • Minimise adverse impacts on populations, particularly the effects of nutrient enrichment and weed propagules from all sources. • Ensure there is no disturbance in areas where the Camden white gum occurs, excluding necessary actions to manage the conservation of the species. • Manage any changes to hydrology that may result in changes to flood characteristics or sedimentation • Undertake survey work in suitable habitat and potential habitat, particularly along the Nattai and Wollondilly River's and in the Wallacia-Bents Basin and Camden-Cobbity areas, to locate any additional populations / occurrences / remnants. Whilst the project will result in some impact to the important population of Camden White Gum between Wallacia and Bents Basin, as a result of a slight mean rise in the water level in the Nepean River, this cannot be said to be significantly adverse to any of the above listed recovery actions. Furthermore the project has in fact collected substantial population data for the species, which will be submitted to BioNet therefore implementing one of the listed recovery actions for the species.

Based on the assessment provided above, it is concluded that Camden White Gum is unlikely to be significantly impacted by the project, and as such offsetting in accordance with the EPBC Act Environmental Offsets Policy (CoA 2012) and the EPBC Act is not required.

Appendix 7 Species expert reports

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ecology | planning | offsets

Upper South Creek Advance Water Recycling Centre

Expert Report for Pimelea spicata

Prepared for: Sydney Water

17 February 2021 Version: 1.0 – Draft

PROJECT NUMBER	2020-228			
PROJECT NAME	Upper South Creek Advance Water Recycling Centre			
SUBJECT	Expert Report for *Pimelea spicata*			
PREPARED FOR	Sydney Water			
AUTHOR/S	Elizabeth Norris			
REVIEW	**Technical**	**QA**	**Version**	**Date to client**
	Bruce Mullins		1.0 – Draft	17 February 2021
ACKNOWLEDGEMENTS	Front cover photo: *Pimelea spicata,* Prospect Reservoir 2019, B. Towle			
LICENCES	**Scientific Licence**		SL101557	
	BioNet Sensitive Species Data Licence		1115	
	Animal Research Authority Ethics Licence		Fauna Surveys and Monitoring (16/346)	
	Scientific Collection - Aquatic		P19/0009-1.0 & OUT19/2602	

This report should be cited as: 'Ecoplanning (2020). Upper South Creek Advance Water Recycling Centre – *Expert Report for Pimelea spicata*. Prepared for Sydney Water.'

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Glossary and abbreviations

Acronym	Description
BAM	Biodiversity Assessment Method
BC Act	NSW *Biodiversity Conservation Act 2016*
BDAR	Biodiversity Development Assessment Report
DECC	NSW Department of Environment and Climate Change (now EES)
DPIE	NSW Department of Planning, Industry and Environment
DNG	Derived native grassland
EES	NSW Environment, Energy and Science Group
EFP	Environmental flow pipeline
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
m/km	Metres/kilometres
LGA	Local Government Area
NSW	New South Wales
OEH	NSW Office of Environment and Heritage (now EES)
SOS	Saving our Species
TEC	Threatened Ecological Community
TWP	Treated water pipeline
USC AWRC	Upper South Creek Advance Water Recycling Centre

1 Introduction

1.1 Purpose of the expert report

The purpose of this report is to provide a scientific assessment of the current status and conservation of *Pimelea spicata* within the assessment area of the Upper South Creek Advance Water Recycling Centre, known as the USC AWRC, and associated treated water and brine pipelines ('the project'), being undertaken by Sydney Water.

An expert report may be prepared under Section 6.5 of the BAM (DPIE 2020a) in place of completing a threatened species survey where:

- it is unlikely that a species may occur within the study area,
- survey effort is inadequate, and/or
- the reliability of detecting the species during survey is low.

This report will specifically determine whether:

- *Pimelea spicata* is likely to be present and, if so, provide estimates of the habitat area within the proposed impact areas, or
- Whether the species is unlikely to be present, and if so, no further assessment is required.

1.2 Project background

- Sydney Water is planning to build and operate new wastewater infrastructure to service the South West and Western Sydney Aerotropolis Growth Areas. The proposed development will include a wastewater treatment plant known as the USC AWRC, herein known as 'the project'. An overview of the location of the proposed infrastructure is provided in **Figure 1.1**. Additional components of the project are provided below.
- Advanced Water Recycling Centre – a wastewater treatment plant with the capacity to treat up to 50 ML of wastewater per day, with ultimate capacity of up to 100ML per day. The centre will produce high quality treated water, renewable energy, biosolids and brine.
- Treated water pipelines from the USC AWRC to the Nepean River at Warragamba River. The pipelines are designed to release treated water at Wallacia Wier (17 km in length), and to release high quality treated water between Warragamba Dam and Warragamba Weir as environmental flows (5 km in length).
- Brine pipeline (24 km long) from the USC AWRC to Lansdowne, where it connects to Sydney Water's existing Malabar wastewater network.

Sydney Water is planning to deliver the project in stages, with Stage 1 comprising building and operating the USC AWRC. This also includes building all pipelines to their ultimate capacity. Further details on the project description are included in the USC AWRC Scoping Report (Sydney Water 2020).

The timing and scale of future stages will be phased to respond to drivers including population growth rate and the most efficient way for Sydney Water to optimise its wastewater systems.

Impact area, impact assessment area, study area and subject land

The following terms are used in this report and correspond to terms used in the Biodiversity Development Assessment Report (Biosis in prep.) for the project:

- **Impact area** – the area to be directly impacted by construction and operation of the project, including identified compound areas and access tracks. The impact area is generally 12.5 m either side of the pipeline alignments but is wider or narrower in certain areas. For the Water Recycling Centre site, this impact area comprises the entire 80 ha site.
- **Impact assessment area** – a wider area, generally 12.5 m either side of the impact area to allow for design flexibility.
- **Study area** – The broader area in which the impact area and impact assessment area is located, including all areas of direct and indirect impact, the required 500 m buffer on the impact area, and larger areas to provide context to the project.
- **Subject land** – The subject land is land to which the BAM is applied in Stage 1 to assess the biodiversity values of that land (DPIE 2020a). The subject land occurs within the study area and is synonymous with the impact area.

The impact assessment area and study area are referred to in this report and illustrated in **Figure** 1.1 and **Figure 1.2**, and mostly traverse the local government areas of Wollondilly, Penrith, Liverpool and Fairfield.

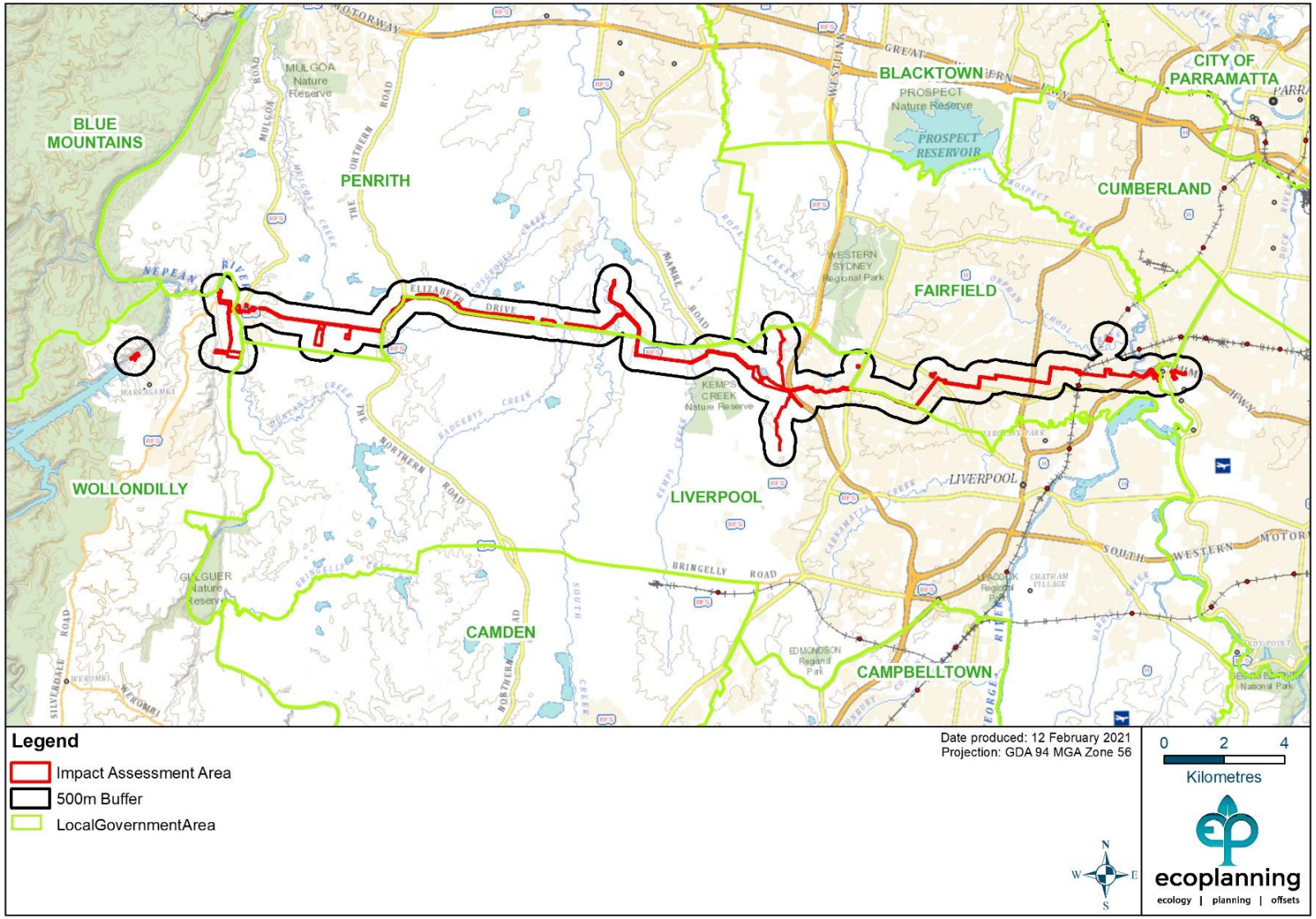

Figure 1.1: Location

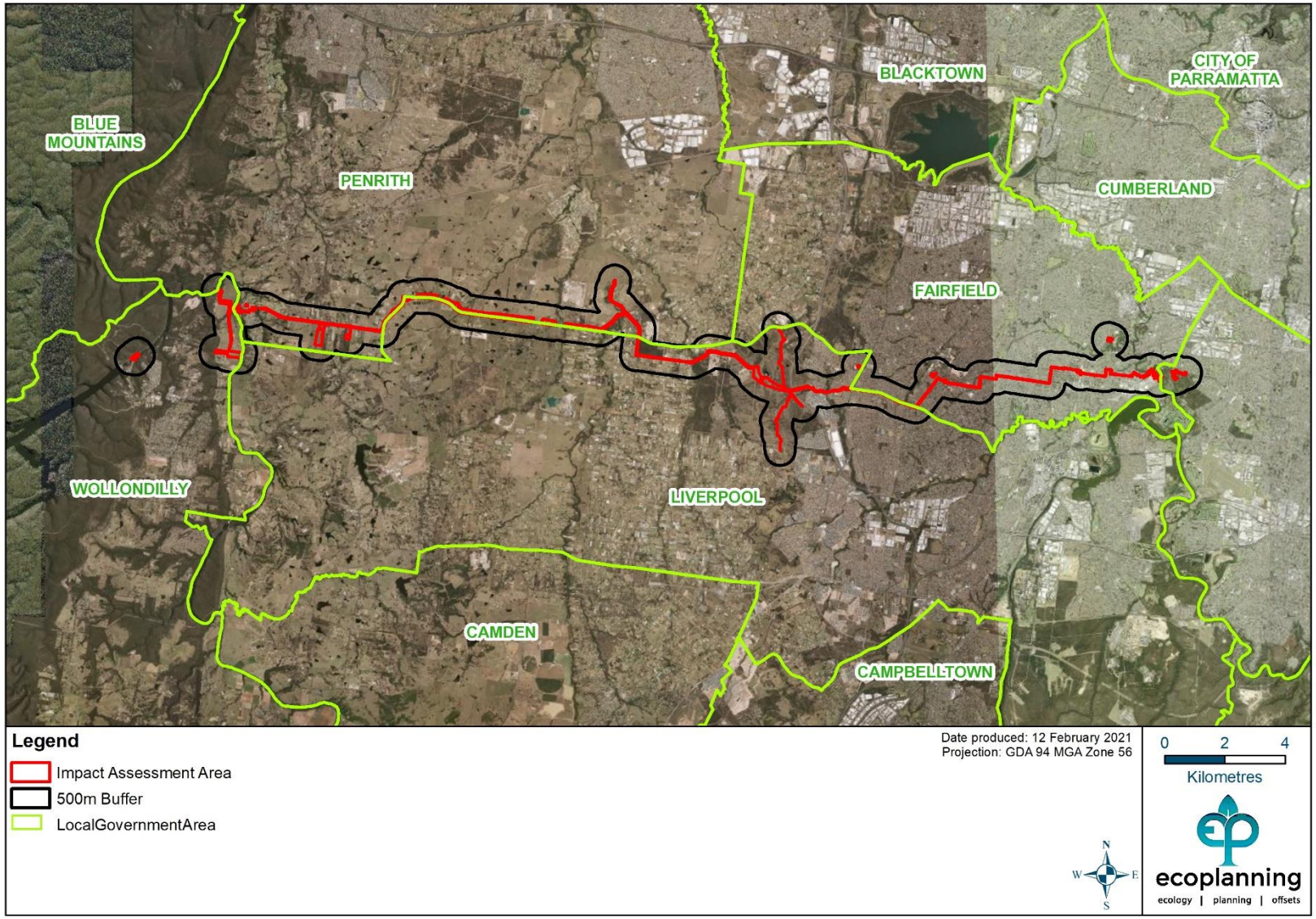

Figure 1.2: Impact assessment area and study area (500 m buffer)

1.3 This study

1.3.1 Study area

The project predominantly occurs within the Cumberland Plain with the western end extending towards the Blue Mountains Plateau. This area predominantly contains patches of low to moderate quality native vegetation throughout suburban and peri-urban areas with high condition patches of vegetation at the eastern and western ends in undeveloped areas.

High condition patches of vegetation at the eastern end of the project alignment are contiguous with vegetation conserved in the riparian corridors of Prospect Creek and Georges River, and the Lansdowne Reserve BioBank Site. High condition patches of vegetation at the western end of the project alignment are contiguous with the Greater Blue Mountains World Heritage Area and the Warragamba Dam Special Area. Moderate condition patches within the central section of the project alignment form continuity with vegetation conserved in Western Sydney Parklands and Kemps Creek Nature Reserve.

The broader study area has a long history of pastoral and agricultural farming, specifically, cattle, poultry, bee keeping and market gardens, supplying the Sydney market with products from 1800 to the mid-20th century. The majority of the study area remains peri-urban whilst suburban and urban development predominates to the east. The northern section of Kemps Creek currently contains land used for commercial agriculture including cattle grazing. The land use history has contributed to the condition of the vegetation and current infestations of priority, agricultural and environmental weeds through clearing, under-scrubbing, logging, pasture improvement and introduction of exotic species.

Existing land uses throughout the extent of the impact area and impact assessment area include:

- Conservation and recreation in reserves and parks including Lansdowne Reserve, Lennox Reserve, Cabravale Memorial Park and Western Sydney Parklands.
- Residential and commercial development and supporting infrastructure throughout Lansdowne, Cabramatta, Elizabeth Hills, Cecil Hills and some sections of Kemps Creek and Wallacia.
- Peri-urban development between Wallacia and Luddenham and primary production, including commercial grazing, commercial nursery and market gardens from Kemps Creek to Luddenham in addition to the west of Wallacia.
- Conserved bushland and water infrastructure in the vicinity of Warragamba, including the Warragamba Special Area.

1.4 Justification for use of expert report

An expert report for *Pimelea spicata* is required as part of the threatened species assessment and preparation of a BDAR for the project. In particular, the expert report aims to provide a more comprehensive level of ecological and scientific assessment for the following reasons:

a) Survey effort and timing - although survey can be conducted all year following the DPIE survey guidelines (DPIE 2020b), survey was limited by land access, which for the most part, was fairly restricted due to the sensitive nature of the project.
b) *Pimelea spicata* is cryptic in nature and is difficult to detect when not in flower. Its flowering is sporadic and unpredictable throughout the year, although peak times have been reported (see **Section 1.7.3**). During drought conditions or following other disturbances it may not be apparent above ground at the time of survey. Increasingly dry and hot summers have become more frequent across western Sydney (James 2018).

1.5 Credentials of expert – Elizabeth Norris (BSc, MSc)

I am a botanist/ecologist with over 37 years of experience in vegetation survey, long term vegetation monitoring, plant identification, conservation and habitat assessment and threatened species survey across western Sydney, inland NSW, Queensland and the Kimberley, WA. I have worked within the NSW government (National Herbarium of NSW), have operated my own ecological consultancy for six years full time, and have been employed as a senior botanist/ecologist for the past 13 years and a position I still hold.

A summary of my credentials as required under the Biodiversity Assessment Method (BAM, 2020) is provided in **Table 1.1**. Experience in targeted threatened species surveys and a copy of my Curriculum Vitae is provided in **Appendix A**.

Table 1.1: Credentials of Elizabeth Norris

BAM Section	BAM Requirement	Details
BAM s 6.5.2.8 (g)	Name of expert	Elizabeth Norris
BAM s 6.5.2.3 (a)	The expert's qualifications	Bachelor of Science, Macquarie University 1983 Master of Science, Macquarie University 1996
BAM s 6 5 2 3 (b)	History of experience in ecological research and survey method, for the relevant species	Field surveys and relevant projects: • Western Sydney Parklands 2019. Targeted threatened species surveys of Parklands Estate for future planning and development, Wallgrove Road and Yallock Place – targeted surveys for ***Pimelea spicata.*** • NSW Department of Planning, Industry and the Environment 2020. Saving our Species (SOS) monitoring for ***Pimelea spicata***, Prospect Reservoir. • Brownlow Hill Pty Ltd 2018. Targeted survey for *Pimelea spicata* across suitable habitat, as part of overall BSAR assessment. ***Pimelea spicata*** recorded. • Roads and Traffic Authority Camden Valley Way 2012. ***Pimelea spicata*** survey prior to road widening works. • NSW Dept of Planning 2011 . Schofields Biodiversity Assessment – targeted threatened species survey – recorded Shale Plains Woodland, River Flat Eucalypt Forest and Swamp Oak Floodplain Forest identified. Targeted searches for *Acacia pubescens, Dillwynia tenuifolia,* ***Pimelea spicata*** and *Grevillea juniperina.* • Biobanking Pilot Project at Cranebrook - 2007 • Hawkesbury City Council 2006: Habitat modelling and targeted threatened species surveys for ***Pimelea spicata****, Pimelea curviflora* var. *curviflora, Persoonia hirsuta, Dillwynia tenuifolia, Pultenaea parviflora, Grevillea juniperina* identified and recorded as part of the survey. • Former Riverstone Abattoirs 2006. Targeted threatened flora species (16 species) including ***Pimelea spicata****.* Cumberland Shale Plains Woodland, Alluvial Woodland and Shale-gravel Transition Woodland. • Urban & Rural Design 2002. Yamaha, Wetherill Park – targeted threatened species survey for proposed warehouse development. Cumberland Shale Plains Woodland. ***Pimelea spicata*** recorded. • Threatened community and threatened species (including ***Pimelea spicata***) surveys for numerous projects across the Sydney Basin (refer CV, various dates).

BAM Section	BAM Requirement	Details
BAM s 6.5.2.3 (c)	A resume detailing projects pertaining to the survey of the relevant species	Resume and CV of relevance to this report attached – **Appendix 1**
BAM s 6.5.2.3 (d)	Their employer's name and period of employment (where relevant)	Ecoplanning P/L August 2018 to present.
BAM s 6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant species to which the survey relates	• NSW Department of Planning, Industry and the Environment (2020). SOS monitoring for ***Pimelea spicata***, Prospect Reservoir. • Department of Environment Water Heritage and the Arts (2009). EPBC Conservation Advice for the Growth Centres Strategic Assessment – input on threatened species distributions across the Cumberland Plain. • Department of Environment Water Heritage and the Arts 2007. Review of Draft Conservation Advices for 14 threatened flora species under the EPBC Act. • Blacktown City Council 2008. Apointed expert witness for BCC to the Land and Environment Court for proposed three private residential developments at Riverstone, Sydney. Confirmed presence of Shale Plains Woodland, Shale Gravel Transition Forest, Cooks River Castlereagh Ironbark Forest EECs

1.6 Methods used in the preparation of this report

As land access to conduct targeted surveys was limited, this report is a desktop assessment of the ecology and habitat requirements of *Pimelea spicata*, which were then extrapolated across the study area to determine the area of potential *Pimelea spicata* habitat that may occur in the vegetation communities identified and mapped within the impact assessment area. This desktop assessment has drawn on available data sources including:

- Draft vegetation mapping provided by Biosis (2021)
- Biometric plot data completed by Biosis within the study area for the project (Biosis 2020).
- A review of habitat data and associated vegetation communities held with BioNet Atlas database records.
- A review of species distribution in relation to underlying geologies and associated Mitchell Landscapes and soil landscapes.
- Cross-reference to vegetation mapping by Tozer et al. (2010) and OEH (2016)
- A review of previous surveys completed (as noted in Section 1.7.1) within and the USC AWRC impact assessment area and adjacent areas within to the study area.

- Reference to known sites with similar habitat to that present within the USC AWRC assessment area.
- Previous targeted searches and personal knowledge.

1.7 Species surveys

1.7.1 Summary of survey work undertaken

To assess the impacts of the proposed USC AWRC project a review of available biometric survey records was undertaken (DPIE 2020c) together with any new biometric and target survey that had been undertaken (Biosis 2020) as part of the project.

Previous survey

A review of BioNet Atlas database records found that the distribution of previous survey data within proximity to the USC AWRC is variable with more concentrated survey effort confined to areas such as Lansdowne Reserve, the M7 corridor and environs, Kemps Creek and Wallacia. To date, previously completed biometric plots located within or adjacent the USC AWRC study area are few and hence overall survey effort has been low.

Previous survey within the USC AWRC assessment area include quantitative plot data at sites in Wallacia west of the Nepean River with three plots completed along Bents Basin Road as part of a vegetation survey within Lots 1 // DP986736 and Lot 6 // DP1067758 (A. Clements & Associates 2015) and a single plot intersects the corridor at Cecil Hills, west of the M7 (S. Griffiths 2001). A summary is provided in **Table 1.2** and **Figure 1.3**.

Further plots are located within the study area adjacent to the impact assessment area at the following sites and are illustrated in **Figure 1.3**.

- Wallacia – 11 plots as part of a property vegetation survey (A. Clements & Associates 2015)
- Luddenham Showground - one plot as part of the Priority Growth Areas survey for DPIE (Ecoplanning 2018)
- Badgery's Creek – six plots as part of the Western Sydney Airport Stage 1 survey (GHD 2017)
- Kemps Creek – 19 plots as part of the Cumberland Plain Vegetation Mapping project (DPIE 2020d), Growth centres Offsets surveys (DPIE 2006) other vegetation surveys (Niche 2013)
- Lansdowne Reserve – 13 plots as part of a vegetation survey undertaken by DPIE (2014)

To date, *Pimelea spicata* has not been recorded in any biometric plots within, or in proximity to, the USC AWRC impact assessment area[1] with the exception of those plots located in Lansdowne Reserve where numerous records for the species have been recorded.

Table 1.2: Prior surveys within the USC AWRC assessment area[1]

Previous study	Survey	Number of plots	Results
A. Clements & Associates (2015)	Vegetation survey, Bents Basin Road, Wallacia	3	No *Pimelea spicata* recorded
S. Griffths (2012)	Vegetation survey, Cecil Hills	1	No *Pimelea spicata* recorded

[1] Source of plot locations from DPIE 2020c (WMS files imported into ArcGIS)

1.7.2 Land access

Land within the impact assessment area comprises a combination of privately owned rural and semi-rural holdings west of the M7 motorway, urban development east of the M7 motorway and a network of road corridor infrastructure throughout. Given the sensitive and confidential nature of the project, access to conduct field investigations on private land was not sought within potential areas of habitat for this report.

1.7.3 Survey timing

Surveys for *Pimelea spicata* are best conducted when flowering, which tends to be sporadic and probably related to rainfall (DPIE 2019). Flowering times have been recorded from May to January (Rye 1990), peak flowering in March to April (Benson and McDougall 2001) and June to September following the 2003 drought (noted in DPIE 2019). Overall, *Pimelea spicata* is likely to flower opportunistically and peak flowering times may vary from year to year (DPIE 2019). The species may reduce to underground rhizomes, particularly as a result of disturbances such as drought, fire or grazing so may only be present as rootstock or as seed (James 2018, DPIE 2019). This means that some sites may exhibit few mature plants, but experience considerable recruitment following disturbance, such that estimates of above ground abundance may be a poor indicator of the potential abundance of the population at a site (DPIE 2019).

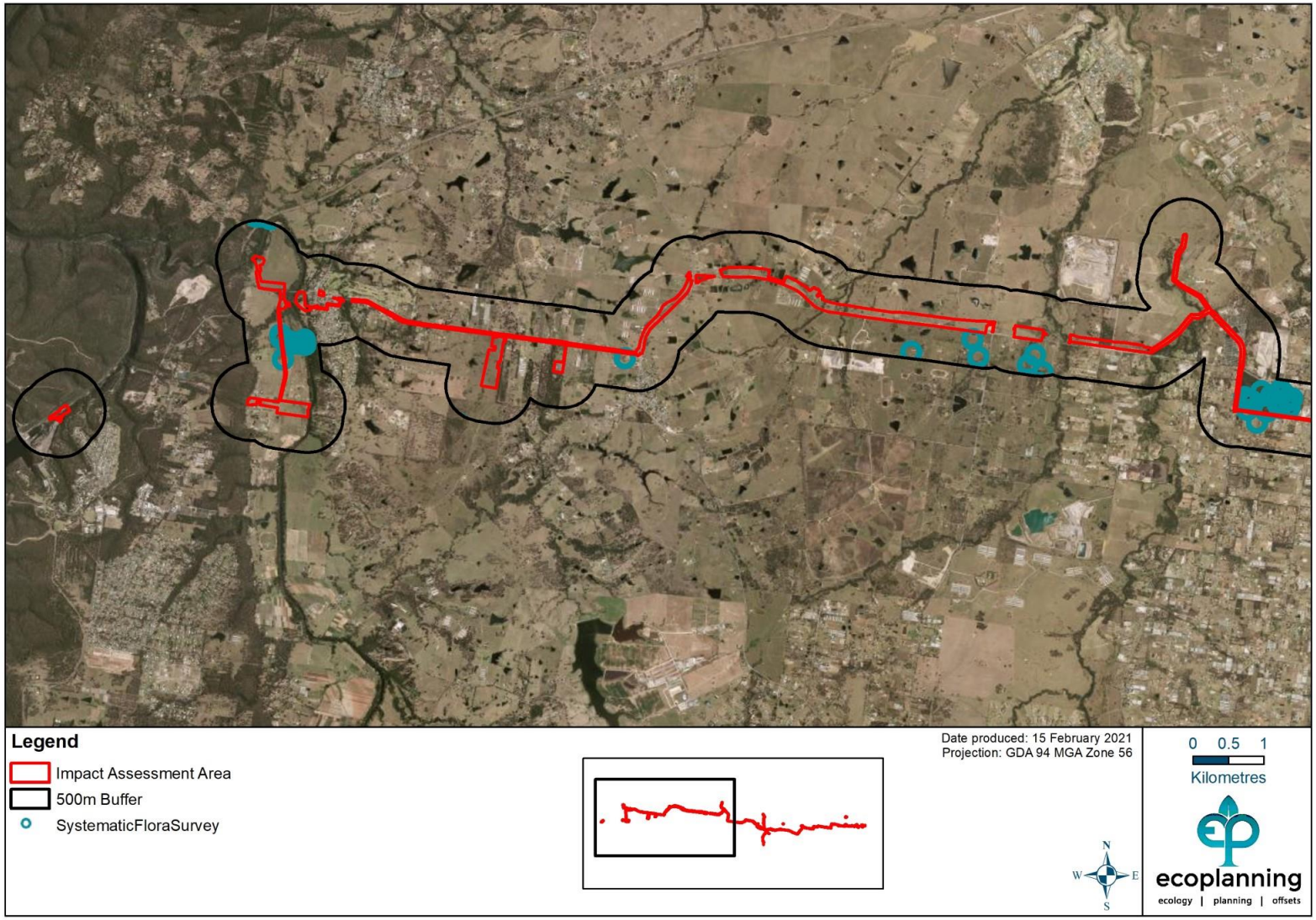

Figure 1.3: Previous surveys (biometric plots) within and adjacent to the USC AWRC impact assessment area -Warragamba to Badgerys Creek

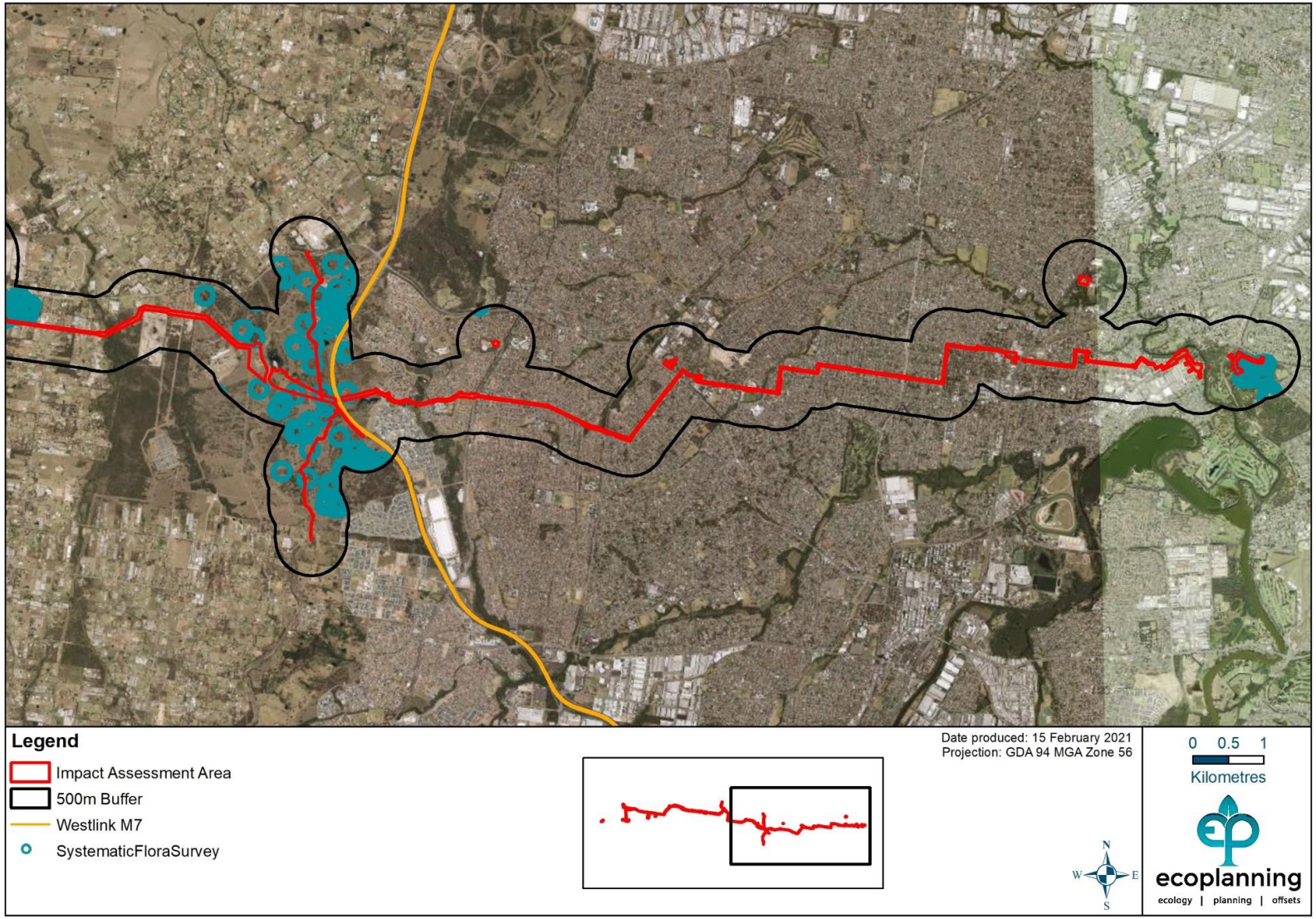

Figure 1.4: Previous surveys (biometric plots) within and adjacent to the USC AWRC impact assessment area - Badgerys Creek to Lansdowne Reserve

2 Species information

2.1 Species description

Pimelea spicata R. Br. was first described by Robert Brown in 1810 (Brown 1810) from a specimen collected 'near Parramatta' in 1802. In 1848 Stephan Endlicher, an Austrian Botanist, redescribed and published it under the name *Calyptrostegia spicata* (R. BR.) Endl. (Endlicher 1848), however, the basionym, *Pimelea spicata,* remains the original, validly published name of the taxon and has been retained in subsequent taxonomic treatments (Bentham & von Mueller 1873; Threlfall 1982; Rye 1990).

Pimelea spicata is listed as endangered under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Pimelea spicata is a slender decumbent to erect or spreading shrub to 50 cm in height and is glabrous with the exception of the inflorescence. The stems are brown or reddish-brown but on new growth appear yellow with older stems often see intertwining with grasses and herbs. The leaves are opposite to subopposite, green and paler green on the lower surface and are narrow elliptical to elliptical in shape. Leaf dimensions range from 5.5-20 mm long and to 1.5-8 mm wide, are acute to obtuse with a prominent mid-rib on the lower surface and are usually held outwards from the stem (Threllfall 1982; Heads 1990; James et al. 1999; Harden 2000; Benson & McDougall 2001; DEC 2006).

The inflorescence is a terminal raceme with the glabrous peduncles up to 14 mm long at maturity, and with the pedicels also glabrous. The racemes are compact when young but are elongated and interrupted at maturity lacking bracts and having a glabrous rachis (**Plate 2.1**). Flowers are bisexual, tubular in shape and are white to pink-tinged in colour with four spreading petals and are 7-10 mm long (**Plate 2.1**). The sepals are sparsely hairy. The flowers are glabrous with the exception of a few short hairs at the top of the floral tube. The mature fruit is green, glabrous except for a few short hairs at the apex, is ovoid in shape and small being 2.25-2.5 mm long and 1.0-1.25 mm wide. The fruit is a 1-seeded ovoid, glabrous black nut (Threllfall 1982; Heads 1990; James et al. 1999; Harden 2000; Benson & McDougall 2001; James 2018, DPIE 2019).

2.2 Biology/ecology

Pimelea spicata has an inconspicuous cryptic habit and is a slender decumbent to erect or spreading shrub that has an underground carrot-like taproot (DEC 2005). It may vary in size from a single stem up to 50 sprawling stems at maturity (DEC 2005; pers. obs.). Older stems are many-branched and can intertwine amongst surrounding grasses and herbs, such as can be found amongst *Microlaena stipoides* (Weeping Grass) and other grasses and forbs under shrubs including *Bursaria spinosa* (Blackthorn). It prefers part shade and can be easily out-competed by invasive weeds such as *Asparagus asparagoides* (Bridal Creeper).

Pimelea spicata has a carrot-like tap-root and although not previously known to spread vegetatively (Benson and McDougal 2001) it has been reported that mature plants may spread over short distances through underground rhizomes to assist in recovery from disturbances such as fire, mechanical damage and grazing (DEC 2006, DPIE 2019) and has the ability to resprout from the base when favourable conditions return (DEC 2006, DPIE 2019). It is not

known at what age the tap root is of sufficient size to enable re-sprouting (recovery plan). It is a resilient species and can survive in small, highly disturbed sites (pers. obs.).

Flowering can occur at any time with peaks during March and April (Benson and McDougall 2001) with fruit and seed collected in June. The mechanisms by which seed is dispersed is not clearly understood but possibly ant-dispersed (NPWS 2000 in Benson & McDougall 2001).

Seed production is the primary means of recruitment (James 2018) with germination from seed without any treatment previously recorded (Benson and McDougal 2001). The mechanisms by which seed is dispersed are unknown, however, the majority of seedlings appear within 30 cm of the adult plants (DEC 2006).

The longevity of *Pimelea spicata* seed is unknown.

Plate 2.1: ***Pimelea spicata*** **– a) elongated inflorescence (E. Norris), and b) flowers (B. Towle) - Prospect Reservoir, March 2019**

2.3 Distribution and abundance

Pimelea spicata is restricted to the Sydney Basin IBRA bioregion where it occurs in two disjunct regions, namely to the Cumberland sub-region in western Sydney and the Illawarra subregion, south of Sydney. The Recovery Plan for *Pimelea spicata* (DEC 2006) identified 25 populations occurring within the Cumberland Plain with a further five populations in the Illawarra. Based on current BioNet Atlas records (December 2020) there are approximately 58 sites of varying population sizes across the Cumberland Plain and a further 10 in the Illawarra, however, a number of these records are now located within greatly urbanised areas and may now be lost. One of the largest populations was that occurring at Badgery's Creek but much of this has been removed as part of the Western Sydney Aerotropolis development. Other large

populations on the Cumberland Plain occur at Prospect and Camden Golf Course and at Shellharbour in the Illawarra (E. Lee pers. comm. 2021).

Cumberland Plain

Historically, *Pimelea spicata* is likely to have been relatively abundant across the Cumberland Plain and the Illawarra , however, clearing and development have impacted much of the habitat. Cumberland Plain Woodland communities provide habitat for the species across western Sydney (for example Cumberland Shale Plains Woodland) but much of the distribution of these communities has been reduced to less than 10% of the pre-European extent with many areas reduced to scattered trees and derived grasslands (DEC 2006).

A number of early collections, held at the National Herbarium of NSW, are provided in **Table 1.1**. Although details of latitude and longitude for National Herbarium collections are provided in the BioNet Atlas database, locality details for older collections usually refer to general rather than precise localities and hence are not as accurate. Latitude and longitude added at a later date are based on the general locality provided by the collector; e.g. 'Parramatta', 'Prospect' and 'Fairfield'.

Table 2.1: Early collections of *Pimelea spicata* (National Herbarium of NSW records)

Date (year)	Collector	Details
1802-1805	R Brown ♦	Parramatta to Richmond
1800-1810	G. Caley	Parramatta
1886	H. Deane	Fairfield
1899	E. Cheel	Shellharbour – two collections
1906	W.M. Carne	North Richmond
1912	R.H. Cambage	Prospect

♦ Robert Brown Collection held Royal Botanic Gardens, Kew

On the Cumberland Plain *Pimelea spicata* records are known to extend from Freemans Reach in the north, south as far as Douglass Park, east to Condell Park and west as far as Mulgoa, Greendale and the Williamswood Biobank site in the vicinity of Razorback Range. A number of population records occur in areas associated with urban expansion including the suburbs of Blacktown, Horsley Park, Prospect, Lansdowne and Narellan.

In the Illawarra, several populations occur in the Shellharbour region including Hoffman Park, Blackbutt Forest Reserve, Grey Park, Windang Island and within Killalea State Park south of Shellharbour. Several records are known from Minnamurra Headland north of Kiama Downs Reserve, and the single most southerly record dated 1999 is from Black Head Reserve at Gerroa. Most records are found at Hoffman Park and Blackbutt Forest Reserve, Shellharbour and all records are known from within 5 km from the coast.

The relative abundance of *Pimelea spicata* ranges from occasional to frequent (Benson & McDougall 2001; pers. obs.) with most sites having only a few individuals to estimates of hundreds of plants (DEC 2006).

2.4 Reservation status

The species is not well represented within conservation reserves with most populations occurring on private land. Several populations are also found within the National Park Estate (e.g. Wianamatta Regional Park), and within council reserves managed by Local Governments including Freemans Reach Reserve, Freemans Reach; Melrose Park, Blacktown; Herbert's Hill Reserve, Narellan and Blackbutt Forest Reserve, Shellharbour.

Under the Saving our Species (SOS) program, two priority management sites have been established, as follows:

- Prospect Nature Reserve in the Blacktown LGA
- Narellan - William Howe Regional Park in the Camden and Campbelltown LGAs

Both these priority management sites are National Parks and Wildlife Reserves. These priority management sites aim to secure the species in the long term through regular monitoring of populations, threats to populations and adaptive management over time.

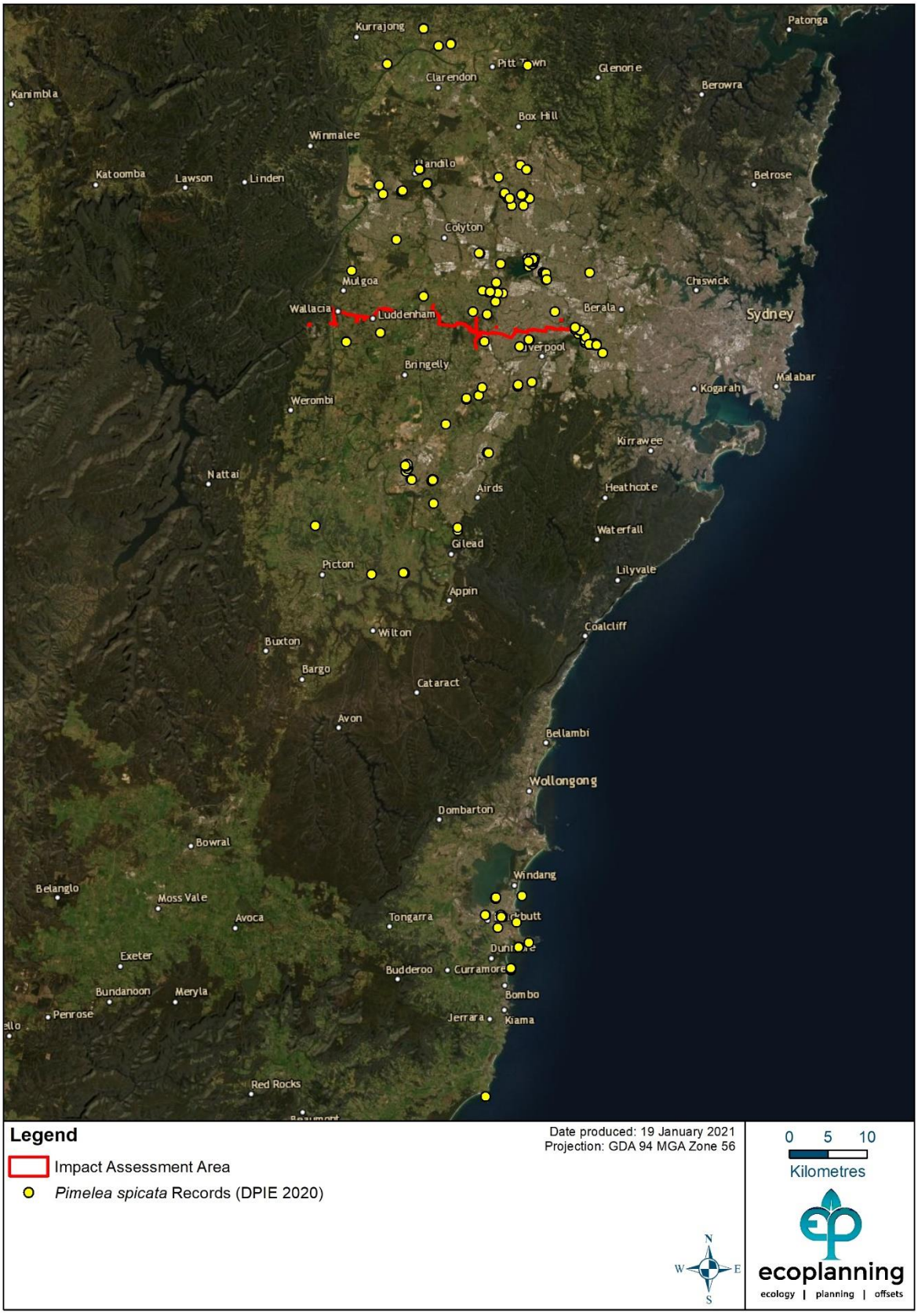

Figure 2.1: *Pimelea spicata* BioNet Atlas database records in relation to the USC AWRC

2.5 Habitat

Pimelea spicata is found in grassy woodlands on undulating low hills on the Wianamatta shales (Ashfield and Bringelly shales) on the Cumberland Plain and on grassy coastal headlands on soils derived from the Budgong Sandstone and Bombo Latite in the Shellharbour area (Tozer et al. 2010, SELLS 2014, James 2018). It can also be found in highly disturbed areas such as road verges, table drains, road embankments and ploughed paddocks (DPIE 2019) as well as highly disturbed small remnants amongst industrial infrastructure (pers. obs.). Disturbed areas and areas where woody weeds prevail can still afford habitat once weeds are removed and disturbances such as mowing and grazing cease (James 2018).

Sydney region – Cumberland IBRA sub-region

Pimelea spicata occurs mostly within the Cumberland Plain Mitchell Landscape, and to a much lesser degree in other landscapes including the Kurrajong Fault Scarp, Ashfield Plains, Hawkesbury-Nepean Channels and Floodplains and the Georges River Alluvial Plain. The Cumberland Plain comprises low rolling hills of Triassic shales and lithic sandstones (DECC 2002) covered in some areas by the tertiary gravels and quaternary sediments, with quaternary alluvium of the South Creek soil landscape found along the main streams. The Blacktown and Luddenham soil landscapes predominate over this landscape with the majority of records for *Pimelea spicata* occurring within the Blacktown and Luddenham soil landscapes where shales predominate. The Blacktown Soil Landscape also supports extensive areas of Shale Plains Woodland.

The species is predominantly found in Shale Plains Woodland, Shale Hills Woodland, Cumberland Moist Shale Woodland and associated derived native grasslands. Associated tree species include *Eucalyptus tereticornis* (Forest Red Gum) and *E. moluccana* (Grey Box). A common shrub associate is *Bursaria spinosa* (Blackthorn) which may afford protection of the species from grazing and grassy species including *Themeda triandra* (Kangaroo Grass) and *Microlaena stipoides* (Weeping Grass). Typical habitat is illustrated in **Plate 2.2**.

Plate 2.2: Habitat of *Pimelea spicata* at Camden (left - 2012) and Prospect Reservoir (right - 2018) – Cumberland Shale Plains Woodland (E. Norris)

In the Sydney region, *Pimelea spicata* is known to occur, or predicted to occur, in three vegetation communities all of which are associated with threatened ecological communities (James 2018, DPIE 2020). The PCTs and their related threatened ecological community are provided in **Table 2.2**.

Table 2.2: PCTs and related TECs in the Sydney region in which *Pimelea spicata* is known or predicted to occur (DPIE 2020)

PCT	PCT Name	Related TEC (BC Act)	*P. spicata* recorded	TEC Status	
				BC Act	EPBC Act
830	Cumberland Moist Shale Woodland	Moist Shale Woodland in the Sydney Basin Bioregion	✓	E	CE
849	Cumberland Shale Plains Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion	✓	CE	CE
850	Cumberland Shale Hills Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion	✓	CE	CE

✓ - *Pimelea spicata* known to occur

Other PCTs in which *Pimelea spicata* has been recorded are listed in **Table 2.3** and are based on correlating vegetation mapping (e.g. Tozer et al. 2010; OEH 2016) with known species records, for example, 'Alluvial Woodland' west of Duncan's Creek south of Wallacia, and in Shale Sandstone Transition Forest and Sydney Hinterland Grey Gum Ridgetop Forest south of Rosemeadow. It should be noted, however, that the PCTs listed in **Table 2.3** are dependent upon the location accuracy of individual records together with the accuracy of vegetation mapping at each record locality.

Table 2.3: Other PCTs in which *Pimelea spicata* has been recorded correlating with current vegetation mapping and BioNet Atlas database records.

Vegetation community	PCT Name and ID	Related TEC (BC Act)	*P. spicata* recorded	TEC Status	
				BC Act	EPBC Act
Alluvial Woodland (Tozer et al. 2010)	Cumberland Riverflat Forest PCT 835	River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	✓	E	CE
Shale Sandstone Transition Forest	Cumberland Shale – Ironbark Forest PCT 1395	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	✓	CE	CE

Vegetation community	PCT Name and ID	Related TEC (BC Act)	*P. spicata* recorded	TEC Status	
				BC Act	EPBC Act
Sydney Hinterland Grey Gum Ridgetop Forest	Sydney Hinterland Grey Gum ridgetop forest PCT 1790	Not associated with a TEC	✓	-	-

✓ - *Pimelea spicata* known to occur

Lake Illawarra region

Pimelea spicata occurs mostly within the Mitchell Landscapes of the Dapto-Wollongong Coastal Slopes and the Kiama Coastal Slopes with most records occurring within the latter landscape. Underlying geologies comprise the Budgong Sandstones of the rolling hills and the Bombo Latite of the Permian Gerringong volcanics that are exposed around the coastal headland areas. Soils are dominated by those of the Shellharbour and Bombo soil landscapes.

In the Shellharbour region in the Illawarra region, *Pimelea spicata* is known to occur, or predicted to occur in two vegetation communities, namely PCT 838 Forest Red Gum – Thin-leaved Stringybark grassy woodland on coastal lowlands and PCT 898 Coastal Headland Grassland (DPIE 2020c), both of which are threatened ecological communities. Most records occur in the Mitchell Landscape of the Kiama Coastal Slopes, with the populations at Hoffman Park in Shellharbour occurring in the Dapto-Wollongong Coastal slopes, and all are within 5 km of the coast (DPIE 2019).

The PCTs and their related threatened ecological community are provided in **Table 2.4**.

Table 2.4: PCTs and related TECs in the Illawarra Region in which *Pimelea spicata* is known to occur

PCT	PCT Name	Related TEC	P. *spicata* recorded	TEC Status	
				BC Act	EPBC Act
838	Forest Red Gum – Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin Bioregion	Illawarra Lowland Grassy Woodlands in the Sydney Basin Bioregion	✓	E	CE
898	Coastal Heathland Grassland	Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregion	Potential[1]	E	-

[1] Occurrences on coastal areas in the Shellharbour region occur within un-mapped vegetation and hence 'potential' is noted

PCT 838 occurs on lower slopes as woodland with an open shrub layer and a continuous grassy groundcover and has loamy soils derived from a number of different substrates. Typical species include *E. tereticornis* (Forest Red Gum) and *E. eugenioides* (Thin-leaved Stringybark) over a shrub and ground layer species including *Breynia oblongifolia* (Coffee Bush), *Eustrephus latifolius* (Wombat berry), *Pittosporum undulatum* (Sweet Pittosporum), *Carex*

longebrachiata, Commelina cyanea (Native Trad), *Dichondra repens* (Kidney Weed), *Oplismenus imbecillis, Lobelia purpurascens* (Whiteroot), *Microlaena stipoides* (Weeping Grass) and *Themeda triandra* (Kangaroo Grass).

PCT 898 is restricted to coastal headlands where it occurs as scattered occurrences along the coast including some off-shore islands. Typical species include *Banksia integrifolia* subsp. *integrifolia* (Coast Banksia), *Casuarina glauca* (Swamp Oak), *Westringia fruiticosa* (Coastal Rosemary), *Themeda triandra* (Kangaroo Grass), *Microlaena stipoides* (Weeping Grass), *Lomandra longifolia* (Spiny-headed Mat-rush) and *Hibbertia scandens* (Climbing Guinea Flower).

For the purposes of this report, there is no further discussion in relation to the Illawarra populations.

3 Description of the subject land

3.1 Landscape context and land use history

The USC AWRC study area is wholly located within the Cumberland Plain, an extensive area overlain with Wianamatta Shale, providing the developing colony of the 1800s better soils for agricultural and pastoral activities. As such, the Cumberland Plain has been historically and extensively cleared with large areas of open country interspersed with woodland of varying condition and cover. Extractive industries, such as that at Prospect, urbanisation and developing infrastructure have also had significant impact upon the vegetation communities across the Cumberland Plain over time and continues to this day. The study area comprises privately owned rural and semi-rural holdings, road network infrastructure, urbanised areas and reserves.

For the most part, the study area traverses gently undulating terrain intersected by numerous major north flowing drainage lines including the Nepean River, Cosgroves Creek, Badgerys Creek, Kemps Creek and Hinchinbrook Creek.

The western section of the study area, west of the M7, traverses the rural and rural residential, grazing, agricultural and light industry lands of the Wallacia, Luddenham, Badgerys Creek and Kemps Creek, whilst the eastern section, east of the M7, traverses the urbanised areas of Cecil Hills, Cabramatta, Canley Vale and Lansdowne.

Land within the Wallacia, Luddenham, Badgerys Creek and Kemps Creek section of the study area is largely cleared with remnant native vegetation generally confined to drainage lines, road corridors and uncleared and semi cleared parcels of land adjacent to the study area such properties west of Luddenham and the uncleared bushland at Kemps Creek adjacent to Bill Andersons Park. East of the M7, remnant native vegetation is far less common with most confined to areas along Hinchinbrook Creek, reserves in Bonnyrigg Heights and Cabramatta associated with clear Paddock Creek and Green Valley Creek respectively and the prominent tract of vegetation within Lansdowne Reserve.

3.2 Native vegetation – Plant Community Types (PCTs)

The following section provides details on the all the mapped PCTs found within the impact assessment area and is based upon the work of Biosis (2020).

3.2.1 Treated Water Pipeline (TWP) and Environmental Flow Pipeline (EFP) impact assessment area

West of the M7, the predominant native vegetation community occurring within the impact assessment area is PCT 849 Grey Box-Forest Red Gum grassy Woodland mapped in three condition classes, namely ‘intact’, ‘scattered trees’ and ‘thinned’. Where creek lines and drainage lines intersect the impact assessment area, PCT 835 Forest Red Gum – Rough-barked Apple grassy woodland has been recorded. Both are threatened ecological communities, i.e. Cumberland Shale Plans Woodland and River-flat Eucalypt Forest, respectively. Several other PCTs are also present but occur less frequently.

3.2.2 Brine Pipeline impact assessment area

For the most part, the predominant native vegetation community occurring east of the M7 is also PCT 849 Grey Box-Forest Red Gum grassy Woodland represented by small, isolated patches of remnant vegetation amongst dense urbanised areas generally found as scattered trees. The eastern end of the impact assessment area coincides with Lansdowne Reserve where extensive areas of native vegetation is present. At this locality a large area of PCT 849 has been mapped and verified by previous plot data (refer **Figure 1.3**) and where a number of records for *Pimelea spicata* occur.

A summary of the mapped PCTs (Biosis 2021) is provided in **Table 3.1** and illustrated in **Figure 3.1** to **Figure 3.7**.

Table 3.1: Summary of all PCTs within the impact assessment area (Biosis 2021)

PCT No	PCT Scientific Name	TEC	Comments
724	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Shale Gravel Transition Forest (SGTF)	Occurring between Wallacia and Luddenham, and in the Kemps Creek area. Mapped as intact, thinned or scattered trees.
725	Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Cooks River Castlereagh Ironbark Forest (CRCIF)	Occurring in the Kemps Creek area. Mapped as intact, thinned or scattered trees.
781	Coastal Freshwater Lagoons	Sydney Freshwater (SFW) Wetlands	Three small occurrences – Wallacia, Kemps Creek and west of the M7.
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial lats of the Cumberland Plain	River-flat Eucalypt Forest (RFEF)	Mapped at various locations throughout impact assessment area in association with drainage channels and streams. Mapped mostly as thinned or scattered trees with few areas mapped as intact.
849	Grey Box-Forest Red Gum grassy Woodland on flats of the Cumberland Plain	Cumberland Shale Plains Woodland (CPW)	Widespread and scattered throughout impact assessment area. Mapped mostly as thinned or scattered trees with few areas mapped as intact. A large patch is located at Kemps Creek.
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland	Several patches at Kemps Creek. Mapped as intact, thinned and scattered trees.

PCT No	PCT Scientific Name	TEC	Comments
1083	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux	Not associated with a TEC -	On slopes upslope of the Warragamba River, northwest of the township of Warragamba. Mapped as thinned.
1105	River Oak open forest of major streams	Not associated with a TEC	Small areas adjacent to the Warragamba and Nepean Rivers. Mapped as thinned.
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies	Not associated with a TEC	Two sites – west of Wallacia and adjacent to the Warragamba River. All mapped as intact.
1800	Swamp Oak Open forest on river-flats of the Cumberland Plain and Hunter Valley	Swamp Oak Floodplain Forest (SOFF)	Several small areas mapped in association with drainage lines. Mostly mapped as thinned but several areas mapped as scattered trees.
0	Urban native / exotic	Not associated with a TEC	Scattered occurrences throughout

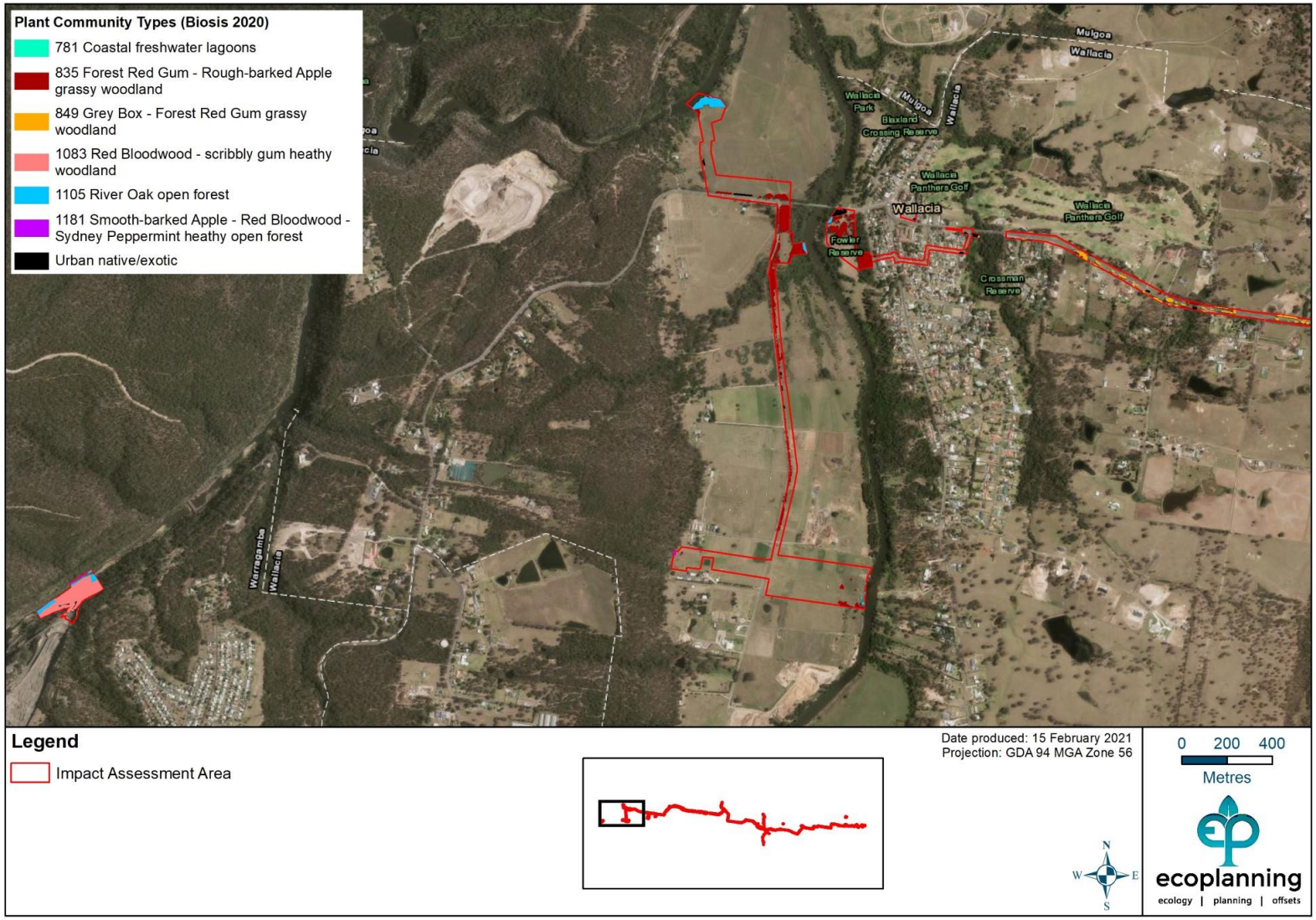

Figure 3.1: Vegetation communities mapped within the impact assessment area – Wallacia area (Biosis 2021)

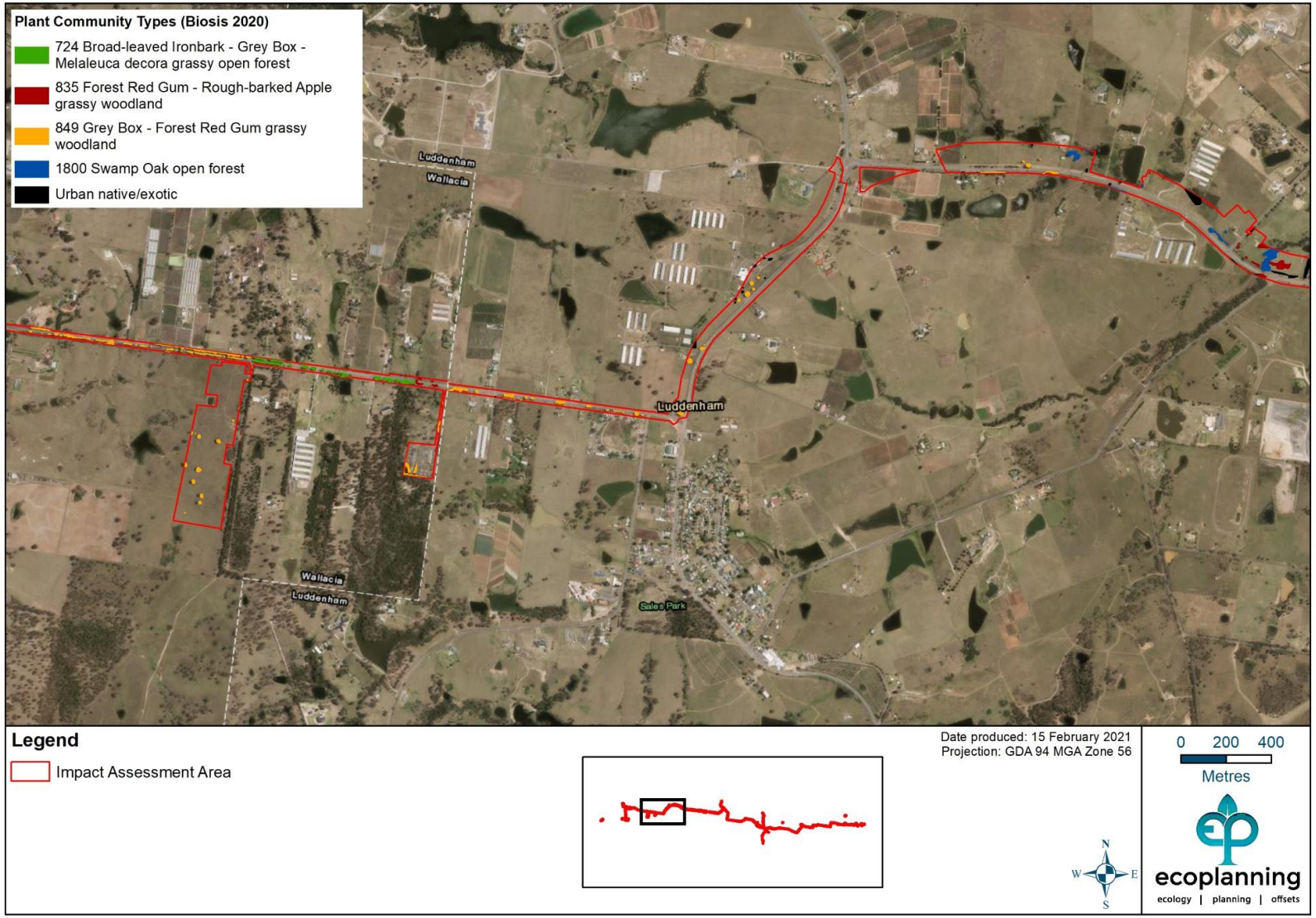

Figure 3.2: Vegetation communities mapped within the impact assessment area – Luddenham area (Biosis 2021)

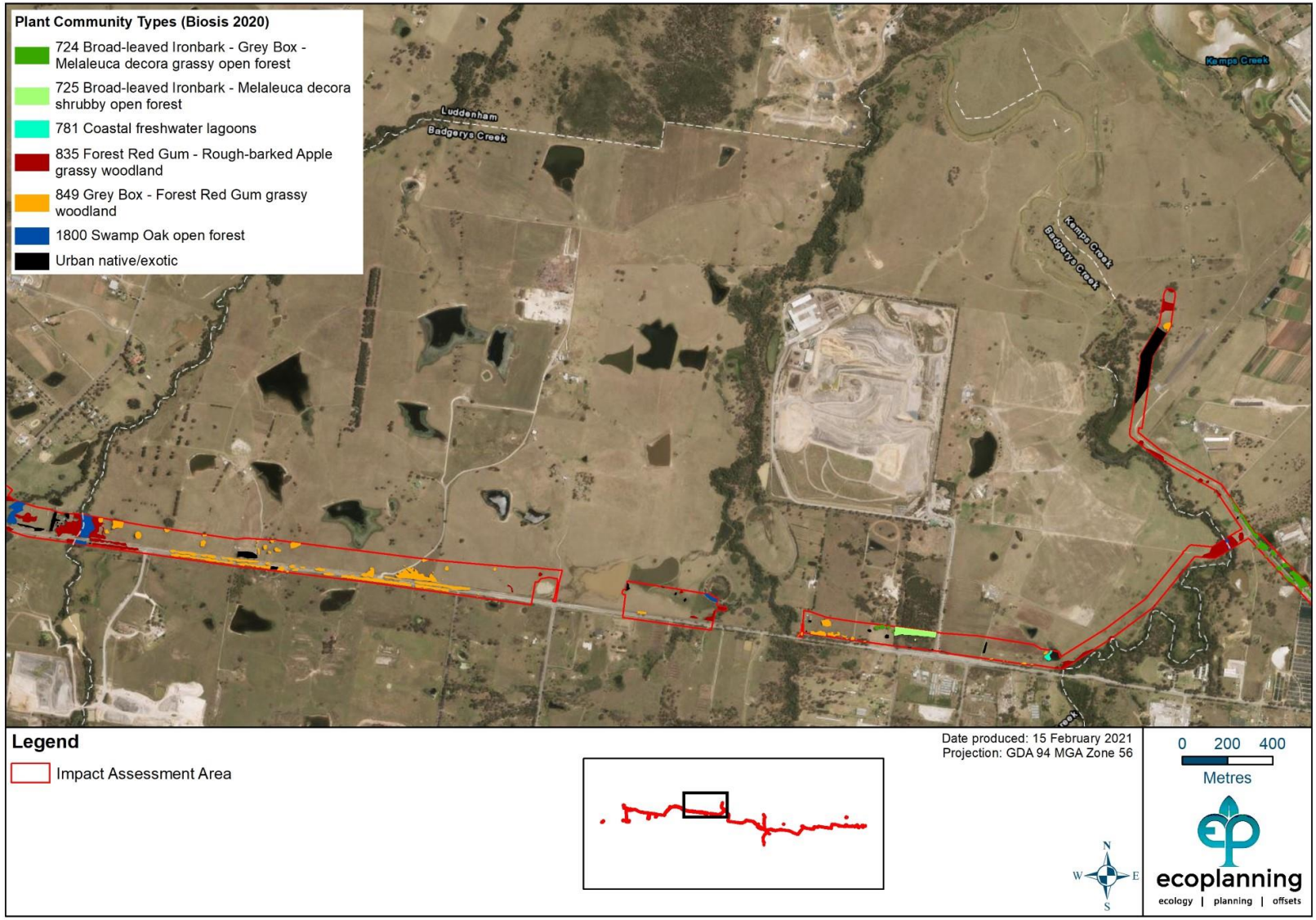

Figure 3.3: Vegetation communities mapped within the impact assessment area – Badgery's Creek area (Biosis 2021)

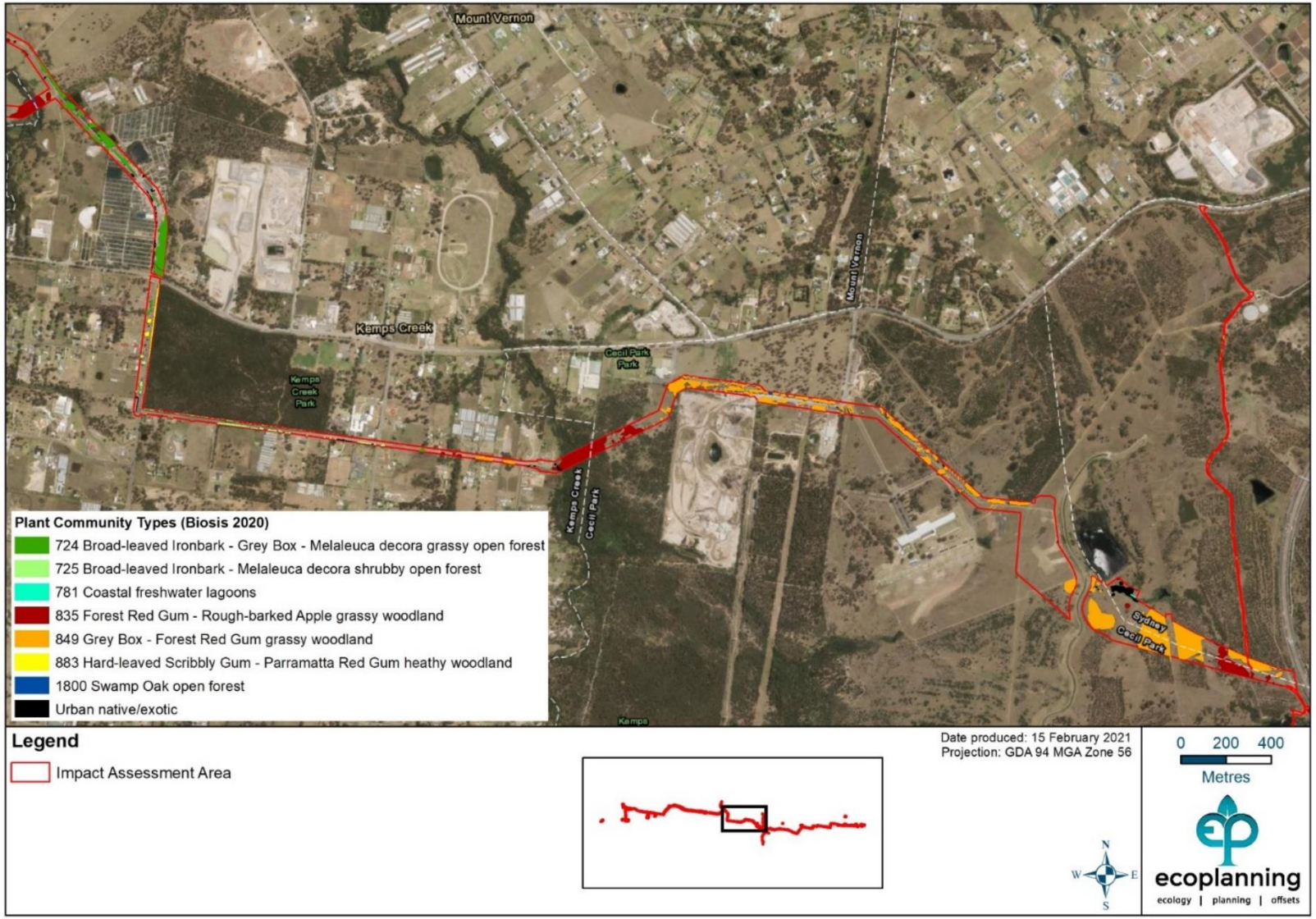

Figure 3.4: Vegetation communities mapped within the impact assessment area – Kemps Creek area (Biosis 2021)

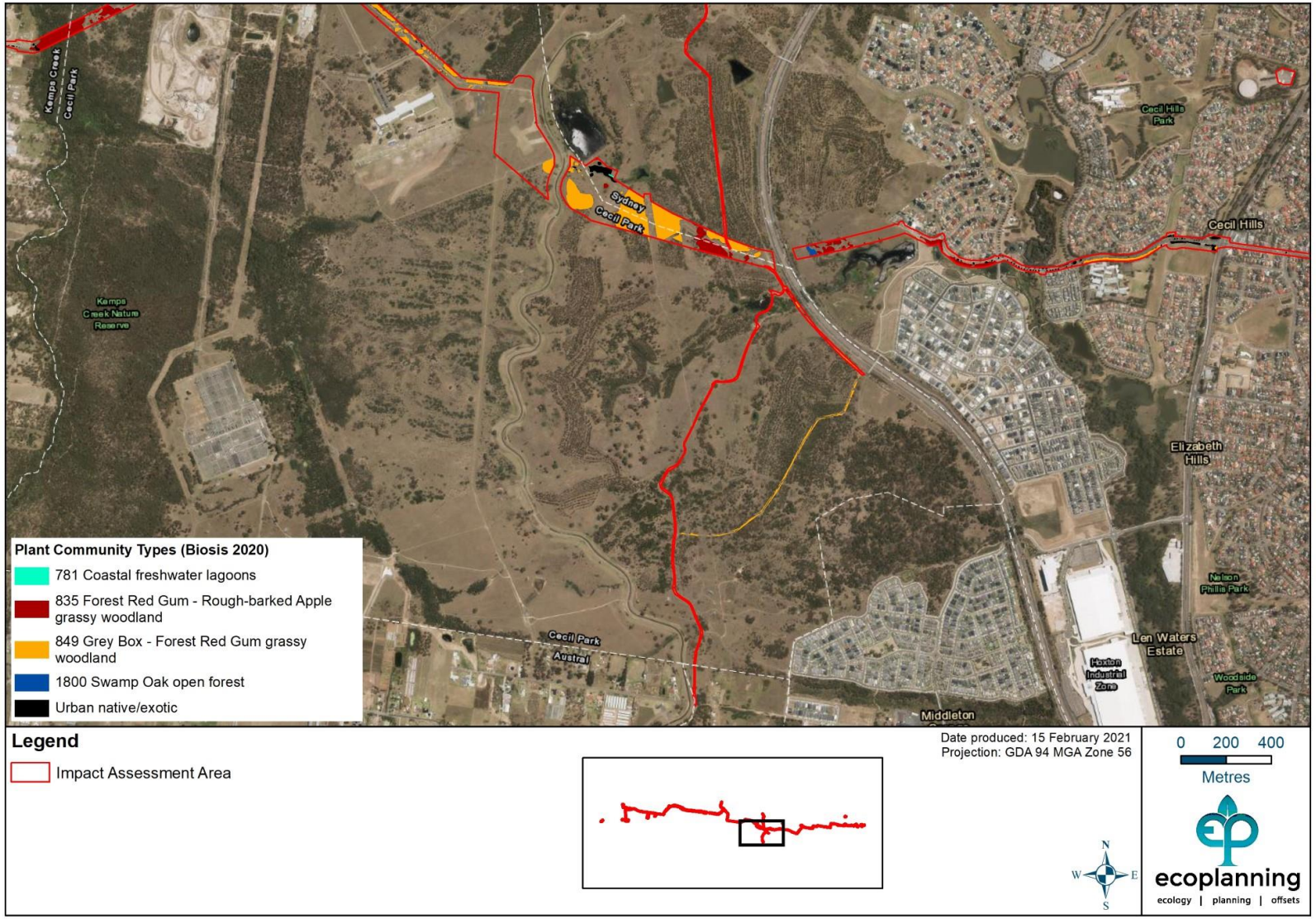

Figure 3.5: Vegetation communities mapped within the impact assessment area – Cecil Park area (Biosis 2021)

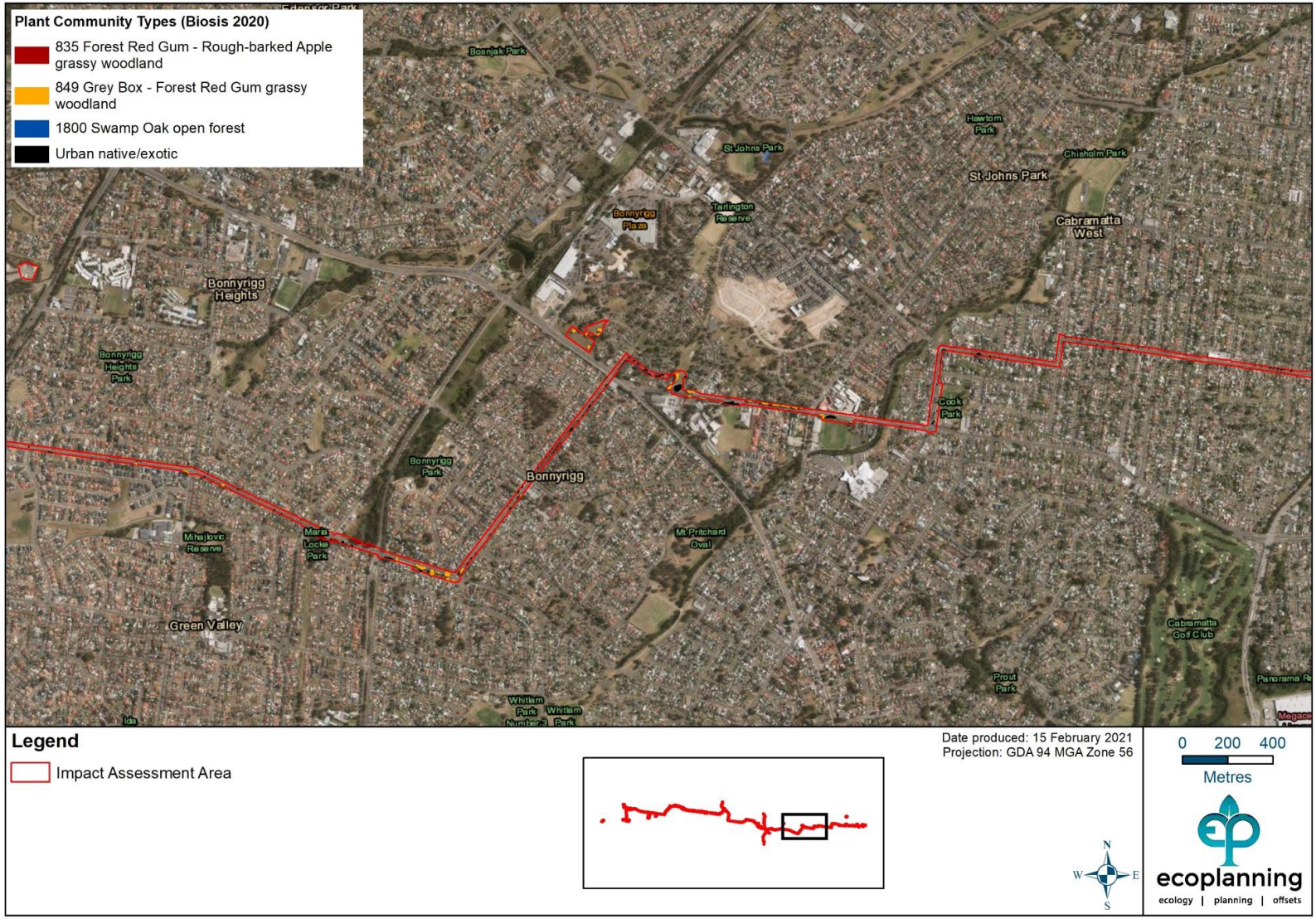

Figure 3.6: Vegetation communities mapped within the impact assessment area – Bonnyrigg and Cabramatta area (Biosis 2021)

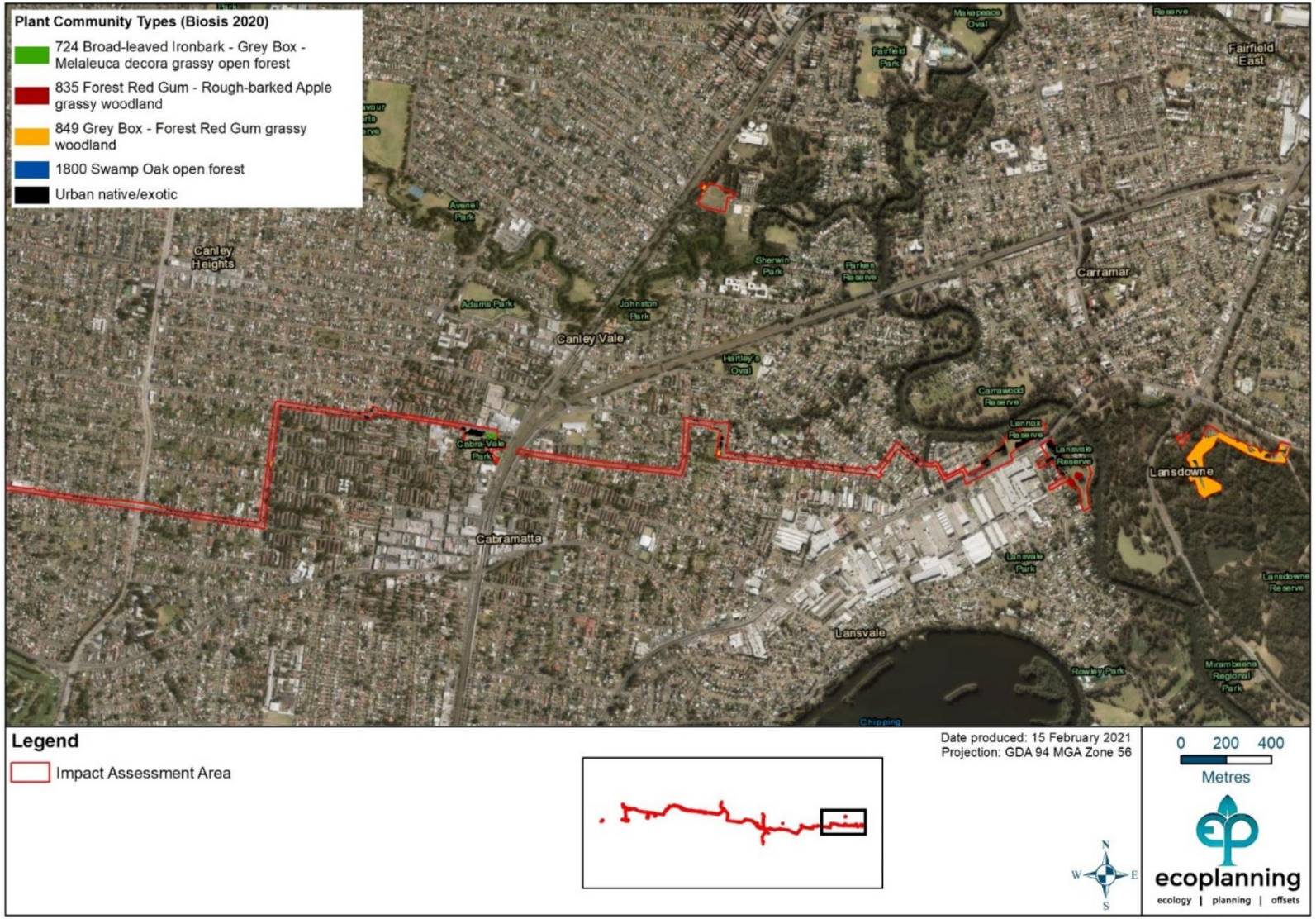

Figure 3.7: Vegetation communities mapped within the impact assessment area – Canley Vale and Lansdowne area (Biosis 2021)

3.3 Potential habitat for *Pimelea spicata*

As outlined in **Section 2.5** and **Section 3.2**, there are a number of PCTs in which *Pimelea spicata* are known or have the potential to occur. Of the communities listed in **Table 3.1** together with a review of records within the Cumberland Plain in association with the impact assessment areas, those PCTs that are relevant which may provide potential habitat are:

- PCT 849 – Cumberland Shale Plains Woodland (Grey Box-Forest Red Gum grassy Woodland on flats)
- PCT 835 – Cumberland Riverflat Forest (Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats)

Within the impact assessment area, PCT 849 Cumberland Shale Plans Woodland comprises almost 50% (19.68 ha) of the mapped vegetation occurring in 'intact', 'scattered trees' and 'thinned' condition classes with 'scattered trees' and 'thinned' the most common (17.81 ha). Potential habitat for *Pimelea spicata* is likely to be where PCT 849 is found having similar attributes to known records (refer **Section 2.5**), namely landscape attributes, dominant species and habitat condition. This is of particular relevance to those areas located between Wallacia and the M7 where PCT 849 occurs in more consistently.

Although less likely to occur in PCT 835 Cumberland Riverflat Forest, *Pimelea spicata* has previously been recorded in similar habitat (e.g. Greendale area 2017). PCT 835 comprises approx. 24% (11.31 ha) of the mapped vegetation also occurring in 'intact', 'scattered trees' and 'thinned' condition classes with and 'thinned' the most common (8.14 ha). For the most part PCT 835 is found in narrow and linear patches bordering drainage lines, with a large patch located within private property north of Kemps Creek Nature Reserve.

With the exception of Lansdowne Reserve, potential habitat has not been identified east of the M7 where the impact assessment area follows the road infrastructure network through urbanised areas and where scattered trees in a modified urbanised landscape are found.

4 Assessment of species presence and suitable habitat

4.1 Species records, habitat assessments and suitable habitat

4.1.1 Existing records in the impact assessment area

Existing records for *Pimelea spicata* used in this report were sourced from the BioNet Atlas database, which includes records held by the National Herbarium of NSW. Some of these records are in locations that have been developed and urbanised and may no longer be present but may help to identify vegetation types.

There are no BioNet Atlas database records for *Pimelea spicata* in the impact assessment area or study area. Several recent records occur in proximity to the eastern end of the impact assessment area within Lansdowne Reserve (**Table 4.1**and **Figure 2.1**).

Table 4.1: *Pimelea spicata* records in proximity to the USC AWRC infrastructure

Location	Date	No. of individuals	Details
Mirambeena Reserve, Lansdowne	21/01/2010	14	Closest record is approx. 340 m northwest of the impact assessment area and recorded in PCT 849 Shale Plains Woodland (OEH 2016).
Lansdowne Reserve, Lansdowne	Various dates: 01/05/1998 26/02/2010 19/08/2010	> 46	Closest record is approx.150 m south east from the impact assessment area. A number of other records are also located within Lansdowne Reserve

A number of previous surveys have been undertaken in the vicinity of the M7 in association with the Western Sydney Parklands. No *Pimelea spicata* were recorded during these surveys, despite potential suitable habitat being present (i.e. where areas of PCT 849 Cumberland Shale Plains Woodland has been mapped). This area, however, comprises planted native vegetation composed of species typical of PCT 849 with a highly disturbed understorey dominated by exotic grasses.

4.1.2 Habitat assessments and prior surveys within the impact assessment area

Information concerning prior surveys and habitat assessment was obtained via the NSW BioNet Flora Survey Data Collection data set accessed via the SEED data portal (EES 2020). All registered biometric plots including survey details were then mapped in ArcGIS and details accessed through the Flora Surveys in the BioNet database. Prior surveys undertaken in the USC AWRC are described in **Section 1.7.1**.

The availability of data from prior surveys is dependent upon individuals and consultancies uploading their data (a condition of the DPIE Scientific Licence granted under Part 2 of the BC

Act). A large number of reports submitted to consent authorities as part of development and other proposals may not necessarily be registered in the BioNet Flora Survey Data Collection data set and hence access to a potentially larger data set is not available.

4.2 Surveys completed for this assessment

4.2.1 Desktop vegetation mapping

The condition classes of vegetation within the impact assessment area is based on the information provided by Biosis (2020a). This was undertaken utilising aerial imagery (NearMap) of the subject land and following methodology is provided.

Determination of vegetation classes

Vegetation layers were prepared by Biosis' GIS technical staff by drawing the initial vegetation "extent" polygons. Following the preparation of polygons within the GIS, an appropriately qualified botanist assigned PCT and vegetation condition based upon the following general rules:

- Assign PCT using all available data sources including soils layer, geology layer, LiDAR derived layers, watercourses, slope/topography, aspect, and existing mapping.
- Assign a condition class to be confirmed by field assessment, where possible.
- Consider expected density of tree and shrub layer when assigning condition.
- Map areas of derived native grassland (DNG) and potential DNG throughout the subject land.

The condition classes used to describe vegetation within the subject land during desktop vegetation mapping include the three classes outlined in **Table 4.2**. Areas classified as urban native and exotic vegetation were also identified and mapped. PCT 849 Cumberland Shale Plains Woodland (Grey Box-Forest Red Gum grassy Woodland on flats) was the most common vegetation community recorded.

Table 4.2: Vegetation condition classes and their defining characteristics

Condition class	Defining characteristics
Intact	Native vegetation that was in good condition and has maintained structural integrity. It may be composed of: • A diversity of vegetation layers with a tree density close to natural. • Low levels of evidence of historical disturbance. • Vegetation cover will be uniform and there are fewer visible gaps where the "forest floor" can be seen from the aerial imagery. • Older (taller) regrowth woodland where it can be expected that native understorey strata have also regenerated.
Thinned	This vegetation is modified and likely to be highly variable. It may be composed of: • Woodlands that have a partly cleared canopy resulting in a more open structure than intact vegetation. • Vegetation that has been under-scrubbed (shrub layer removed) or is dominated by exotic species in the understorey.

Condition class	Defining characteristics
	• Younger (shorter) and scattered/patchy/scraggly regrowth vegetation.
Scattered Trees	A single tree or small group of trees surrounded by native or exotic grassland, or areas of cultivation. It may be composed of: • Vegetation where one or more structural layers may be absent (e.g. shrubs and/or grasses/forbs). • Scattered shrubs and/or regrowth juvenile / semi-mature trees. • Grasslands in between scattered trees/shrubs where species are predominantly native (i.e. DNG).
Urban native / exotic	Non-grassland vegetation in urban and rural area comprising: • Planted non-indigenous street trees and landscaped areas. • Orchards and areas of intensive cropping. • Areas of exotic vegetation. • Other vegetation that does not conform to one of the above four categories.

4.2.2 Field validation

Following the desktop review and vegetation mapping outlined in **Section 4.2.1**, all vegetated areas within the impact assessment area were ground-truthed by Biosis and 30 biometric plots were completed as part of this process (Biosis 2020). Details are provided in **Table 4.3** and the location of biometric plots are provided in **Figure 4.1** and **Figure 4.2**. These surveys did not record *Pimelea spicata* (Biosis 2020).

Table 4.3: Biometric plot data completed within the impact assessment area (Biosis 2020)

PCT Name	Area (ha)	Number of plots surveyed
724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest	2.86	4
725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest	1.04	4
781 - Coastal Freshwater Lagoons	0.10	1
835 - Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats (Riverflat Eucalypt Forest)	11.31	6
849 - Grey Box-Forest Red Gum grassy Woodland on flats	19.09	6
883 - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland	0.23	2
1083 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux	1.81	1
1105 - River Oak open forest of major streams	0.86	1
1181 - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest	0.07	1
1800 - Swamp Oak Open forest on river-flats	1.53	3
Total native vegetation communities	**39.5**	**29**
Urban/exotic	7.02	1
Total	**45.93**	**30**

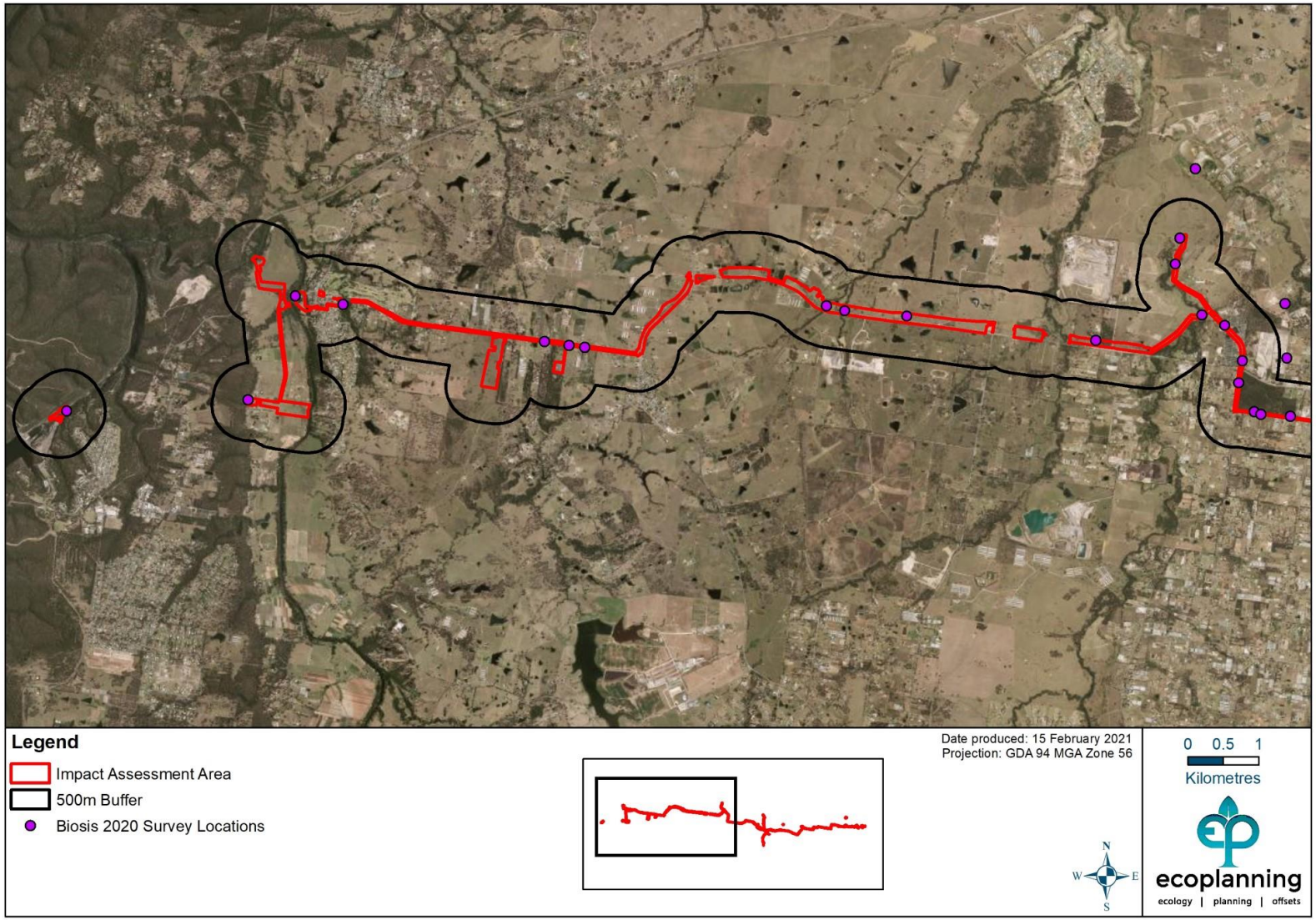

Figure 4.1: Biometric plot surveys conducted within impact assessment area – Warragamba to Kemps Creek (Biosis 2020)

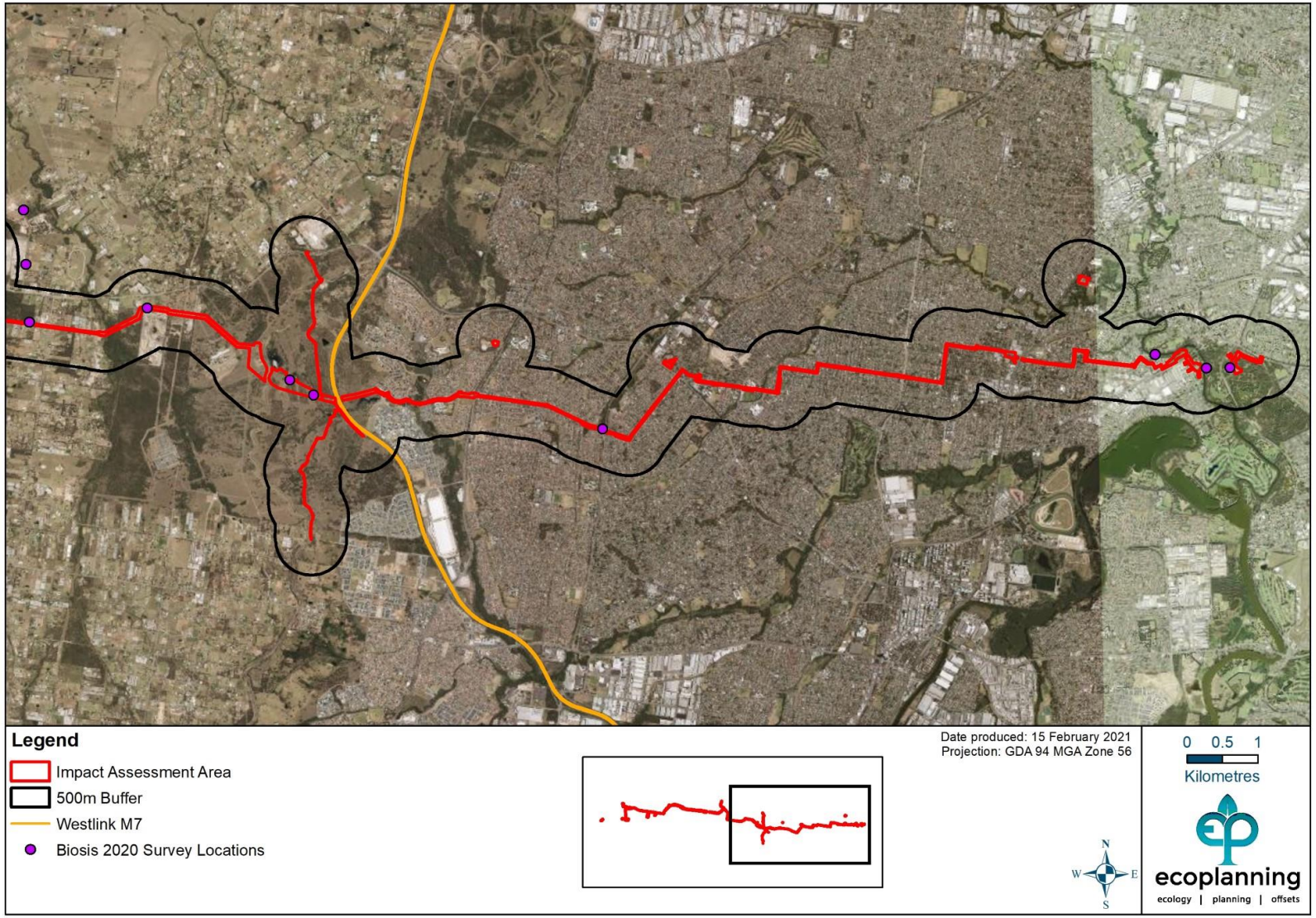

Figure 4.2: Biometric plot surveys conducted within impact assessment area – Kemps Creek to Lansdowne Reserve (Biosis 2020)

4.3 Assessment of species presence and justification (BAM 6.5.2.8c, 6.5.2.5)

Based on BioNet Atlas database records and the mapped distribution of potential habitat within the impact assessment area (PCT 849 Cumberland Shale Plains Woodland and PCT 835 Cumberland Riverflat Forest) it is considered that *Pimelea spicata* has the potential to occur. Although no populations have previously been recorded within the impact assessment area, there is a reasonable likelihood that the species is present. For the most part, the impact assessment area is linear, confined to road corridors and adjacent private land, however those areas with the greatest likelihood of occurrence are those where tree canopy is more continuous, and where a regenerating shrub layer has been recorded (Biosis 2021a).

4.4 Assessment of suitable habitat

Suitable habitat for *Pimelea spicata* has been determined by the following attributes:

- A review of habitat data and associated vegetation communities held with BioNet Atlas database records
- Reference to desktop vegetation mapping provided by Biosis (2020)
- Reference to vegetation mapping by Tozer et al. (2010) and OEH (2016)
- A review of high resolution aerial imagery (NearMap 2021)
- Reference to known sites with similar habitat to that present within the impact assessment area
- Reference to the BioNet Classification (DPIE 2020f)
- Previous targeted searches and personal knowledge
- A review of species distribution in relation to underlying geologies and associated soil landscapes.

Key habitat attributes used to identify potential habitat are provided below.

4.4.1 Key habitat attributes used and justification

Habitat and associated vegetation communities

Pimelea spicata is typically associated with PCT 830 Cumberland Moist Shale Woodland, PCT 849 Cumberland Shale Plains Woodland, PCT 850 Cumberland Shale Hills Woodland. It has occasionally been recorded in other communities, namely PCT 835 Forest Red Gum – Rough-barked Apple grassy woodland (Riverflat Eucalypt Forest), PCT 1395 Cumberland Shale – Ironbark Forest and PCT 1790 Sydney Hinterland Grey Gum ridgetop forest. Where the species occurs on the Cumberland Plain the dominant canopy species include *E. moluccana* (Grey Box), *E. tereticornis* (Forest Red Gum) and *E. crebra* (Narrow-leaved Ironbark).

Within the impact assessment area two vegetation community are likely to provide potential habitat for the species, namely PCT 849 Grey Box-Forest Red Gum grassy Woodland on flats (Cumberland Shale Plains Woodland) and PCT 835 Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats (Riverflat Eucalypt Forest). Of the total area of vegetation communities mapped in the impact assessment area, PCT 849 comprises almost half the area (**Table 4.3**).

Habitat condition

Across its range *Pimelea spicata* prefers woodland with a shrubby to grassy understorey over shales as well the grassy woodlands such as those sites in the Illawarra. It is also known to occur in disturbed sites following mowing and other similar disturbances, will appear at sites post-fire and is often found along track edges in disturbed vegetation.

Review of high resolution aerial imagery (NearMap 2021) together with vegetation validation and mapping (Biosis 2021) indicates that much of the vegetation within the impact assessment area is degraded and weedy, however, *Pimelea spicata* is tolerant of such modified and disturbed habitats.

Vegetation mapping for the for the impact assessment areas has identified three condition states, namely 'intact', 'scattered trees' and 'thinned' (Biosis 2021) all of which are likely to provide potential habitat for the species. Although *Pimelea spicata* can tolerate degraded sites, small and isolated mapped polygons have been excluded, given that many occur adjacent to road pavements and in urbanised areas. Further, areas that were once over cleared landscapes that now support native plantation vegetation, such as at Cecil Hills Park, west of the M7 (review of Google Earth imagery dated 2005) have also been excluded.

Distribution in relation to soils and vegetation mapping

Soils within the impact assessment area that have similar attributes and associated vegetation types to known records include areas where the Blacktown and Luddenham soil landscapes are present and mapped as having PCT 849 Cumberland Shale Plains Woodland.

4.4.2 Identification of habitat polygons

Areas of potential habitat within the impact assessment area have been identified based upon the attributes described in **Section 4.4.1**. As this report is largely desktop-based a precautionary approach has been taken in identifying potential habitat polygons in order to capture areas of higher likelihood of occurrence within the three condition classes. The most common condition class of PCT 849 Cumberland Shale Plains Woodland and PCT 835 Riverflat Eucalypt Forest within the impact assessment area is 'thinned'.

A total 9.21 ha of potential *Pimelea spicata* habitat has been identified in the impact assessment area (**Table 4.4**, **Figure 4.3**, **Figure 4.4**, **Figure 4.5** and **Figure 4.6**).

In accordance with Section 5.2.5 of the BAM (2020) each polygon is to be buffered by 30 m. Given the narrow and linear nature of the habitat polygons (road reserves) this is somewhat impracticable to achieve.

Table 4.4: Areas (ha) of PCTs identified as potential habitat for *Pimelea spicata*

PCT ID		Area of PCTs in impact assessment area (ha)	Area of PCTs in habitat polygons (ha)
835 Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats (Riverflat Eucalypt Forest)	intact	1.70	1.12
	thinned	8.14	0.30
	Scattered trees	1.47	-
849 Grey Box-Forest Red Gum grassy Woodland on flats (Cumberland Shale Plains Woodland)	Intact	1.87	1.79
	Thinned	13.77	5.18
	Scattered trees	3.44	0.81
	Total	**30.39**	**9.21**

4.4.3 Survey effort

Prior surveys

As discussed in **Section 1.7.1**, to date there have been few prior surveys within the impact assessment area with sites along Bents Basin Road the only plot based surveys identified.

Surveys undertaken in the impact assessment area as part of the project

The level of survey effort undertaken within the habitat polygons was subject to access permissions as discussed in **Section** □ and **1.7.2**. Of the 30 biometric plots completed (Biosis 2020) (**Figure 4.1** and **Figure 4.2**), six were undertaken in PCT 849, with one in 'intact' class (Lansdowne Reserve), three in 'scattered trees' and two in 'thinned' condition classes, and six plots were undertaken in PCT 835, with one in 'intact' class (Lansdowne Reserve), one in 'scattered trees' and four in 'thinned' condition classes. *Pimelea spicata* was not recorded.

Targeted searches were also undertaken throughout the impact area as part of the targeted flora survey effort for the BDAR (C. Wharfe, pers. comm.). *Pimelea spicata* was not recorded.

4.4.4 Impact minimisation and mitigation measures relevant to *Pimelea spicata*

Vegetation across the impact assessment areas is largely highly modified with areas of 'thinned' and 'scattered trees' the most common condition state identified and mapped. Areas of 'intact' and hence less modified vegetation are also mapped. Threats to *Pimelea spicata* relevant to this project include the following:

- Habitat degradation and loss due to clearing
- Invasion and competition from various woody and herbaceous weeds species such as Asparagus asparagoides (Bridal Creeper)
- Habitat degradation due to rubbish dumping
- Habitat degradation and road maintenance through slashing and spraying
- Hydrological changes and soil movement

In view of protecting individuals of *Pimelea spicata* that may occur within the impact assessment area the following minimisation and mitigation measures are provided:

- Seek access permission, where possible, to undertake targeted searches for Pimelea spicata in areas of identified potential habitat on private property in order to gain an understanding of the presence or absence of the species and its distribution and abundance.
- Seek access permission, where possible, to undertake targeted searches for *Pimelea spicata* in adjoining areas of previously mapped PCT 849 Shale Plains Woodland and PCT 850 Shale Hills Woodland (Tozer et al. 2010, OEH 2016) to identify populations off-site.
- If *Pimelea spicata* is located within the impact assessment area, consider slight re-design changes of the pipeline network and associated infrastructure accommodate protection of populations where practicable.

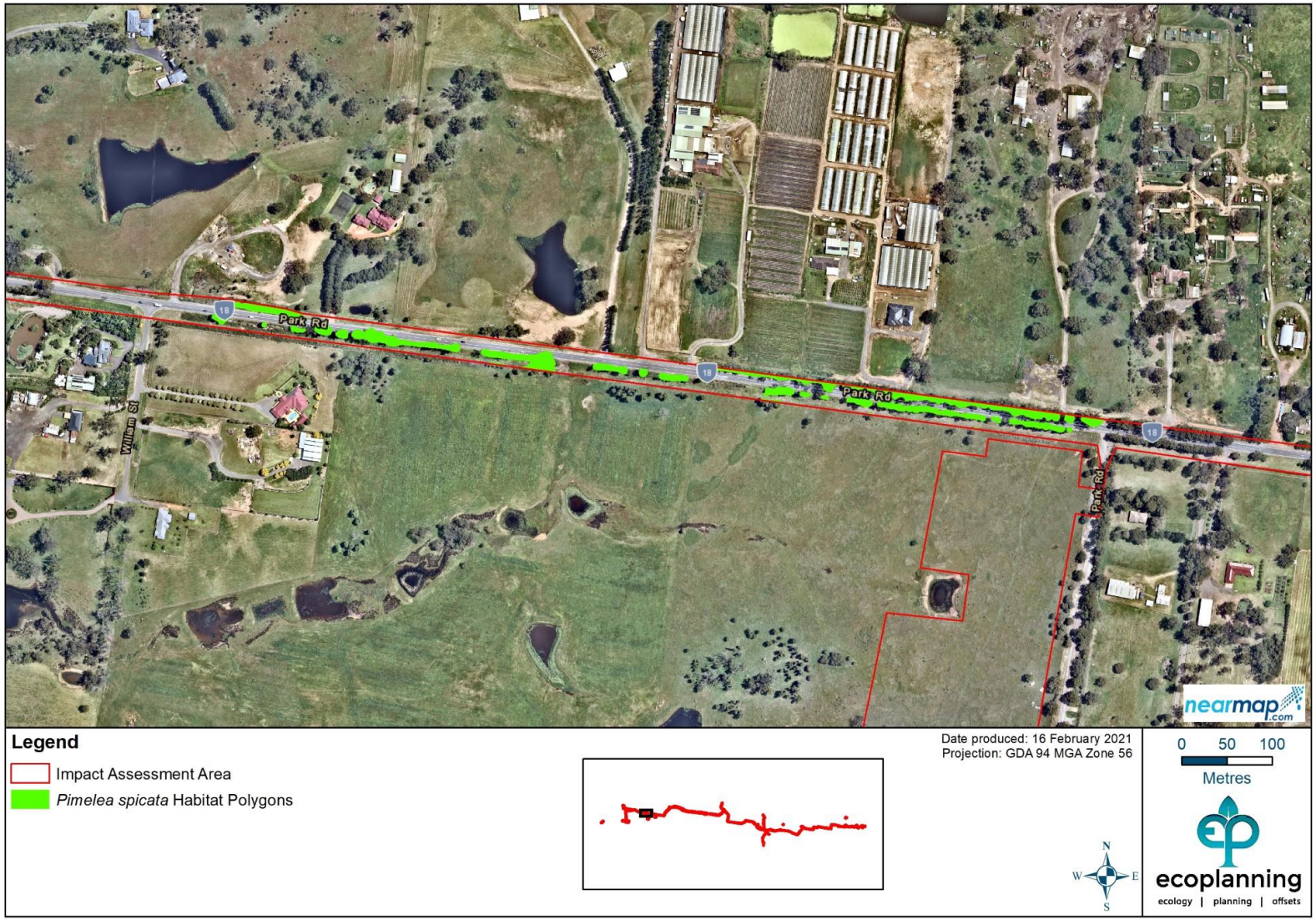

Figure 4.3: Habitat polygons within the impact assessment area – Wallacia to Luddenham area

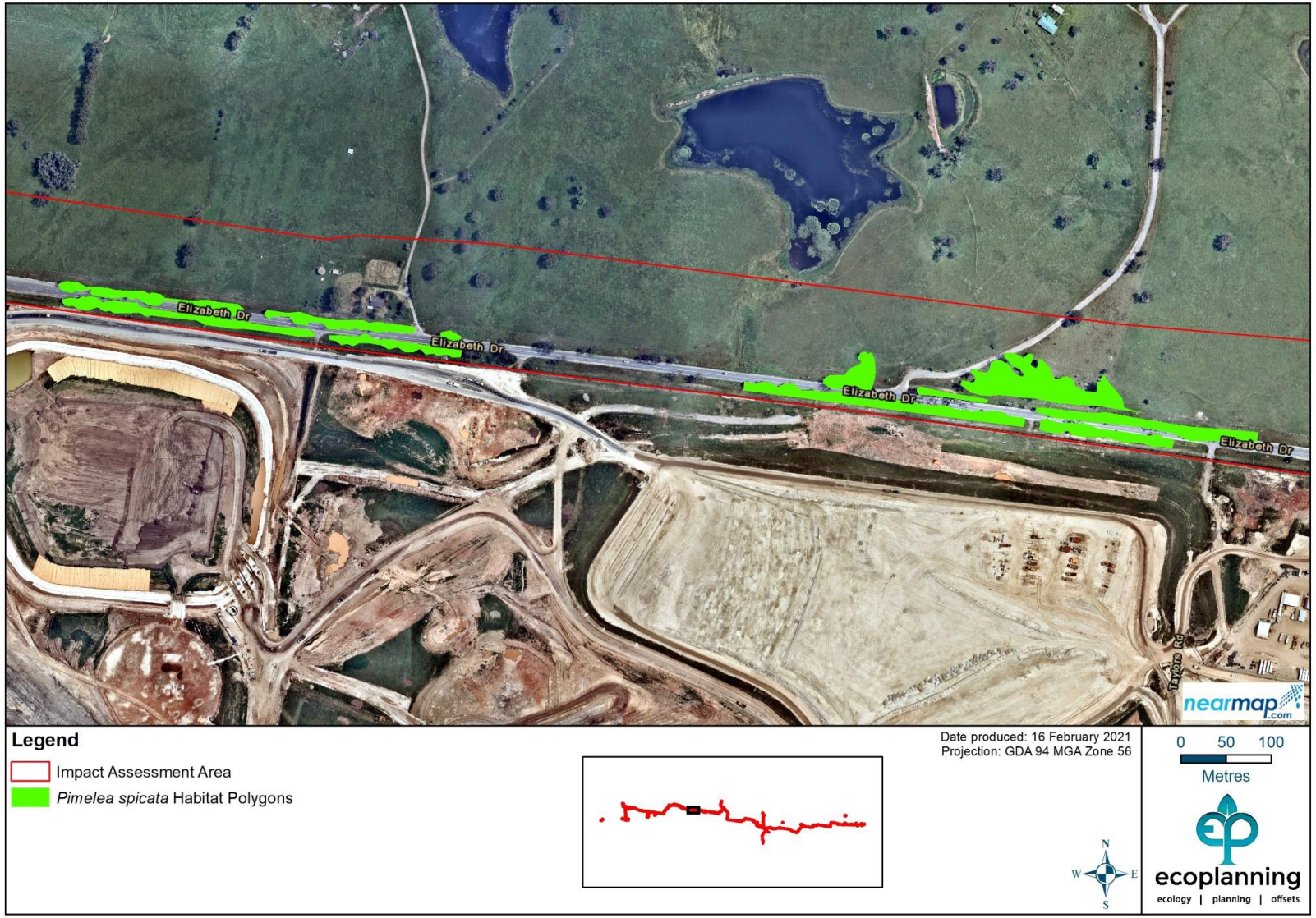

Figure 4.4: Habitat polygons within the impact assessment area – Western Sydney Airport area

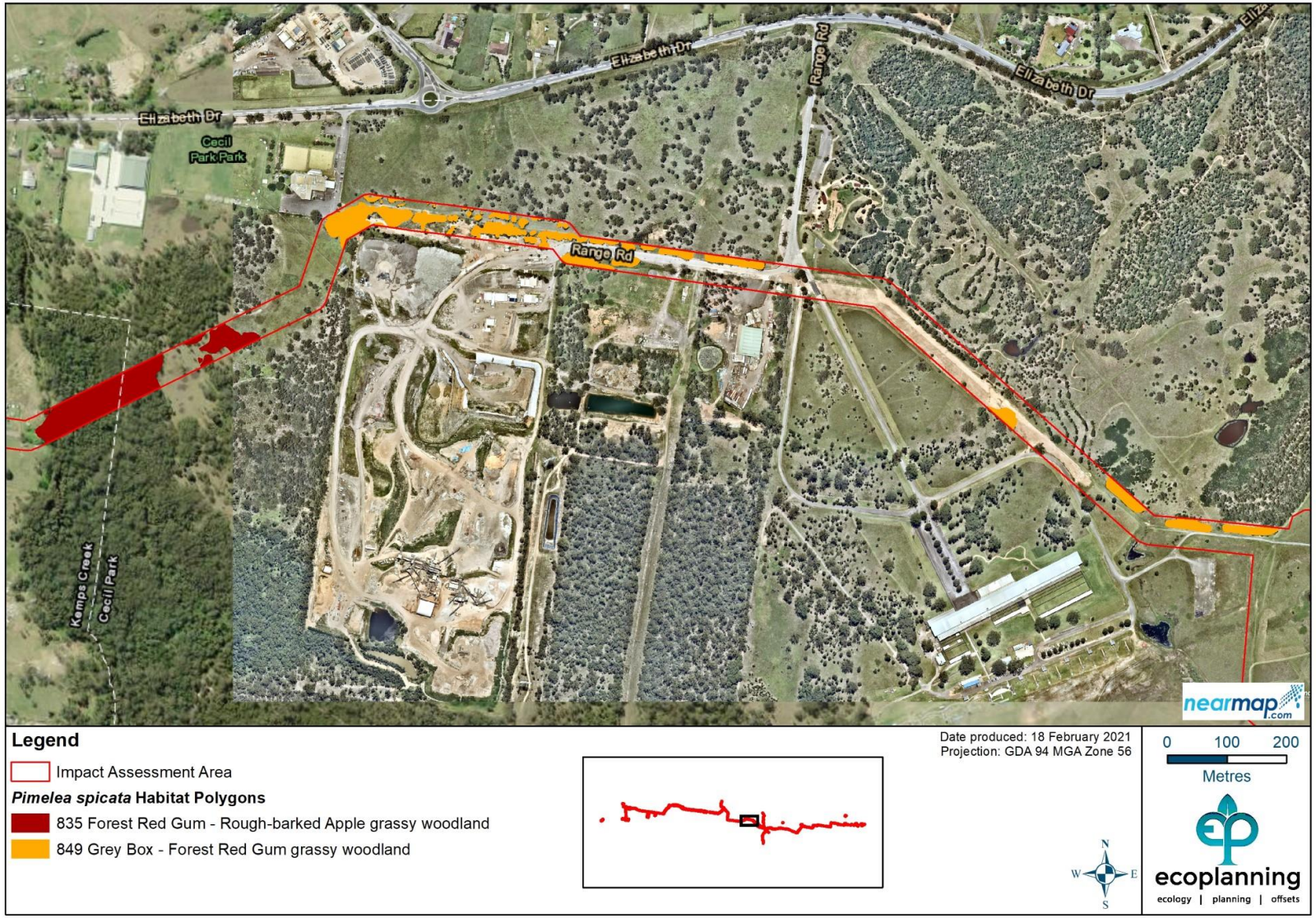

Figure 4.5: Habitat polygons within the impact assessment area – Kemps Creek area

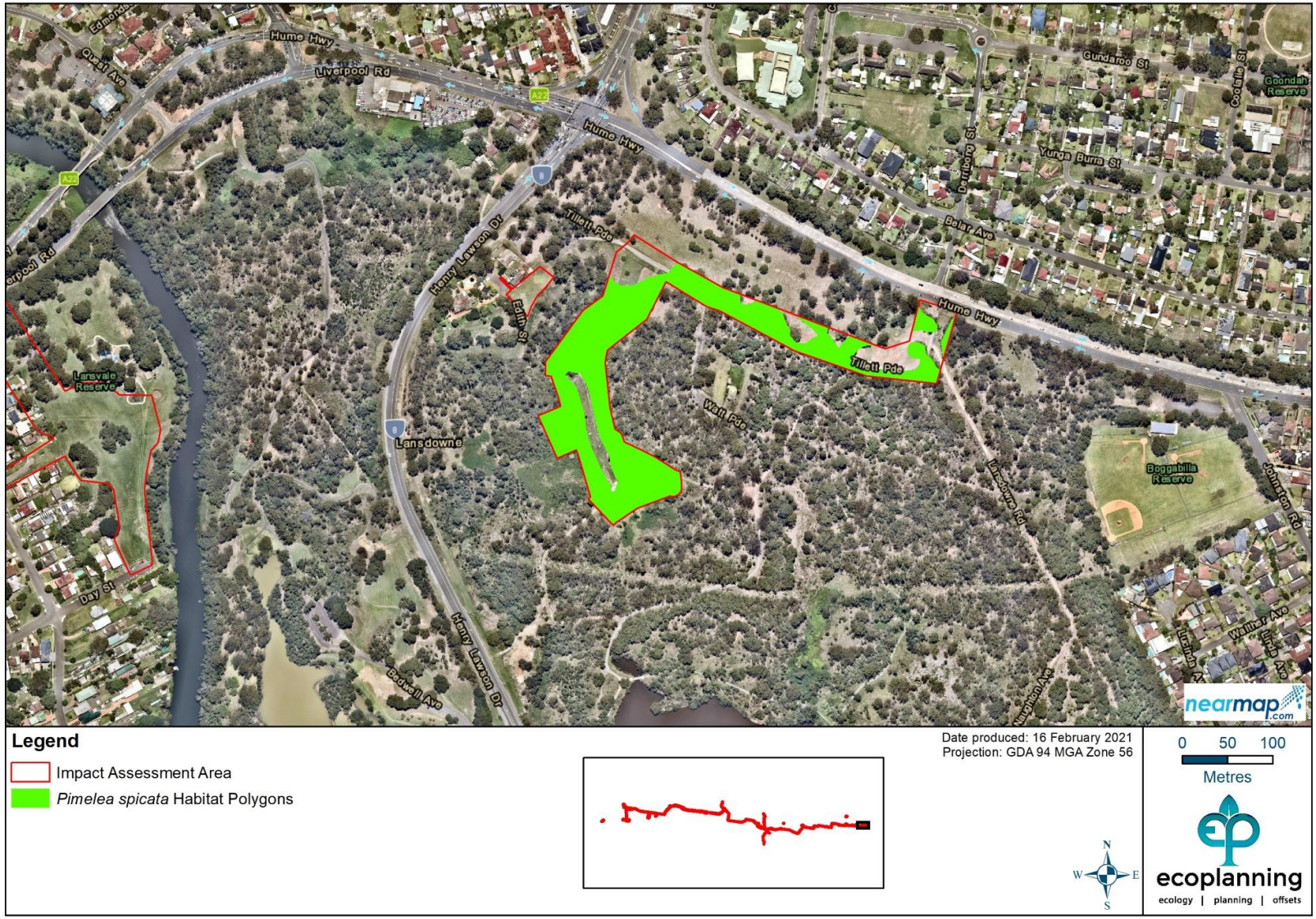

Figure 4.6: Habitat polygons within the impact assessment area – Lansdowne Reserve

5 Summary and conclusion

This expert report provides an assessment of the potential for *Pimelea spicata* and its habitat to occur within the impact assessment area. The expert report has been predominantly based on desktop information. Despite no known records for the species in the impact assessment area, similar habitat to known records is present. Most records located in proximity to the impact assessment area are those at Mirambeena Regional Park and Lansdowne Reserve, Lansvale where several populations occur.

A total area of 7.79 ha in PCT 849 Cumberland Shale Plains Woodland, and a total of 1.42 ha in PCT 835 Riverflat Eucalypt Forest is identified as potential habitat within the impact assessment area with most occurring in the Luddenham and Badgerys Creek area. As *Pimelea spicata* can be found in native vegetation in variable condition (intact to highly modified and disturbed), all condition classes identified in the impact assessment area have been considered as potential habitat, namely 'intact', 'thinned' and 'scattered trees".

Prior surveys within the impact assessment are few and widely separated (one survey at Wallacia and one survey at Cecil Hills). For the USC AWRC project the level of survey effort within the impact assessment area has been variable and limited by access to private property but has aimed to sample a range PCTs and polygons throughout. To date, no *Pimelea spicata* has been recorded within the assessment area.

The likelihood that *Pimelea spicata* has the potential to occur is based upon the following:

- knowledge of the species ecology,
- the presence of vegetation communities, soils and habitat consistent with known locations of the species,
- the presence of local records, particularly in the Lansvale area,
- the ability of the species to occur in small areas of disturbed remnant vegetation
- the cryptic nature of the species being often difficult to find amongst dense foliage,
- the ability of the species to persist as rootstock and regenerate following impacts such as fire or continuous mowing or other disturbances,
- the author's expertise.

Despite that *Pimelea spicata* has not been recorded in the impact assessment area, the presence of vegetation, soils and habitat that is similar to known records resulted in the conclusion that there is a reasonable likelihood that the species may occur and that suitable habitat, such as that found within Mirambeena Regional Park and Lansdowne Reserve be managed to protect the species.

6 Information used in this assessment

6.1 DPIE data, maps

NearMap (2020) Accessed at: https://admin.nearmap.com/api/identityserver/v1/login?signin=fb8e9f095ba0fb9940d4ebf6df43c836

NSW Department of Planning, Industry and the Environment (DPIE 2020c). BioNet Atlas database. Accessed at: https://www.environment.nsw.gov.au/NSWVCA20Prapp/default.aspx

NSW Department of Planning, Industry and Environment (2020f) BioNet Vegetation Classification. Accessed at: https://www.environment.nsw.gov.au/NSWVCA20Prapp/LoginPR.aspx

NSW Government (2020) SEED Data Portal. Accessed at: https://www.seed.nsw.gov.au/

NSW Government Spatial Services (2020) Sixmaps. Accessed at: https://maps.six.nsw.gov.au

6.2 Biosis – draft vegetation mapping

Biosis (2020a). Draft vegetation mapping prepared for the USC AWRC and associated infrastructure projects. Supplied in ArcGIS 10.8 format.

Biosis (2020b). Biometric plot data for surveys within the impact assessment area.

6.3 ArcGIS

ESRI ArcGIS v10.8 has been used in the assessment and mapping for this expert report.

7 Acknowledgements

For information regarding previous surveys and plot data within and adjacent to the impact assessment area thanks are due to the following individuals:

- Biosis – Callan Wharfe for project description and background information used in this report and other relevant information
- Ecoplanning – Lucas McKinnon – for surveys at Luddenham for the Priority Growth areas project.
- Ecoplanning – Brian Towle for surveys for discussions on SOS projects and habitat data for *Pimelea spicata*

For access to the *Pimelea spicata* specimen collections at National Herbarium of NSW and database records, I thank Hannah McPherson, Collections Manager.

8 References

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Bannerman, S.M. and Hazelton, P.A. (1990). Soil Landscapes of the Penrith 1:100,00 Sheet. Soil Conservation Service of NSW, Sydney.

Benson, D. and Howell, J. (1990). The bushland of Sydney and its suburbs. Kangaroo Press. In association with the Royal Botanic Gardens Sydney.

Benson, D.H. and McDougall, L (2001). Ecology of the Sydney plant species Part 8: dicotyledon families Rutaceae to Zygophyllaceae. *Cunninghamia* 7(2): 241-455.

Bentham, G. and von Mueller (1873). Thymeleae in Flora Australiensis, a description of the Plants of the Australian Territory, Volume 6, Thymeleae to Dioscorideae. L. Reeve and Co., Covent Garden, London.

Biosis (20201). USC AWRC Biometric Survey Plot data, Sydney Water.

Biosis (2021). Draft vegetation mapping prepared for the USC AWRC project.

Brown, R. (1810). *Thymelææ* in Prodromus floræ Novæ Hollandiæ et Insulæ Van-Diemen 362. Accessed at: https://www.ipni.org/p/3469-2

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Endlicher, S. (1848). Genera Plantarum Supplementum (1848) Vindobonae.

GHD (2017). Western Sydney Airport Stage 2 Project. Appendix K1 Biodiversity, Western Sydney Airport EIS Volume 4 – Technical Reports. Accessed at: https://www.westernsydneyairport.gov.au/media-resources/resources/environmental-assessment

Google Earth Pro – 2005 aerial imagery of the Liverpool Offtake Reservoir area.

Griffiths, S. (2001). Vegetation survey and plot data, Cecil Hills. Data retrieved from BioNet Atlas records as WMS files for import into ArcGIS.

Hazelton, P.M. and Tille, P.J. (1990). Soil Landscapes of the Wollongong – Port Hacking 1:100,000 Map Sheet and report. Soil Conservation Service, Sydney.

Hazelton, P. (1992). Soil Landscapes of the Kiama 1:100,000 Map Sheet and report. Dept. of Conservation and Land management, Sydney.

Heads, M.J. (1990). Genus *Pimelea* in Flora of Australia, Vol. 18: pp. 134-211. Australia Government Publishing Service, Canberra.

James, T., McDougall, L. and Benson, D. (1999). Rare bushland plants of Western Sydney. Royal Botanic Gardens, Sydney.

James, T. (2018). Expert report for *Pimelea spicata* Spiked Rice Flower. Strategic Assessment for Cumberland Plain Conservation Plan. Prepared for NSW Department of Planning and Environment.

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NSW Department of Conservation and Climate Change (2002). Descriptions for NSW (Mitchell) Landscapes Version 2.

NSW Department of Environment, Energy and Science (EES) (2020). SEED data portal. Accessed at: https://www.environment.nsw.gov.au/research-and-publications/seed-data-portal

NSW Department of Planning, Industry and the Environment (2019) *Pimelea spicata* – profile. Accessed 2020 at: https://www.environment.nsw.gov.au/ThreatenedSpeciesApp/profile.aspx?id=10632

NSW Department of Planning, Industry and the Environment (DPIE 2020a). Biodiversity Assessment Method manual.

NSW Department of Planning, Industry and the Environment (DPIE 2020b). Surveying threatened plants and their habitats: NSW survey guide for the Biodiversity Assessment Method.

NSW Department of Planning, Industry and the Environment (DPIE 2020c). BioNet Atlas database. Accessed 2020 at: https://www.environment.nsw.gov.au/atlasapp/Default.aspx?a=1

NSW Department of Planning, Industry and the Environment (DPIE 2020d). BioNet Atlas – *Pimelea spicata* – Sydney Basin: Distribution and vegetation associations. Accessed 2020 at:: https://www.environment.nsw.gov.au/ThreatenedSpeciesApp/profileData.aspx?id=10632&cmaName=Ocean

NSW Department of Planning, Industry and the Environment (DPIE 2020d). Cumberland Plain Mapping Project NSW Department of Conservation and Climate Change 1997-2002.

NSW Department of Planning, Industry and the Environment (DPIE 2020f). BioNet Vegetation Classification. Accessed 2020 at: https://www.environment.nsw.gov.au/NSWVCA20Prapp/default.aspx

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Royal Botanic Gardens and Domain Trust (2020). PlantNet – NSW FloraOnline. Accessed 2020 at: https://plantnet.rbgsyd.nsw.gov.au/search/simple.htm

Sydney Water (2020). Scoping Report Upper South Creek Advance Water Recycling Centre.

Threlfall, S (1982). The Genus *Pimelea* (Thymeleaceae) in Eastern Mainland Australia. Brunonia Vol. 5: 113-201.

Tozer, M.G., Turner, K., Simpson, C., Keith, D.A., Beukers, P., MacKenzie, B., Tindall, D. and Pennay, C. (2006, mapping). Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. NSW Department of Environment and Conservation & NSW Department of Natural Resources.

World Flora Online Consortium (2020). World Flora Online. Accessed at: http://www.worldfloraonline.org/

Appendix A Curriculum vitae for Elizabeth Norris

Biography

- 35 years of experience in botanical and ecological research in the New South Wales (Sydney Basin, coastal New South Wales, Hunter Valley, North and South Western Slopes and Plains), Queensland and the Kimberley, Western Australia, often to remote areas.
- Undertaken systematic floristic surveys, targeted flora surveys, vegetation monitoring, the development of strategic conservation plans, and ecological assessments.
- Ecological expert to the NSW Land and Environment Court
- Written species descriptions for the Flora of NSW
- Provided technical advice at flora workshops.

Qualifications

Master of Science (by research) – Macquarie University, 1996

Post Certificate Electron Microscopy (Sydney TAFE) – 1986

Bachelor of Science (combined Biology & Palaeontology major) – Macquarie University, 1984

Accreditations

BioCondition v2.1 – Application, Assessment and Scoring, Queensland Herbarium, Department of Science, IT, Innovation and The Arts

NSW Department of Planning Industry and Environment nominated Qualified Expert status:

- Qualified Expert reports for potential impacts of mine subsidence on threatened flora species and upland swamps within the Metropolitan Coal Lease Area
- Providing Expert Reports for *Pimelea curviflora* var. *curviflora*
- Providing Expert Reports for *Pimelea spicata* (Spiked Rice Flower)

Current Employment

Senior Botanist/Ecologist at Ecoplanning from August 2018

- Flora and fauna surveys, habitat assessments and long-term flora monitoring projects
- Threatened species surveys and monitoring
- Preparation of environmental impact assessment reports
- Biodiversity Offset Assessments
- Plant identification and in-house staff training

Previous relevant employment

2007-2018: Senior Botanist/Ecologist at Eco Logical Australia

2001-2018: Self-employed flora/ecological consultant trading as Liz Norris Ecological Consultant – casual capacity

2007-2016: Visiting Researcher, National Herbarium, Royal Botanic Gardens, Sydney (Non-paid position)

2001-2007: Research Associate/Technical Officer, National Herbarium, Royal Botanic Gardens Sydney – Stipeae Project

1986-1992: Technical Officer, Ecological Sciences Division, National Herbarium, Royal Botanic Gardens Sydney

1986-1986 Acting Scientific Officer, Plant Sciences, National Herbarium, Royal Botanic Gardens, Sydney

1982-1986: Technical Officer, Plant Sciences Division, National Herbarium, Royal Botanic Gardens, Sydney

Expertise

Botanist and ecological consultant specialising in vegetation survey and monitoring, habitat assessments, plant identification, threatened species survey and monitoring.

Professional memberships

Ecological Consultants Association NSW– member since 2001

Ecological Society of Australia – casual member since 1988

Committee participation

Ecological Consultants Association of NSW – Ordinary Council Member 2005-2013

Ecological Consultants Association of NSW – 2nd Vice President 2013-2014

Projects within the Sydney Basin – Pittwater, Yengo and Cumberland IBRA sub-regions of relevance to this report.

Targeted threatened species surveys and monitoring

- Pennant Hills Park, Ern Holmes Pavilion 2020. Flora and Fauna Assessment – targeted species surveys including *Pimelea curviflora* var. *curviflora.*
- BlackAsh Bushfire Consulting 2020. Ecological Constraints Assessment – targeted species surveys including *Pimelea curviflora* var. *curviflora.*
- Kemps Creek, Devonshire Road 2019. Ecological Constraints Assessment – targeted species surveys – *Dillwynia tenuifolia, Acacia pubescens* recorded.

- Western Sydney Parklands 2019. Targeted threatened species surveys of Parklands estate for future planning and development, Wallgrove Road and Yallock Place.
- NSW Department of Planning, Industry and the Environment (2019). SOS monitoring for ***Pimelea spicata***, Prospect Reservoir.
- Maraylya, Neich Road BDAR, 2019. Targeted species surveys for residential development proposal. *Pimelea curviflora* var. *curviflora* recorded.
- Deerubbin Land Council, 2018. Targeted surveys for *Dillwynia tenuifolia, Pultenaea parviflora, Persoonia nutans*, *Pimelea curviflora* var. *curviflora* and *Marsdenia viridiflora*.
- Brownlow Hill Pty Ltd 2018. Targeted survey for ***Pimelea spicata*** across suitable habitat, as part of overall BSAR assessment. *Pimelea spicata* recorded.
- Lend Lease 2017. Camden, Mt Gilead – targeted species surveys as part of land release development. *Pomaderris brunnea* recorded.
- Draft Ingleside Biodiversity Strategy 2016. Targeted surveys for numerous species including *Pimelea curviflora .var. curviflora*.
- Glenorie, Old Northern Road 2015, Flora and fauna assessments for proposed residential cluster subdivision – targeted searches for numerous species (14 species) including *Pimelea curviflora* var. *curviflora**.***
- Lend Lease 2015. Bingara Gorge development – targeted searches for *Epacris purpurascens* var. *purpurascens, Grevillea parviflora* subsp. *parviflora, Pimelea curviflora* var. *curviflora, Persoonia bargoensis* and *Melaleuca deanei.*
- Crusader Union, Galston Gorge 2015. Targeted searches and mapping for *Darwinia peduncularis, Lasiopetalum joyceae, Melaleuca deanei**,** Pimelea curviflora* var. *curviflora and Tetratheca glandulosa.*
- Glenorie, Old Northern Road 2014. Flora and fauna constraints assessment – targeted threatened species searches (14 flora species) including for *Pimelea curviflora* var. *curviflora.*
- Nurragingy Reserve, Blacktown 2012. Trenching works – targeted threatened species surveys including ***Pimelea spicata*** as part of electrical installation trenching works for playground upgrades. Reports prepared for Furnass Landscaping Enterprises Pty Ltd.
- Roads and Traffic Authority Camden Valley Way 2012. ***Pimelea spicata*** survey prior to road widening works.
- NSW Dept of Planning 2011 . Schofields Biodiversity Assessment – targeted threatened species survey – recorded Shale Plains Woodland, River Flat Eucalypt Forest and Swamp Oak Floodplain Forest identified. Targeted searches for *Acacia pubescens, Dillwynia tenuifolia,* ***Pimelea spicata*** and *Grevillea juniperina*.
- St Madelines and Marion College, Kenthurst, 2010. Flora survey targeted threatened species searches including *Pimelea curviflora* var. *curviflora*. *Darwinia biflora* recorded.
- Dural, Pellitt Lane 2010. Threatened species surveys (25 species) for proposed residential development, including *Pimelea curviflora* var. *curviflora.*
- Aldi Warehouse Development, Prestons 2007. Flora and fauna assessment threatened species searches. Cumberland Shale Plains Woodland.
- NSW Dept. of Environment and Climate Change, 2007. Maroota State Conservation Area: targeted flora surveys for *Acacia bynoeana, Micromyrtus blakelyi, Kunzea rupestris, Olearia cordata, Zieria involucrata, Pimelea curviflora* var. *curviflora, Tetratheca glandulosa.* All targeted flora recorded, including southerly range extension for *Olearia cordata* population.
- NSW Roads & Traffic Authority – Wisemans Ferry Road Upgrade 2007. Flora survey and targeted threatened species survey for *Acacia bynoeana, Dillwynia tenuifolia,*

Micromyrtus blakelyi, Kunzea rupestris, Pimelea curviflora var*. curviflora, Tetratheca glandulosa. Dillwynia tenuifolia* endangered population in the Baulkham Hills LGA identified within corridor and road construction plans changed to accommodate protection of the population.

- Hawkesbury City Council 2006. Field validation of remnant vegetation within the Hawkesbury LGA– council and crown Reserves. Habitat modelling and targeted threatened species surveys for ***Pimelea spicata****, Pimelea curviflora* var. *curviflora, Persoonia hirsuta, Dillwynia tenuifolia, Pultenaea parviflora, Grevillea juniperina* identified and recorded as part of the survey.
- Land & Environment Court Proceedings 2006. Glenorie Crown Reserve – targeted surveys. *Acacia bynoeana, Hibbertia superans, Pimelea curviflora* var. *curviflora* and *Tetratheca glandulosa* all recorded.
- Integral Energy 2006. Sackville Ferry Road – targeted flora surveys as part of the 11kV Overhead Extension Works. Shale-Sandstone Transition Woodland. Report for Gingra Ecological Surveys.
- Roads & Traffic Authority 2006. Wisemans ferry Road Upgrade Works – targeted survey for threatened species (14 species) including *Pimelea curviflora* var*. curviflora****.*** Shale-Sandstone Transition Woodland and Cattai Shale Cap Forest.
- Former Riverstone Abattoirs 2006. Targeted threatened flora species (16 species) including *Pimelea curviflora* var*. curviflora.* Cumberland Shale Plains Woodland, Alluvial Woodland and Shale-gravel Transition Woodland.
- Urban & Rural Design 2002. Yamaha, Wetherill Park – targeted threatened species survey for proposed warehouse development. Cumberland Shale Plains Woodland. ***Pimelea spicata*** recorded.

DPIE Qualified Expert Reporting

- Impacts to threatened species, threatened ecological communities (upland swamps) and riparian vegetation as a result of mine subsidence in the Metropolitan Coal Lease Area, Helensburgh, Sydney. Reports prepared for Resource Strategies, Brisbane 2017, 2018, 2019 and 2020 (in process).
- Western Sydney Corridors Project 2020– Expert Report for *Pimelea curviflora* var*. curviflora.* Report prepared for Transport for NSW.

Projects/consultancies

- BlackAsh Bushfire Consulting 2020. Ecological Constraints Assessment for proposed future development, Living Choice Glenhaven.
- Urbis P/L 2020. Ecological Constraints Assessment – urban design and transport planning Badgerys Creek Road, Badgerys Creek. Field survey and targeted threatened species searches.
- Annual Growth Centres Reporting 2019. Undertaking BAM Vegetation Integrity plots across numerous sites throughout western Sydney. Verification of ENV mapping and targeted threatened species searches.
- Biosis Pty Ltd 2019. Priority Growth Areas reporting – additional field surveys and advice.
- Kemps Creek, Devonshire Road 2019. Ecological Constraints Assessment. Report prepared for Capital Bluestone Pty Ltd.

- Western Sydney Parklands 2019. Flora and fauna survey of Parklands estate for future planning and development, Wallgrove Road and Yallock Place.
- Dept Planning and Environment 2018. Growth Centres ENV Reconciliation – Roadside rapid assessment surveys, NW Growth Centres.
- Lend Lease 2017. Camden, Mt Gilead – field survey, plot data collection, targeted species surveys as part of land release development.
- Camden Park Historic Site 2017. Biobank feasibility assessment – field survey, vegetation mapping and advice. Cumberland Shale Plains Woodland and Shale Hills Woodland. Report to property owner.
- Maraylya, Maguires Road 2017. Ecological Constraints Assessment – field survey, targeted threatened species survey. Shale Sandstone Transition Forest. Report prepared for Urban & Rural Design.
- Galston Gorge 2015. Ecological Constraints Assessment – field survey, targeted threatened species survey for proposed subdivision. Report for Crusader Union.
- Glenorie, Old Northern Road 2015. Vegetation survey targeted threatened species survey and constraints analysis for proposed cluster development subdivision. Report to property owner.
- Glenorie, Old Northern Road 2014. Flora and fauna constraints assessment – targeted threatened species searches for proposed residential cluster development. Report prepared for the Hills Shire Council.
- Landcom 2014. El Caballo Blanco and Gledswood Rezoning Ecological and Bushfire Assessment: flora and fauna assessment, constraints analysis and targeted threatened species surveys.
- Box Hill Area Precinct Environmental Assessment 2014. Dam de-watering – assessment of aquatic habitat, weeds, flora and fauna and water quality. Report prepared for Dallas Investments.
- Nurragingy Reserve, Blacktown 2012. Trenching works – Flora and fauna surveys as part of electrical installation trenching works for playground upgrades. Reports (Trench A and Trench B) prepared for Furnass Landscaping Enterprises Pty Ltd.
- NSW Dept of Planning 2011. Schofields Biodiversity Assessment – field survey and targeted threatened species survey –Shale Plains Woodland, River Flat Eucalypt Forest and Swamp Oak Floodplain Forest, plus targeted searches for *Acacia pubescens, Dillwynia tenuifolia, Pimelea spicata* and *Grevillea juniperina*. The latter species recorded.
- Castle Hill, Gum Tree Place 2011. Flora and fauna assessment for proposed residential subdivision. Report prepared for Kenthurst Constructions.
- Castle Hill, Church Street 2011. Flora and fauna assessment for proposed subdivision. Report prepared for Kenthurst Constructions.
- NSW Dept of Planning – Box Hill and Box Hill Industrial Precincts 2010. Biodiversity conservation assessment and riparian assessment to inform precinct planning. Threatened species surveys, validation of existing native vegetation.
- Bovis Lend Lease 2010. Wilton Road Trunk Main – ecological assessment. Field survey and reporting for trunk main upgrade works, Wilton Road.
- Dural, Pellitt Lane 2010. Flora and fauna assessment, targeted species searches and wildlife corridor protection for proposed residential development. Report prepared for Innovation Planning Australia.
- Calderwood Urban Development Project 2010. Flora and fauna assessment and ecological survey under Part 3A of the EP&A Act. Report prepared for Delfin Land Lease.

- St Madelines and Marion College, Kenthurst, 2010. Flora survey, tree inspection and targeted threatened species search for Bushfire and Habitat Assessment Report. Report prepared for The Catholic Education Office.
- Beacon Hill 2009. Field survey for proposed retirement village development at Beacon Hill. Report prepared for Beacon Hill Retirement Pty Ltd.
- South Cecil Hills Rezoning Masterplan 2008. Flora and fauna assessment, constraints assessment and targeted threatened species searches for proposed subdivision. Shale Plains Woodland Identified on site. Report prepared for APP Corporation Pty Ltd and Mirvac.
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INVERTEBRATE IDENTIFICATION AUSTRALASIA
• Identifications • Surveys • Environmental Interpretations

ABN 23634681309

Expert report on the Cumberland Plain Land Snail, *Meridolum corneovirens* (Pfeiffer, 1851) for the Upper South Creek Advanced Water Recycling Centre.

Prepared for the Sydney Water Corporation

Stephanie A. Clark

April, 2021

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Contents

1. Introduction

1.1 Project context

Sydney Water is planning to build and operate new wastewater infrastructure to service the South West and Western Sydney Aerotropolis Growth Areas known as the Upper South Creek Advanced Water Recycling Centre (USCAWRC) and includes the following components:

- Advanced Water Recycling Centre – a wastewater treatment plant with the capacity to treat up to 50 ML of wastewater per day, with ultimate capacity of up to 100 ML per day,
- Treated water pipelines from the Advanced Water Recycling Centre to the Nepean River at Wallacia Weir, and immediately downstream of the Warragamba Dam, and
- Brine pipeline from the Advanced Water Recycling Centre to Lansdowne, where it connects to Sydney Water's existing Malabar wastewater network.

An expert report may be used as part of the threatened species assessment as outlined in the Biodiversity Assessment Method (BAM) (OEH 2017). The BAM requires surveys for all 'Species Credit Species' (SCS) identified as likely to occur in the study area unless an expert report is prepared, or the species is assumed to be present.

1.2 Purpose of the expert report

Large areas of suitable habitat were unable to be surveyed due to land access issues and the snail is an uncommon species that can easily be misidentified. For these reasons, an expert report on *Meridolum corneovirens* was required to supplement the data collected as part of the survey effort undertaken for the preparation of the projects Biodiversity Development Assessment Report (BDAR) by Biosis.

The purpose of this report is to provide an assessment of the current status and potential presence of *P. duralensis* within the proposed USCAWRC impact assessment area and to determine whether:

- The species is unlikely to be present and thus requires no further assessment; or
- The species is known or likely to be present, and if so the report must provide estimates of potential habitat within the area under consideration.

1.3 The study area

The USCAWRC impact assessment area will traverse western Sydney from near the base of Warragamba Dam in the west to Lansdowne in the east.

The USCAWRC impact assessment area is shown on Figure 1.

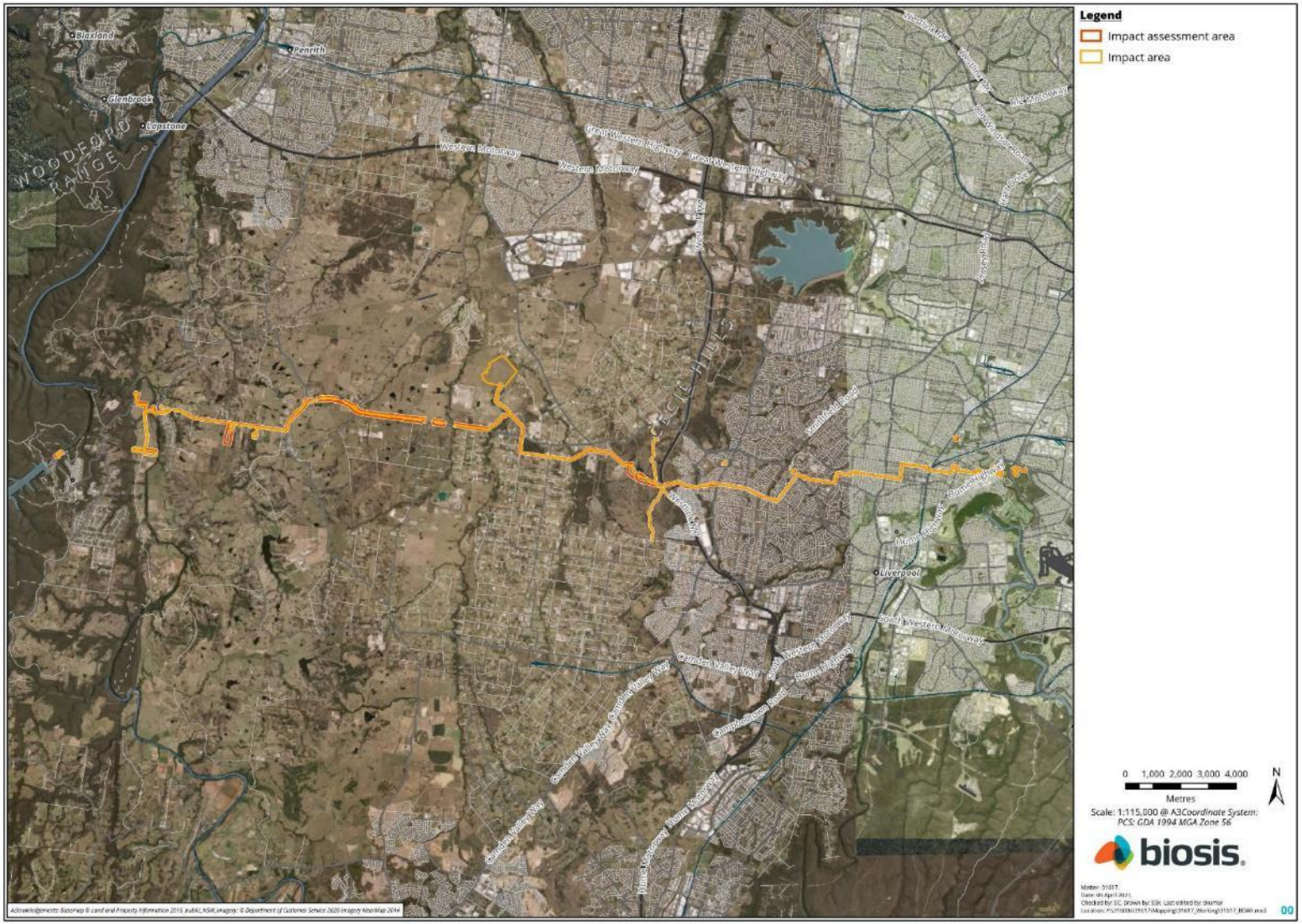

Figure 1. Showing the location of the USCAWRC project.

1.4 Reasons for use of an expert report

An expert report for *M. corneovirens* is required as part of the threatened species assessment for the USCAWRC project for the following reasons:

i. Large areas of habitat were not able to be surveyed. Access was not available for ecologists to enter a number of properties to conduct BAM surveys or targeted fauna surveys. This restricted the opportunity to visit all potential areas of habitat within the proposed development footprint.
ii. Section 6.3 of the BAM (OEH 2017) states targeted survey or an expert report is required to confirm presence/absence of SCS on the subject land. This species has been searched for during the survey by Biosis but is very cryptic. Preparation of an expert report will supplement the field surveys to identify the area of occupancy and likely density of individuals.
iii. The species' relatively small size, its cryptic habitat, its ability to remain dormant in unfavourable environmental conditions and it can be easily overlooked/missed by non-specialists.

1.5 Credentials of expert

Dr Stephanie Clark is an invertebrate taxonomist with more than 32 years of experience in the identification and taxonomy of molluscs (and in particular terrestrial and freshwater gastropods). She currently consults worldwide on invertebrate identification through her business Invertebrate Identification Australasia.

Dr Clark was the first expert to be approved by OEH as an Expert under section 6.5.2.4 of the Biodiversity Assessment Method on the 15 May 2018 (valid for the next six years). A resume is included in the Appendix.

2 Species information

2.1 Species description

The shell is globose to subglobose in shape (Figure 2), up to about 24 mm in height and 29 mm in width. Spire moderately elevated. Aperture roundly ovate, up to about 14 mm in height and 19 mm in width. Total number of whorls 4.8–5.7. Last teleoconch whorl rounded, or with slight angulation; up to about 21 mm in height. Shell sculpture consists of coarse growth lines and weak pustules. Teleoconch periostracal sculpture of weak zigzag ridges. Protoconch sculpture weakly pustulose. Shell uniform brown to tan or olive green, darker coloured individuals not uncommon. Red umbilical patch typically absent, occasionally faintly present. Red subsutural band very thin. Inner lip white (rarely pale pink), strongly reflected, largely occluding umbilical depression in adults, lip thin and not reflected in juveniles. Outer lip moderately deflected below midline of last whorl. Umbilicus closed to slightly open in adults, open in juveniles (modified from Clark, 2009).

The colour of the body of the snail is grey and the mantle is pale yellow (typical) to yellow.

Figure 2. Specimen of *M. corneovirens* from Mulgoa.

2.2 Life cycle

Little is known of the biology, fecundity and longevity for the species. It is a hermaphrodite and capable of selfing, it lays clutches of about 20-25 small, round, white eggs in moist, dark places (Clark, 2009, Ridgeway *et al*., 2014), such as at the base of grass clumps and under logs (Figure 3). The snails probably live between 2-5 years but can certainly estivate in the soil or under logs etc. for several months, especially when conditions are dry, such as those prevailing in Sydney in 2019. They feed predominately on fungi but have been observed eating fresh dead individuals of *M*. *corneovirens* and other carrion, paper, plant detritus and old shells (Clark, personal observations; Ridgeway *et al*., 2014).

The snails are generally active at night or on moist, warm overcast days.

A.  **B.** 

Figure 3. **A.** An individual of *M. corneovirens* laying eggs in a grass clump at Mount Druitt. **B.** Three egg clutches of *M. corneovirens* that were found under a log at Kemps Creek.

2.3 Distribution and abundance

The species is endemic to the Cumberland subregion in the western portion of Sydney, from Pitt Town in the north to Tahmoor in the south and from Georges Hall in the east to Mowbray Park in the west (Clark, 2005; 2009, NSW OEH Cumberland Plain Land Snail – profile). The total number of individuals of *M*. *corneovirens* across its range is unknown, nor

the densities that the species can occur. It can be relatively common when suitable habitat is present. However, most known populations are found on relatively small, isolated patches of habitat that are often surrounded by some combination of industrial, agricultural or urban development.

2.4 Habitat requirements

Meridolum corneovirens is wholly restricted to western Sydney and is primarily associated with the critically endangered Cumberland Plain Woodland ecological community. However, it has also been found in the following listed ecological communities: Moist Shale Woodland, Shale Gravel Transition Forest, Shale Sandstone Transition Forest, Cooks River/Castlereagh Ironbark Forest, Castlereagh Scribbly Gum Woodland, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest. It can be found in leaf litter, grass tussocks, under logs and non-natural debris such as cardboard and old furniture etc. Where conditions permit it will bury into loose soil up to 10 cm such as under logs and around the bases of trees (Clark, 2009; Ridgeway et al., .2014).

3 Description of the study area

3.1 Land use history

From the early 1800s there has been extensive clearing of the native vegetation for agricultural, industrial and urban development, which has resulted in a significant reduction in the extent of the native vegetation, leading to increased fragmentation and isolation of the remaining remnants. This increased fragmentation has led to a loss of biodiversity and to the spread of invasive and non-indigenous species.

The extensive clearing, fragmentation and degradation of the remaining vegetation remnants has led to a reduction in the distribution, extent and abundance of *M. corneovirens* that existed prior to European settlement.

3.2 Landscape context

The majority of the study area consists of gentle undulating hills and valleys and is bounded by the sandstone cliff lined valleys of the Nepean River on the western, southern and south western boundaries and the Georges River on the south eastern boundary and the Cecil Hills Ridge and the Castlereagh sand deposits along the northern and eastern boundaries.

3.3 Native vegetation communities

Meridolum corneovirens inhabits a range of vegetation types across the study area, although most typically it is found in the Cumberland Plain Woodlands.

The species has been recorded from the following plant community types (PCTs) which are found within the USCAWRC impact assessment area:

PCT 724 – Broad-leaved Ironbark – Grey Box – *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain.
725 –Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion.
PCT 835 - Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain.
PCT 849 - Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain.

The species will potentially be found in any remaining intact or relatively intact remnants / patches of suitable habitat, especially if there is a well-developed leaf litter layer, plenty of woody debris on the ground, mixture of native grasses and few exotic/invasive species. It can also be found at the boundaries of plant communities that do provide suitable habitat and those that typically do not such as where Cumberland Plain Woodland adjoins Swamp Oak Floodplain Forest in the western parts of the Cumberland Subregion.

4 Assessment of species presence and habitat

4.1 Existing records and surveys

Meridolum corneovirens has previously been recorded from several locations close to and just within the USCAWRC impact assessment area (Clark, 2009, Bionet, 2020, Clark, personal observations from 1998-2021, Biosis observations 2020-2021) (Figures 4-16).

To the best of the author's knowledge there have been no region-wide surveys for *M. corneovirens* that encompass the entire range of the species since 1999 when the author was asked by NSW National Parks and Wildlife Service (NPWS) to survey 130 sites across the greater Sydney area. During this survey, the species was detected at 61 sites, none of which fall within the USCAWRC impact assessment area.

The majority of the previous records are from targeted surveys for development sites by the author and other consultants, general collecting by the author, colleagues and other random observations by the general public, local and state government personnel.

4.2 Surveys completed for this assessment

A single targeted survey for *M. corneovirens* was completed by the author for this assessment at the publicly accessible Mirambeena Regional Park, Lansdowne. However, no access could be arranged for the author to any other relevant area.

4.3 Assessment of species presence

4.3.1 Likelihood of species presence

There are three records of *M. corneovirens* that fall within the future development footprint of the USCAWRC project (Figures 4-16).

However, there is potential for *M. corneovirens* to be found in areas of suitable habitat within the project's impact area and impact assessment area that have yet to be surveyed,

or that have been surveyed but conditions were not conducive to detecting the species at the time of the survey, especially if there is plenty of leaf litter and woody debris.

4.3.2 Justification for determining presence

The species polygons (Figures 4-16) are based on a combination of the vegetation communities where the species has been found during previous surveys and the assumption that where suitable habitat is present within the study area that the species is likely to be present, but due to a variety reasons (such as access issues and weather conditions) the species has not been detected.

4.4 Assessment of suitable habitat

4.4.1 Suitable habitat within the study area

Suitable habitat was presumed to include all the PCT's mentioned above that had been mapped as either intact or thinned that occur across the USCAWRC corridor.

4.4.2 Species polygons

Figures 4-16 show the species polygons for *M*. *corneovirens* across the USCAWRC impact assessment area.

4.4.3 Estimate of area of habitat

Across the USCAWRC impact assessment area there is a total of 26.67 hectares of potential habitat for *M. corneovirens* (Table 1), of which 8.96 hectares occurs within the impact area and will be removed as part of the future development.

PCT	Impact area	Impact assessment area	Totals
724 intact	**0.40**	**0.29**	**0.69**
724 thinned	**1.14**	**0.63**	**1.77**
725 intact	**0.00**	**0.52**	**0.52**
835 intact	**0.58**	**1.05**	**1.63**
835 thinned	**3.23**	**5.23**	**8.46**
849 intact	**0.93**	**0.95**	**1.88**
849 thinned	**2.68**	**9.04**	**11.72**
Totals	**8.96**	**17.71**	**26.67**

Table 1. Lists the area of each of the different PCTs (in hectares) that provide known or suitable habitat for *M*. *corneovirens* across the USCAWRC study area.

The total area in hectares of each of the different PCTs and condition states listed above in which *M*. *corneovirens* can potentially be found across the USCAWRC study area are listed in Table 1.

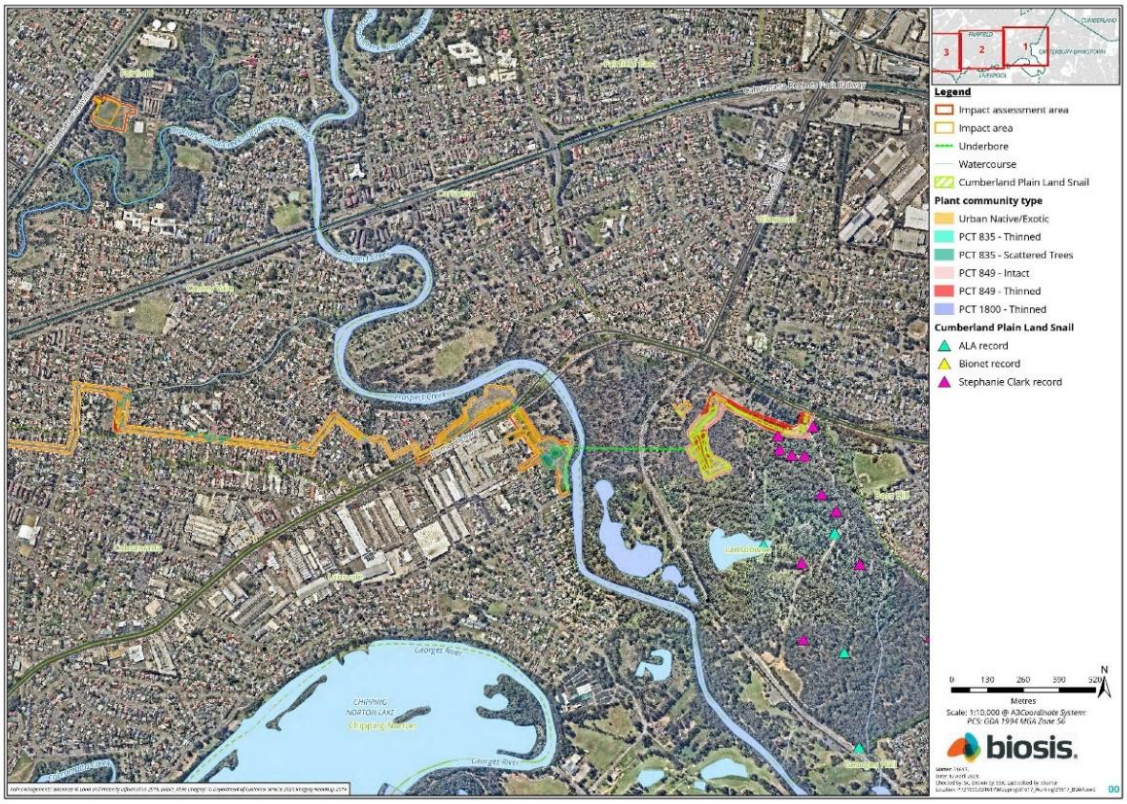

Figure 4. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

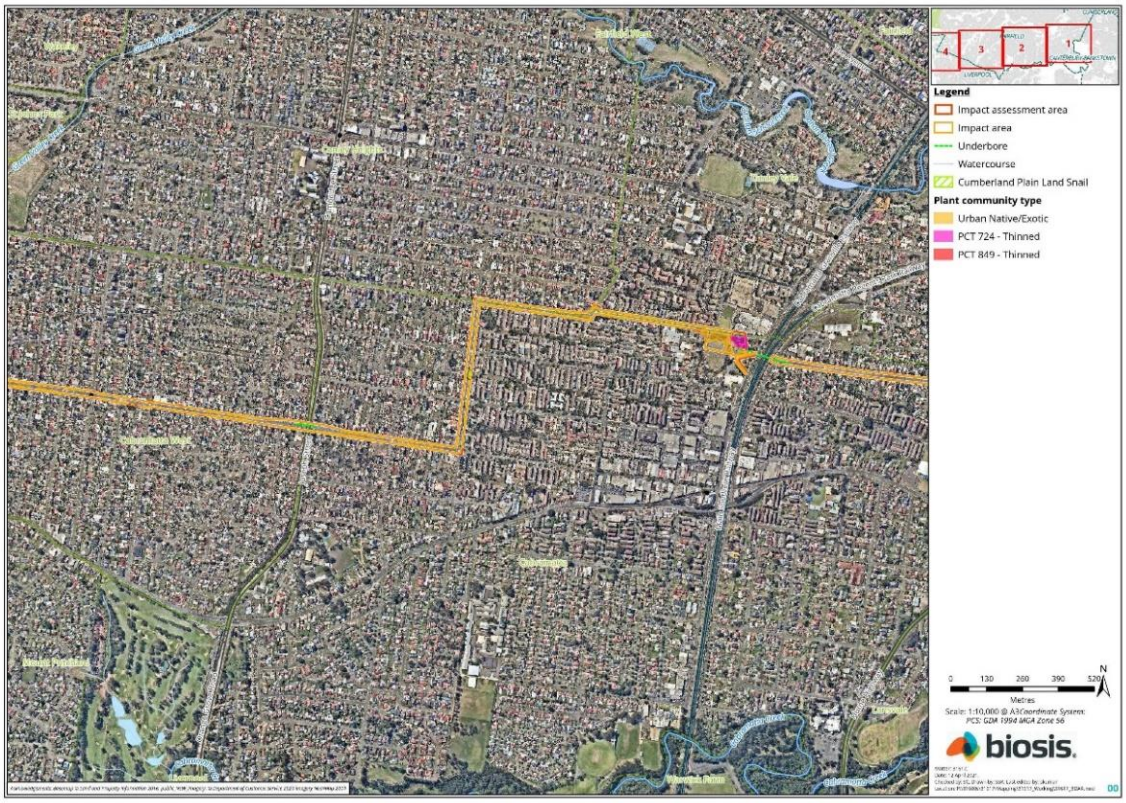

Figure 5. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

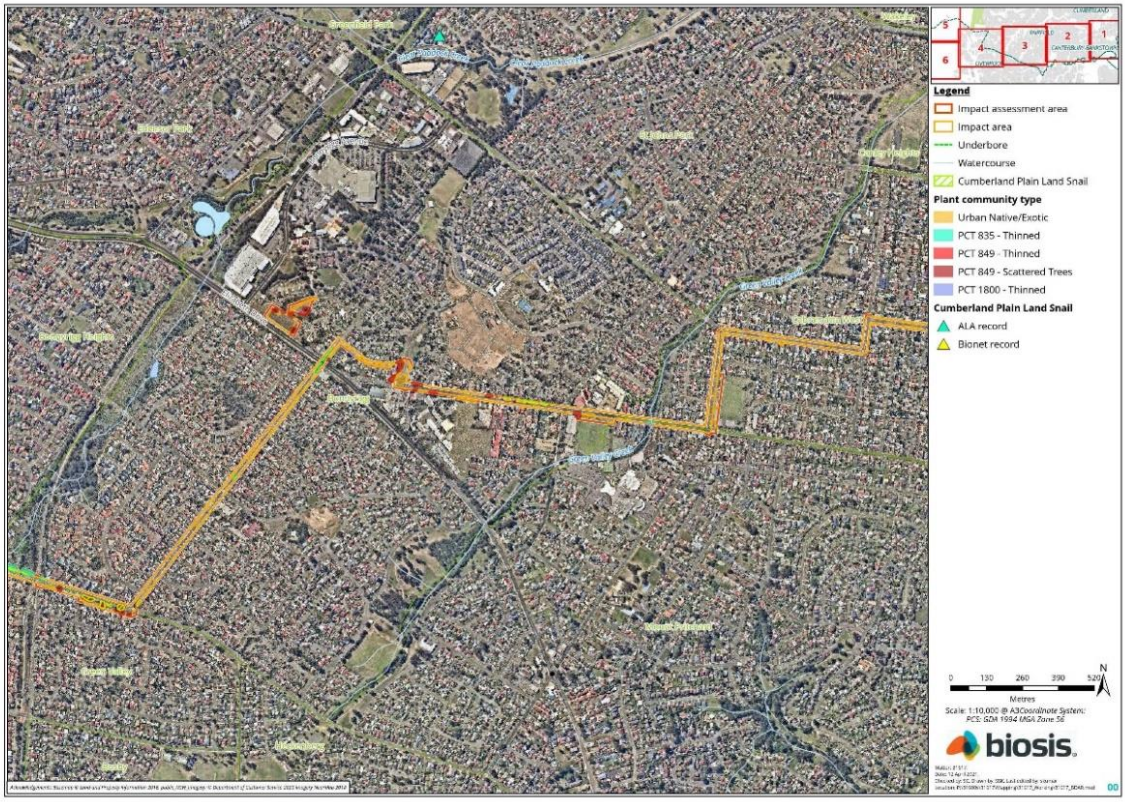

Figure 6. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

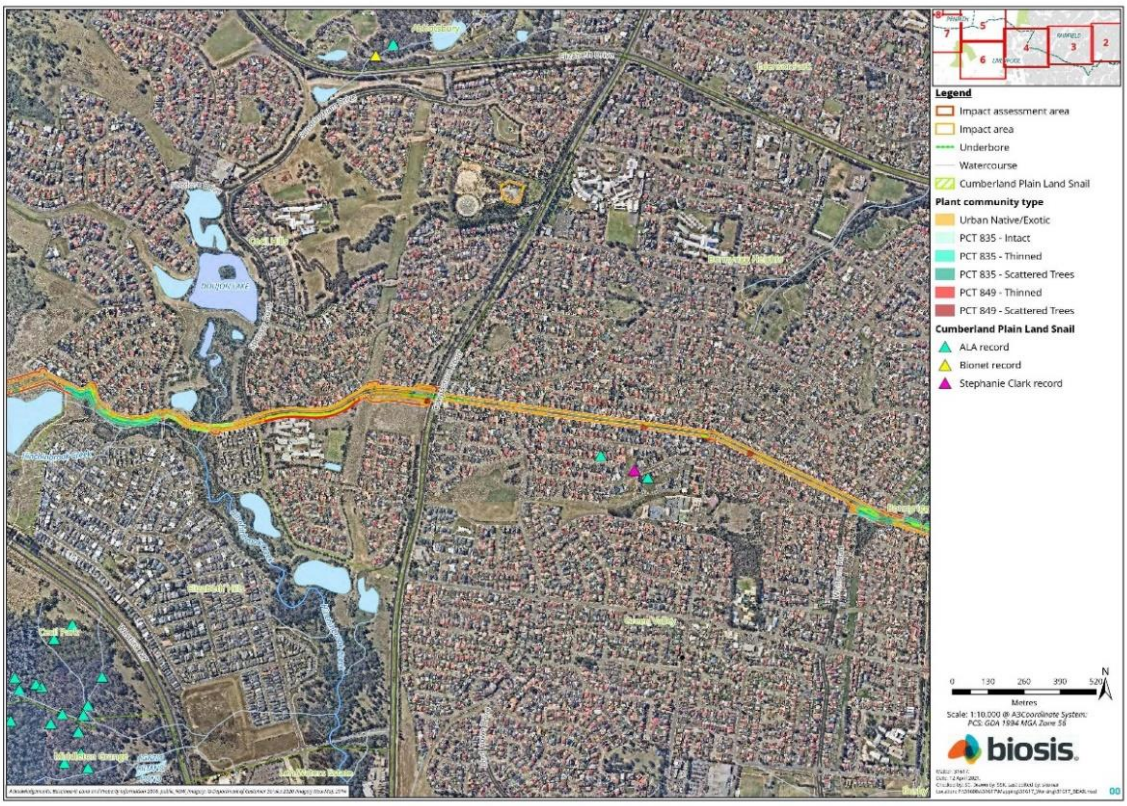

Figure 7. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

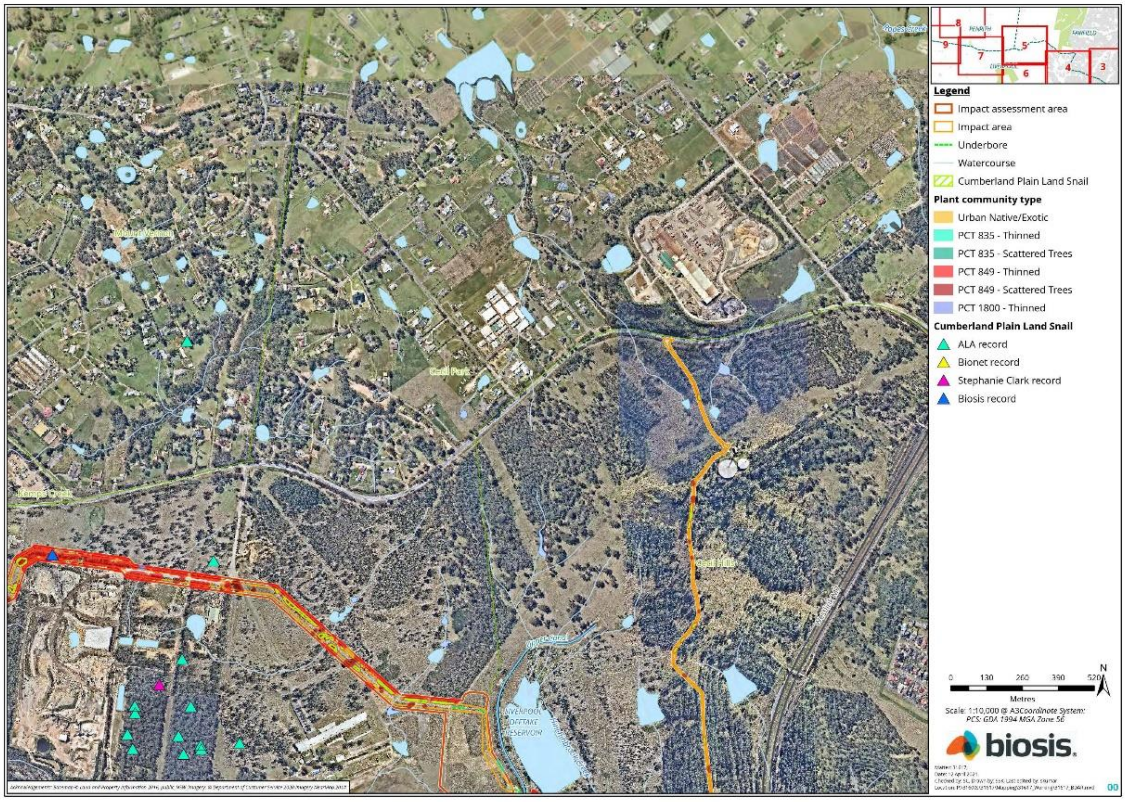

Figure 8. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

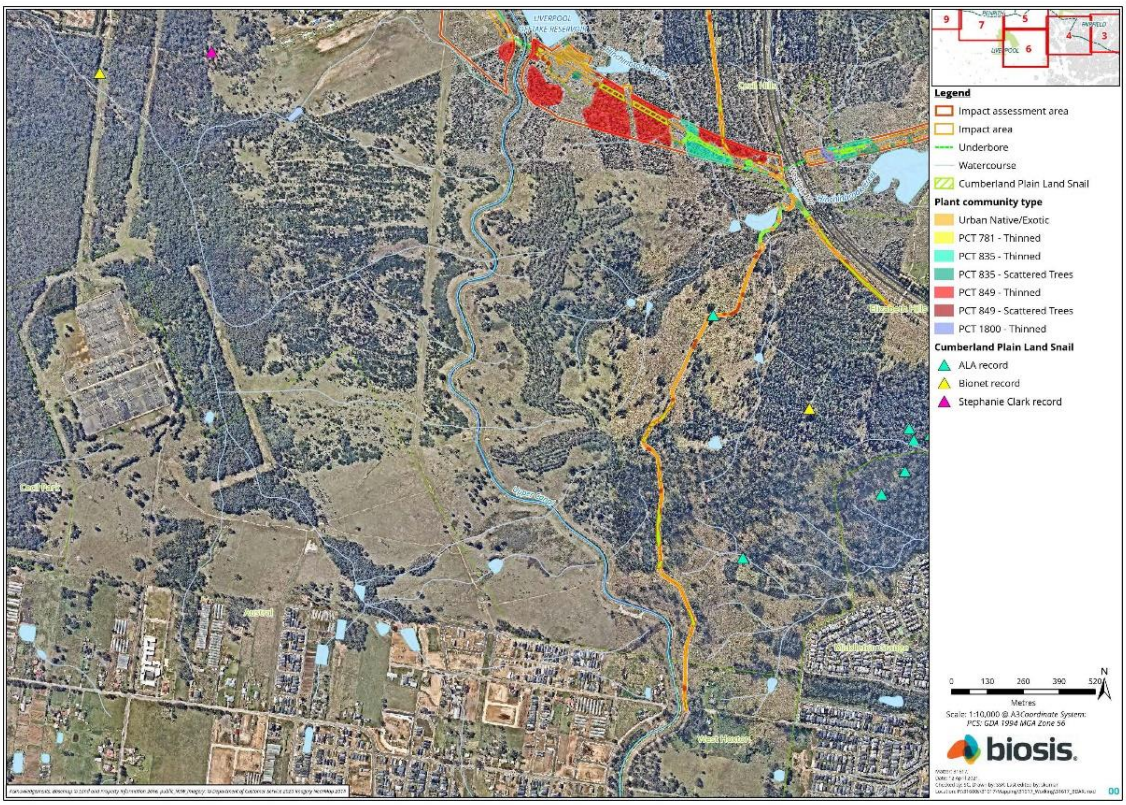

Figure 9. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

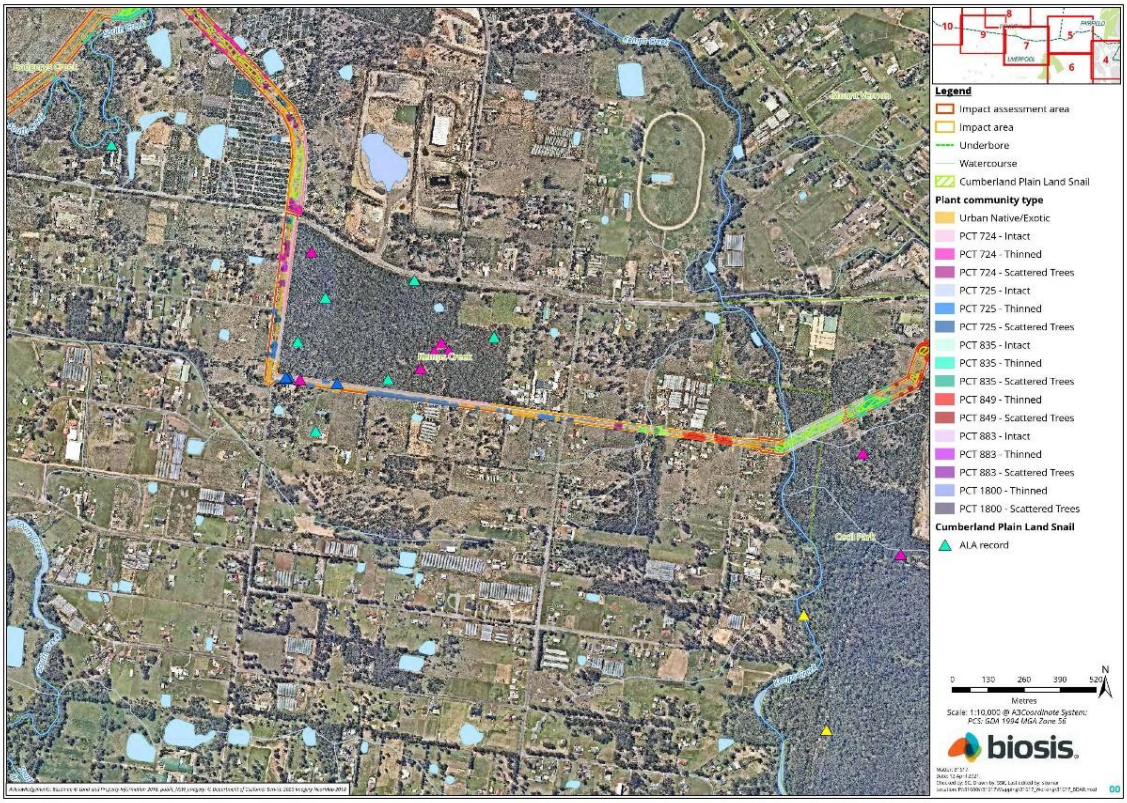

Figure 10. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

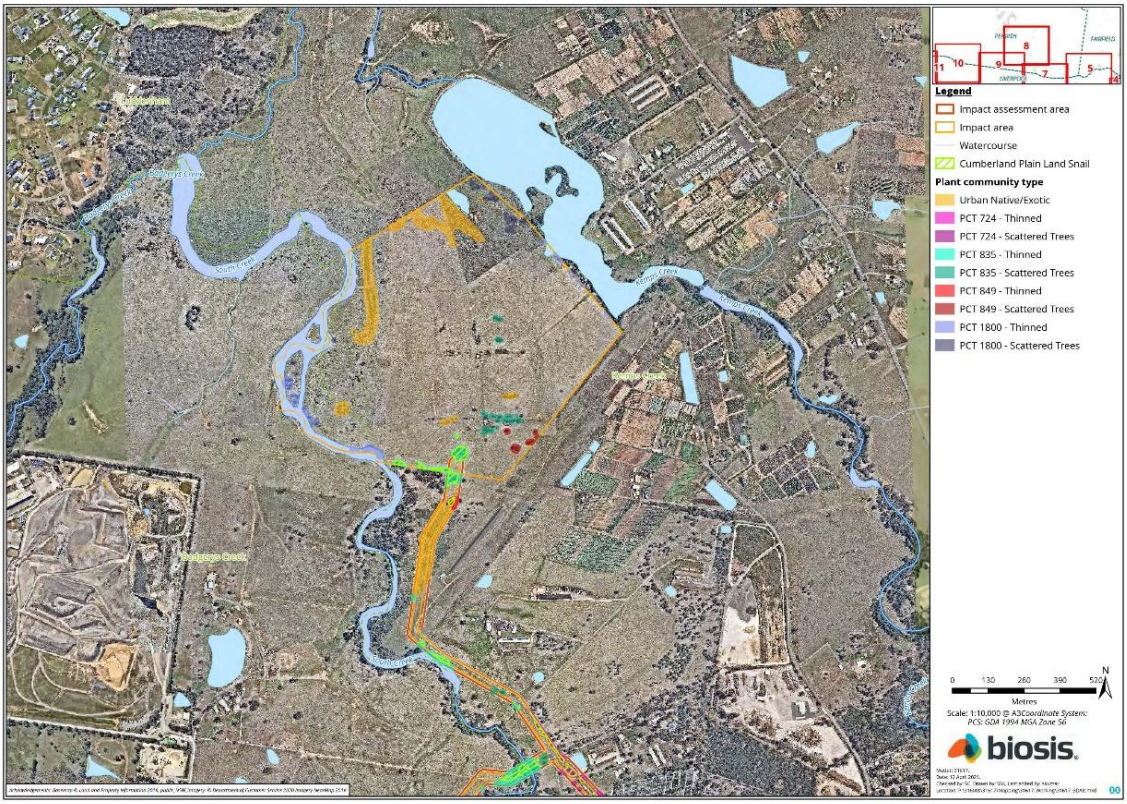

Figure 11. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

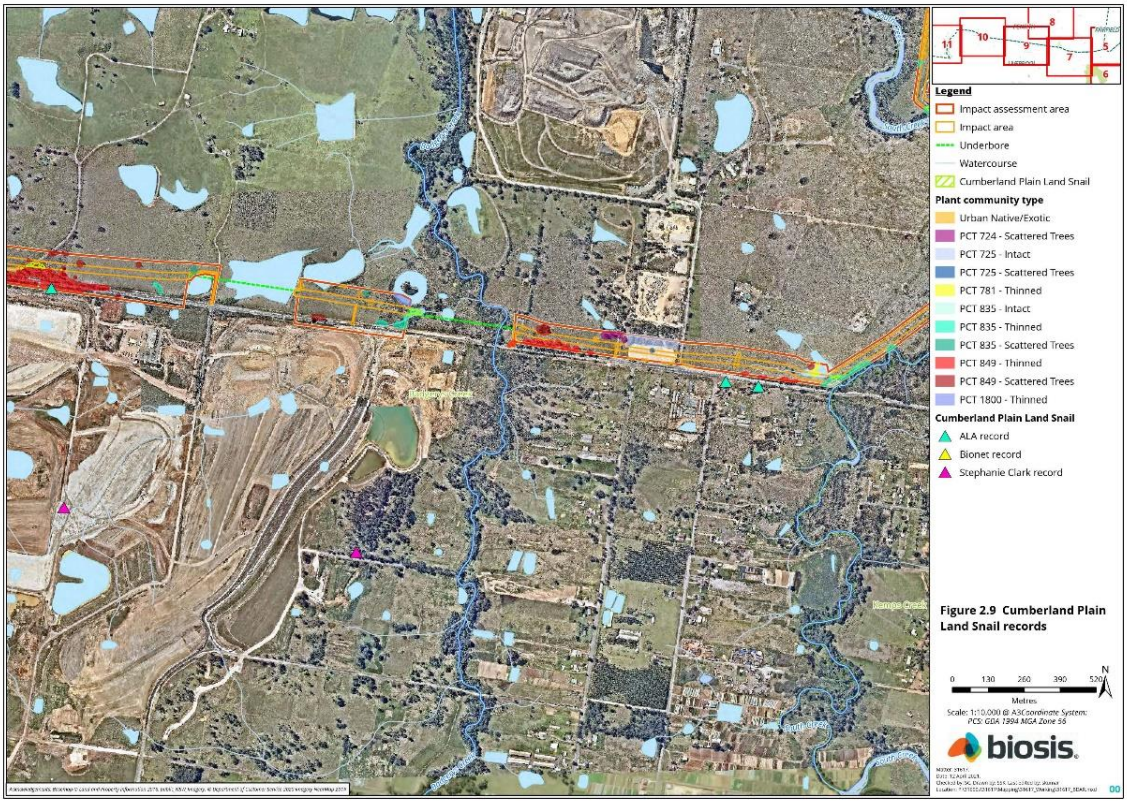

Figure 12. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

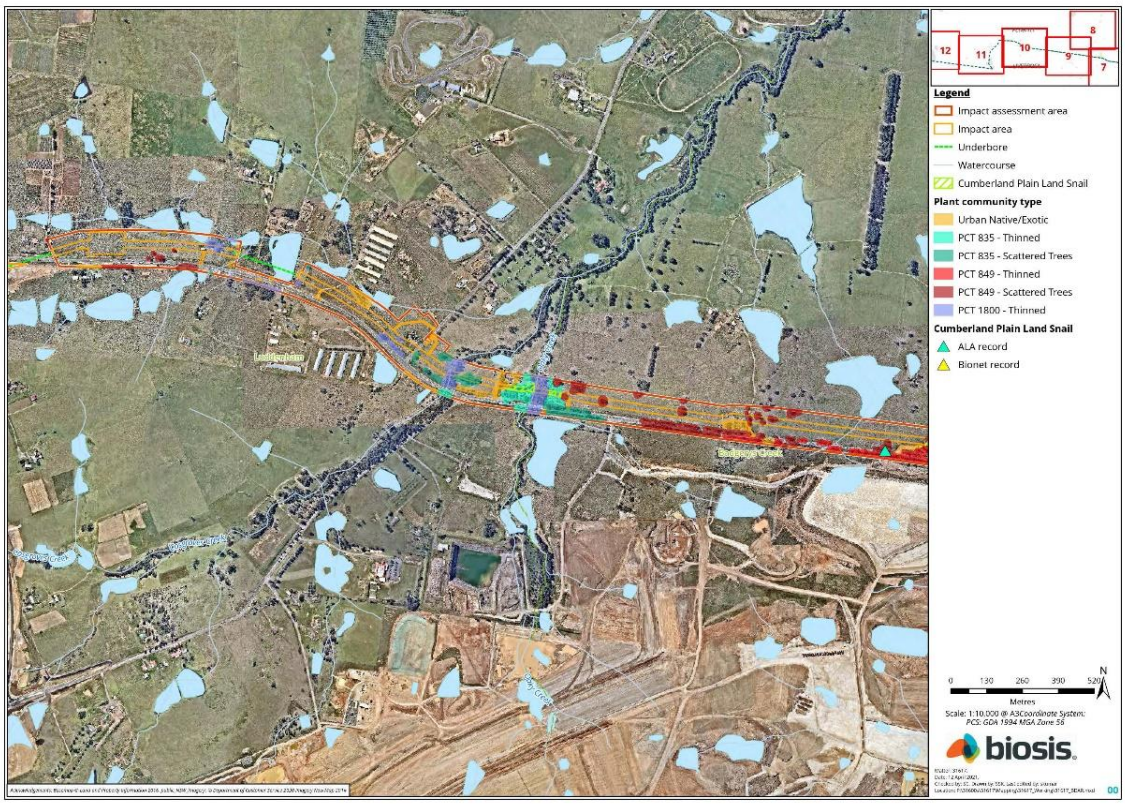

Figure 13. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

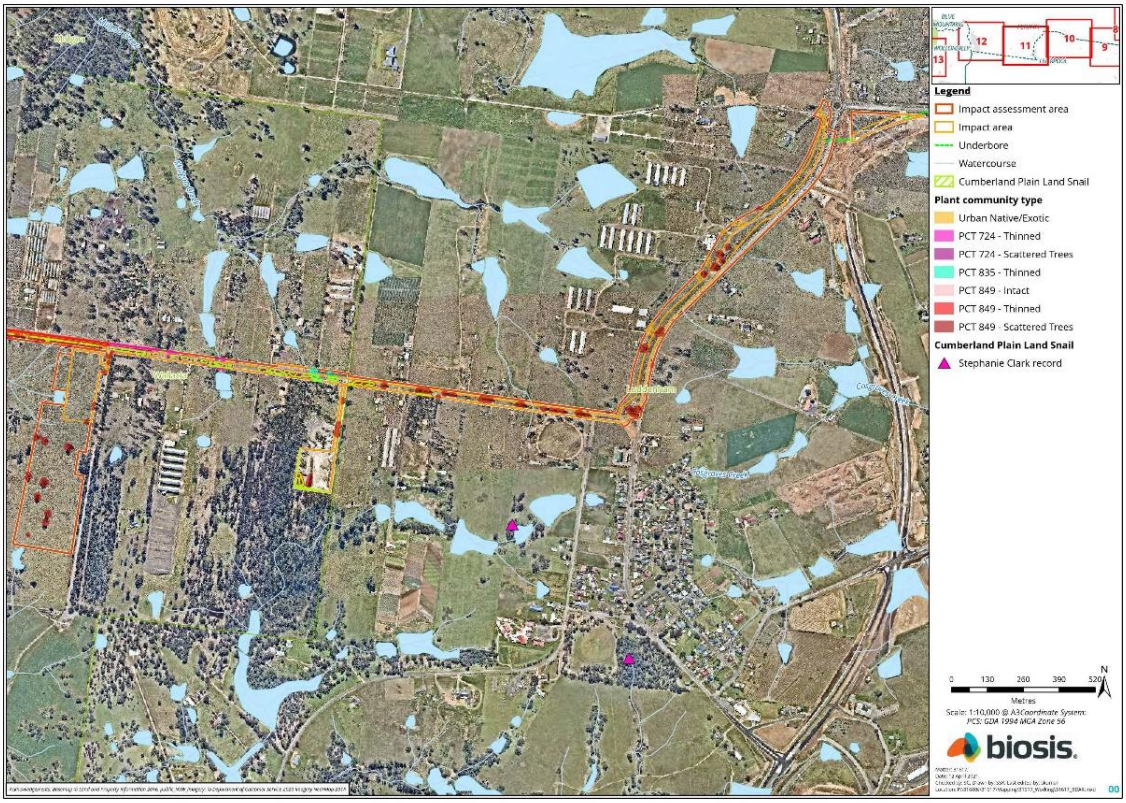

Figure 14. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

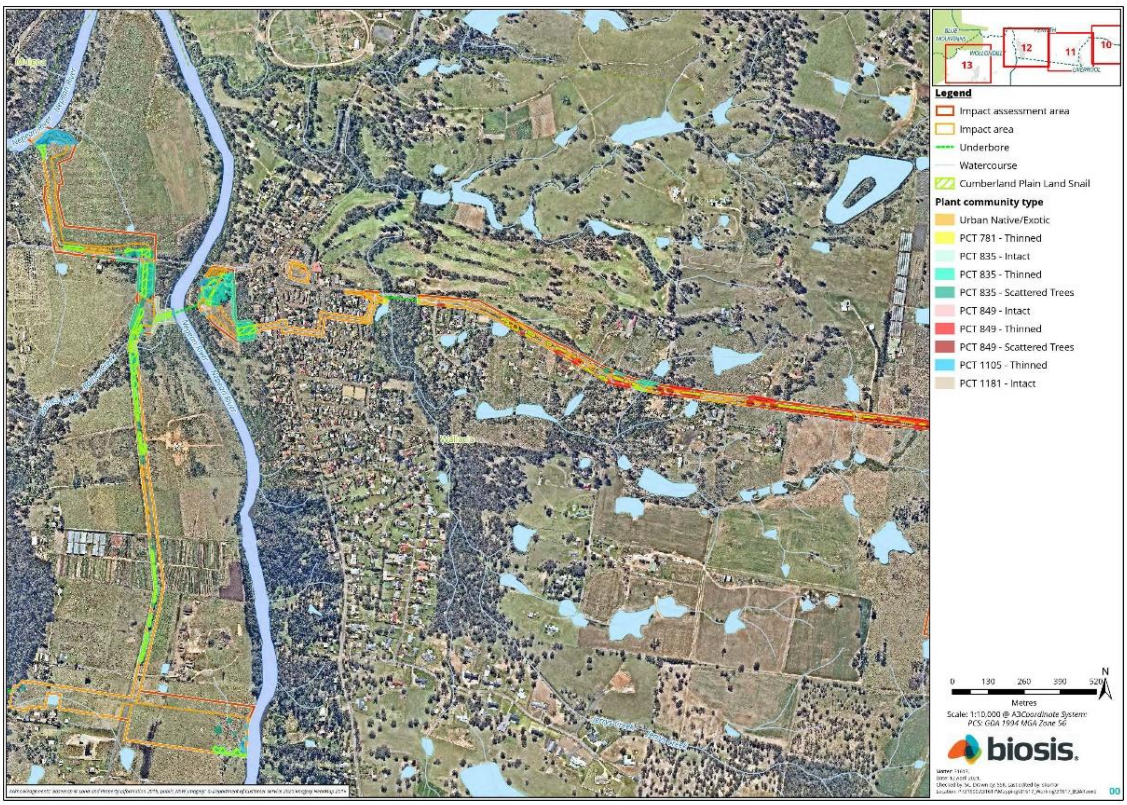

Figure 15. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

Figure 16. Map of the USCAWRC showing records of *M*. *corneovirens* and the species polygons.

5 Information used in this assessment

The information used to make the above assessment is drawn from the literature (Clark, 2005, 2009; Cumberland Plain Land Snail – profile) and the authors' personal observations and knowledge of the species built up over the past 32 years. The author also prepared the original Cumberland Plain Large Land Snail as it was then called, threatened species information and environmental impact assessment guidelines information sheets in 1999.

Additional records were obtained by searching the BioNet and ALA (Australian Living Atlas) databases and Biosis provided its records.

Vegetation mapping for the corridors was provided by Biosis.

GIS analysis of the PCT's and preparation of the species polygons following the authors' requirements were provided by Biosis.

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7 Appendix: Curriculum Vitae of Stephanie Clark

PERSONAL

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EDUCATION

Ph.D., 2005. University of Western Sydney, New South Wales, Australia. Taxonomy and conservation.
M.Sc., 1998. Macquarie University, New South Wales, Australia. Taxonomy and genetics.
B.App.Sc., 1990. University of Technology, Sydney, New South Wales, Australia. Major biochemistry.

ACCREDITATIONS ETC

I am listed as a Biodiversity Expert under Section 6.5.2.4 of the BAM, under the Biodiversity Conservation Act, 2017 for the snails *Meridolum corneovirens* and *Pommerhelix duralensis* as 16 May 2018.

PROFESSIONAL EXPERIENCE

Current and/or completed:

1997 - present. Consultant work (Invertebrate Identification Australasia - Owner) for various Australian and United States councils, government agencies (State, Commonwealth and Federal), environmental consultancies, mining companies and developers on short and medium term projects dealing mostly with molluscs and insects (particularly endangered species surveys, monitoring and management plan preparation).

June 2019 - July 2019. Identified over 630 lots of Arizonian land and freshwater molluscs for the Field Museum of Natural History, Chicago, IL.

Oct 2017 - Completed Biodiversity Assessment Method (BAM) course.

Aug 2017 - Sept 2017. Conduct one day snail identification workshops for the Department of Agriculture & Water Resources, biosecurity biomonitoring sections in Sydney, Melbourne and Perth.

Sept 2016 - Mar 2017. Identified almost 4000 lots of North American land and freshwater molluscs for the Field Museum of Natural History, Chicago, IL.

Feb 2015 - Mar 2016. Prepared a list of all the names and synonyms applied to the non-marine molluscs of North America, for the Field Museum of Natural History, Chicago, IL.

Oct 2014 - Feb 2016. Prepare a status report for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) on the Shortface Lanx (*Fisherola nuttallii*) in Canada.

Jan 2013. Conducted a one day workshop on the identification of the endangered Cumberland Land Snail (*Meridolum corneovirens*) for the Ecological Consultants Association of NSW, Mount Annan, NSW, Australia.

PROFESSIONAL SOCIETIES

American Malacological Society
Conchological Society of Great Britain & Ireland
The Ecological Consultants Association of New South Wales
Malacological Society of London
Malacological Society of Australasia

Member of the IUCN SSC Mollusc Specialist Group.

RESEARCH INTERESTS

Systematics, population and conservation genetics of invertebrates, particularly terrestrial and freshwater molluscs.

EXPERIENCE

I have over 34 years' experience in the collection, identification and taxonomy of marine, estuarine, freshwater and terrestrial molluscs in 30 countries and 40 US states. I extensive experience collecting molluscs in the estuarine areas of particularly eastern Australia from Queensland to Victoria and am a co-author on a CD-ROM identification guide to the estuarine and freshwater molluscs of New South Wales released in 2000. I have dissected individuals from several hundred populations of freshwater and terrestrial molluscs.

LEGAL EXPERIENCE

I have served as an expert witness for the Land and Environment Court of New South Wales on six occasions since 1997 and have provided expert testimony for several other cases.

PROFESSIONAL ACTIVITIES

Research Associate at the Australian Museum, Sydney, NSW, July, 2017 to present.

Research Associate at the Field Museum of Natural History, Chicago, Illinois, June, 2010 to present.

Invited participant at the IUCN Red List workshop assessing the Red List status of the world's freshwater molluscs, organised jointly by the Zoological Society of London, the Encyclopedia of Life (EOL), International Union for Conservation of Nature (IUCN), and the IUCN SSC Mollusc Specialist Group. Held in London, United Kingdom, February, 2010.

Served on the Status Review Panel for the federally endangered Idaho Springsnail (*Pyrgulopsis robusta*), in Boise, Idaho, for the United States Fish and Wildlife Service, Western Region, October, 2005.

TELEVISION

Short interview about my PhD project on the endangered endemic Sydney land snail *Meridolum corneovirens*, aired on 'Totally Wild' (a children's educational program on wildlife and the environment), Australia wide, 7 May 2002.

Short interview regarding the endangered endemic Sydney land snail *Meridolum corneovirens* and how the Olympic Coordinating Authority (OCA) has helped in its conservation, aired on 'A Current Affairs' (a prime time news and current affairs program) Australia wide on the 15 September, 1998.

RADIO

Short interview with Brian Bury, 4BC, Brisbane, about Australian native snail diversity aired Nov. 2002.

NEWSPAPER/INTERNET

Several interviews about molluscs, endangered species and rediscovering a species previously thought to be extinct, with national, local and internet media outlets, both in Australia and the United States since 2002.

Some recent examples:
ABC News: When Birds Overshadow Snails -- And Why That's a Problem
http://abcnews.go.com/Technology/story?id=734467&page=1

http://www.cofc.edu/~fwgna/archive/9May05.html

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Gerber, J. and Clark, S.A. 2015. First record of the predatory land snail *Streptostele* (*Tomostele*) *musaecola* (Pulmonata: Streptaxidae) in the continental United States. *American Conchologist* **43(4)**:26-28.

Hauk, A., Clark, S.A., McCravy, K.W., Jenkins, S.E. and Lydeard, C. 2015. A Survey of Terrestrial Gastropods of the Alice L. Kibbe Life Science Station in West-Central Illinois. *Northeastern Naturalist* **22(2)**:299-306.

Bieler, R., Mikkelsen, P.M., Timothy M. Collins, T.M., Glover, E.A., González, V.L., Daniel L. Graf, D.L., Harper, E.M., John Healy, J., Kawauchi, G.Y., Sharma, P.P., Staubach, S., Strong, E.E., Taylor, J.D., Tëmkin, I., Zardus, J.D., Clark, S., Guzmán, A., McIntyre, E., Sharp, P. and Giribet, G. 2014. Investigating the Bivalve Tree of Life – an exemplar-based approach combining molecular and novel morphological characters. *Invertebrate Systematics* **28(1)**:32-115.

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INVERTEBRATE IDENTIFICATION AUSTRALASIA
• Identifications • Surveys • Environmental Interpretations

ABN 23634681309

Expert report on the Dural Land Snail, *Pommerhelix duralensis* (Cox, 1868) for the Upper South Creek Advanced Water Recycling Centre.

Prepared for the Sydney Water Corporation

Stephanie A. Clark

April, 2021

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Contents

1. Introduction

1.1 Project context

Sydney Water is planning to build and operate new wastewater infrastructure to service the South West and Western Sydney Aerotropolis Growth Areas known as the Upper South Creek Advanced Water Recycling Centre (USCAWRC) and includes the following components:

- Advanced Water Recycling Centre – a wastewater treatment plant with the capacity to treat up to 50 ML of wastewater per day, with ultimate capacity of up to 100 ML per day.
- Treated water pipelines from the Advanced Water Recycling Centre to the Nepean River at Wallacia Weir and immediately downstream of the Warragamba Dam.
- Brine pipeline from the Advanced Water Recycling Centre to Lansdowne, where it connects to Sydney Water's existing Malabar wastewater network.

An expert report may be used as part of the threatened species assessment as outlined in the Biodiversity Assessment Method (BAM) (OEH 2017). The BAM requires surveys for all 'Species Credit Species' (SCS) identified as likely to occur in the study area unless an expert report is prepared, or the species is assumed to be present.

1.2 Purpose of the expert report

Large areas of suitable habitat were unable to be surveyed due to land access issues and the snail is an uncommon species that can easily be misidentified. For these reasons, an expert report on *Pommerhelix duralensis* was required to supplement the data collected as part of the survey effort undertaken for the preparation of the projects Biodiversity Development Assessment Report (BDAR) by Biosis.

The purpose of this report is to provide an assessment of the current status and potential presence of *P. duralensis* within the proposed USCAWRC impact assessment area and to determine whether:

- The species is unlikely to be present and thus requires no further assessment; or
- The species is known or likely to be present, and if so the report must provide estimates of potential habitat within the area under consideration.

1.3 The study area

The USCAWRC impact assessment area will traverse western Sydney from near the base of Warragamba Dam in the west to Lansdowne in the east.

The USCAWRC impact assessment area is shown on Figure 1.

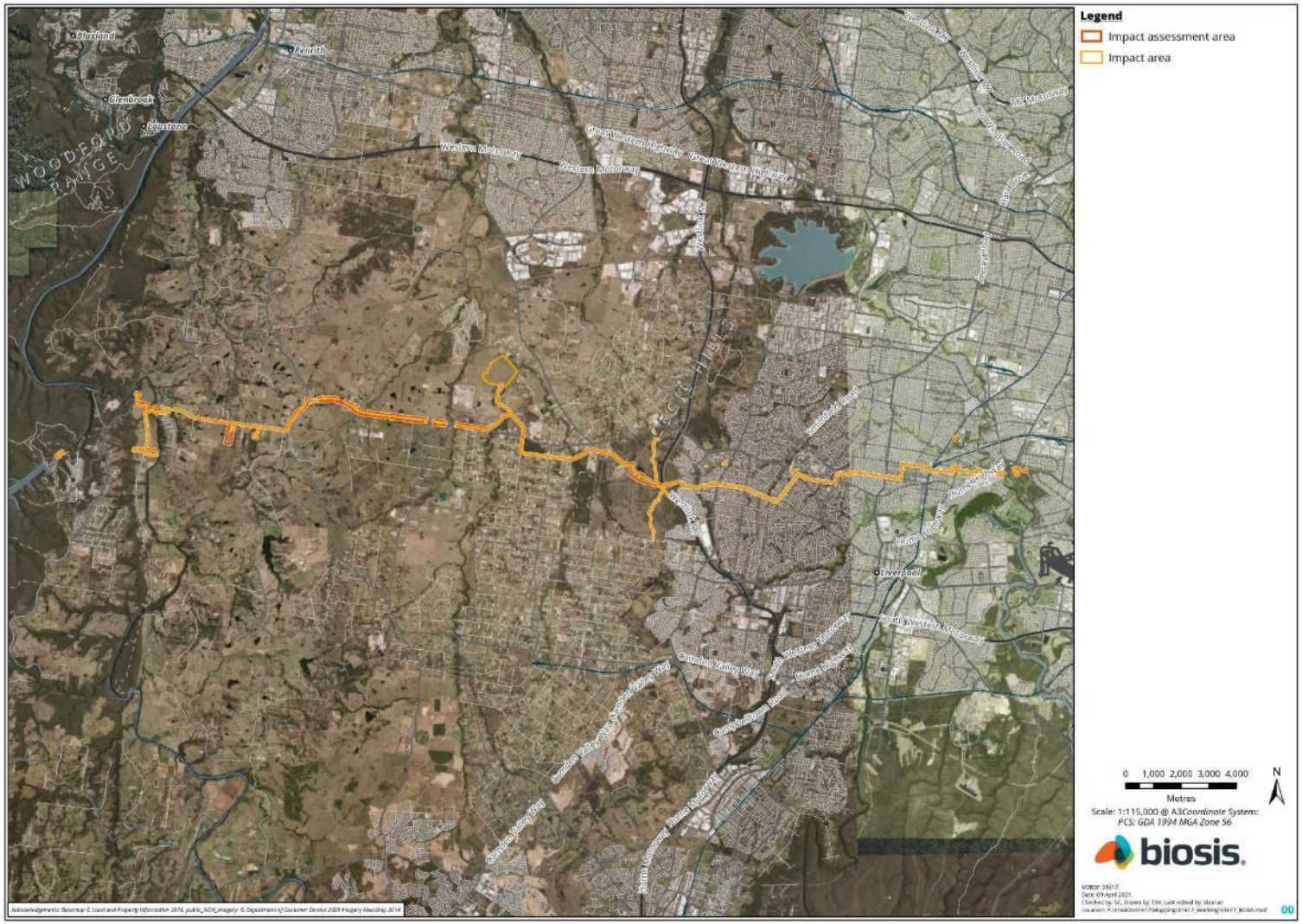

Figure 1. Showing the location of the USCAWRC project.

1.4 Reasons for use of an expert report

An expert report for *P. duralensis* is required as part of the threatened species assessment for the USCAWRC Corridor for the following reasons:

i. Large areas of habitat were not able to be surveyed. Access was not available for ecologists to enter a number of properties to conduct BAM surveys or targeted fauna surveys. This restricted the opportunity to visit all potential areas of habitat within the proposed development footprint.
ii. Section 6.3 of the BAM (OEH 2017) states targeted survey or an expert report is required to confirm presence/absence of SCS on the subject land. This species has been searched for during the survey by Biosis but is very cryptic. Preparation of an expert report will supplement the field surveys to identify the area of occupancy and likely density of individuals.
iii. The species' relatively small size, its cryptic habitat, its ability to remain dormant in unfavourable environmental conditions and it can be easily overlooked/missed by non-specialists.

1.5 Credentials of expert

Dr Stephanie Clark is an invertebrate taxonomist with more than 32 years of experience in the identification and taxonomy of molluscs (in particular terrestrial and freshwater gastropods). She currently consults worldwide on invertebrate identification through her business Invertebrate Identification Australasia.

Dr Clark was the first expert to be approved by OEH as an Expert under section 6.5.2.4 of the Biodiversity Assessment Method on the 15 May 2018 (valid for the next six years). A resume is included in the Appendix.

2 Species information

2.1 Species description

The shell is subglobose in shape (Figure 2), up to about 23 mm in height and 24 mm in width. Spire moderately elevated. Aperture roundly ovate, up to 12 mm in height and 16 mm in width. Total number of whorls 4.5–5.8. Last teleoconch whorl rounded with weak to strong angulation (typical); up to about 14 mm in height. Shell sculpture consists of moderate to prominent growth lines. Teleoconch periostracal sculpture of strong zigzag ridges with smaller ridges between major ridges. Protoconch sculpture pustulose. Shell uniformly dark brown to black, lighter coloured individuals not uncommon. Red umbilical patch faint to absent. Red subsutural or supraperipheral bands absent. Inner lip pale pink to pale mauve, strongly reflected, partially or entirely obscuring the umbilical depression in adults, lip thin and not reflected in juveniles. Outer lip slightly deflected below midline of last whorl. Umbilicus narrowly open to closed in adults, open in juveniles (modified from Clark, 2009).

The colour of the body of the snail is grey and the mantle is dark yellow.

Figure 2. The original specimen of *P. duralensis* from Dural (20 mm in diameter).

2.2 Life cycle

Little is known of the biology, fecundity and longevity for the species. It is a hermaphrodite and capable of selfing, it lays clutches of about 20-25 small, round, white eggs (Clark, 2009, Ridgeway *et al*., 2014) in moist, dark places such as at the base of grass clumps and under logs and are virtually identically to those of *Meridolum corneovirens* (Figure 3A). The snails probably live between 2-5 years but can certainly estivate in the soil or under logs etc. for several months, especially when conditions are dry, such as those prevailing in Sydney in 2019. They feed predominately on fungi (Figure 3B) but have been observed eating fresh dead individuals of *P. duralensis* and other carrion, paper, plant detritus and old shells (Clark, personal observations; Ridgeway *et al*., 2014).

The snails are generally active at night or on moist, warm overcast days.

A.  **B.** 

Figure 3. **A.** An individual of *Meridolum corneovirens* laying eggs in a grass clump at Mount Druitt. **B**. An individual of *P. duralensis* feeding on fungus at Hunts Creek Reserve, Carlingford, Sydney.

2.3 Distribution and abundance

The species is endemic to the Cumberland subregion in the north western portion of Sydney, from Wisemans Ferry in the north to Parramatta in the south and from Epping in the east to about Kurrajong (Clark, 2005; 2009, NSW OEH Dural Land Snail – profile). The total number

of individuals of *P. duralensis* across its range is unknown, nor the densities that the species can occur. The species can be relatively common when suitable habitat is present. However, most known populations are found on relatively small, isolated patches of habitat that are often surrounded by some combination of industrial, agricultural or urban development.

2.4 Habitat requirements

Pommerhelix duralensis is restricted to northern half of Sydney and is primarily associated with Hawkesbury Sandstone Vegetation, Shale Sandstone Transition Forest and Sydney Turpentine-Ironbark Forest. However, it has also been found in the following listed ecological communities: Shale Sandstone Transition Forest, Sydney Turpentine-Ironbark Forest, Shale Gravel Transition Forest, Castlereagh Scribbly Gum Woodland, Blue Gum High Forest and Agnes Banks Woodland. It can be found in leaf litter, grass tussocks, under logs and non-natural debris such as cardboard and old furniture and so on (Clark, 2009; Ridgeway et al., 2014).

3 Description of the study area

3.1 Land use history

From the early 1800s there has been extensive clearing of the native vegetation for agricultural, industrial and urban development, which has resulted in a significant reduction in the extent of the native vegetation, leading to increased fragmentation and isolation of the remaining remnants. This increased fragmentation has led to a loss of biodiversity and to the spread of invasive and non-indigenous species.

The extensive clearing, fragmentation and degradation of the remaining vegetation remnants has led to a reduction in the distribution, extent and abundance of *P. duralensis* that existed prior to European settlement.

3.2 Landscape context

The majority of the study area consists of gentle undulating hills and valleys and is bounded by the sandstone cliff lined valleys of the Nepean River on the western, southern and south western boundaries and the Georges River on the south eastern boundary and the Cecil Hills Ridge and the Castlereagh sand deposits along the northern and eastern boundaries.

3.3 Native vegetation communities

Pommerhelix duralensis inhabits a range of vegetation types across the study area, although most typically it is found in the Sandstone Forest.

It has been recorded from the following plant community types (PCTs) which are found within the USCAWRC impact assessment area:
PCT 1083 - Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion.

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

The species will potentially be found in any remaining intact or relatively intact remnants / patches of suitable habitat, especially if there is a well-developed leaf litter layer, plenty of woody debris on the ground, mixture of native grasses and few exotic/invasive species. It can also be found at the boundaries of plant communities that do provide suitable habitat and those that typically do not, such as where Shale Sandstone Transition Forest adjoins Cumberland Plain Woodland.

4 Assessment of species presence and habitat

4.1 Existing records and surveys

Pommerhelix duralensis has previously been recorded from several locations across the Sydney Basin but to date has not been recorded from within the USCAWRC impact assessment area (Clark, 2009; Bionet, 2020; ALA, 2020; Clark, personal observations from 1998-2019, Biosis observations 2020-2021) (Figures 4-9).

To the best of the author's knowledge there have been no region-wide surveys for *P. duralensis* that encompass the entire range of the species.

4.2 Surveys completed for this assessment

No surveys have been completed as part of this assessment by the author as no access could be arranged for the author to areas of potential habitat.

4.3 Assessment of species presence

4.3.1 Likelihood of species presence

There are no records of *P. duralensis* that fall within the future development footprint of the USCAWRC impact assessment area (Figures 4-9).

However, there is potential for *P. duralensis* to be found in areas of suitable habitat within the project's impact area and impact assessment area that have yet to be surveyed, or that have been surveyed but conditions were not conducive to detecting the species at the time of the survey, especially if there is plenty of leaf litter, woody debris and mixture of native grasses.

4.3.2 Justification for determining presence

The species polygons (Figures 4-9) are based on a combination of the vegetation communities where the species has been found during previous surveys and the assumption that where suitable habitat is present within the study area that the species is likely to be present, but due to a variety reasons (such as access issues and weather conditions) the species has not been detected.

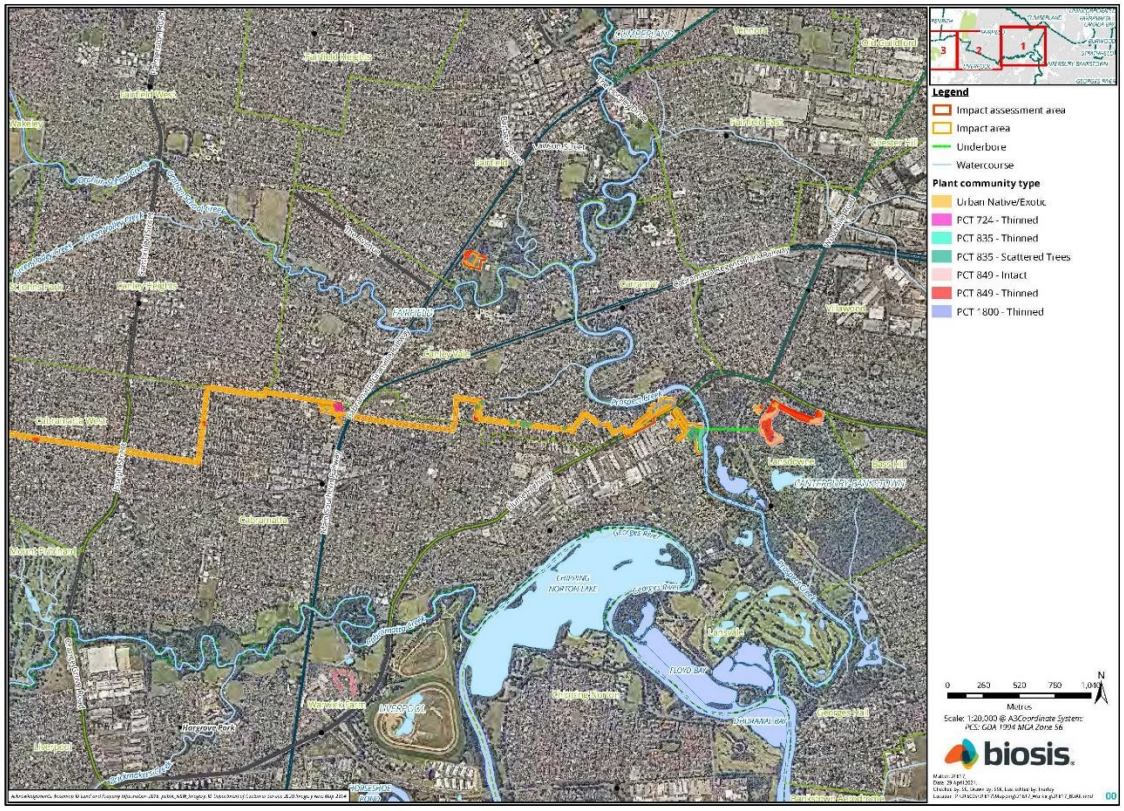

Figure 4. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

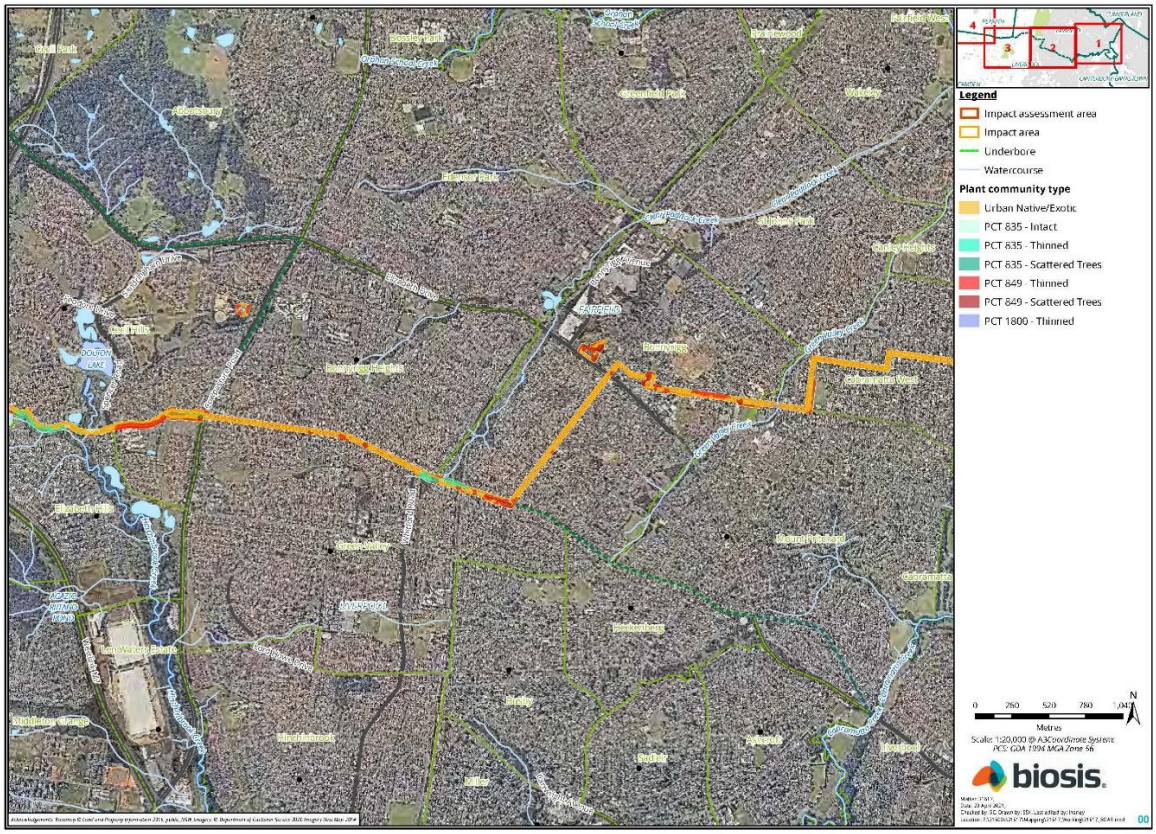

Figure 5. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

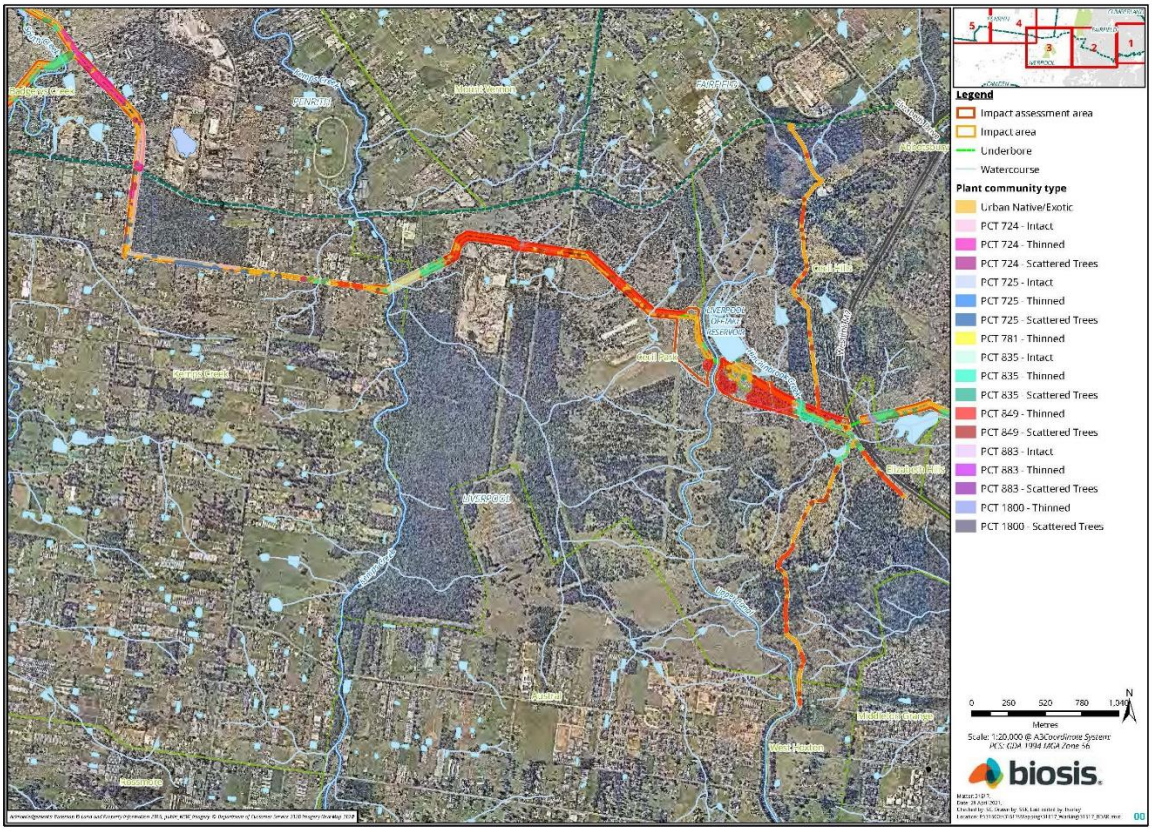

Figure 6. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

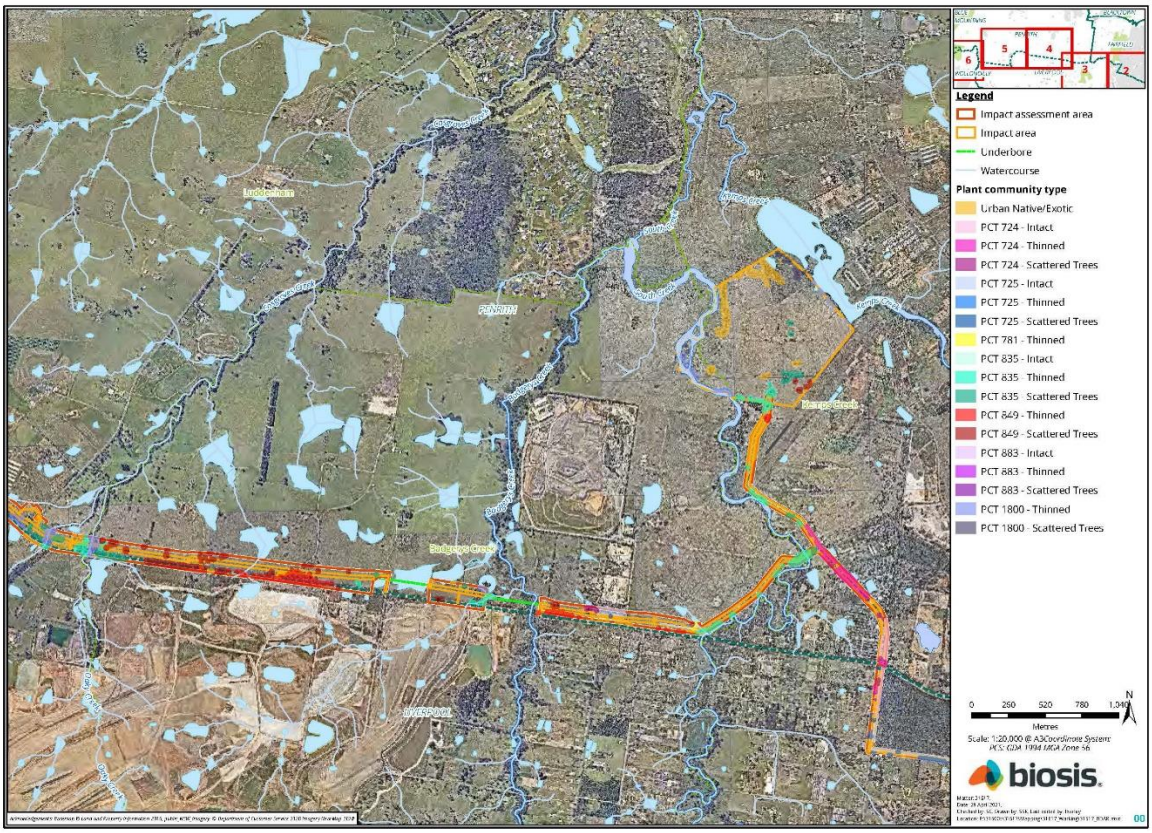

Figure 7. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

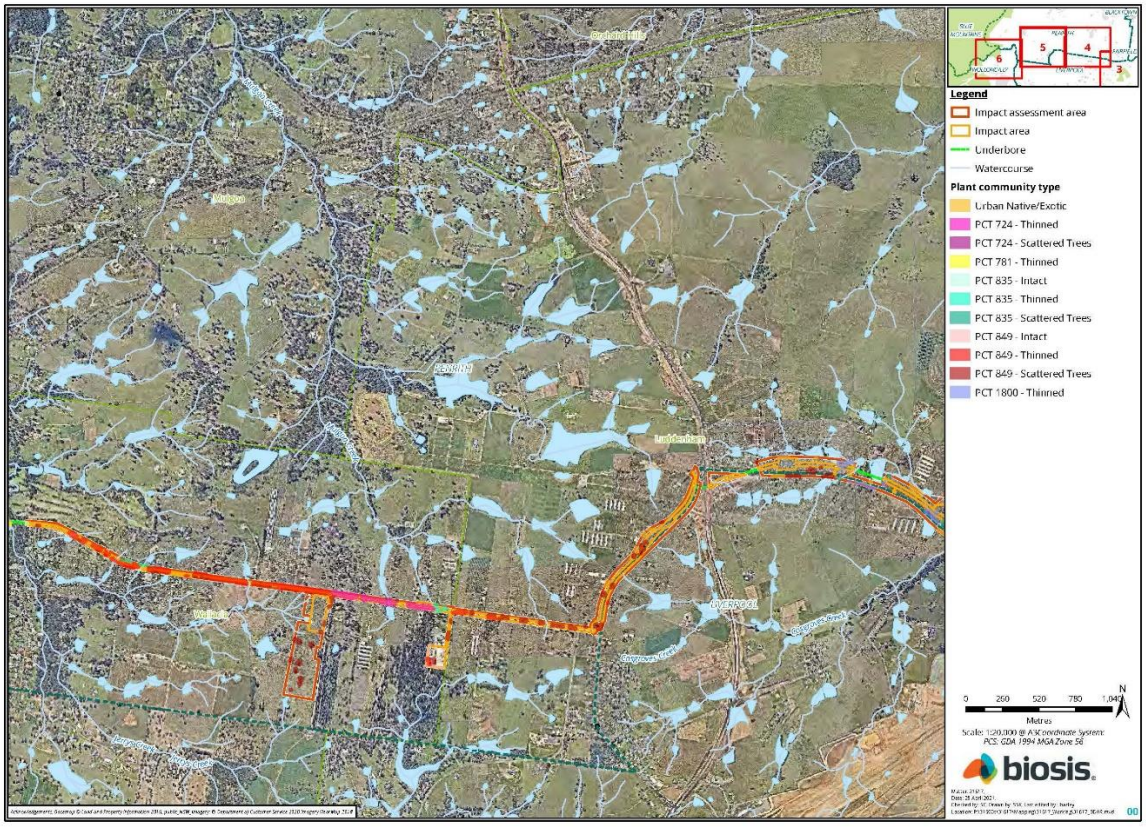

Figure 8. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

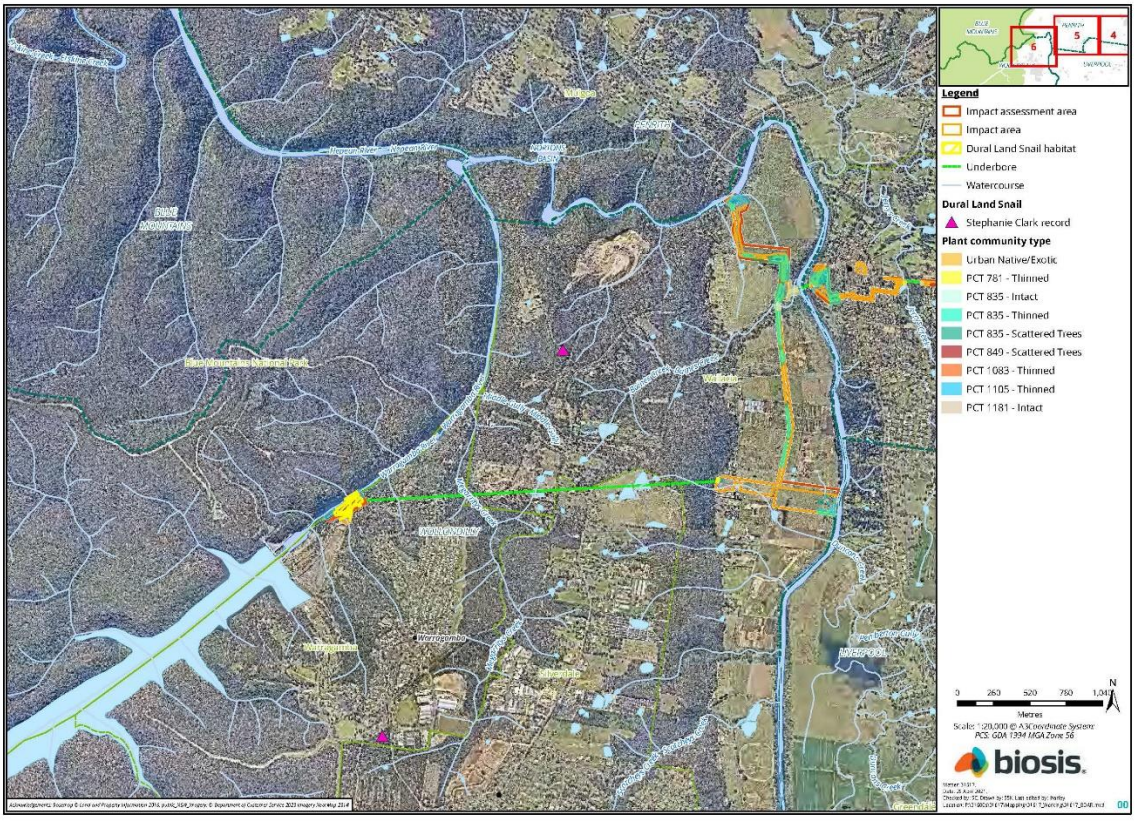

Figure 9. Map of the USCAWRC showing records of *P. duralensis* and the species polygons.

4.4 Assessment of suitable habitat

4.4.1 Suitable habitat within the study area

Suitable habitat was presumed to include all the PCT's mentioned above that had been mapped as either intact or thinned that occur across the USCAWRC corridor.

4.4.2 Species polygons

Figures 4-9 show the species polygons for *P. duralensis* across the USCAWRC impact assessment area.

4.4.3 Estimate of area of habitat

Across the USCAWRC impact assessment area there is a total of 1.88 hectares of potential habitat for *P. duralensis* (Table 1), of which 1.45 hectares occurs within the impact area and will be removed as part of the future development.

The total area in hectares of each of the different PCTs and condition states listed above in which *P. duralensis* can potentially be found across the USCAWRC study area are listed in Table 1.

PCT	Impact Area	Impact assessment area	Total
1083 thinned	**1.38**	**0.43**	**1.81**
1181 intact	**0.07**	**0.00**	**0.07**
Totals	**1.45**	**0.43**	**1.88**

Table 1. Lists the area of each of the different PCTs (in hectares) that provide known or suitable habitat for *P. duralensis* across the USCAWRC study area.

5 Information used in this assessment

The information used to make the above assessment is drawn from the literature (Clark, 2005, 2009; Dural Land Snail – profile) and the authors' personal observations and knowledge of the species built up over the past 32 years.

Additional records were obtained by searching the BioNet and ALA (Australian Living Atlas) databases.

Vegetation mapping for the corridors was provided by Biosis.

GIS analysis of the PCT's and preparation of the species polygons following the authors' requirements were provided by Biosis.

6 References

Clark, S.A. 2005. Systematics, spatial analysis and conservation genetics of *Meridolum corneovirens* and related forms (Gastropoda: Camaenidae) from the Sydney Region of Australia. Ph.D. Thesis, University of Western Sydney, Richmond, Sydney, New South Wales. pp. i-xiii, 1-256.

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7 Appendix: Curriculum Vitae of Stephanie Clark

CURRICULUM VITAE OF STEPHANIE CLARK

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EDUCATION

Ph.D., 2005. University of Western Sydney, New South Wales, Australia. Taxonomy and conservation.
M.Sc., 1998. Macquarie University, New South Wales, Australia. Taxonomy and genetics.
B.App.Sc., 1990. University of Technology, Sydney, New South Wales, Australia. Major biochemistry.

ACCREDITATIONS ETC

I am listed as a Biodiversity Expert under Section 6.5.2.4 of the BAM, under the Biodiversity Conservation Act, 2017 for the snails *Meridolum corneovirens* and *Pommerhelix duralensis* as 16 May 2018.

PROFESSIONAL EXPERIENCE

Current and/or completed:

1997 - present. Consultant work (Invertebrate Identification Australasia - Owner) for various Australian and United States councils, government agencies (State, Commonwealth and Federal), environmental consultancies, mining companies and developers on short and medium term projects dealing mostly with molluscs and insects (particularly endangered species surveys, monitoring and management plan preparation).

June 2019 - July 2019. Identified over 630 lots of Arizonian land and freshwater molluscs for the Field Museum of Natural History, Chicago, IL.

Oct 2017 - Completed Biodiversity Assessment Method (BAM) course.

Aug 2017 - Sept 2017. Conduct one day snail identification workshops for the Department of Agriculture & Water Resources, biosecurity biomonitoring sections in Sydney, Melbourne and Perth.

Sept 2016 - Mar 2017. Identified almost 4000 lots of North American land and freshwater molluscs for the Field Museum of Natural History, Chicago, IL.

Feb 2015 - Mar 2016. Prepared a list of all the names and synonyms applied to the non-marine molluscs of North America, for the Field Museum of Natural History, Chicago, IL.

Oct 2014 - Feb 2016. Prepare a status report for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) on the Shortface Lanx (*Fisherola nuttallii*) in Canada.

Jan 2013. Conducted a one day workshop on the identification of the endangered Cumberland Land Snail (*Meridolum corneovirens*) for the Ecological Consultants Association of NSW, Mount Annan, NSW, Australia.

PROFESSIONAL SOCIETIES

American Malacological Society
Conchological Society of Great Britain & Ireland
The Ecological Consultants Association of New South Wales
Malacological Society of London
Malacological Society of Australasia

Member of the IUCN SSC Mollusc Specialist Group.

RESEARCH INTERESTS

Systematics, population and conservation genetics of invertebrates, particularly terrestrial and freshwater molluscs.

EXPERIENCE

I have over 34 years' experience in the collection, identification and taxonomy of marine, estuarine, freshwater and terrestrial molluscs in 30 countries and 40 US states. I extensive experience collecting molluscs in the estuarine areas of particularly eastern Australia from Queensland to Victoria and am a co-author on a CD-ROM identification guide to the

estuarine and freshwater molluscs of New South Wales released in 2000. I have dissected individuals from several hundred populations of freshwater and terrestrial molluscs.

LEGAL EXPERIENCE

I have served as an expert witness for the Land and Environment Court of New South Wales on six occasions since 1997 and have provided expert testimony for several other cases.

PROFESSIONAL ACTIVITIES

Research Associate at the Australian Museum, Sydney, NSW, July, 2017 to present.

Research Associate at the Field Museum of Natural History, Chicago, Illinois, June, 2010 to present.

Invited participant at the IUCN Red List workshop assessing the Red List status of the world's freshwater molluscs, organised jointly by the Zoological Society of London, the Encyclopedia of Life (EOL), International Union for Conservation of Nature (IUCN), and the IUCN SSC Mollusc Specialist Group. Held in London, United Kingdom, February, 2010.

Served on the Status Review Panel for the federally endangered Idaho Springsnail (*Pyrgulopsis robusta*), in Boise, Idaho, for the United States Fish and Wildlife Service, Western Region, October, 2005.

TELEVISION

Short interview about my PhD project on the endangered endemic Sydney land snail *Meridolum corneovirens*, aired on 'Totally Wild' (a children's educational program on wildlife and the environment), Australia wide, 7 May 2002.

Short interview regarding the endangered endemic Sydney land snail *Meridolum corneovirens* and how the Olympic Coordinating Authority (OCA) has helped in its conservation, aired on 'A Current Affairs' (a prime time news and current affairs program) Australia wide on the 15 September, 1998.

RADIO

Short interview with Brian Bury, 4BC, Brisbane, about Australian native snail diversity aired Nov. 2002.

NEWSPAPER/INTERNET

Several interviews about molluscs, endangered species and rediscovering a species previously thought to be extinct, with national, local and internet media outlets, both in Australia and the United States since 2002.

Some recent examples:
ABC News: When Birds Overshadow Snails -- And Why That's a Problem
http://abcnews.go.com/Technology/story?id=734467&page=1

http://www.cofc.edu/~fwgna/archive/9May05.html

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Keenan, S.W., Audrey T. Paterson, A.T., Niemiller, M.L., Slay, M.E., Clark, S.A. and Engel, A.S. 2017. Observations of the first stygobiont snail (Hydrobiidae, *Fontigens* sp.) in Tennessee. *Proceedings of the 17th International Congress of Speleology* **2017**:91-94.

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Ponder, W.F., Hallan, A., Shea, M. and Clark, S.A. 2016. Australian Freshwater Molluscs. The snails and bivalves of Australian inland waters. Interactive key http://keys.lucidcentral.org/keys/v3/freshwater_molluscs/

Johannes, E.J. and Clark, S.A. 2016. Freshwater mollusc declines, local extinctions and introductions in five northern California streams. *Tentacle* **24**:22-25.

Campbell, D., Clark, S.A., Johannes, E., Lydeard, C. and Frest, T. 2016. Molecular phylogenetics of the freshwater gastropod genus *Juga* (Cerithioidea: Semisulcospiridae). *Biochemical Systematics and Ecology* **65**:158-170.

Gerber, J. and Clark, S.A. 2015. First record of the predatory land snail *Streptostele* (*Tomostele*) *musaecola* (Pulmonata: Streptaxidae) in the continental United States. *American Conchologist* **43(4)**:26-28.

Hauk, A., Clark, S.A., McCravy, K.W., Jenkins, S.E. and Lydeard, C. 2015. A Survey of Terrestrial Gastropods of the Alice L. Kibbe Life Science Station in West-Central Illinois. *Northeastern Naturalist* **22(2)**:299-306.

Bieler, R., Mikkelsen, P.M., Timothy M. Collins, T.M., Glover, E.A., González, V.L., Daniel L. Graf, D.L., Harper, E.M., John Healy, J., Kawauchi, G.Y., Sharma, P.P., Staubach, S., Strong, E.E., Taylor, J.D., Tëmkin, I., Zardus, J.D., Clark, S., Guzmán, A., McIntyre, E., Sharp, P. and Giribet, G. 2014. Investigating the Bivalve Tree of Life – an exemplar-based approach combining molecular and novel morphological characters. *Invertebrate Systematics* **28(1)**:32-115.

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Upper South Creek Advanced Water Recycling Centre – Green and Golden Bell Frog Expert Report

Sydney Water

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Template 2.8.1

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1. Introduction

1.1 Background

Sydney Water is proposing to build and operate a new wastewater treatment plant in Kemps Creek in Western Sydney. This is to be known as the Upper South Creek Advanced Water Recycling Centre (AWRC). Together with the treated water and brine pipelines, these elements collectively are the 'project'.

The AWRC will produce treated water at three different quality levels that will be typically released in different locations:

- Advanced (very high-quality treated water) - preferentially used for dry weather releases to the Nepean River, environmental flows to the Warragamba River and wet weather releases to South Creek.
- Tertiary (high-quality treated water) - additional volumes released to the Nepean River.
- Wet weather (lowest level of treatment) - released to South Creek when inflows to the plant exceed the capacity of the tertiary treatment systems.

The advanced and tertiary releases will also be suitable for a range of recycled water uses and the advanced treatment process produces brine as a by-product, which will be transferred to Sydney Water's Malabar wastewater system.

The project has been declared State Significant Infrastructure and hence, an Environmental Impact Statement (EIS) is to be prepared by Sydney Water in accordance with the project specific *Secretary's Environmental Assessment Requirements* (SEARs SSI-8609189) updated 28 January 2021. The NSW Biodiversity Offset Scheme (BOS) applies and a Biodiversity Development Assessment Report (BDAR) is required to be prepared. This assessment needs to apply the NSW BAM (OEH 2017a) to the project, and provide a BDAR to support and inform the EIS for the project by addressing relevant SEARs. This includes:

- Identifying how the proponent proposes to avoid and minimise impacts to biodiversity.
- Identifying any potential impact that could be characterised as serious and irreversible.
- Describing the offset obligations required to compensate for any unavoidable biodiversity impacts resulting from the project.
- Considering and assessing the project and reference design in accordance with other relevant legislation such as the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

One species needing consideration is *Litoria aurea*, the Green and Golden Bell Frog (GGBF), which has been identified as potentially present within the proposed impact assessment area. Surveys have not been able to be completed for this species due to land access restrictions and, therefore, the presence and any needs for offsets have not been able to be established as part of the BDAR. This expert report has been included as a component of the BDAR to adequately assess this species.

1.2 Purpose of the expert report

Section 6.5.2 of the Biodiversity Assessment Method sets out the following essential requirements for the preparation of an expert report:

- Identify the relevant species or population.
- Justify the use of an expert report.
- Indicate and justify the likelihood of presence of the species or population.
- Estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made.
- Demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report.
- Identify the expert and provide evidence of their expert credentials.

The report needs to determine whether:

- The target species is unlikely to be present, in which case no further assessment is required, or
- The target species is likely to be present in which case the expert report must provide estimates of habitat area within the impact assessment area.

1.3 Project context

- The project is needed to provide wastewater services to the South West Growth Area (SWGA) and Western Sydney Aerotropolis Growth Area (WSAGA) and has been sized to service the projected 2056 population. Ultimately, it is expected the plant will treat up to 100 ML of wastewater per day. Sydney Water is making a staged infrastructure application seeking approval for:
- A concept proposal for the project to build and operate a new wastewater treatment plant to treat up to its ultimate capacity, including associated treated water and brine pipelines.
- A detailed approval for Stage 1 of the project to build and operate the wastewater treatment plant to treat up to 50 ML of wastewater per day and build the associated treated water and brine pipelines to the ultimate capacity.

The location of the proposed infrastructure for the AWRC is presented in Figure 1 and consists of three identifiably separate components.

1.3.1 Advanced Water Recycling Centre

This will provide for a wastewater treatment plant with the capacity to treat up to 50 ML of wastewater per day, with ultimate capacity of up to 100 ML per day. The AWRC will produce:

- High-quality treated water suitable for a range of uses including recycling and environmental flows.
- Renewable energy, including through the capturing of heat for cogeneration.
- Biosolids suitable for beneficial reuse.
- Brine, as a by-product of reverse osmosis treatment.

The AWRC will treat wastewater through an advanced treatment process. This includes:

- Inlet works for preliminary treatment.
- Primary, secondary and tertiary wastewater treatment.
- Advanced treatment including through reverse osmosis.
- Disinfection systems.
- Biosolids handling facilities.
- Cogeneration for heat and energy production.
- Odour control facilities.

- Pipeline to South Creek for releases during wet weather.
- Pumping stations to transfer treated water to the Nepean and Warragamba Rivers, and the brine to the Malabar treatment works.

The AWRC will be constructed on Part Lot 21 DP 258414 in Kemps Creek, which is a 80 ha site (Figure 1). It is expected that approximately 50% of the site will be required for the main operational components of the AWRC. During construction, a range of construction materials and equipment will be required to build the AWRC and during operation, a range of chemicals are to be used in the wastewater treatment process and so need consideration for management. The AWRS requires a range of ancillary infrastructure, such as an administration building, roads, connection to power, car parking, chemical storage and water detention and retention basins along with roof-mounted and ground-mounted solar photovoltaics. The extent of this infrastructure and timing of instalment is yet to be fully determined.

The project also includes landscaping some of the non-operational areas consistent with the government's vision for parkland areas in the region and will include opportunities to integrate landscaping on the AWRC site into the broader parkland areas.

1.3.2 Treated water pipelines

This linear infrastructure will consist of:

- One below-ground pipeline about 16 km long from the AWRC to the Nepean River at Wallacia Weir, for the release of treated water. This will generally follow Elizabeth Drive, the Northern Road, Park Road and Silverdale Road (see Figure 2).
- Infrastructure from the AWRC to South Creek to release excess treated water and wet weather flows.
- A below-ground pipeline of 4-5 km length from the main treated water pipeline at Wallacia to a location between the Warragamba Dam and Warragamba Weir, to release high-quality treated water to the Warragamba River as environmental flows. Some of the impact assessment area will follow Silverdale Road and Bents Basin Road.

1.3.3 Brine pipeline

The Brine pipeline will be another below-ground pipeline about 24 km long that transfers brine from the AWRC to Lansdowne, in south-west Sydney, where it connects to Sydney Water's existing Malabar wastewater network (Figure 3).

1.3.4 Project delivery

Sydney Water is planning to deliver the project in stages, with Stage 1 comprising:

- Building and operating the AWRC to treat an average dry weather flow of up to 50 ML per day.
- Building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 AWRC.

The timing and scale of future stages will be phased to respond to drivers including population growth rate and the most efficient way for Sydney Water to optimise its wastewater systems.

The pipelines will be below ground. Construction of the pipelines will require the use of a range of materials and equipment as will the ongoing operation and maintenance requirements. They will have some above ground components including maintenance holes, valve pits and covers, scour chambers, ventilation structures, energy dissipation structures and headwalls. Depending on how design and hydraulic assessments progress, other above ground structures such as barometric loops may be required. These all have the

potential to provide permanent but very small changes to the landscape.

1.4 Impact assessment area

As previously noted, the location of the AWRC is provided in Figure 1 and the individual components described in section 1.2. Information for this area encompassed by this infrastructure and a buffer zone of 1 km around the infrastructure was obtained from a range of data layers including:

- Native vegetation: provided by Biosis
- Waterbodies: NSW LPI
- GGBF Records: NSW BioNet.

1.4.1 Advanced Water Recycling Centre

The AWRC itself is located in the suburb of Kemps Creek and falls within the Penrith City LGA. It is to be built between Kemps Creek and South Creek and will cover part of South Creek channel and an area of floodplain (Figure 2). The nearest major roads are Mamre Road, which is located approximately 1 km to the east, Elizabeth Drive, which is located approximately 1.8 km to the south. Both are single carriageways, but carry significant numbers of vehicles each day and are very busy during morning and afternoon peak hours.

The land on which the AWRC is be to constructed and the surrounding lands within 1 km are cleared rural lands, used historically for grazing and contains only the odd scattered trees except for a few small strips of trees on the edge of stream beds. More extensive riparian vegetation is retained on South Creek to the immediate south of the AWRC and on Badgerys Creek to the west. There are also a several small sheds as associated infrastructure. The AWRC will not require the removal of any significant consolidated areas of remnant vegetation, formed roads or housing.

Features located within the surrounding 1 km include:

- One area of remnant vegetation of approximately 1000 m X 300 m located to north west and bordered by Badgerys Creek and South Creek. This land adjoins a housing estate and is partly bisected by a golf course.
- The Twin Creeks housing estate that is located to the west of the remnant lands.
- Fleurs Aerodrome and Radio Telescope site, which is located to the immediate south of the AWRC and may potentially be slightly impacted by the development.
- The SUEZ Kemps Creek Resource Recovery Park that is located to the southwest.

The short stretch of infrastructure from the AWRC to South Creek passes through cleared rural lands and runs over the floodplain of South Creek. It may impact minimally on infrastructure, including Fleurs Aerodrome, depending on the exact route. It is located generally to the east of South Creek and is likely to have minimal impact on riparian vegetation and no impacts on formed roads or residential areas.

1.4.2 Treated Water Pipeline

High quality treated water produced by the AWRC will be released to the Nepean River via the treated water pipeline. It is expected that some of the treated water will be reused in recycled water schemes, but the project allows for the full flow to be released to waterways, if required.

The 16 km of pipeline from the AWRC to Wallacia Weir generally follows the route of Elizabeth Drive and

Park/Silverdale Road (Figure 3) and so follows what is a pre-existing disturbed impact assessment area along these roads. This route runs through a landscape dominated by cleared rural lands. It crosses under the additional major roads of Luddenham Road, The Northern Road and Mulgoa Road. It crosses South Creek, Badgerys Creek, Oaky Creek, Cosgroves Creek, Jerrys Creek and the Nepean River. It does not pass under/through any larger areas of remnant native vegetation, although some vegetation is present in association with Jerrys Creek and under the Nepean River. It passes through one area of suburban development at Wallacia. The end point at Wallacia Weir will potentially impact on riparian vegetation associated with the Nepean River and that is continuous with the larger area of native vegetation present within the Blue Mountains National Park. It crosses through the Penrith Local Government Area and Wollondilly Shire.

The other section of pipeline running between the Nepean River and the Warragamba River will initially pass south through cleared rural lands with some infrastructure and back under Silverdale Road and Bents Basin Road. Once it turns west the pipeline will pass under areas of native vegetation, and again under Silverdale Road and Megarrity's Creek, to the outlet to be constructed on the eastern bank of the Warragamba River. This stretch of the pipeline will be constructed via trenchless technology. The extent that it will impact the native vegetation through the short and long term depends on the exact path and if other surface infrastructure is required along that length.

1.4.3 Brine Pipeline

This pipeline will run from the AWRC to Lansdowne, in south-west Sydney (Figure 4) and passes through the Penrith, Liverpool, Fairfield and Canterbury-Bankstown LGAs. This pipeline will run south from the AWRC and alongside the Treated Water Pipeline to start with before heading east, running to the south of Elizabeth Drive, through the Western Sydney Parklands and then into densely populated suburban areas for the majority of its route. The pipelines crosses numerous major roads and several creeks with highly disturbed riparian zones. The main habitat features that the Brine Pipeline will intersect include:

- The floodplain to the east of South Creek where it runs in parallel with the other pipelines leading from the AWRC.
- A larger patch of retained vegetation bordered by Elizabeth Drive, Western Road, Cross Street and Devonshire Road in Kemps Creek.
- The Western Sydney Parklands, which forms a major area of recreational lands with some native vegetation. This is bordered by Kemps Creek (the water body) in the west and the suburb of Cecil Hills in the east. There are varying degrees of vegetation present, some of which is remnant and some planted, most of which looks to be disturbed to some degree. The riparian vegetation surrounding Kemps Creek (itself) where the pipeline crosses forms part of one of the largest patches of intact vegetation that the pipeline with trench through and is contiguous with Kemps Creek Nature Reserve. The extent to which this would fragment or form a barrier to movements of the GGBF, if it were present, would depend on the actual construction undertaken.
- Prospect Creek and Lansdowne Reserve located at the end of the pipeline. Prospect Creek forms a corridor with moderately vegetated banks linked to the Georges River to the south and the Prospect Reservoir to the north.

1.5 Reasons for use of an expert report

Section 6.5.2.8 b of the Biodiversity Assessment Method (OEH 2017) places two specific requirements for

where an expert report can be used instead of surveys:

- an expert report can only be used instead of a survey for species to which species credits apply
- an expert report may be obtained instead of undertaking a species survey at a development site, clearing site, land to be biodiversity certified or a biodiversity stewardship site.

The GGBF meets the first criteria, being a species credit species under the *Biodiversity Conservation Act 2016* (BC Act).

The GGBF is known to inhabit the types of landscapes present within the impact assessment area of the AWRC and associated pipelines and historic records exist across broadly, albeit very limited, across the planning area (Figure 1). Field survey is unable to be undertaken to adequately assess the presence of the GGBF within the impact assessment area, with extensive areas of potential habitat occurring on private lands that cannot be accessed.

On that basis, an expert report was determined to be required for this species.

CREDENTIALS OF EXPERT

Dr Lemckert is an Ecologist that has been undertaking studies into the ecology and management of frogs since 1986 and has been a principal ecological consultant since 2011. His skills include survey design/ implementation/ targeted species surveys, data handling, analysis and interpretation and the production of high level reports including papers published in international peer-reviewed journals and technical reports and recovery plans for the Commonwealth and NSW Governments. He has also been an expert witness for the assessment of the impacts of alleged illegal clearing for the Commonwealth, NSW and Local Governments (Hornsby Council) and provided expert advice to NSW DPI for legal considerations over the potential for forestry operations to impact on rock outcrop dependent species. At the broadest level Dr Lemckert represented Forests NSW (now Forestry Corporation NSW) as a reptile and amphibian expert in the Comprehensive Regional Assessments and Regional Forest Agreement Process carried out between 2000 and 2002 and as an expert in fauna management for negotiations over a new Threatened Species License for harvesting operations in 2014. He provided an expert review of the developed assessment process for impacts on Matters of National Environmental Significance for two proposed Coal Seam Gas Developments in Queensland and has completed two rounds of expert review of the status of Australia's amphibians for the IUCN.

Dr Lemckert is an acknowledged expert on eastern Australian frogs having completed his MSc and PhD on the ecology and management of frogs in this region and has published over 70 papers (or book chapters) in Australian and International peer-reviewed journals. He has been used by both the NSW and Commonwealth Governments as an expert witness in court cases assessing the impacts of land clearing on threatened frogs. He is a member of the Amphibian Specialist Group of the IUCN, secretary of the NSW Declining Frog Working Group of NSW and past president of the Australian Society of Herpetologists. He co-supervised two PhD students, a Master of Applied Science Student and three Bachelor of Science (Honours) students who completed theses addressing issues of frog biology and conservation. He is listed as an accredited expert by the NSW Department of Planning, Industry and Environment (DPIE) to provide expert reports under the Biodiversity Assessment Method (BAM). He has produced an expert report for the GGBF for the Warragamba Dam raising project and for the Strategic Assessment for the Cumberland Plain Conservation Plan. He has recently written the survey guidelines for NSW threatened frog species to be used in assessments under the Biodiversity Assessment Method (BAM) (for the NSW Department of Planning, Industry and Environment).

Recent works on the Green and Golden Bell Frog include the survey of and recording of the species at 30 sites in the Meroo Lakes area for the first and fourth years of the Saving our Species Monitoring Program, the rapid response and management of an intrusion of thousands of juvenile Green and Golden Bell Frogs into a development site at Kooragang Island and pre-clearance surveys and monitoring of the Green and Golden Bell Frogs detected along the South Nowra Upgrade of the Princes Highway.

Dr Lemckert can demonstrate his expertise on the GGBF through the following publications and reports:

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In addition, he is recognised as an expert in the species having been engaged by:

- Kooragang Island KIEWF facility survey and relocation of Green and Golden Bell Frogs from five separate areas requiring the relocation of over 1000 juvenile Green and Golden Bell Frogs into selected translocation ponds (2020).
- Blacktown Council to complete surveys for the Green and Golden Bell Frog in around the old Riverstone Meat Works to determine potential presence of the species for future development of the site (2020).
- NSW Office of Environment and Heritage (now DPIE) to complete a baseline survey for the Meroo Lake population of the GGBF for the Saving Our Species (SOS) program (2016-2017 and current).

- NSW Office of Environment and Heritage to be part of the expert panel determining the categorisation of this species under the SOS program and in determining the populations requiring specific management to meet the SOS requirement to have a viable population maintained 100 years into the future.
- Daracon to provide expert advice and survey for this species at Kooragang Island for a soil emplacement facility (2019-2020).
- NSW Roads and Maritime Services to conduct expert surveys for this species in the area around Sydney Airport, Gerringong, Shortland to Sandgate, South Nowra and Berry to Bomaderry, locating the species at Gerringong and South Nowra (2011-2016).
- Port Kembla Coal Terminal to conduct annual ongoing monitoring of this species as part of a Green and Golden Bell Frog Management Plan (2014-2017).
- John Holland Group and Daracon to provide expert advice and survey for this species at Kooragang Island for a rail and road corridor upgrade (2015-2016).
- EPBC surveys for the GGBF at Port Kembla to determine the presence/absence of this species in relation to a proposed development along Masters Road (2014).
- Wollongong Golf Club to complete repeat surveys at Wollongong Golf Course as part of pre- clearing of drainage culverts (2013).
- Provided expert opinion on the status of this species during assessments undertaken for the IUCN in 2001 and 2016.
- Provided expert opinion on the habitat requirements, sub-population status and reservation requirements for the Green and Golden Bell Frog during the NSW Government's Comprehensive Regional Assessment program (2000-2001).
- Distribution surveys through its historic range between Sydney, NSW, and the Gippsland area of eastern Victoria, as part of a project to look at overlap zones and pre-mating isolating mechanisms between the Green and Golden Bell Frog and Southern Bell Frog (*Litoria raniformis*) (1986-1987).

Specific to the AWRC development, Dr Lemckert has:

- Undertaken a survey for the GGBF in the study area for the proposed second airport at Badgerys Creek.
- Conducted site inspections and completed expert reports for Biocertification for the Western Sydney Growth Areas program (2018-2019) and transport corridors (2020).

Dr Lemckert's full CV is provided as Appendix A of this report.

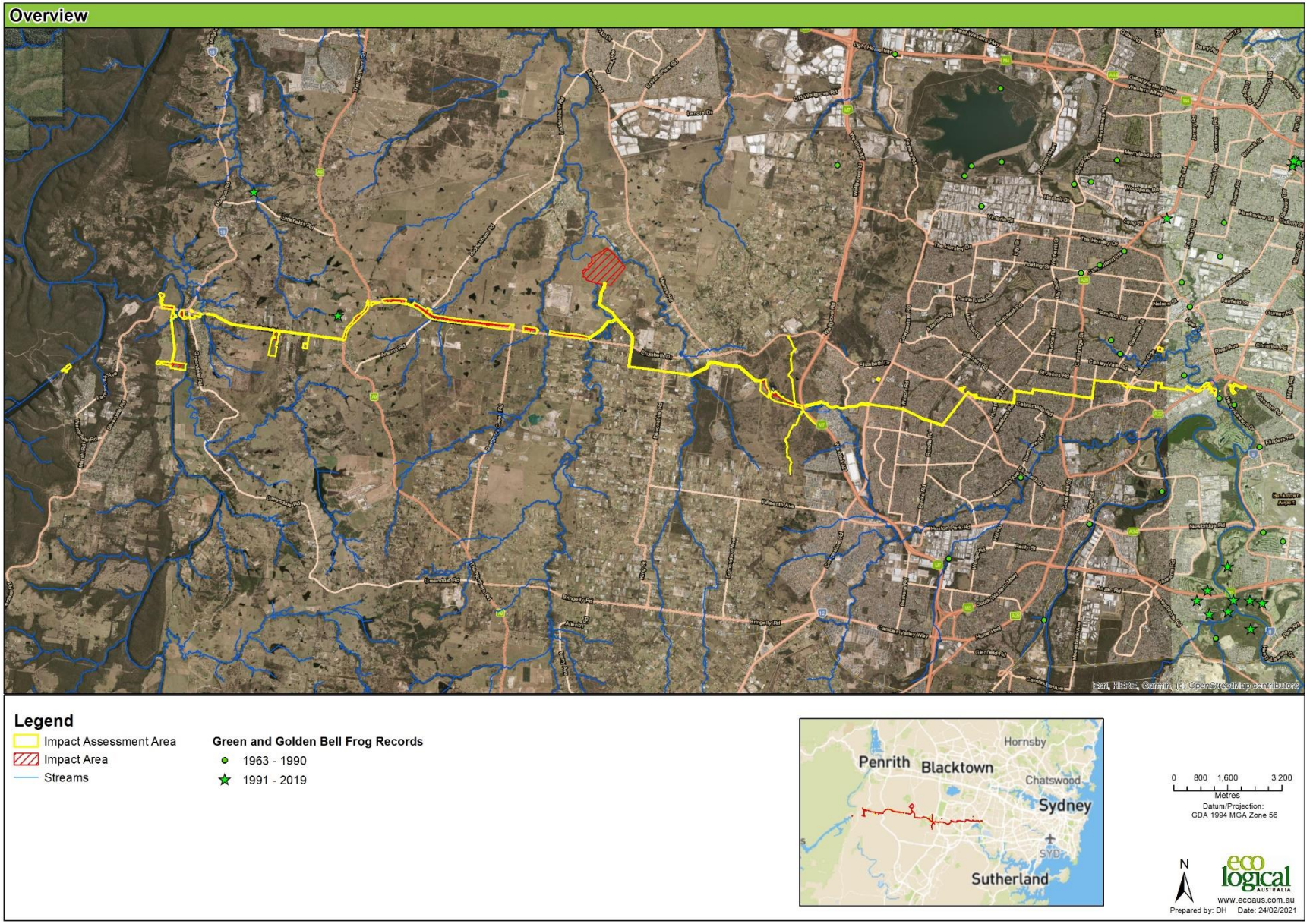

Figure 1: Location of the AWRC facility and associated infrastructure showing water bodies, vegetation and GGBF records

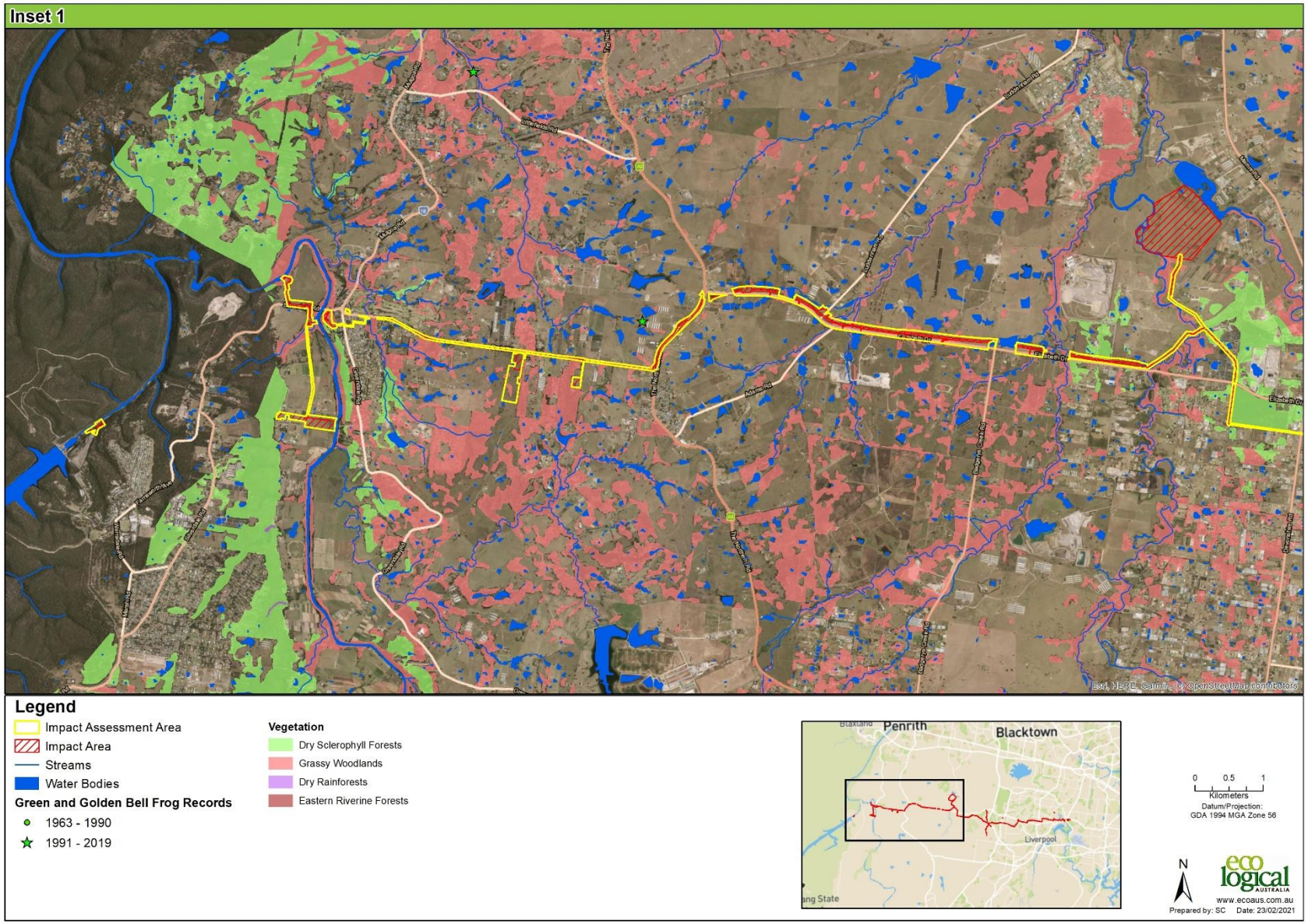

Figure 2: Western half of AWRC facility and associated infrastructure showing water bodies, vegetation and GGBF records

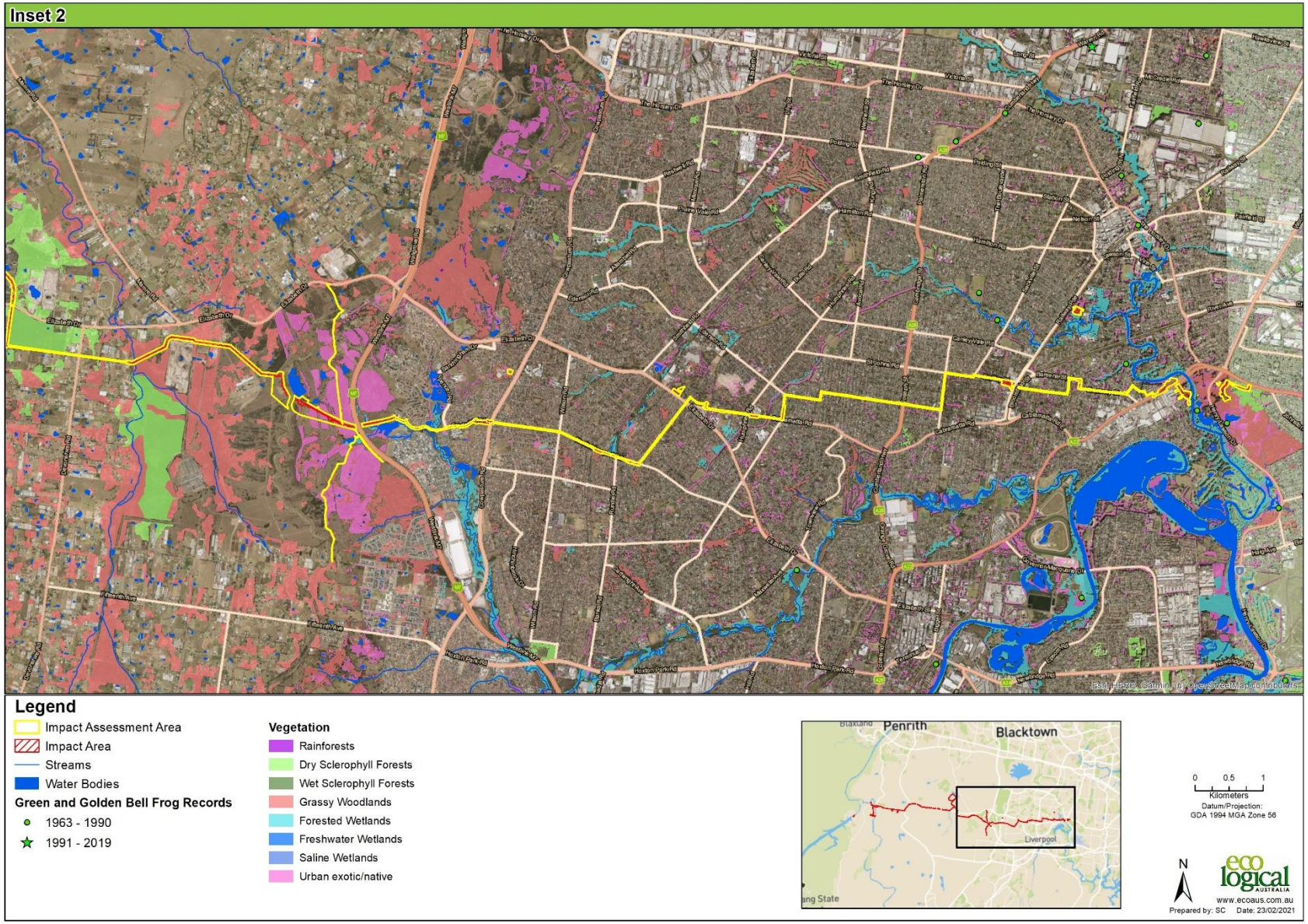

Figure 3: Eastern half of AWRC facility and associated infrastructure showing water bodies, vegetation and GGBF records

2. Species information

2.1 Species description

The GGBF is an endemic Australian tree frog that is a member of the family Hylidae. It is a large species for Australia, ranging in an adult size for males of 57-69 mm and females 65-108 mm snout to vent length (Tyler and Knight 2009; Clulow and Swan 2018). The species gets its name from the typical colour of the body which is often a vivid green splotched with gold (Plate 1). However, in some individuals the back may be almost entirely green whereas other have dominant gold markings. There is a pale creamish-white stripe running along the side, extending from the upper eyelids usually almost to the groin. The species also has blue or bluish-green markings in the thighs and groin. The snout is relatively pointy and the belly granular. There is rarely a mid-dorsal stripe, which typically distinguishes this frog from the Southern Bell Frog, *Litoria raniformis*.

Plate 1: Typical adult Green and Golden Bell Frogs

2.2 Life cycle

The GGBF is considered to have a calling season that extends from spring to autumn (Lemckert and Mahony 2008). Within that period of time calling is tied strongly to rainfall events. The advertisement call is a “whaaark whaark whark” that is produced by the male. Calling occurs mainly at night, but occasionally males will call during the day when conditions are especially favourable (DEC 2005). The males call in groups floating on the surface of the water usually holding on to emergent vegetation, with males synchronising their calls with a lead calling male so that they all call essentially at the same time (Barker et. al. 1995; Pyke and White 2001). This may help to confuse predators by masking individual calls. Male GGBF reach sexual maturity at around 45–50 mm snout-vent length (DEC 2005), which would usually be reached in the first season after metamorphosis.

Females of the GGBF reach sexual maturity at a snout-vent length of around 65 mm, which usually takes to their second season after metamorphosis (DEC 2005). Female GGBF produce a particularly large number of eggs for an Australian species, with Pyke and White (2001) suggesting an average clutch size is about 3700 eggs, but with van de Mortel & Goldingay (1996) recording a maximum clutch of 11,682 eggs. Egg size is around 4 mm in diameter.

Spawn is laid among aquatic vegetation, with it initially floating on the water surface as a mass, but sinking within 24 hours of being laid. The eggs typically hatch 2–5 days after ovipositing/fertilisation (Anstis 2013) with water temperature playing a role in development time (eggs hatch faster in warmer water) and can hatch in less than one day.

The tadpoles can tolerate salinity levels of six parts per thousand (ppt) without any apparent effects (Kearney et al. 2012), while salinity of 8 ppt or higher decreases growth rates and increases mortality rates (Christy and Dickman 2002), although adults can tolerate much higher salinity levels. The pH of a pond does not appear to affect the likelihood of the eggs to hatch (Pyke and White 2001).

Tadpoles grow at variable rates depending on conditions and availability of food. They can reach up to 80 mm in length before metamorphosis, although they will metamorphose at smaller body lengths. Time to metamorphosis is variable and dependent on conditions and time of year, taking between two and eleven months, but with a mean of three months (Anstis 2013). Tadpoles may overwinter if breeding occurs late in autumn. They would be expected to typically eat algae and other aquatic vegetation and can often be seen sucking at the surface of the water, presumably to take in organic material floating on the water surface. But their actual diet has not been studied. As for most species, it is likely that tadpoles will also eat dead animal material if it is available, including other tadpoles.

2.3 Distribution and abundance

2.3.1 Broad distribution

The distribution has been recorded from Yuraygir National Park on the far North Coast of NSW to around Lakes Entrance in south-eastern Victoria (White and Pyke 2008). Notably, Courtice and Grigg (1975) completed a detailed study of the distribution of the GGBF and in Gippsland and found it only as far west as Marlo, where it abutted and had a potential hybrid zone with *Litoria raniformis*, which was the prevailing species west of that point. In the mid-1980s the species was recorded at least 60 km further west at Nowa Nowa and Litoria raniformis were no longer present in that location (F. Lemckert Pers. Obs.) and then 15 km further west at Lakes Entrance by White and Pyke (2008). By 2011 they had been recorded another 70 km to the west at Dutson Downs (Gippsland Water 2021). This may suggest a westward expansion of the species in Victoria since the 1970s. Historically the species was known from a number of sites at least 50 km inland into the NSW ranges including at Bathurst (White and Pyke 1999), Bungendore (Humphries 1979) and 30 km inland at Ulong on the NSW north coast (Moore 1961). The furthest and now only extant “inland” population is near Hoskinstown in the Southern Tablelands of NSW (Osborne et al. 2008). Natural GGBF populations are also known from three islands off the coast of NSW; Bowen Island, Kooragang Island and Broughton Island (DEC 2005). Extra-limital populations have been introduced to New Zealand (Pyke et. al. 2002), and New Caledonia and Vanuatu (Pyke and White 2001) with the species occurring in high densities in some areas (M. Mahony Pers. Comm.).

The extent of occurrence of the species estimated to be approximately 150,000 km² (Mahony 1999). The extent of occurrence has declined further since that time and is continuing to reduce as populations are also known to have continued to decline (Mahony et. al. 2013).

2.3.2 Distribution in the Cumberland Subregion

A total of 13,146 records for the GGBF are available on the Cumberland Subregion (based on NSW BioNet records). This looks to be a large number of records, but is highly skewed by the records from Sydney

Olympic Park and the majority (>95 %) come from the eastern third of the Cumberland Subregion. The very limited number of records in the western half of the Cumberland Subregion suggests that the GGBF may never have been common or widespread across this region, despite the apparently adaptable nature of this frog (see Section 2.4). Notably, most of these relatively few records were from before 1990.

The Draft NSW GGBF Recovery Plan (DEC 2005) lists one core populations for this species that may have relevance to this assessment. This is the St Marys key population located in an area 10 km to the north and centred around St Marys, Mt Druitt, Prospect and Riverstone. This population is potentially relevant as a source of dispersing individuals that may at least occasionally enter into the impact assessment area (See section 2.4.4).

2.3.3 Abundance

The GGBF was recorded as once being a very abundant and widespread frog (Goldingay 1996). Fletcher (1889) stated that this species was commonly be encountered in the Sydney area and Harrison (1922) noted that this species was "probably our best known frog" and was "known to me since childhood". Extensive surveys for the species by Courtice and Grigg (1975) in the early 1970s recorded it very regularly and abundantly across coastal NSW and into southeast Victoria. However, there was a serious decline of the species in the 1980s, with the timing being uncertain, but with frogs having disappeared from many historic sites by 1987 (F. Lemckert Pers. Obs.). By 1996 the GGBF was regarded as rare by White & Pyke (1996) and its recorded declines recognised to be of concern (White 1995). Populations of over 1,000 frogs were (and likely still are) present at Kooragang Island, Broughton Island and Homebush (Hamer et. al. 2002), but the other locations it is known from are much smaller populations (DEC 2005). Even in 2005 the GGBF was recognised as having declined to less than 50 populations in NSW (DEC 2005) and the declines have been continuing (Mahony et. al. 2013) with accounts such as that by Daly (2014) noting that the population known from Nowra has apparently continued to contract from a previous expansion. The amphibian chytrid fungus has been implicated as the main driver of these severe declines (Mahony et. al. 2013), although habitat loss (Goldingay 1996) and introduced predatory fish (Pyke and White 1999, Goldingay 2008) have also been suggested to have played significant roles in population declines and losses.

Over the short-term the GGBF can exhibit significant local population fluctuations when conditions result in high tadpole survivorship (e.g. Daly 2014). The GGBF has a life cycle that fits what is termed to be an R-selected species (Hamer and Mahony 2007), producing large numbers of offspring and adults have relatively shorter lifespans. Hence, there is a relatively rapid turnover of individuals and survival of the local population depends on occasional very successful seasons, when population size and area utilised rapidly increase, interspersed with years of low recruitment when numbers fall away and there are local extinctions in less favourable areas of habitat. This is considered to be a typical pattern for amphibians (Alford and Richards 1999). In fact, The GGBF has been suggested to be a colonising species with a series of its attributes suit this lifestyle: habitat generalist, high fecundity, rapid growth, early sexual maturity, and relative high dispersal ability (Hamer & Mahony 2007). White and Pyke (1999) suggest that the GGBF rapidly move into areas of newly created breeding habitat that represent sites with little competition for the developing tadpoles from other species, are open and so provide good thermal environments and lack or have minimal predators such as dragonfly larvae or fish present.

Nearly all currently known populations within Australia are located within 10 km of coastal locations (Mahony et. al. 2013). This is considered most likely as a result of saline influences from groundwater or sea spray producing conditions unsuitable for the growth of the amphibian chytrid fungus, but still leaving conditions that the GGBF can survive and breed in.

Plate 2: Examples of pond breeding habitats observed in proximity to the impact assessment area

Plate 3: Habitat along Kemps Creek to the south of the location of the proposed AWRC facility. **a) Creek line itself with poor water quality and b) Overgrown Phragmites wetland adjacent to creek**

Plate 4: Example of typically preferred breeding and foraging habitat and basking GGBF. Note the dense emergent vegetation and areas of clear water that allow adults protection whilst basking

2.4 Habitat requirements

2.4.1 Breeding Habitat

Breeding sites for the GGBF include a wide range of natural water bodies and the species has been recorded inhabiting all but fast flowing streams (Pyke & White 1996). It also inhabits many human- created environments, including highly disturbed sites such as abandoned mines and quarries (Pyke et. al. 2002), as well as artificial wetlands that have been created at both Kooragang Island (Hamer et. al. 2002) and Sydney Olympic Park (Darcovich and O'Meara 2008). Pyke & White (1996) undertook a review of the known breeding habitat of the GGBF and found that they preferred to breed in water bodies that were still, shallow, ephemeral, unshaded, with aquatic plants and free of the Plague Minnow (Gambusia holbrooki) and other predatory fish. This study also found that breeding occurs in a significantly higher proportion of sites with ephemeral (temporary) ponds, rather than sites with fluctuating or permanent ponds. Hamer et. al. (2002) found a similar result for the GGBF populations at Kooragang Island where larger males would move to ephemeral water bodies to breed when they were available, although reproduction was also associated with permanent water bodies. The frogs in that study also tended to remain relatively faithful to one water body. The presence of the Plague Minnow does not exclude GGBF from breeding in a water body, but success appears to be dependent on the presence of more complex aquatic vegetation, which allows the GGBF to breed successfully (Hamer et. al. 2002). Hence the Plague Minnow does still appear to be a sole determinant of the likely presence of the GGBF in most situations.

2.4.2 Non-breeding habitat

The GGBF is unusual for an Australian frog in that the species appears to remain generally associated with water bodies (remain within 50 metres) throughout the year rather than dispersing away from water bodies between breeding events to undertake foraging and find shelter. Most frogs migrate 100-300 metres from the breeding site to settle into recognisably different complementary non-breeding habitat (Lemckert 2004). Terrestrial habitats immediately adjacent to water bodies (< 50 m) are typically used for foraging and shelter and preferably consist of grassy areas and vegetation no higher than woodlands and contain a range of diurnal shelter sites such as logs, rocks or dense vegetation (Pyke and White 1996). However, there are observations of GGBF moving into taller forests (e.g. dry sclerophyll forest at Nowra; M. Greenlees Pers. Comm. and dense woodlands at Meroo; F. Lemckert Pers. Obs.) and even foraging in suburban backyards (DEC 2005). This again demonstrates the historic adaptability and lack of habitat specificity of this frog.

Adult frogs show a strong site fidelity in regards to returning to the same ponds over time (Hamer et al. 2008), but their movements around those ponds and immediately adjacent areas are relatively random for most individuals and especially juveniles (F. Lemckert Pers. Obs.). Females though, have been observed to congregate together into specific shelter and foraging sites in areas immediately adjacent to breeding sites (Hamer 1998, Pyke and White 2001).

Shelter sites are used when GGBFs are inactive and so vulnerable and are of added importance in providing secure over-wintering locations. Studies at Kooragang Island have suggested that females may use slightly different non-breeding areas to males and may have very important and specific over- wintering areas located in dense vegetation (M. Mahony Pers. Comm.). Whether this is the same for other populations is unknown, but there is evidence from Sydney Olympic Park that females there also concentrate in certain locations (J. O'Meara Pers. Com.).

Another unusual aspect of the GGBF is its well known habit of basking, typically within areas of aquatic vegetation (see *Plate 4*), apparently to increase body temperatures (Pyke and White 2001). Basking in frogs is unusual (being generally nocturnal), but such activities in ectotherms typically allow for periods of greater activity or faster digestion of food items. Whilst the importance of this activity for its physiological requirements is not known, individual GGBF appear to bask regularly. On this basis, it is likely that basking is an important physiological activity for the GGBF. Basking typically occurs within or on the edge of emergent aquatic vegetation, which likely allows individuals the option to make a rapid escape from diurnal predators. The presence of water bodies that contain emergent vegetation are known important determinants of the presence of GGBF (Pyke and White 1996; Hamer et al. 2002) and form an important resource for the GGBF and in the consideration of their potential presence.

Whilst GGBF may retain a closer association with water bodies and appear to generally be faithful to a single water body for their general activities, they can move along and between different water bodies, particularly as part of migrations to and from breeding sites (Hamer et al. 2002). Studies have revealed that the species move distances of up to 1 km (Hamer et. al. 2008) and mark/recapture studies have found individuals moved up to 3 km (Pyke & White 2001). Individual GGBF even have the potential to disperse as far as 10 km (White & Pyke 2008). There are records of GGBFs several hundred metres from major drainage lines or other waterbodies (Gillespie 1996) and this may represent long-distance dispersal between water bodies. Hamer et al. (2008) noted that male GGBFs at Kooragang Island often moved > 200 metres to reach an ephemeral breeding site, crossing over extended grassland areas and other habitats including disturbed habitats.

Christy (2001) and Muir (2008) state that terrestrial movements of the GGBF are primarily undertaken through more open environments that contained patches of shelter such as rocks, logs or ponds or areas of thick vegetation. Such habitats provide relatively little impediment to the movements of frogs but allow for individuals to seek shelter as required. Terrestrial movements are typically undertaken at night and are most likely associated with rainfall events (F. Lemckert Pers. Obs.) which would provide protection against desiccation.

Mahony (1999) cautions that the studies that have been carried out since the declines of the GGBF do not necessarily identify the actual preferred requirements of the species. He notes that the changed environment and factors causing the declines may have “altered” the optimal habitats for the species in comparison to their habitat use patterns prior to the declines. This is based on the fact that the use of ephemeral breeding sites was not noted for the bell frog group in earlier habitat descriptions. Such altered habitat use has been noted for other species such as Litoria lorica that now is only present in open rocky streams whereas it was once known as a rainforest stream species (Puschendorf 2011). This change is attributed to the impacts of the chytrid fungus, with the frog only surviving in a relatively extreme environment where the fungus is affected by the hotter conditions. Given the chytrid fungus appears also to have been at least a significant contributor (and probably the major one) to the decline of the GGBF, there is a significant potential that the GGBF is now living successfully only in a different set of environments to what it historically did. However, that is unlikely to ever be confirmed.

2.4.3 Metapopulation dynamics

A critical consideration in the likely presence/absence of the GGBF are metapopulation dynamics. The GGBF is considered to follow a classical metapopulation structure with the “local” population consisting as a series of patchy populations within the larger metapopulation. Individuals move regularly between a mosaic of wetlands across a broad area throughout a single breeding season (Hamer et al. 2008; Hamer & Mahony 2010).

There is high site-specific population turnover with local extinctions being balanced by colonisations by regularly dispersing individuals, but with the overall population remaining stable. There are core sites that provide ongoing and regular reproductive success and that maintain long-term populations, but the major part of the population dynamics is driven by inter-year success of breeding at a range of available breeding sites, with years of very good reproductive success leading to opportunities to expand ranges and colonise new sites. On Kooragang Island, GGBF typically reside in permanent waterbodies where they exhibit high site fidelity, but during periods of high rainfall disperse over several hundred metres to breed at ephemeral water bodies that have flooded (Hamer et al. 2008). Reproductive activity (e.g. calling) typically occurs over several nights at these ephemeral waterbodies, with individuals returning to core permanent waterbodies. In times of poor rainfall, the core sites become the refuges for the species and Valdez et al. (2015) found that probability of occupancy of a site increased at large and permanent wetlands.

Following on from this is the identified need for connected sites to allow this population interaction. Hamer (2016) found that the presence of the GGBF at sites at Nowra was dependent on accessibility of ponds, a factor mediated both by the presence of vegetation and the extent of roads in the area, with the presence of roads providing a likely serious barrier to pond use. The presence of vegetation directly around ponds correlated significantly with the potential for greater species diversity. The type of pond available also was important, with the species avoiding steep sided concrete ponds. The apparent negative impacts of roads was confirmed in follow up work (Hamer 2018) where it was again found that the extent of accessible habitat (habitat close to ponds and not isolated from the pond by a road) positively influenced the likelihood of pond occupancy. Extinctions of GGBF were significantly more likely to occur at ponds in areas with higher densities of roads, but were significantly less likely at ponds with higher aquatic vegetation cover. The spatial arrangement of wetlands and the extent of wetlands measured in a 1 km radius has been found to be an important predictor of pond occupancy by GGBF in studies by Hamer et al. (2002), Hamer and Mahony (2010) and Valdez et al. (2015) with more ponds, ponds in closer proximity and already occupied ponds increasing the potential for the GGBF to be present or occupy a previously unoccupied pond (Puschendorf et al. 2011).

2.4.4 Vegetation associations

The OEH profile records the GGBF to be associated with a broad range of vegetation formations and classes within the Sydney Basin Interim Biogeographic Region, the location of the AWRC and infrastructure (https://www.environment.nsw.gov.au/threatenedspeciesapp/profileData.aspx?id=10483&cmaName=Sydney+Basin). These are:

1. Dry sclerophyll forests (shrub/grass sub-formation)
    - Cumberland Dry Sclerophyll Forests
2. Dry sclerophyll forests (shrubby sub-formation)
    - Sydney Coastal Dry Sclerophyll Forests
    - Sydney Hinterland Dry Sclerophyll Forests
3. Forested wetlands
    - Coastal Floodplain Wetlands.
4. Freshwater wetlands
    - Coastal Freshwater Lagoons.
5. Grasslands
    - Maritime Grasslands
    - Temperate Montane Grasslands.

6. Grassy woodlands
    - Coastal Valley Grassy Woodlands
    - Miscellaneous ecosystems
    - Highly disturbed areas with no or limited native vegetation
    - Water bodies, rivers, lakes, streams (not wetlands).
7. Heathlands
    - Coastal Headland Heaths
    - Sydney Coastal Heaths
    - Wallum Sand Heaths.
8. Miscellaneous ecosystems
    - Highly disturbed areas with no or limited native vegetation
    - Marine environments
    - Rocky islands
    - Water bodies, rivers, lakes, streams (not wetlands).
9. Rainforests
    - Dry Rainforests.
    - Littoral Rainforests
    - Northern Warm Temperate Rainforests.
10. Saline wetlands
    - Mangrove Swamps
    - Saltmarshes.
11. Wet sclerophyll forests (grassy sub-formation)
    - Northern Hinterland Wet Sclerophyll Forests
    - Southern Tableland Wet Sclerophyll Forests.
12. Wet sclerophyll forests (shrubby sub-formation)
    - North Coast Wet Sclerophyll Forests
    - Southern Escarpment Wet Sclerophyll Forests.

The most important feature to note is that this list of vegetation associations is relatively broad covering wetlands and swamps, woodlands, dry sclerophyll forests and dry rainforest. That is essentially all possible environments present within the Cumberland Subregion and reflects the understanding that the GGBF is a very adaptable species with little in the way of habitat limitations. This also conforms with the GGBF being recognised for its use of highly disturbed environments and areas without native vegetation. In the context of assessing the likely presence/absence and, if present, the abundance of this species, the type of vegetation present has little relevance. The value of vegetation is being present to provide GGBF shelter and locations where food may be found.

2.4.5 Threats

The OEH profile for this species lists the following as threats to this species:

- Alteration of drainage patterns and stormwater runoff.
- Frog Chytrid Fungus, a fungal pathogen.
- Predation by feral animals such as foxes.
- Herbicides and other weed-control measures.
- Road mortality, where populations are already small due to other threats.

- Predation by exotic fish such as Plague Minnow.
- Loss of suitable breeding habitat through alteration by infilling and destruction of wetlands.
- Current knowledge of the status of the population and threats to the population is poor.
- Species occurs on private land where land management practices may not be suitable for the species, e.g. grazing and loss of breeding habitat.
- Changes in salinity due to sea level rise. Frogs are unable to breed in waters with salt concentrations of greater than 6 parts per 1,000.
- Overgrowth of pond vegetation leading to declining water temperature.
- Small population size.
- Lack of information regarding habitat permanency.
- Drying of breeding habitat as a result of increased temperatures and more frequent droughts.
- Lack of landscape connectivity leading to isolation of small populations.
- Heavy metal pollution.
- Four-wheel drives impacting habitat.

The Australian Government's Species Profile and Threats Database (SPRAT) (https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1870) lists the following threats for GGBF:

- Habitat removal.
- Habitat degradation (which includes siltation, changes to aquatic vegetation diversity or structure reducing shelter, increased light and noise, grazing, mowing, fire).
- Habitat fragmentation.
- Reduction in water quality and hydrological changes (for example, pollution, siltation erosion and changes to timing, duration or frequency of flood events).
- Disease (for example, infection of the frog with chytrid fungus (*Batrachochytrium dendrobatidis*) resulting in chytridiomycosis).
- Predation by introduced predators including the Plague Minnow (*Gambusia holbrooki*), Cats (*Felis catus*) or Foxes (*Vulpes vulpes*).
- Introduction or intensification of public access to GGBF habitats.

The IUCN Redlist profile for the GGBF (Hero et al. 2004) notes the following in regards to threats to the GGBF: "The cause(s) of the apparent declines observed in populations of all taxa within the *L. aurea* complex are unclear (Gillespie et al. 1995). Investigations of disappearances among the group have primarily focused on *L. aurea* and *L. castanea* and two major directions in research have been pursued: the role of increased ultraviolet radiation; and the impact of the introduced fish, Gambusia (Mahony 1999). It is also possible that disease, such as a viral infection or chytrid fungus, might have contributed to the decline of this species (W. Osborne pers. comm.). Chytrid fungus was detected in this species in Hoskinstown and Homebush Bay in Sydney, New South Wales". This information can be considered to be relatively dated.

In regard to the AWRC and facilities, the majority of these threats would already be in place and not significantly added to by the proposed development. The following are considered to be of relevance as the proposed development may significantly add to already existing threats:

- Habitat removal, degradation and fragmentation (through construction of the facilities).
- Introduced aquatic predators (access to breeding streams).

- Spread of the amphibian chytrid fungus.
- Hydrological changes (through the introduction of treated water into the river systems).

2.4.6 Variables determining Green and Golden Bell Frog presence

This information provides the following important points when trying to assess the potential presence of the GGBF in any area:

- The GGBF is more likely to be present where multiple suitable breeding sites are within a close enough proximity for frogs to migrate between them with relative ease.
- The GGBF is more likely to be present where multiple non-breeding water bodies are present in an area and within close enough proximity to allow migration between them (and breeding sites) with relative ease.
- The GGBF is more likely to be present where the connectivity of breeding and non-breeding habitat contains a matrix (vegetation and shelter) that facilitates migration.
- The GGBF is more likely to be present at a location when there are other GGBF occupied ponds in close proximity.
- The GGBF is unlikely to be present within areas containing a large number of introduced fish.

3. Description of the study area

The following information has been taken directly from the Biodiversity Development Assessment Report (BDAR) produced by Biosis (Biosis 2021) unless otherwise noted.

3.1 Land use history

The following information has been derived from the Cumberland Plain Recovery Plan (DECCW 2010a). At the time of European settlement, the Cumberland Subregion would have consisted of extensive areas of grassy woodlands were present along with wooded areas including ironbark and turpentine forests, dry rainforests, and floodplain communities. Agricultural development commenced before 1800 and by the middle of the 19th century most of the region was either being grazed or was cultivated. Clearing for agriculture was later supplemented by clearing for residential, commercial and industrial purposes.

The project predominantly occurs within the Cumberland Plain with the western end extending towards the Blue Mountains Plateau. This area predominantly contains patches of low to moderate quality native vegetation throughout suburban and peri-urban areas with high condition patches of vegetation at the eastern and western ends in undeveloped areas. High condition patches of vegetation at the eastern end of the impact assessment area are contiguous with vegetation conserved in the riparian corridors of Prospect Creek and Georges River. High condition patches of vegetation at the western end of the impact assessment area are contiguous with the Greater Blue Mountains World Heritage Area and the Warragamba Dam Special Area. Moderate condition patches within the central section of the impact assessment area form contiguity with vegetation conserved in Western Sydney Parklands and Kemps Creek Nature Reserve.

The broader study area has a long history of pastoral and agricultural farming, specifically, cattle, poultry, bee keeping and market gardens, supplying the Sydney market with products from 1800 to the mid-20th century. The majority of the study area remains peri-urban whilst suburban and urban development predominates to the east. The northern section of Kemps Creek currently contains land used for commercial agriculture including cattle grazing. The land use history has contributed to the condition of the vegetation and current infestations of priority, agricultural and environmental weeds through clearing, under-scrubbing, logging, pasture improvement and introduction of exotic species.

Existing land uses throughout the extent of the impact are and impact assessment area include:

- Conservation and recreation in reserves and parks including Lansdowne Reserve, Lennox Reserve, Cabravale Memorial Park and Western Sydney Parklands.
- Residential and commercial development and supporting infrastructure throughout Lansdowne, Cabramatta, Elizabeth Hills, Cecil Hills and some sections of Kemps Creek and Wallacia.
- Peri-urban development between Wallacia and Luddenham and primary production, including commercial grazing, commercial nursery and market gardens from Kemps Creek to Luddenham in addition to the west of Wallacia.
- Conserved bushland and water infrastructure in the vicinity of Warragamba, including the Warragamba Special Area.

3.2 Landscape features

The following landscape feature, as defined by the BAM, are relevant to the project.

3.2.1 Bioregions

The impact area and impact assessment area occur within the Sydney Basin IBRA bioregion and the Cumberland and Wollemi IBRA subregions. The Sydney Basin Bioregion lies on the central east coast of NSW and covers an area of approximately 3,624,008 hectares. It occupies about 4.53 % of NSW and is one of two bioregions contained wholly within the state. The bioregion extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee. The bioregion is bordered to the north by the North Coast and Brigalow Belt South bioregions, to the south by the South East Corner Bioregion and to the west by the South Eastern Highlands and South Western Slopes bioregions. The Sydney Basin Bioregion is one of the most species diverse in Australia. This is a result of the variety of rock types, topography and climates in the bioregion (OEH 2016).

The Cumberland IBRA subregion occurs on the coastal side of the Lapstone monocline and is characterised by low rolling hills and wide valleys in the rain shadow area of the Blue Mountains. Underlying geology is predominantly formed from Triassic Wianamatta group shales and sandstones with occasional volcanic intrusions, in addition to Tertiary river gravels, sands and Quaternary alluvium along ancient and current waterways. Vegetation of the Cumberland IBRA subregion consists of dry and wet sclerophyll forests on sandstone and transitional slopes and hills, dry sclerophyll woodlands on plains and shale hills, alluvial forests on riverflats and wetlands in lagoons, swamps and floodplains (OEH 2016).

The Wollemi IBRA subregion occurs across the Great Dividing Range and is characterised by a mountainous landscapes comprising sandstone plateaus, steep cliff faces, benched rock outcrops and deep gorges. Underlying geology consists of Hawkesbury Sandstone and quartz sandstones of the Narrabeen Group with occasional volcanic diatremes. Vegetation of the Wollemi IBRA subregion consists of dry sclerophyll forests on exposed slopes and ridgetops, wet sclerophyll forests on protected slopes, within deep gorges and adjacent to waterways, upland swamps in soaks and drainage depressions and heaths on windswept ridges on skeletal soils (OEH 2016).

3.2.2 NSW (Mitchell) Landscape

The impact area and impact assessment area span multiple Mitchell Landscapes associated with the Sydney Basin Bioregion including Cumberland Plain, Georges River Alluvial Plain, Hawkesbury-Nepean Channels and Floodplains and the Kurrajong Fault Scarp.

The majority of the impact area and impact assessment area occur on the Cumberland Plain component of the Sydney Basin. This landscape is characterised by low rolling hills and valleys and underlying geology consists of Triassic shales and lithic sandstones interspersed with a small number of volcanic vents, Tertiary river gravels and sands and Quaternary alluvium along major streams. General elevation is between 30 and 120 m and local relief is 50 m. Soils consist of uniform red to brown clays around volcanic hills and red and brown texture-contrasts soils on crests, grading to harsh yellow soils in valleys.

Associated vegetation is influenced by location within the rain shadow of the Blue Mountains and consists of dry sclerophyll woodlands and pockets of dry sclerophyll forests throughout with forested wetlands occurring on poorly drained valley floors (Mitchell 2002).

The eastern extent of the impact area and impact assessment area and adjacent waterways occurs on the Georges River Alluvial Plain component of the SB Cumberland landscape within the Sydney Basin. The topography is characterised by the channel, floodplain and terraces of the Georges River on Quaternary and Tertiary alluvial sediments. Soils are predominantly a mixture of yellow brown to orange clayey sand with some limited gravel intrusions on elevated terraces. General elevation is between 0 to 30 metres and local relief is 10 metres. Associated vegetation consists of forested wetlands on floodplains and along waterways and estuarine swamps and small pockets of mangroves or saltmarsh on estuary sands (Mitchell 2002).

The Hawkesbury – Nepean Channels and Floodplains component of the SB Cumberland landscape within the impact area and impact assessment area occurs in the vicinity of perennial waterways and historic floodplains with corresponding topography. Underlying geology consists of Quaternary sand and gravel with general elevation of 0 to 20 metres and local relief <10 metres. Soils comprise sands upstream of the Warragamba River junction with the remainder of the landscape consisting of undifferentiated alluvial sands to sandy loams or clay loams. Associated vegetation consists of forested wetlands on river flats, reed dominated wetlands on river beds and lower banks, sedgelands in large swamps and lagoons and in tidal areas, small pockets of mangroves and saltmarsh in intertidal zones (Mitchell 2002).

The western extent of the impact area and impact assessment area occurs within the Kurrajong Fault Scarp component of the SB Wollemi landscape between Wallacia and Warragamba. The topography is characterised by dissected and broken slopes with abundant rock outcrops spanning across the Lapstone monocline and Kurrajong fault scarp. Underlying geology consists of Tertiary Quartz sandstone and shale with general elevation of 100 to 250 metres and local relief of 100 metres. Soils are predominantly yellow brown sands interspersed with occasional yellow texture-contrast soils. Associated vegetation consists of dry sclerophyll forests throughout, dry sclerophyll woodlands on transitional zones with other Mitchell landscapes and swamps behind fault blocks on deep sands (Mitchell 2002).

3.2.3 Soil

The dominant geology in the impact area and impact assessment area comprises Wianamatta Group shales throughout the eastern and central extents intersected with Bringelly Shale, Alluvial Valley Deposits, Alluvial Floodplain Deposits, Alluvium and Ashfield Shale near riparian corridors and associated tributaries. The western end of the impact assessment area is underlain by Hawkesbury Sandstone intersected by Rickabys Creek Gravel and Colluvial talus deposits in the vicinity of riparian corridors.

The impact area and impact assessment area occur on the following soil landscapes of the *Soil Landscapes of the Penrith 1:100,000 Sheet map* (Bannerman & Hazelton 1990):

- Berkshire Park Alluvial soil landscape.
- Blacktown Residual soil landscape.
- Gymea Erosional soil landscape.
- Hawkesbury Colluvial soil landscape.
- Luddenham Erosional soil landscape.
- Richmond Alluvial soil landscape.
- South Creek Alluvial soil landscape.

The Berkshire Park Alluvial soil landscape is characterised by gently undulating low rises on Tertiary terraces of the Hawkesbury-Nepean River system. Soils are weakly pedal and mottled orange heavy clays and clayey

sands with occasional ironstone nodule intrusions. Soils exhibit low fertility, are strongly acidic, hardsetting, impermeable and are subject to localised high erodibility. Vegetation associated with this soil landscape has been mostly cleared with only isolated pockets of dry sclerophyll forest remaining.

The Blacktown Residual soil landscape is characterised by gently undulating rises (<5%) over Wianamatta Group and Hawkesbury shales with local relief of 30 metres. Soils are shallow to moderately deep and comprise red and brown podzolic soils on crests, upper slopes and well-drained areas and yellow podzolic soils and soloths on lower slopes and poorly drained areas. The soil quality is known to exhibit low fertility, poor drainage and is not susceptible to erosion. Vegetation associated with this soil landscape consists of wet and dry sclerophyll forests in areas exposed to moderate to high rainfall and grassy woodlands in areas exposed to moderate to low rainfall.

The Gymea Erosional soil landscape is characterised by undulating to rolling rises and low hills with broad convex crests and moderately inclined sideslopes (10 to 25%) over Hawkesbury Sandstone with local relief of 20 to 80 metres and localised rock outcrops (<25%). Soils are shallow to moderately deep and comprise yellow earths and earthy sands on crests and insides of benches, shallow siliceous sands on leading edges of benches, localised gleyed podzolic soils and yellow podzolic soils on shale lenses and siliceous sands and leached sands along drainage lines. Soils have low fertility, are strongly acidic, highly permeable and are moderate to highly erodible. Vegetation associated with this soil landscape consists of dry sclerophyll woodland and open forests.

The Hawkesbury Colluvial soil landscape is characterised by rugged, rolling to very steep hills with narrow crests and ridges, narrow incised valleys with steep sideslopes and rocky benches (>25%) on Hawkesbury Sandstone with local relief of 40 to 200 metres and rock outcrops (>50%). Soils are shallow discontinuous lithosols or siliceous sands on rock outcrops, earthy sands and yellow earths on the inside of benches, joints and fractures, localised yellow and red podzolic soils on shale lenses and yellow earths along drainage lines. Soils exhibit low fertility, are strongly, highly permeable and are highly susceptible to erosion. Vegetation associated with this soil landscape consists predominantly of dry sclerophyll forests with pockets of wet sclerophyll forest or rainforest in less exposed areas.

The Luddenham Erosional soil landscape is characterised by undulating to rolling low hills with narrow ridges, hillcrests and valleys (5 to 20%) over Wianamatta Group shales and Minchinbury Sandstone with local relief of 50 to 80 metres. Soils are shallow to moderately deep and comprise dark podzolic soils or massive earthy clays on crests, moderately deep red podzolic soils on upper slopes and moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines. Soils exhibit low to moderate fertility, have low permeability and are susceptible to minor gully and moderate sheet erosion. Vegetation within this soil landscape has been extensively cleared with pockets of dry sclerophyll woodlands and forests remaining.

The Richmond Alluvial soil landscape is characterised by mainly flat quaternary terraces of the Nepean and Georges Rivers (<1%) on Quaternary Alluvium with local relief of <3 metres. Soils are poorly structured orange to red clay loams, clays and sands with occasional presence of ironstone nodules. Soils exhibit low to very low fertility, are sodic, impermeable and are highly susceptible to erosion. Vegetation associated with this soil landscape has been extensively cleared with pockets of remnant riparian forest and wetlands

The South Creek Alluvial soil landscape is characterised by floodplains, valley flats and drainage depressions (>5%) on the flat, incised channels of the Cumberland Plain with local relief of 10 metres. Soils consist of deep

layered sediments over bedrock comprising structured plastic clays or structured loams in or adjacent to drainage lines, red and yellow podzolic soils on terraces usually in combination with patchy structured grey clays, leached clay and yellow solodic soils. Soils exhibit low fertility, are strongly acidic, have hardsetting surfaces, poor drainage and are susceptible to very high to extreme erosion. Vegetation associated with this soil landscape consists of riparian forests and wetlands.

3.2.4 Native vegetation

NPWS (2002) noted that only 13% of the pre-1750 extent of the Cumberland Plain vegetation remained as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas. The majority (76%) of the remaining bushland is privately owned, and only 8% is protected within the formal reserve system. The region's bushland is also highly fragmented, comprising 2,446 individual remnants (DECCW 2010b), but the 81 largest remnants contain 51% of the remaining bushland. Many of these large, intact remnants occupy public land and so can be expected to be maintained into the foreseeable future. Larger remnants are typically more diverse and resilient than smaller remnants, being less susceptible to 'edge effects' and being less likely to be fully subjected to catastrophic events. Biodiversity loss caused by habitat fragmentation has been demonstrated to significantly increase once clearing levels exceed 70% of the landscape (Freudenberger et al. 1997; WALGA 2004) and this threshold has been passed on the Cumberland Subregion.

Biosis (2020) identified the following plant communities present in their study area that covered the impact assessment area and a 500 m buffer:

- 724: *Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion listed as Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* (Critically Endangered Ecological Community [CEEC], EPBC Act) and *Shale Gravel Transition Forest in the Sydney Basin Bioregion* (Endangered Ecological Community [EEC], BC Act)
- 725: *Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion listed as Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion* (CEEC, EPBC Act) and *Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion* (EEC, BC Act)
- 781: *Coastal freshwater lagoons of the Sydney Basin Bioregion* and *South East Corner Bioregion listed as Sydney Freshwater Wetlands in the Sydney Basin Bioregion* (EEC, BC Act).
- 835: *Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion listed as River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* (EEC, BC Act).
- 849: *Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion listed as Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* (CEEC, EPBC Act) and *Cumberland Plain Woodland in the Sydney Basin Bioregion* (CEEC, BC Act).
- 883: *Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion listed as Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion* (EEC, EPBC Act) and *Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion* (Vulnerable Ecological Community [VEC], BC Act. Referred to as Castlereagh Scribbly Gum Woodland throughout.
- 1083: *Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion.* Referred to as Coastal Sandstone Ridgetop Woodland throughout.

- 1105: *River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion*. Referred to as River Oak Open Forest throughout.
- 1181: *Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion*.
- 1800: *Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley listed as Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community* (EEC, EPBC Act) and *Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* (EEC, BC Act).

The location of the PCTs relative to the impact assessment area are provided in Figures 1, 2 and 3.

3.2.5 Rivers and streams

Thirty-five waterways flow through the study area, of which the majority are within the Hawkesbury-Nepean Catchment, whereas Prospect Creek falls within the Georges River Catchment (NSW LPI 2016). These waterways are listed below in accordance with the project design feature they occur along and the corresponding Strahler Stream Order (Strahler 1964):

Treated Water Pipeline.

- Nepean River (seventh stream order waterway) including:
  - One tributary (first stream order waterway).
- South Creek (sixth stream order waterway).
- Badgerys Creek (fourth stream order waterway):
  - One unnamed tributary (third stream order waterway).
- Cosgroves Creek (fourth stream order waterway):
  - Two unnamed tributaries (second stream order waterways).
  - One unnamed tributary (first stream order waterway).
- Baines Creek (third stream order waterway).
- Oaky Creek (third stream order waterway).
- Two tributaries of Mulgoa Creek (first stream order waterways).
- Jerrys Creek (fourth stream order waterway) including:
  - Five tributaries (first stream order waterways).

Environmental Flows Pipeline:

- Warragamba River (ninth stream order waterway).
- Megarrity's Creek (third stream order waterway).

Brine Pipeline:

- Prospect Creek (fourth stream order waterway).
- Kemps Creek (fourth stream order waterway):
  - One unnamed tributary (second stream order waterway).
  - Three unnamed tributaries (first stream order waterways).
- Green Valley Creek (second stream order waterway).
  - Hinchinbrook Creek (second stream order waterway):

  - Unnamed tributary (third stream order waterway).
  - Unnamed tributary (first stream order waterway).
- Clear Paddock Creek (first stream order waterway).
- Upper Canal (first stream order waterway).
- Two unnamed creeks (first stream order waterways).

The pipeline alignments are to be underbored beneath the bed of most major waterways that intersect with the impact area and impact assessment area including Prospect Creek, The Upper Canal, Badgerys Creek and the Nepean River at Blaxland's Crossing.

3.2.6 Wetlands

Patches of vegetation mapped as Proximity Area for Coastal Wetland under SEPP (Coastal Management) 2018 occur within the impact assessment area including:

- Vegetation lining the banks of Prospect Creek including a small waterbody in Lansdowne Reserve, Lansdowne.
- Vegetation lining the banks of Clear Paddock Creek north of North Liverpool Drive in Fairfield.
- Vegetation between Doujon Lake and Feodore Drive in Cecil Hills.

Vegetation mapped as Coastal Wetland under the SEPP occur immediately adjacent to the impact area and impact assessment area at Prospect Creek.

Prospect Creek is also mapped on the Coastal Environment Area Map and Coastal Use Area Map under SEPP (Coastal Management) 2018.

Of these wetland areas, the small waterbody in Lansdowne Reserve is mapped as Reservoir in the NSW Wetlands layer (DPIE 2010). Other areas mapped as Reservoir under the Wetlands layer (DPIE 2010) include:

- Liverpool Offtake Reservoir within Western Sydney Parklands approximately 480 metres east of the International Shooting Centre at Cecil Park.
- Tadpole Lake, forming an enlarged section of Kemps Creek to the immediate north of the AWRC site at Kemps Creek.
- A small dam in Lot 63 DP1087838 located north of Elizabeth Drive in Badgerys Creek.
- Warragamba River below Warragamba Dam at Warragamba.

None of the above wetland features are included in the Directory of Important Wetlands in Australia (DoIW 2004) or are classified as a Ramsar wetland. The impact assessment area is not located within the vicinity of any wetlands included on the List of Wetlands of International Importance developed under the Ramsar convention.

Mapped wetlands at Prospect Creek consist of Cumberland Swamp Oak Riparian Forest (PCT 1800) lining the upper banks and small widely separated pockets of reedland/sedgeland along the lower banks.

Mapped wetlands (DPIE 2010) along Clear Paddock Creek between Elizabeth Drive and St John's Park at Fairfield consist of Cumberland Swamp Oak Riparian Forest (PCT 1800) lining the upper banks and Coastal Wetlands (PCT 781) lining the lower banks. Coastal Wetlands in this section of the waterway are largely dominated by Broadleaf Cumbungi *Typha orientalis* and scattered pockets of Common Rush *Juncus usitatus* along the lower banks.

3.2.7 Connectivity features

Primary connectivity features which occur directly within or adjacent to the impact assessment area are predominantly formed from intact bushland conserved within protected areas. Secondary connectivity features include the riparian corridors of the 35 waterways which intersect with the impact area and impact assessment area. These connectivity features provide abundant breeding, foraging and dispersal resources for terrestrial and arboreal mammals, flying mammals, avifauna, amphibians and invertebrates and may form areas of permanent residency for some species.

Tertiary connectivity features include small patches of remnant and secondary PCTs scattered across the landscape which form stepping stone connectivity suitable for highly mobile avifauna and flying mammals. Dispersal potential for flora species and less mobile fauna species is predominantly restricted to within the impact area and adjoining primary and secondary connectivity features; however highly mobile fauna species are likely to utilise tertiary connectivity corridors to disperse through the landscape.

The eastern part of the impact assessment area contains a BioBank site located Lansdowne Reserve. The BioBank site contains high condition Cumberland Plain Woodland in addition to a large population of Downy Wattle and Native Pear. The interior, less disturbed sections of the BioBank site contain large areas of intact biological soil crust and the groundcovers include a diverse array of native grasses, sedges, herbs and forbs.

3.2.8 Areas of geological significance

There were no recorded karst formations within the study area or within the 500 metre buffer area surrounding the study area. The western end of the study area in the vicinity of Warragamba Dam and the Greater Blue Mountains Area across the Warragamba River contained cliffs and other rock formations which contained deep overhangs and caves. The remainder of the study area contained no caves, crevices, cliffs or other areas of geological significance.

3.2.9 Climate

Key climate statistics for the weather stations located for the areas associated with the AWRC and pipelines are shown in Table 1. This demonstrates simply that the Cumberland Plain receives moderate rainfall and has a generally mild climate.

Table 1: Key climatic statistics for the AWRC infrastructure impact assessment area (taken from the Bureau of Meteorology)

Weather station	Mean total rainfall (mm)	Mean January maximum (°C)	Mean July minimum (°C)
Orchard Hills Treatment Works	832.7	28.5	5.3
Badgerys Creek	794.3	28.6	3.8
Bankstown Airport	782.1	28.8	5.1

4. Impact assessment area as Green and Golden Bell Frog habitat

4.1 Green and Golden Bell Frogs in the region

Overall, there is a significant absence of records of the GGBF from a broad area of the Sydney Basin. Historically the species was well known from the Hawkesbury River where it was estimated that millions of individuals lived in the 1960s and 1970s (A. White Pers. Comm.). This poorly documented large population along with other historic descriptive records of the frog from western Sydney (e.g. near Picton; Copland 1957) that are not held within databases indicates that the absence of records must partly have been due to a lack of survey, especially prior to the decline of the GGBF in the 1980s.

There have been some historic surveys conducted across the Sydney Basin, but the extent of this work is poorly documented and generally unavailable to view. This includes surveys carried out around Badgerys Creek as part of a succession of assessments for the proposed second Sydney Airport site. For example, I personally have conducted unsuccessful surveys in this area of the second Sydney Airport in the late 1990s for as well as surveys at places such as Orchard Hills, Riverstone, Blair Athol, Macarthur and along the Nepean River near Picton. Many other surveys would have been completed for a wide range of developments as part of impact assessments for developments of all types. The details of these surveys are not published and it is likely the results of most are not even downloaded, hampering efforts to understand the extent of surveys carried out.

Regardless, the majority of records of GGBF ever obtained should still have been included in the NSW BioNet and it would still be likely that the available records reasonably indicate relatively how widespread the GGBF was across southwestern Sydney prior to the 1980s. The minimal set of available records for most of southwestern Sydney looks very likely to indicate a true historic rarity of the species in southwestern Sydney, which has been exacerbated by the declines occurring after 1980. Possibly the GGBF may not have preferred the woodlands that were present prior to European settlement. There would have been relatively few good breeding sites outside of river systems with smaller streams and creeks not providing the breeding habitat required to sustain a broad population. The species is also considered to be dependent on disturbance for longer term success (Pyke and White 2001) and these environments may not have suffered enough regular disturbance to provide broad areas of breeding and foraging habitat for the GGBF in the area.

The clearing of the woodlands to create farms and grazing land should have favoured this species, but if it did, it never appeared to have been able to spread to take advantage of the new habitat. Perhaps invasive fish rapidly followed the establishment of what is otherwise favourable habitat and supressed the GGBF from using the landscape. The Plague Minnow was widely distributed for mosquito control after World War 2 in response to concerns that mosquitoes might spread disease from returning soldiers and this pest species is ubiquitous across ponds and streams. It is a known predator of GGBF eggs and tadpoles and is widely regarded to eliminate or seriously supress GGBF populations at a water body once the Plague Minnow has established there (Mahony et. al. 2013).

Regardless, the majority of records are from prior to 1990, indicating that most populations that once occurred in western Sydney are likely to now be extinct. This fits the pattern of declines noted for the GGBF by Mahony et al. (2013) that populations rarely persist more than 10 km from the coast, apparently due to the impacts of the chytrid fungus. The entire impact assessment area meets this criterion.

I note that there have been a number of records since 1990 of GGBF located in a zone around Riverstone, which is to the north of Kemps Creek. These records have usually been located in association with river and

creek systems and have looked somewhat random in their timing. These records appear to come from individual GGBF that migrate from a property at Riverstone where a private landholder has set up what can be described as a GGBF sanctuary. At this site he provides breeding ponds and mulch beds that provide both food and heated shelter sites for the frogs to over-winter. These conditions and the overall setting provide a situation where the GGBF appears to be able to survive regardless of the presence of the chytrid fungus and the frogs remain consistently breeding on that property. However, they have never been able to establish ongoing populations in immediately surrounding areas and the individuals located away from the property on streams lines have been juveniles, indicating that they were almost certainly young individuals dispersing across the landscape from the Riverstone property. Whilst this semi-managed population on the property appears to be self-sustaining, the GGBF appears to be unable to persist outside of this property. This is important as the ongoing records could otherwise suggest that there is a significant naturally occurring population present in western Sydney, and relatively close to the impact assessment area. However, such a natural self-sustaining population is highly unlikely to exist and the occasional records would be expected to cease if the landholder stopped assisting the GGBF population on the property.

4.2 Advanced Water Recycling Centre Development as potential habitat

An assessment of the known records for GGBF for each of the different sections of the AWRC impact assessment area is provided below, along with the suitability of habitat. This is based mainly on consideration of the factors provided in Section 2.4.6.

4.2.1 Advanced Water Recycling Centre

The construction of the AWRC would cover over part of South Creek and an area of floodplain that provides what would be considered suitable physical habitat for the GGBF and would also be a potential movement corridor for the GGBF across the broader area. However, habitat that the GGBF could move through will be retained on both sides of the facility and Badgerys Creek and Kemps Creek will not be interrupted by the development and so movement corridors would still be present.

The Plague Minnow appears to be widespread through the creek systems of the area and would be present in any water body on the floodplain.

There are no records for the GGBF from within the proposed AWRC construction site at Kemps Creek or in the surrounding 1000 m or even 2000 m.

4.2.2 Water pipeline

The pipeline generally runs along major roads and so through already disturbed locations that are unlikely to represent any form of significant habitat for the GGBF. The rural lands in general provide potentially suitable foraging and migratory habitat, although there is not usually much cover on the ground that can be used for shelter outside of the fringing vegetation of the ponds. The route passes under several creek systems, but these are highly disturbed and provide poor habitat (e.g., *Plate 3*).

The area where the pipeline runs through at the western end around the Wallacia Weir and on to the Warragamba River contains large areas of retained native vegetation that the species can travel through and find shelter and feeding habitat. However there are few ponds in this retained native vegetation and so there is little breeding habitat. The Warragamba River may provide suitable breeding habitat where swampland and billabongs form adjacent to the main channel.

Again, non-native fish and particularly the Plague Minnow are prevalent in the stream/river systems and adjacent water bodies, greatly decreasing their potential value as breeding habitat. Isolated ponds in rural lands along the pipeline routes may be out of the flood level and so potentially free from the Plague Minnow and so provide better breeding habitat. However, these sites tend to have limited to no emergent vegetation (see *Plate 2*) and do again provide for sub-optimal breeding and shelter habitat. Overall, there is suitable habitat present through much of the proposed route, but it is of lower quality and varies.

There is one record from within 1 km of the boundary of the proposed corridor along Elizabeth Drive, which is located just to the northeast of the junction with Park Road at Luddenham (Figure 4). The record point is not on a water body, but is in close proximity to several larger human created dams located on cleared rural lands. This is a post-1990 record, but the lack of any other records from nearby to this location indicates that there is no persistent presence of the GGBF in the local area. The frog is most likely to have been a dispersing individual.

4.2.3 Brine Pipeline

The majority of this area is developed heavily with suburban housing, industrial areas and large numbers of roadways. Prospect Creek remains present and has some retained riparian vegetation. It provides a corridor between Georges River and Lansdowne Reserve in the south and Prospect Reservoir in the north. The area of Lansdowne Reserve and the floodplain of Prospect Creek has several larger mapped water bodies present, but this part of the pipeline is notable for otherwise having very few even slightly natural water bodies present. This is because it is a suburban area rather than rural and any human constructed ponds that may once have been present are now gone. This greatly reduces any potential breeding sites and Prospect Creek will contain the Plague Minnow. More importantly, there are not the stepping stone ponds and dams to assist in migration present as are found in the rural landscapes and the presence of housing and factories provides hostile habitats if frogs were to attempt to disperse into and through this area.

The area around Lansdowne Park at the far eastern end of the proposed Brine Pipeline route provides a suitable landscape of habitat for the GGBF, with the presence of retained native vegetation adjacent to Prospect Creek and evident floodplain and swamps providing a good mosaic for the GGBF to inhabit. However, the area is surrounded by high density urban development with the only linkage being along Prospect Creek that ultimately runs though highly urbanised locations and has a high density of varying sized roads. It is expected to be too isolated to maintain a viable long-term population unless connection is maintained through the creek system. Given its highly disturbed state, certain presence of feral fish and likely levels of pollution, the creek is unlikely to provide a favourable corridor.

The Western Sydney Parklands that the Brine Pipeline runs through what would seem to be suitable habitat, but there are no records present from this area. It is a relatively extensive area of land with a moderate coverage of native vegetation in varying condition states. There are some water bodies present that can provide breeding habitat, although these are likely to contain the Plague Minnow. The site is most limited in potential by its isolation from other areas of suitable habitat by surrounding developments that will likely prevent frogs from migrating to and from adjacent lands to meet metapopulation processes.

The presence of large numbers of larger roads provide significant barriers to dispersal and potential areas of mortality for any local populations of the GGBF. This affects the majority of the route of the Brine Pipeline and is a major negative effect for the GGBF through the majority of the proposed route.

There are several records from within 1 km of the very eastern end of the Brine Pipeline in the area of Lansdowne Reserve (Figure 5). However, these are all pre-1990 and are likely to have been connected with an historic population associated with the area of the Prospect Reservoir.

4.3 Habitat survey of the impact assessment area

As previously noted, targeted surveys for the GGBF were not able to be completed as part of the assessment due to access and timing constraints. Instead a daytime visual survey was conducted in and around the impact assessment area that directly assessed the extent, types and qualities of aquatic and terrestrial habitat present, and considered how the overall proposed development might impact on those habitats. This survey was carried out on the 18th of January 2021 and involved driving through and adjacent to the impact assessment area. This work confirmed the relative quality of the landscape as foraging and breeding habitat and, in particular, the spatial arrangement of water bodies and connectivity of habitats. Roads and urban development form effective blocks to connectivity and the field survey indicated the extent to which these are currently operating and how the AWRC development might contribute to reduced connectivity. This survey indicated that the environment is already greatly compromised by long-term development of western Sydney, indicating that any impacts from the AWRC development is unlikely to add greatly to already existing impacts (see Section 5).

Figure 4: Record of the GGBF within 1 km of the Waste Water Pipeline

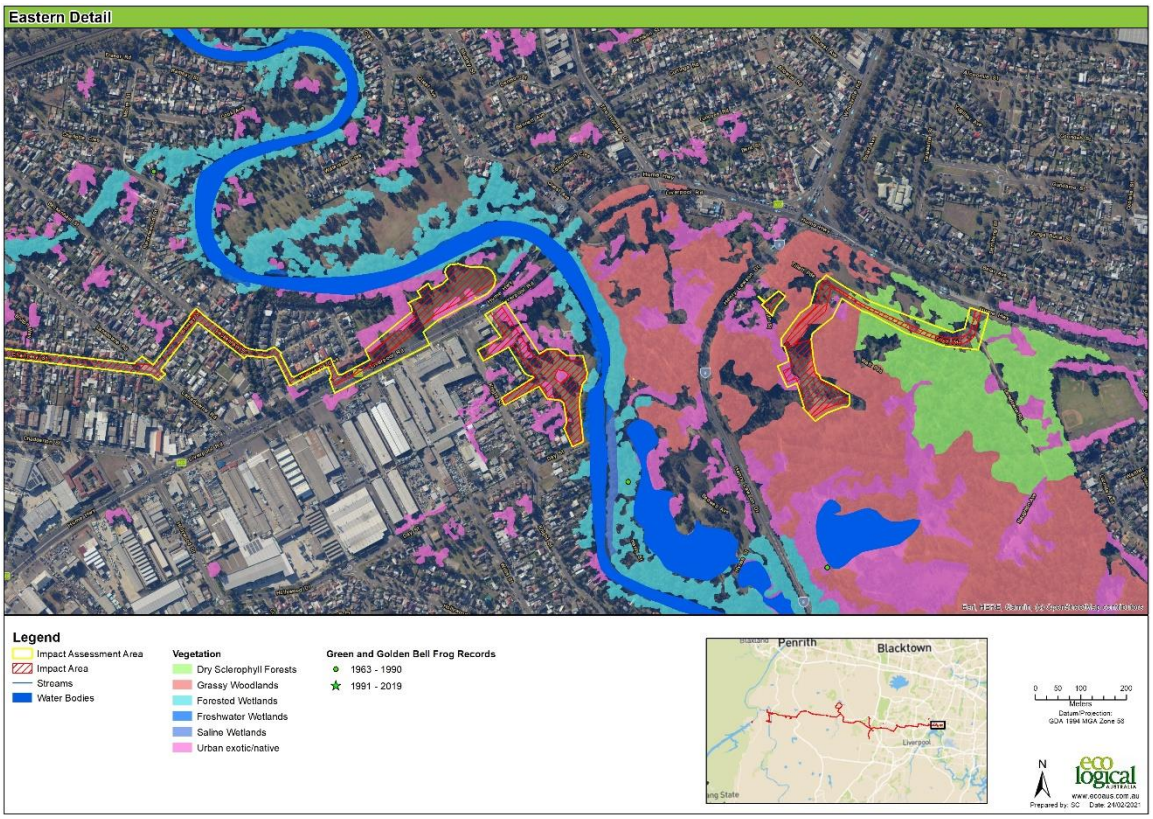

Figure 5: GGBF records associated with Prospect Creek and Lansdowne Reserve

5. Species presence in the impact assessment area

5.1 Main features determining presence

The main consideration at this time in regards to the presence of the GGBF in any location is whether the area is greater than 10 km from the coast. Studies have demonstrated that water bodies this close to the coast can have saline influences that inhibit the growth of the chytrid fungus. Based on the few recent records of the GGBF further than 10 km from the coast, the GGBF is only likely to be present where a refuge is provided from the fungus. This can be because of human intervention to create ideal breeding conditions and temperatures that retard the effects of the fungus (e.g. habitats created at Riverstone by a backyard breeder) or where historic land use has provided an "anti-fungicidal" environment (i.e., have chemical properties that inhibit growth) that supresses the growth of the fungus, but is not too toxic for the frogs and tadpoles themselves. It is not feasible to map such locations based on historic use, and it would be unlikely that documentation would be extensive and accurate enough to provide clear guidance as to whether an available aquatic environment provided conditions that were suitable to prevent strong growth, but still allow the persistence of the GGBF. If such conditions do exist, it would seem very likely that the species would already have been recorded there and already identified the habitat as suitable. Hence the best understanding of the suitability of sites is based on recent records of the GGBF.

Secondarily, studies have demonstrated a relationship to exist between the probability of occupancy of a pond by GGBF and both the presence of other GGBF nearby and the connectivity of wetland sites within the landscape. The spatial arrangement of permanent wetlands must provide a short enough distance and suitable matrix of intervening habitat for frogs to move between ponds, as well as a large enough number and types of wetlands within a 1 km radius to provide multiple interactive breeding sites (Hamer et al. 2002; Hamer & Mahony 2010; Valdez et al. 2015; Hamer 2018). The maintenance of a viable GGBF population at a local scale is based on the presence of a high density of well-connected water bodies with suitable intervening habitat.

In particular respect to connectivity, the matrix of roads present is likely to have a major influence on whether GGBF can inhabit an area. A high density of roads and the presence of larger roads with high volumes of traffic provide a negative environment for the GGBF. Their habit of migrating between water bodies to maintain a metapopulation requires free movement to allow populations to remain connected, allow new breeding sites to be colonised and allow local extinctions to be repopulated by dispersing individuals. Large roads represent barriers in both distances that frogs must cover in exposed conditions, and the typically heavier volumes of traffic prohibit the successful crossing by frogs. Numerous smaller roads provide the same effect. Rural areas generally have a low density of roads and so provide a relatively suitable environment for the GGBF where there are water bodies present. Large roads or numerous smaller roads surrounding areas of otherwise suitable habitat makes that habitat unlikely to be used. The presence of roads reduces the potential use even where they do not completely isolate a site and so the greater the presence of roads, the less potential there is for the species to be present.

5.2 Suitability of habitat within the impact assessment area

The information in Section 2 demonstrates the ability of the GGBF to use a broad range of habitats and only urbanised areas represent unsuitable habitat, mainly because of the absence of breeding ponds and the high density of roads and buildings that form barriers to movements.

As noted in Section 4.2, the AWRC and major parts of the pipeline routes are located within a suitable habitat

matrix in the form of rural areas with numerous water bodies within close proximity (< 500 metres). This should provide both breeding and non-breeding water bodies sufficiently close to allow GGBF to migrate between them and with adjacent vegetation and shelters that they would allow them to successfully do so. These surrounding areas would also provide over- wintering sites and vegetated areas to provide supplies of invertebrates as food for GGBF. The exception is the area of heavily urbanised environment that much of the Brine Pipeline runs through, which represents very low quality habitat that the species is highly unlikely to use.

The Plague Minnow is known to be widespread within the stream systems of western Sydney and was observed in all water bodies able to be accessed in the site visit. All streams and any pools occurring on floodplains areas, and any associated swamplands, are severely reduced in value as breeding habitat where the Plague Minnow is present, as they eat the eggs and tadpoles of GGBF when they can easily access them. However the full extent of the effect of the Plague Minnow is uncertain as the GGBF can co-habit sites where there is suitable emergent vegetation and/or where fish free ephemeral sites can develop. Such sites could occur anywhere across the broad landscape, although are likely few.

The widespread presence of roads of differing sizes and traffic volumes would be expected to have a negative impact on any GGBF present, with the severity of that impact depending on their location and extent.

5.3 Green and Golden Bell Frog presence within the impact assessment area

Based on the considerations provided in Section 5.1, the only location within the impact assessment area that I consider has any realistic potential to be used by the GGBF is the area within the Treated Water Pipeline near Elizabeth Drive at Luddenham where there is a record after 1990. However, whilst the environment is potentially suitable for the species given the that there a range of ponds scattered across rural fields at a suitable size and density to provide interconnected breeding habitat, the fact that it is just a single record indicates that no viable population is present. Therefore I consider the GGBF to be absent from the impact assessment area and no further assessment or offset is required.

The three records within 1 km of the Brine Pipeline near the western end of that development (Figure 5) are all pre-1990 and the area is heavily urbanised and has large numbers of roads. Based on this I do not believe that there is any potential for a viable population to be persisting within this location and so no offset polygon is required.

A consideration may be to avoid impacts to habitat that could be significant if the GGBF was ever to recover in population numbers and range as a result of it developing some form or resistance to, or ability to cope with the Chytrid fugus. However, this still does not appear to be a concern. The AWRC facility will not fragment the landscape in any way more than it is currently impacted and so GGBF would still be able to move around as freely as they can now. The AWRC facility will likely impact on areas of ephemeral floodplain at Kemps Creek, but there is significant similar habitat all around that location and that floodplain represents already poor breeding habitat due to the presence of the Plague Minnow. The pipelines occurring within the impact assessment area will be located underground and so do not represent anything more than a short-term impact to the environment. Overall, I do not see that the development would impact the environment to the point where it would create any more of a barrier to movement than currently exists, nor significantly reduce possible foraging, shelter or migratory habitat over what is currently available. Hence it would not impact on the potential for populations to occupy the area in the future, should some form of recovery ever take place.

As no current population or their habitat is present within the impact assessment area no further assessment is considered to be required.

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7. Appendix A Dr Frank Lemckert CV

Frank Lemckert **PRINCIPAL SCIENTIFIC ECOLOGIST**

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland), establishing long-term research and monitoring programs into the management of fauna and developing strategies to mitigate the impacts of human disturbances. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for the Giant Burrowing Frog (*Heleioporus australiacus*) and recent expert review roles on fauna management plans and monitoring strategies for the NSW Natural Resources Commission. Frank is an accredited expert under the NSW Biodiversity Assessment Method (BAM) for a range of threatened frogs and wrote the BAM survey guidelines for NSW's threatened frogs. Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000), been a member of a state regulators advisory group for the management of Cane Toads across Australia and the Taren Point Cane Toad Advisory Group, and provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments. He has authored over 90 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group. He is a recognised expert in frog ecology and management, but has completed management related projects and works on a range of terrestrial vertebrate fauna.

Frank's primary role as a consultant has been to use his expertise and experience in technical writing and threatened species legislation to develop and maintain quality assurance in project reporting including:

- Species Impact Statements.
- >100 flora and fauna reports and assessments of significance using the EP&A Act and EPBC Act.
- Biodiversity Assessment Reports for Warragamba Dam Raising, Nowra Bridge, Golden Highway and Eurobodalla Dam.
- Manager for the Oxley Highway to Kempsey and Frederickton to Eungai ecological monitoring program.
- Lead fauna survey design for the HumeLink transmission line project for Snowy Hydro 2.0.
- Complete targeted survey and monitoring works for threatened frog species including Giant Barred Frogs, Wallum Froglets, Green-thighed Frog and Green and Golden Bell Frogs.
- Construction and Environmental Management Plans, Monitoring Plans and Vegetation Management Plans for roads at Port Macquarie, Berry to Bomaderry and South Nowra.
- Nest Box, microbat and Green and Golden Bell Frog management plans for the Berry to Bomaderry and Oxley Highway to Kempsey Highway Upgrades.
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade.
- Review of two proposed Coal Seam Gas Impact Assessment methods for Matters of National Environmental Significance (contracted by the Commonwealth Government).
- Provision of species credit species expert reports for the Warragamba Dam raising project and Western Sydney Growth Centres Biocertification.

- Roadside mapping, survey and management strategies for the Wallum Froglet and Mahony's Toadlet.
- Develop frog and reptile survey guidelines and impact offset guidelines for the Biodiversity Assessment Method.

QUALIFICATIONS

- Bachelor of Science, University of Sydney, 1984 (Terrestrial Ecology and Marine Management)
- Master of Science, University of Sydney, 1991 (Population biology of the Common Froglet)
- PhD, University of Newcastle, 2009 (Management of forest frogs in timber production forests of NSW).

PROJECT EXPERIENCE

ECOLOGICAL IMPACT ASSESSMENT

- MONITORING OF BAT POPULATIONS AND ASSESSMENT OF POTENTIAL IMPACTS OF THE PROPOSED JEREMIAH WINDFARM AT ADJUNGBILLY, NSW (2019-PRESENT).
- MANAGEMENT OF IMPACTS ON GREEN AND GOLDEN BELL FROGS FOR THE KIWEF PROJECT AT KOORAGANG ISLAND, NSW FOR DARACON (2019-PRESENT).
- IMPACT ASSESSMENTS FOR HOUSING DEVELOPMENTS ON KOALAS IN THE CAMPBELLTOWN AREA (PRIVATE DEVELOPMENT AND CAMPBELLTOWN COUNCIL (2019)
- EXPERT REPORT ON THE GREEN AND GOLDEN BELL FROG FOR TWO WESTERN SYDNEY GROWTH AREAS BIOCERTIFICATION PROJECT (2018-PRESENT)
- WARRAGAMBA DAM RAISING PROJECT TARGET SURVEYS, IMPACT ASSESSMENTS, EXPERT REPORTING (SIX SPECIES) AND Q/A FOR WATER NSW (2018-19)
- GRANITE HILLS WINDFARM BIRD AND BAT STRIKE MODELLING AND ECOLOGICAL IMPACT ASSESSMENT, NIMMITABEL, AKUO ENERGY (2018) AND ELYSIAN WINDFARM, NIMMITABEL, AKUO ENERGY (2018)
- VEGETATION REMOVAL AND THREATENED FROG MANAGEMENT STRATEGIES, NEW INTERCITY FLEET MANAGEMENT FACILITY, JOHN HOLLAND GROUP (2018-PRESENT)
- NOWRA BRIDGE EIS ECOLOGICAL ASSESSMENTS, NSW RMS (2018)
- HEATHCOTE ROAD UPGRADE IMPACT ASSESSMENT AND REVIEW OF MITIGATION MEASURES, NSW RMS (2018-2019)
- EUROBODALLA DAM BIODIVERSITY ASSESSMENT REPORT, EUROBODALLA SHIRE COUNCIL (2017-18).

GOVERNMENT REVIEWS/REPORTS

- BIODIVERSITY ASSESSMENT METHOD FROG SURVEY GUIDELINES FOR SPECIES CREDIT SPECIES (2020)
- EXPERT WORKSHOP TO DEVELOP A NSW-WIDE NIL-TENURE FAUNA MONITORING PROGRAM, NSW NATURAL RESOURCES COMMISSION (2020)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- EXPERT REVIEW OF BIODIVERSITY IMPACT ASSESSMENT REPORT FOR THE HORNSBY QUARRY REHABILITATION PROJECT (2019)
- HORNSBY COUNCIL EXPERT WITNESS FOR DEVELOPMENT IMPACTS AT DURAL, HORNSBY SHIRE COUNCIL (2016)

- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT EVANS HEAD, NSW STATE GOVERNMENT (2016)
- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT SOMERSBY, COMMONWEALTH GOVERNMENT (2015)
- REVIEW OF MONITORING STRATEGIES FOR THE WOOLGOOLGA TO BALLINA AND WARRELL CREEK TO NAMBUCCA HEADS PROGRAMS FOR THE PACIFIC HIGHWAY UPGRADE, NSW RMS (2014)
- REVIEW OF IMPACT ASSESSMENT PATHWAYS FOR TWO LPNG PROJECTS, COMMONWEALTH GOVERNMENT (2013)
- REVIEW OF THREATENED SPECIES MODELLING IN FORESTRY AREAS, VIC FORESTS (2012)
- FLORA AND FAUNA REPRESENTATION IN THE AUSTRALIAN RESERVE SYSTEM, COMMONWEALTH GOVERNMENT (2010)
- FLORA AND FAUNA ENDEMISM PATTERNS ACROSS AUSTRALIA, COMMONWEALTH GOVERNMENT (2009)
- REVIEW IMPACTS TO THREATENED REPTILES AND AMPHIBIANS IN THE SOUTHERN BRIGALOW BELT, FOR WPS (2008)
- EXPERT REPRESENTING FORESTS NSW IN THE COMPREHENSIVE REGINAL ASSESSMENT PROGRAM FOR THE REGIONAL FOREST AGREEMENT PROGRAM (1999-2001)
- EXPERT REVIEW OF FAUNA AND FLORA IMPACTS FOR 13 NSW FORESTRY COMMISSION EIS REPORTS (1992-94).

EPBC REFERRALS

- AUSTEN QUARRY (*EUCALYPTUS PULVERULENTA*), HARTLEY, HY-TEC INDUSTRIES (2014-15)
- MARYS MOUNT KOALA (*PHASCOLARCTOS CINEREUS*) REFERRAL, GUNNEDAH QUARRY PRODUCTS (2015)
- GREEN AND GOLDEN BELL FROG (*LITORIA AUREA*) REFERRALS FOR THE PRINCES HIGHWAY UPGRADE AT SOUTH NOWRA, NSW RMS (2011-2012).

MONITORING PROGRAMS

- NIL-TENURE FERAL MANAGEMENT AND MONITORING STRATEGY FOR THE NARRABRI COAL SEAM GAS PROJECT, SANTOS (2019).
- THREATENED FAUNA MONITORING HUME HIGHWAY, KAPOOKA, NSW RMS (2018)
- GREEN AND GOLDEN BELL FROG BASELINE MONITORING PROGRAM AT MEROO LAKES, NSW OEH (2016-17)
- OXLEY HIGHWAY TO KEMPSEY THREATENED BIODIVERSITY MONITORING, NSW RMS (2013-2017)
- FCNSW STATE-WIDE ECOLOGICAL MONITORING PROGRAM, FORESTRY CORPORATION OF NSW (2009-10)

PLANS OF MANAGEMENT / STRATEGIES

- GREEN AND GOLDEN BELL FROG PRE-CLEARING WORKS KOORAGANG ISLAND (DARACON 2016 & CURRENT)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- NESTBOX, MICROBAT AND GREEN AND GOLDEN BELL FROG MANAGEMENT PLANS, BERRY TO BOMADERRY UPGRADE OF THE PRINCES HIGHWAY, NSW RMS (2017)
- GREEN AND GOLDEN BELL FROG SURVEYS AND MONITORING, PRINCES HIGHWAY UPGRADES AT SOUTH NOWRA AND BERRY TO BOMADERRY, NSW RMS (2012-2017)
- THREATENED FROG MODELLED HABITAT REQUIREMENTS, HORNSBY SHIRE COUNCIL (2016)
- MICROBAT MANAGEMENT PLAN FOR CLARENCETOWN BRIDGE, NSW RMS (2016)

- EASTERN BENTWING-BAT MANAGEMENT PLAN, GERRINGONG, NSW RMS (2014)
- GREEN AND GOLDEN BELL FROG MANAGEMENT STRATEGY, PRINCES HIGHWAY UPGRADE, NSW RMS (2012-2014)
- EXPERT REVIEW OF THREATENED FROG MANAGEMENT PLAN - WOOLGOOLGA TO BALLINA UPGRADE, NSW RMS (2014)
- THREATENED MICROBAT MANAGEMENT PLAN FOR WARRINGAH MALL, NORTHERN BEACHES COUNCIL (2014)
- COMMONWEALTH/NSW GIANT BURROWING FROG RECOVERY PLAN, DEWHA/DECC (2012)
- NSW DPI REPRESENTATIVE FOR THE NATIONAL ADVISORY GROUP ON CANE TOAD MANAGEMENT (2009-2011)
- TAREN POINT CANE TOAD MANAGEMENT ADVISORY GROUP (2007-2008).

TRAINING

- LEAD INSTRUCTOR > 50 WILDLIFE TRAINING SCHOOLS RUN IN NSW, ACT AND VICTORIA PROVIDING PRESENTATIONS ON THE SURVEY, IDENTIFICATION AND MANAGEMENT OF ALL FLORA AND FAUNA. THIS INCLUDED DETAILED INSTRUCTION ON THE MANAGEMENT OF THREATENED WADING AND AQUATIC BIRDS AND OTHER AQUATIC SPECIES PRESENTED TO QUEENSLAND, VICTORIAN, NSW AND COMMONWEALTH GOVERNMENT STAFF (1993-2017)
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